



## NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

WASHINGTON, D.C. 20546

REPLY TO  
ATTN OF: GP

TO: KSI/Scientific & Technical Information Division  
Attn: Miss Winnie M. Morgan

FROM: GP/Office of Assistant General  
Counsel for Patent Matters

SUBJECT: Announcement of NASA-Owned U.S. Patents in STAR

In accordance with the procedures agreed upon by Code GP and Code KSI, the attached NASA-owned U.S. Patent is being forwarded for abstracting and announcement in NASA STAR.

The following information is provided:

U.S. Patent No. : 3,803,617

Government or : 42 USC 2457  
Corporate Employee : Hughes Aircraft Co.  
 : LA, CA

Supplementary Corporate : \_\_\_\_\_  
Source (if applicable)

NASA Patent Case No. : GSC-113/73

NOTE - If this patent covers an invention made by a corporate employee of a NASA Contractor, the following is applicable:

YES  NO

Pursuant to Section 305(a) of the National Aeronautics and Space Act, the name of the Administrator of NASA appears on the first page of the patent; however, the name of the actual inventor (author) appears at the heading of column No. 1 of the Specification, following the words "...with respect to an invention of ..."

*Bonnie L. Woerner*

Bonnie L. Woerner  
Enclosure

[54] HIGH EFFICIENCY MULTIFREQUENCY FEED

[76] Inventors: James C. Fletcher, Administrator of the National Aeronautics and Space Administration, with respect to an invention of; James S. Ajioka; George I. Tsuda, both of Fullerton; William A. Leeper, Anaheim, all of Calif.

[22] Filed: Apr. 14, 1972

[21] Appl. No.: 244,158

[52] U.S. Cl. .... 343/730, 343/786, 343/797, 343/853

[51] Int. Cl. .... H01q 1/00

[58] Field of Search ..... 343/729, 730, 786, 797, 343/853, 854

[56] References Cited

UNITED STATES PATENTS

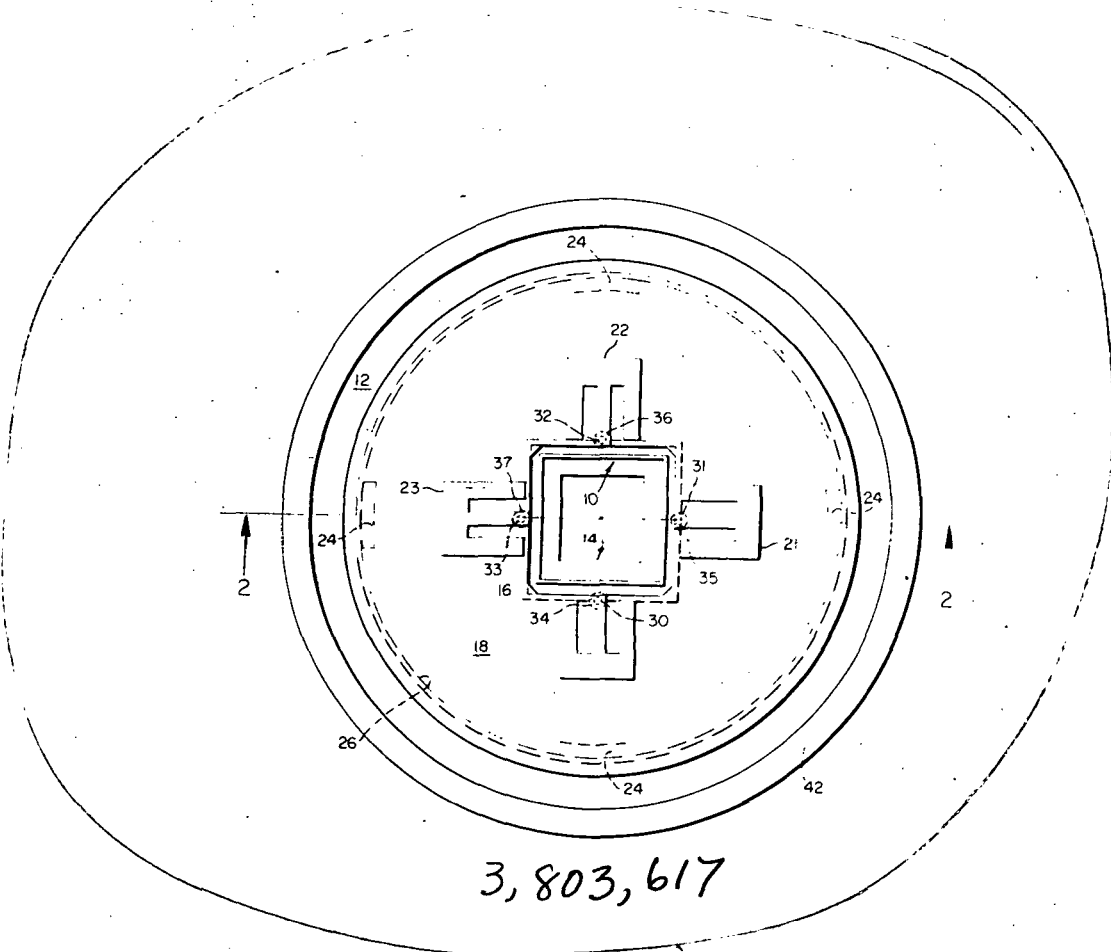
3,205,499 9/1965 Raburn ..... 343/730

Primary Examiner—Eli Lieberman  
Attorney, Agent, or Firm—Leonard Rawicz; Neil B. Siegel; Robert F. Kempf

[57] ABSTRACT

The apparatus of the present invention relates to antenna systems and particularly to compact and simple antenna feeds which can transmit and receive simultaneously in at least three frequency bands, each with high efficiency and polarization diversity. The feed system is especially applicable for frequency bands having nominal frequency bands with the ratio 1:4:6. By way of example, satellite communications telemetry bands operate in frequency bands 0.8 - 1.0 GHz, 3.7 - 4.2 GHz and 5.9 - 6.4 GHz. In addition, the antenna system of the invention has monopulse capability for reception with circular or diverse polarization at frequency band 1.

14 Claims, 12 Drawing Figures



3,803,617

(NASA-Case-GSC-113173) HIGH EFFICIENCY  
MULTIFREQUENCY FEED Patent (NASA) 11 p  
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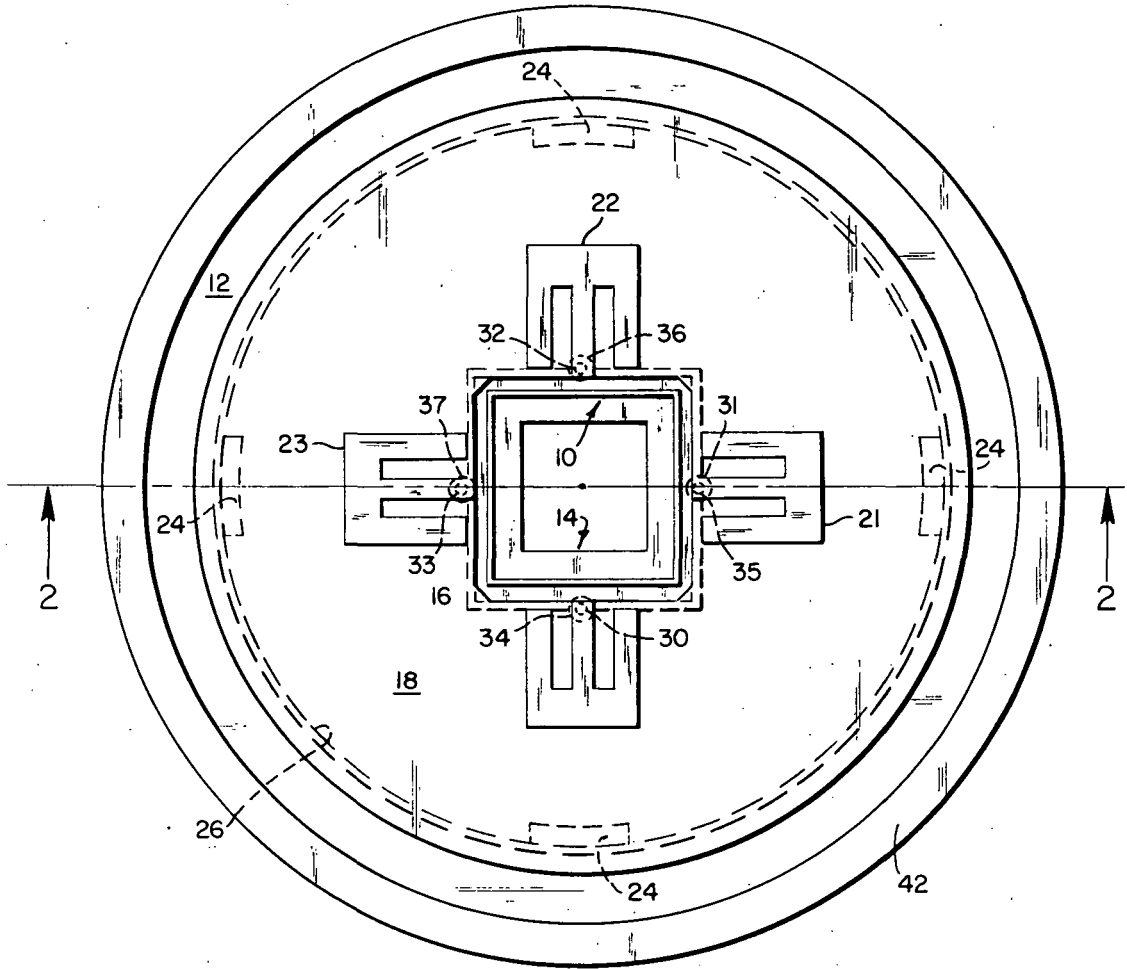


Fig. 1

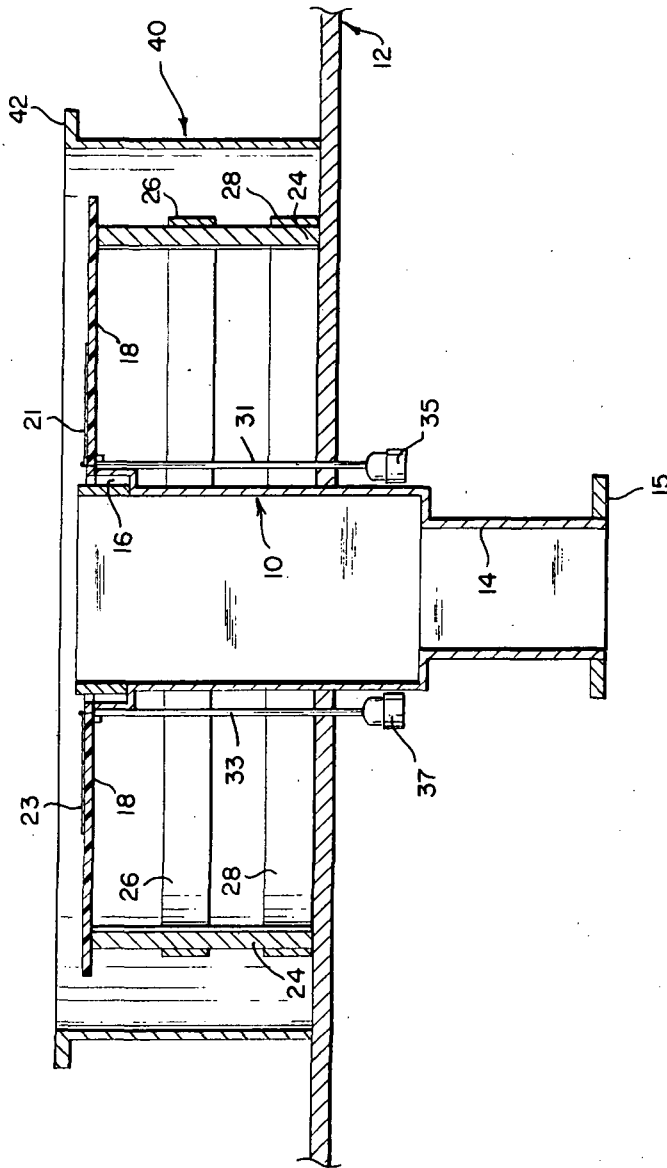


Fig. 2.

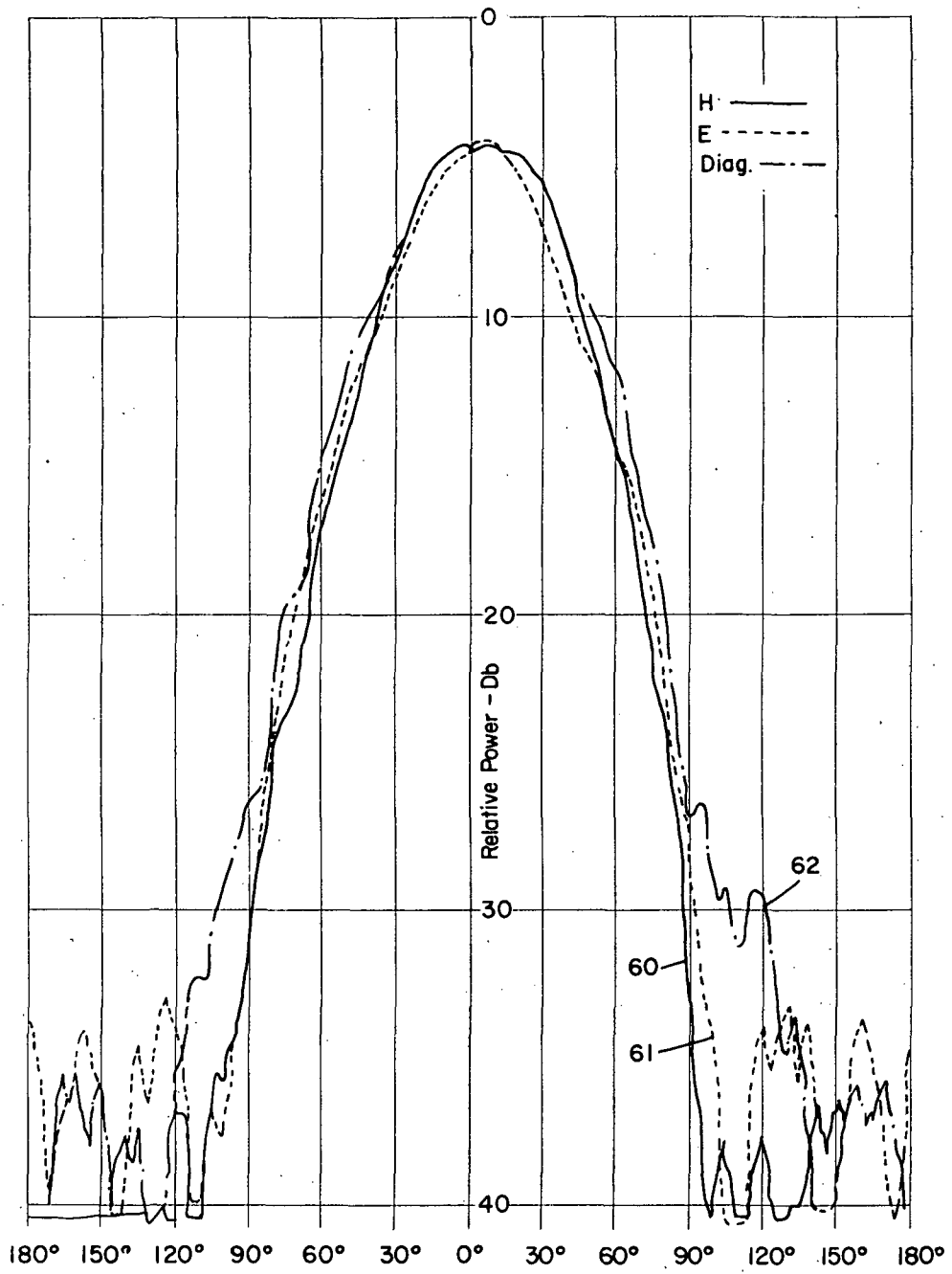


Fig. 3.

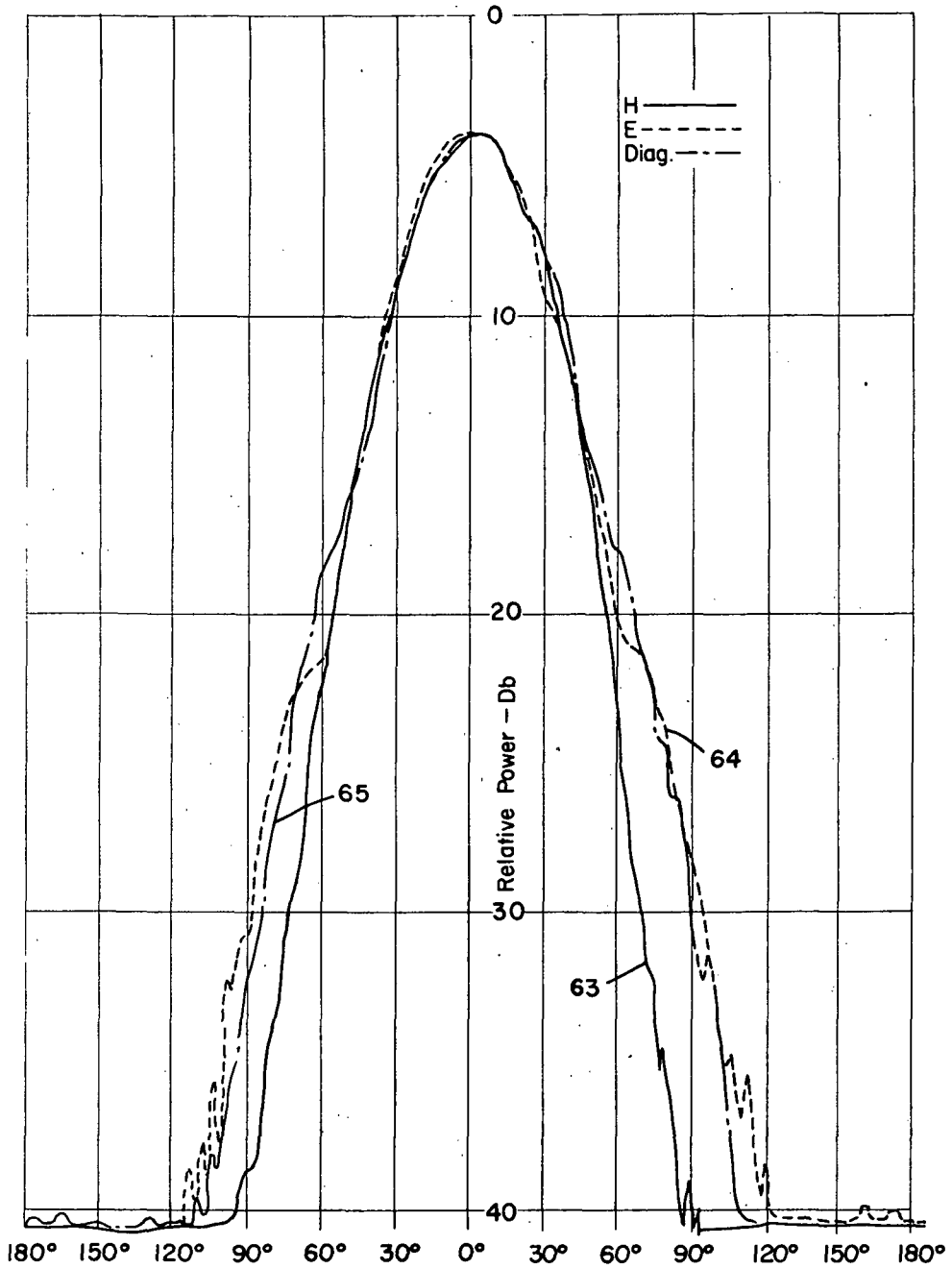


Fig. 4.

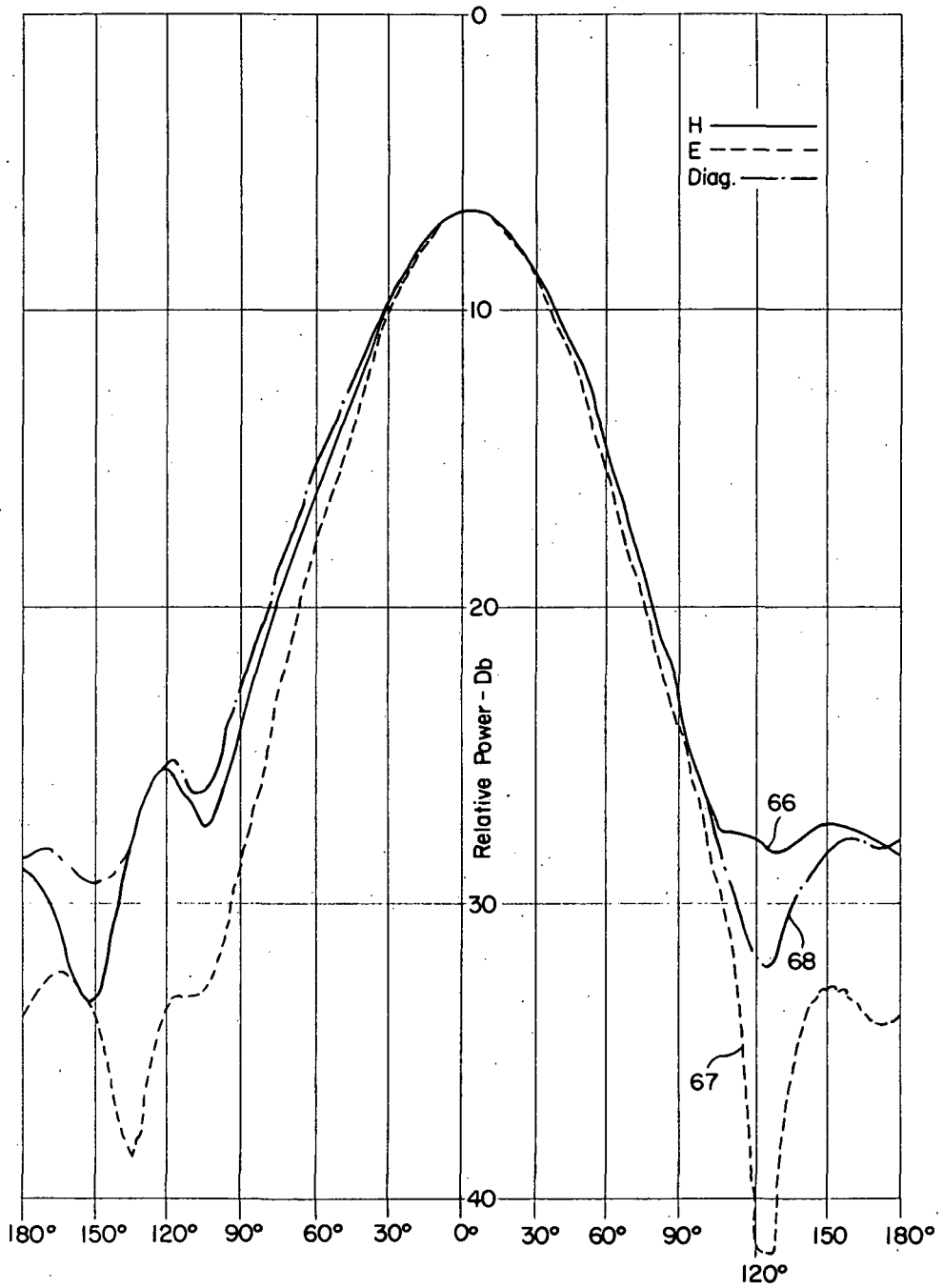


Fig.5.

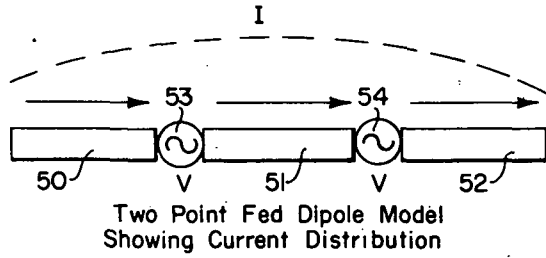


Fig. 6.

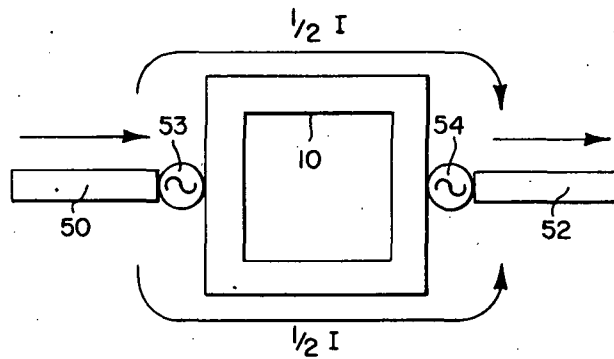


Fig. 7.

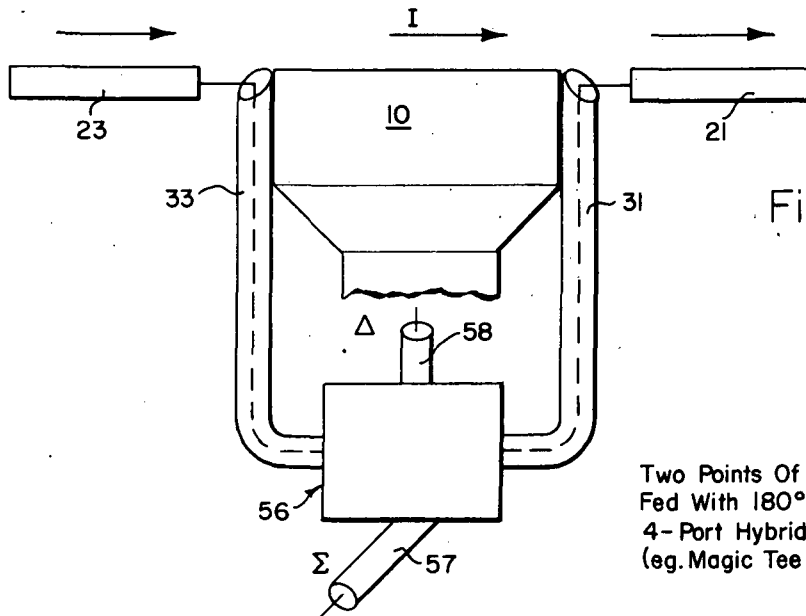


Fig. 8.

Diagram Showing High Freq. Horn As Part Of Low Freq. Dipole



Fig. 9.

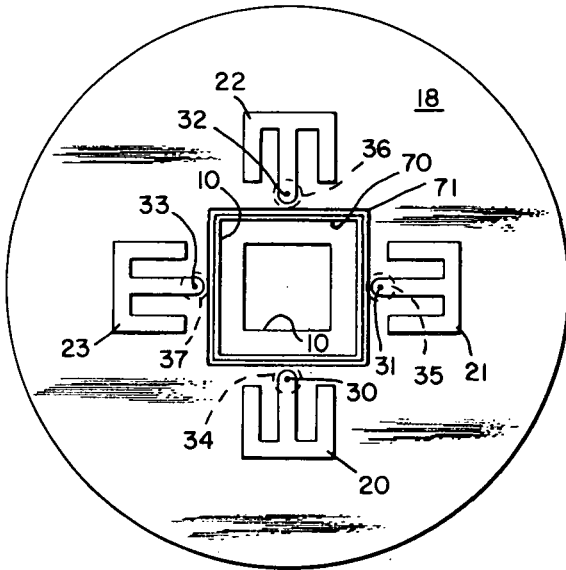


Fig. 10.

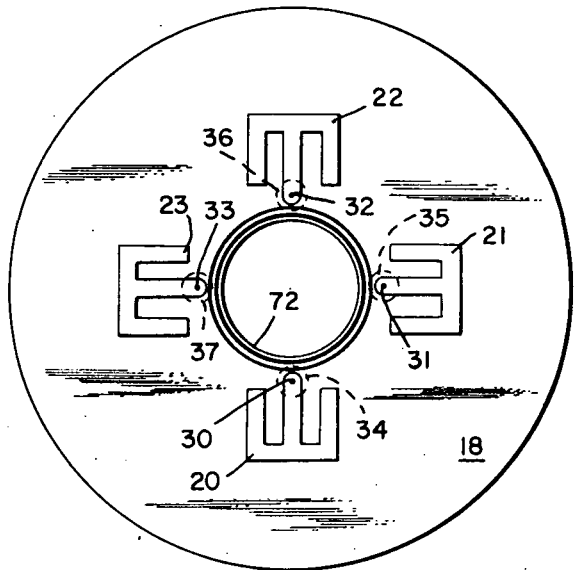


Fig. 11.

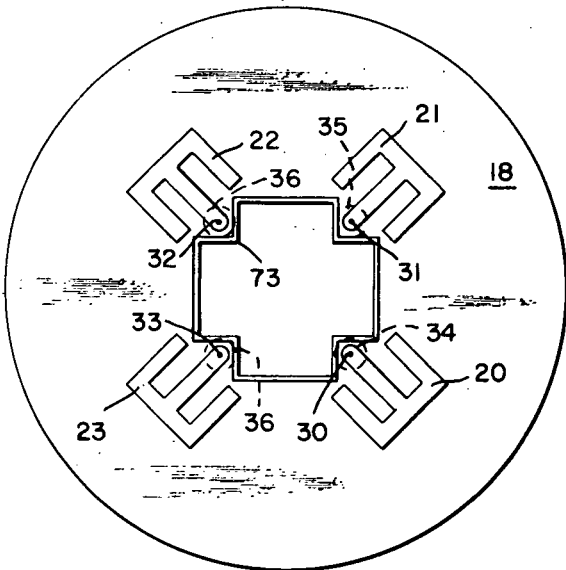
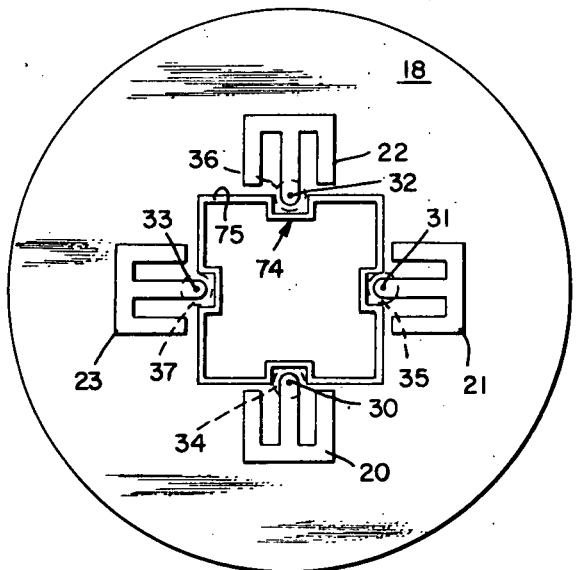


Fig. 12.



**HIGH EFFICIENCY MULTIFREQUENCY FEED****BACKGROUND OF THE INVENTION**

Conventional techniques comprise the use of nested horns or nested dipole clusters. In the case of nested horns, a high frequency horn is nested inside an intermediate frequency horn which, in turn is nested inside a low frequency horn. This system generally has low efficiency because of the mutual aperture blockage effects. In the case of the nested dipole clusters, a high frequency quaddipole array is nested within an intermediate frequency quad-dipole array which, in turn, is nested within a low frequency quad-dipole array. Nested dipole clusters of this type generally have low efficiency due to mutual coupling effects.

**SUMMARY OF THE INVENTION**

The present invention circumvents the problems of mutual blockage and mutual coupling by using a single common aperture for the 6 and 4 GHz frequency bands and a crossed dipole for the 1 GHz frequency band. The crossed dipole is not a conventional dipole in that each dipole is excited at two points with edges of a 6/4 GHz horn as the central portion of the dipole. To achieve a high efficiency, the primary pattern of the feed must illuminate the reflector or lens without an undue amount of "spillover" or without being too directive so as to under illuminate the reflector or lens. The net result is that the feed pattern for all three frequency bands must be nearly identical in all planes and have a common center of phase. This is achieved in the 6/4 GHz common horn by multimoding at 6 GHz so that its effective aperture is less (about three-fourths linear dimension) than the physical aperture of the 6/4 GHz horn while at the 4 GHz frequency it is not multimoded so that it has its full physical aperture. This results in the 6 GHz and 4 GHz frequency bands having similar feed patterns for proper reflector or lens illumination. A crossed set of two 2-point feed strip dipoles are used for the 1 GHz frequency band.

One or more quarter wave chokes surrounding the 6/4 GHz horn aperture prevent coupling to the 1 GHz frequency wave dipole. Also, a choke is built into the dipole wings to further prevent coupling with 4 GHz frequencies. The 6 GHz frequencies are sufficiently far removed from the 1 GHz frequency band so that the coupling to the 1 GHz dipole is sufficiently suppressed by the choke around the horn alone. Separation between the 6 GHz and 4 GHz frequencies is achieved with conventional diplexers. Lastly, the two feed points of the dual feedpoint dipole are connected with a hybrid (e.g., a magic tee). When the difference port is used, the currents in the dipole wings are in phase resulting in a good "sum" pattern. When the "sum" port of the hybrid is used, the currents in the dipole wings are in anti-phase creating a null pattern. Hence, for certain polarizations, the sum port of the hybrid can be used for monopulse tracking applications. This type of tracking is especially applicable in circularly polarized systems.

**BRIEF DESCRIPTION OF THE DRAWINGS**

FIG. 1 shows a plan view of a C band - UHF aperture of a high efficiency multifrequency feed in accordance with the present invention;

FIG. 2 shows a cross-sectional view of the C Band - UHF aperture of FIG. 1;

FIGS. 3-5 illustrate the feed patterns for the H, E and diagonal planes for each of the frequency bands of the apparatus of FIGS. 1 and 2;

FIG. 6 illustrates a schematic of a two point fed dipole model showing current distribution;

FIG. 7 illustrates a schematic showing the manner in which a higher frequency horn feed serves as a central portion of the two point fed dipole in the illustration of FIG. 6;

FIG. 8 illustrates the manner in which the two point fed dipole of FIG. 7 is fed by the use of a 180° 4-Port Hybrid; and

FIGS. 9-12 show alternative configurations of the plan view of the aperture of the multifrequency feed of FIGS. 1 and 2.

**DESCRIPTION**

Referring to FIGS. 1 and 2 of the drawings, there is shown a plan view of the aperture and a cross-section 2-2 thereof, respectively, of the high efficiency multifrequency feed antenna system of the present invention. In particular, a square horn 10 having dimensions suitable to provide a 6 GHz and 4 GHz common aperture extends through the central portion of a conductive ground plane 12. On the back side of ground plane 12 relative to the antenna aperture, the square horn 10 extends into a multimode step section 14 dimensioned for 6 GHz which section 14 terminates in a flange 15. The multimode step section 14 is symmetrically disposed about the center line through horn 10. Surrounding the outer periphery of horn 10 at the lip thereof is disposed a choke section 16 primarily designed to inhibit the flow of 4 GHz energy thereacross.

Relative to the 1 GHz frequency band, a dielectric disc 18 extends radially outwards from the outer lip of choke section 16 for a sufficient distance to support UHF choked dipole arms 20, 21, 22 and 23 which extend outwards from the center of the four sides of horn 10. The outer periphery of dielectric disc 18 is supported by metallic posts 24 which extend to the ground plane 12. A UHF cavity is formed by metal bands 26, 28 disposed about the central portion and adjacent ground plane 12, respectively, of the metallic posts 24. The extremity of the center leg of the UHF choked dipole arms 20-23 nearest horn 10 are fed by the respective center conductors of coaxial lines 30-33, respectively. The coaxial lines 30-33 extend through the ground plane 12 parallel to the center line of horn 10 and are terminated by connectors 34-37, respectively. The outer conductors of coaxial lines 30-33 are electrically connected to the outer periphery of choke section 16 and to the ground plane 12. Lastly, a metal cylinder 40 terminating in a flange 42 is disposed symmetrically about metallic posts 24. Metal cylinder 40 is attached to ground plane 12 and has a height slightly greater than the dimension of square horn 10 which extends through the ground plane 12. The flange 42 provides a support for a radome if desired.

In the operation of the multifrequency prime focus feed of the present invention, the 4 GHz and 6 GHz frequency band signals are fed through the multimode step section 14 to the horn 10. Contemporary multimoding techniques are employed to obtain the multimoding at the 6 GHz frequency band and single moding at the 4 GHz frequency band. In particular, the mode exciters coupled to flange 15 are designed for both the 4 GHz and 6 GHz frequency bands and the common

aperture of horn 10 is dimensioned to be below cutoff for the higher modes at 4 GHz. The separation of the 4 GHz and 6 GHz frequency bands is achieved with conventional diplexers, not shown. Quarter wave choke 16 surrounding the 6/4 GHz horn 10 aperture prevents coupling from the 4 GHz and 6 GHz frequency bands to the 1 GHz frequency dipoles 20-23. Also, there is a choke built into each of the dipoles 20-23 to further prevent coupling with the 4 GHz frequencies. The 6 GHz frequencies are sufficiently far removed that coupling to the 4 GHz dipoles 20-23 is sufficiently suppressed by the choke 16 around the horn 10 alone.

Referring to FIGS. 6-8, there is illustrated the manner in which opposite dipoles 20, 22 and 21, 23 operate. In particular, FIG. 6 illustrates a two point fed dipole having segments 50, 51, and 52 driven by voltage sources 53, 54 which supply a signal voltage, V. When voltage sources 53, 54 drive the dipole segments 50, 51, 52 in phase, the current, I, increases from the left extremity, as shown in the drawing, to a maximum along center segment 51 and then decreases to zero at the right extremity of segment 52. This current distribution is similar to that of a typical dipole, with the exception that it is fed at two points instead of one.

Proceeding to FIG. 7, the center segment 51 of FIG. 6 is replaced with the horn 10. In this case, the current that previously flowed through the center segment 51 divides and flows around opposite sides of the horn 10.

Lastly, FIG. 8 shows the dipoles 50, 52 replaced with the choked dipoles 23, 21, respectively, and the voltage sources 53, 54 provided by coaxial lines 33, 31, as in FIG. 1. The coaxial lines 31, 33 are, in turn, fed with a 180° four-port hybrid 56. When fed through a sum input ( $\Sigma$ ) 57 thereof, the voltages at the outputs of coaxial lines 31, 33 are in anti-phase, creating a null pattern. Alternatively, when fed through the difference input ( $\Delta$ ) 58, the voltages at the outputs of coaxial lines 31, 33 are in phase, resulting in a good "sum" pattern. Hence, for a particular polarization, the sum and null patterns can be used for monopulse tracking applications. Lastly, in a normal mode of operation, the remaining dipoles 20, 22 are fed in phase with a hybrid (not shown) which, in turn, may be fed 90° out of phase relative to the signal applied to hybrid 56, thereby to generate a circularly polarized output signal.

In the multifrequency antenna feed system it is desirable that the feed pattern for each of the three frequency bands be nearly identical in all planes and have a common center of phase. In the 6/4 common horn 10 this is achieved by multimoding at 6 GHz so that its effective aperture is less by about three-fourths linear dimension than the physical aperture of the 6/4 GHz horn 10, while at the 4 GHz frequency it is not multimoded so that it has its full physical aperture. This results in the 6 GHz and 4 GHz frequency bands having similar feed patterns for proper reflector or lens illumination. The horn-dipole assembly is contained in a 1 GHz cavity formed by ground plane 18, and the metal bands 26, 28 whose parameters are adjusted to shape the 1 GHz patterns without affecting the 6 and 4 GHz patterns.

Referring to FIGS. 3-5, there is illustrated measured horizontal, vertical, and diagonal patterns for the 4 GHz, 6 GHz, and 1 GHz frequency bands developed by

the antenna system of FIGS. 1 and 2, respectively. In particular, FIG. 3 illustrates a horizontal pattern 60, a vertical pattern 61, and a diagonal pattern 62 for the 4 GHz frequency band; FIG. 4 illustrates a horizontal pattern 63, a vertical pattern 64, and a diagonal pattern 68 for the 1 GHz frequency band. As can be seen from these figures, the feed patterns of the antenna system of FIGS. 1 and 2 is nearly identical in all planes for each of the three frequency bands, as is required for antenna feeds of this type. Although the described embodiment of the invention was designed for the 3.7 - 4.2 GHz band, the 5.9 - 6.4 GHz band and the 0.8 - 1 GHz band, the principles embodied therein are applicable to other frequency bands.

Referring to FIGS. 9-12, there are illustrated other possible configurations of the multifrequency feed. More particularly, FIG. 9 shows an aperture view with double choke slots 70, 71 surrounding the periphery of horn 10. Choke slot 70, for example, could be designed to impede the 4 GHz frequency band and choke slot 71 designed to impede the 6 GHz frequency band. Referring to FIGS. 10, 11, a circular horn 72 and a crossed-horn 73 are shown, respectively, in place of the square horn 10. In the case of the crossed-horn 73, the choked dipole arms 20-23 emanate from the inside corners thereof. Lastly, FIG. 12 illustrates a horn 74 having indentations adapted to accommodate coaxial lines 30-33. A choke slot 75 about the periphery of the horn 74 follows the aforementioned indentations.

What is claimed is:

1. A high efficiency antenna feed system capable of transmitting and receiving simultaneously in first, second, and third increasingly higher frequency bands, said antenna feed system comprising

means including a horn for providing a common radiating aperture for signals within said second and third frequency bands;

means coupled to said horn for multimoding at said third frequency band therein;

means surrounding said horn for providing a cavity for said first frequency band;

first and second arms resonant in conjunction with said horn at said first frequency band and extending outwards from opposite sides of the periphery thereof; and

means coupled to the respective extremities of said arms nearest said horn for energizing said arms.

2. The high efficiency antenna feed system as defined in claim 1 additionally including means disposed about the periphery of said horn for isolating said first frequency band from said second and third frequency bands.

3. The high efficiency antenna feed system as defined in claim 2 wherein said means disposed about the periphery of said horn for isolating said first frequency band from said second and third frequency bands constitutes a slot formed of conductive material, said slot being one quarter wavelength deep at said second frequency band, thereby to provide a choke.

4. The high efficiency antenna feed system as defined in claim 2 wherein said means disposed about the periphery of said horn for isolating said first frequency band from said second and third frequency bands constitutes first and second parallel slots formed of conductive material, said first slot being one quarter wavelength deep at said second frequency band and said second slot being one quarter wavelength deep at said

third frequency band, thereby to provide first and second chokes at said second and third frequency bands, respectively.

5 5. The high efficiency antenna feed system as defined in claim 1 wherein said first and second arms extending outwards from opposite sides of the periphery of said horn are choked thereby to isolate said first frequency band from said second frequency band.

10 6. The high efficiency antenna feed system as defined in claim 1 additionally including third and fourth arms resonant in conjunction with said horn at said first frequency band and extending outwards from opposite sides of the periphery thereof midway between said first and second arms.

15 7. The high efficiency antenna feed system as defined in claim 6 wherein said first, second, third, and fourth arms extending outwards from the periphery of said horn are choked thereby to isolate said first frequency band from said second frequency band.

20 8. The high efficiency antenna feed system as defined in claim 7 wherein said means surrounding said horn for providing a cavity for said first frequency band includes means for providing a ground plane outwards from the exterior of the rear portion of said horn normal to the axis of rotation thereof, a plurality of metallic posts disposed intermediate said ground plane and the plane of said first, second, third, and fourth arms at periodic intervals along the circumference of a circle of predetermined radius and having a center coinciding with the axis of rotation of said horn, and first and second parallel metallic bands disposed about said plurality of metallic posts.

25 30 9. The high efficiency antenna feed system as defined in claim 1 wherein said first and second arms extending outwards from opposite sides of the periphery of said horn are connected to first and second arms, respectively, of a four-part hybrid junction, having said first and second arms, a sum arm, and a difference arm.

35 40 10. The high efficiency antenna feed system as defined in claim 1 wherein the cross-sectional configura-

tion of said horn is square.

11. The high efficiency antenna feed system as defined in claim 1 wherein the cross-sectional configuration of said horn is circular.

12. The high efficiency antenna feed system as defined in claim 1 wherein the cross-sectional configuration of said horn constitutes the outer configuration of first and second crossed identical rectangles.

13. The high efficiency antenna feed system as defined in claim 1 wherein the cross-sectional configuration of said horn is square with indentations in the center portions of each side thereof.

14. A high efficiency antenna feed system capable of transmitting and receiving simultaneously in first, second, and third increasingly higher frequency bands, said antenna feed system comprising

- a ground plane;
- a horn disposed through said ground plane for providing a common radiating aperture for signals within said second and third frequency bands;
- a step section connected to the input of said horn for multimoding at said third frequency band therein;

first, second, third, and fourth arms resonant in conjunction with said horn at said first frequency band extending outwards from quadrature points of the periphery thereof;

a plurality of metallic posts extending between said ground plane and the plane of said first, second, third, and fourth arms along the circumference of a circle disposed about said horn;

first and second parallel metallic bands disposed about said plurality of metallic posts thereby to provide a cavity resonant at said first frequency band; and

means coupled to the respective extremities of said first, second, third, and fourth arms nearest said horn for energizing said arms.

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