

[54] COAXIAL HORN ANTENNA

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[58] Field of Search 343/776, 777, 778, 786, 343/854

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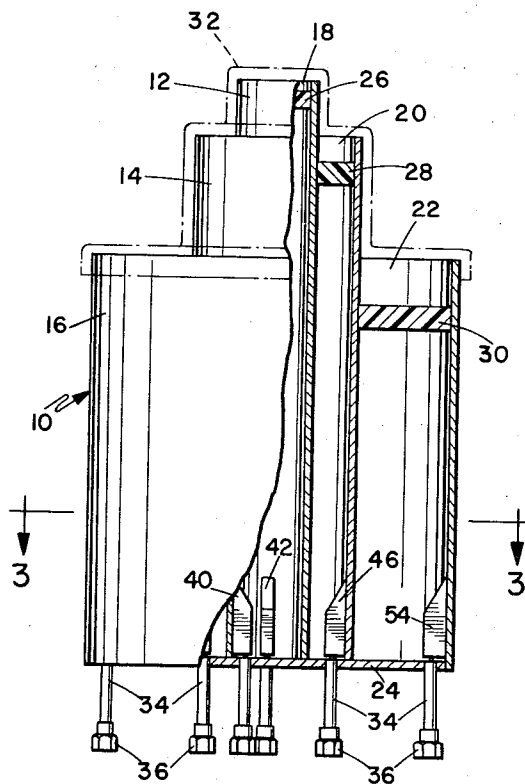
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[57] ABSTRACT

A wide band, multi-mode antenna having a plurality of coaxial, independently fed, radiating horns. Each horn has multiple feeds which can be energized in various phase relationships to control polarization. The antenna can be used as a direct radiator, or to illuminate a reflector, has transmit or receive capabilities, and is adaptable to monopulse operation. The antenna is a compact rigid unit of very simple construction.

1 Claim, 9 Drawing Figures



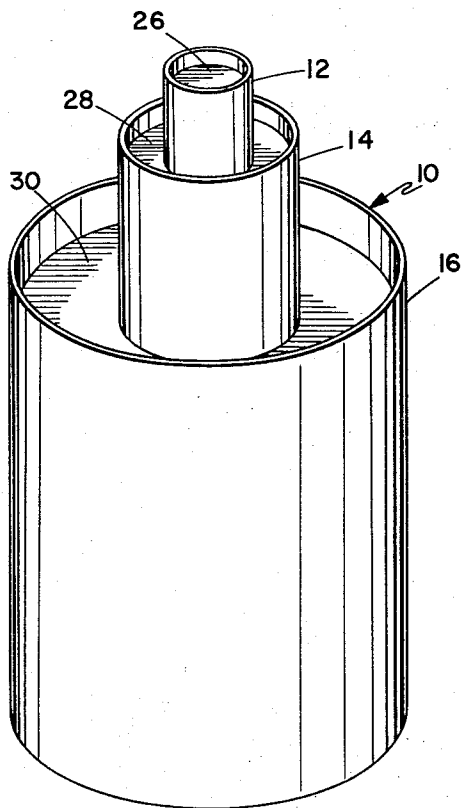


Fig. 1

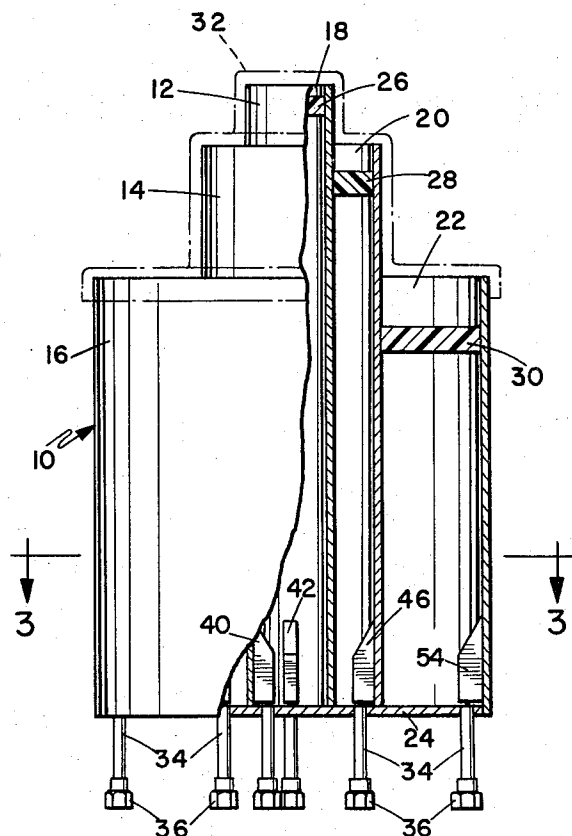


Fig. 2

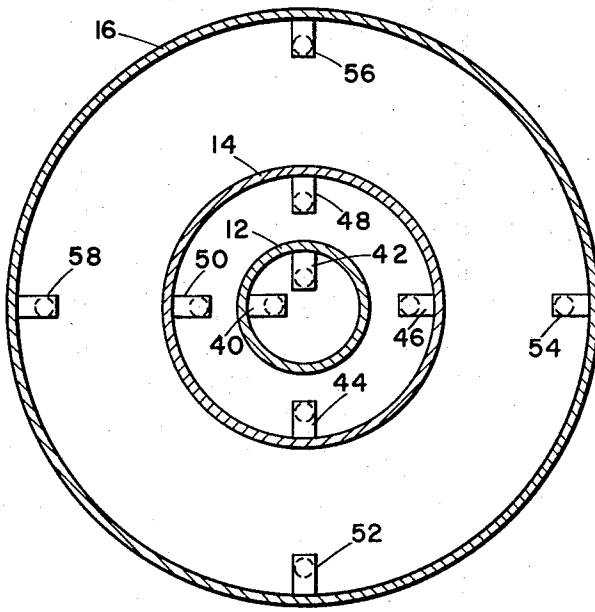


Fig. 3

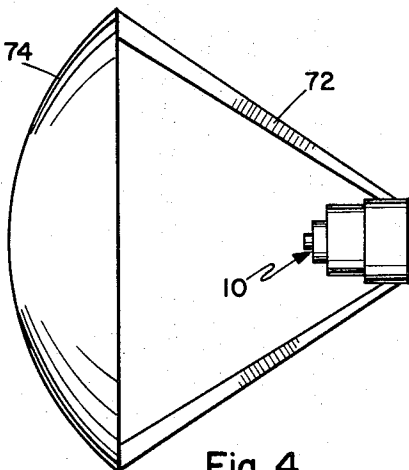
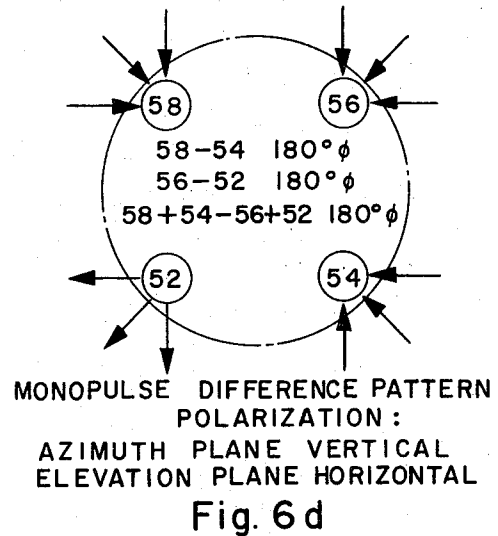
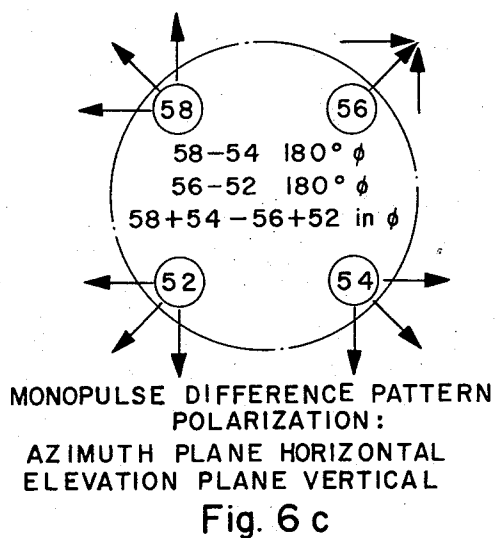
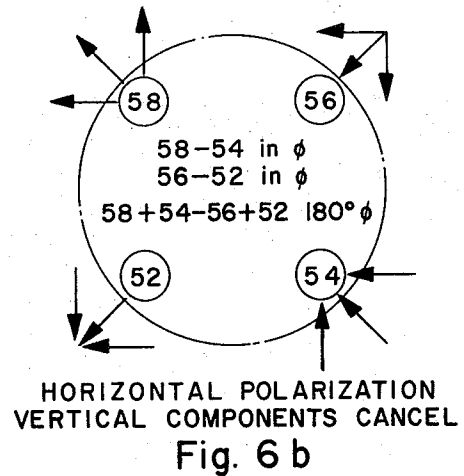
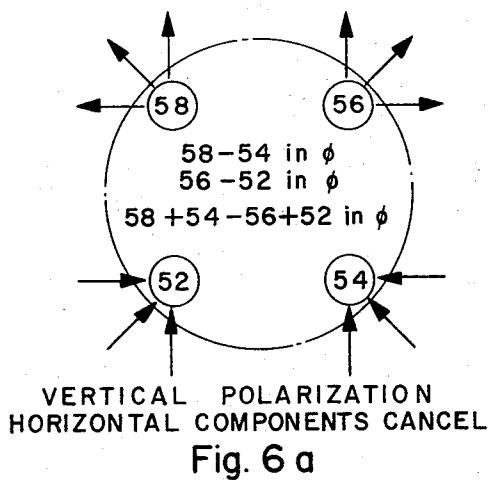
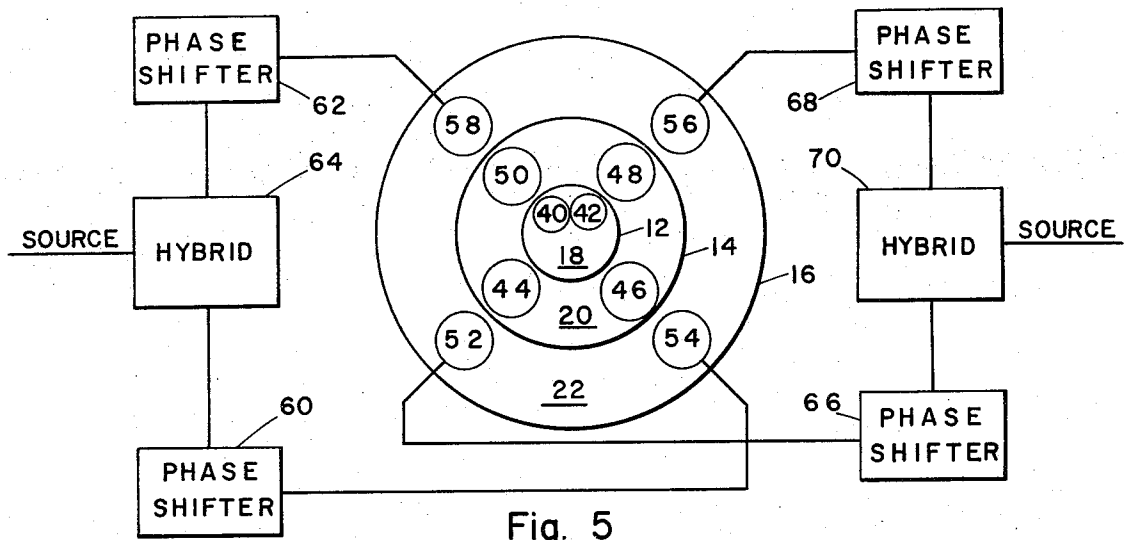


Fig. 4



COAXIAL HORN ANTENNA

BACKGROUND OF THE INVENTION

Wide band antennas usually involve the use of angular or periodic elements, such as cones, spirals and the like. These have limited power capability and are not readily adaptable to polarization changes. The antenna elements are often mounted on some type of supporting structure, resulting in a bulky unit.

SUMMARY OF THE INVENTION

The antenna described herein is very compact for the range of frequencies it is capable of handling, and is a rugged self-supporting structure. Multiple tubular elements are assembled concentrically to provide stepped coaxial horns covering several frequency ranges. Each horn has feeds positioned orthogonally relative to the horn axis, with means for energizing the feeds in selected phase relationships to obtain the required polarization characteristics. The horns are essentially waveguide elements of circular or other suitable cross section, and act in combination in their concentric arrangement to provide coaxial waveguides with substantially equal electrical dimensions. The radiating patterns are thus nearly constant as a function of frequency and the phase center is substantially constant over the entire band of coverage. All the radiating apertures are near planar, but retain good isolation between apertures.

The primary object of this invention, therefore, is to provide a new and improved coaxial horn antenna.

Another object of this invention is to provide a new and improved co-axial horn antenna having concentrically assembled tubular waveguide elements forming stepped coaxial radiating apertures.

Another object of this invention is to provide a new and improved co-axial horn antenna in which each horn has feed elements which can be energized in selected phase relationships.

A further object of this invention is to provide a new and improved co-axial horn antenna having wide band, multi-mode capability.

Another object of this invention is to provide a new and improved co-axial horn antenna which is compact and of rigid structure, adaptable to a variety of installations.

Other objects and many advantages of this invention will become more apparent upon a reading of the following detailed description and an examination of the drawings, wherein like reference numerals designate like parts throughout and in which:

FIG. 1 is a perspective view of a typical configuration of the antenna.

FIG. 2 is a side elevation view, partially cut away.

FIG. 3 is a sectional view taken on line 3-3 of FIG.

FIG. 4 is a side elevation view of the antenna mounted on a reflector.

FIG. 5 is a diagram of a typical arrangement of feed connections to the antenna.

FIG. 6a - 6d are diagrams of the polarization characteristics of the antenna with various phase relationships of the feeds

DESCRIPTION OF THE PREFERRED EMBODIMENT

The antenna as illustrated in FIGS. 1-3 is typical, and

comprises three cylindrical horns 12, 14 and 16 of cylindrical configuration, mounted together in coaxial alignment. The horns are progressively sized to provide an inner radiating aperture 18, a concentric intermediate aperture 20 and a concentric outer aperture 22 at the front end of the antenna. Depending on the particular use of the antenna, any reasonable number of horns may be used and the cross section of the tubular elements need not be circular.

The rear of the antenna is closed by an end plate 24 and the forward end is held in coaxial alignment by dielectric closure elements. These include a disc 26 inset in the end of inner horn 12, a ring 28 between horn 12 and intermediate horn 14, and a ring 30 between horn 14 and outer horn 16. In addition to providing support and sealing the horns for protection, the dielectric elements provide electrical isolation between the radiating apertures. Beamwidth is controlled by staggering the forward ends of the horns, with the inner horn projecting furthest, the staggering also adding to the isolation. Beamwidth is reduced as the stagger is increased and can be set to suit specific characteristics. For some uses it may be desirable to enclose the front of the antenna by a dielectric radome or cover 32, indicated in broken line in FIG. 2.

In the structure illustrated, the inner horn 12 functions as a circular waveguide, with the radiating aperture 18 at the forward end. Aperture 20 is at the forward end of a waveguide using the outer surface of horn 12 and the inner surface of horn 14 as conductors. Aperture 22 is at the forward end of a waveguide formed by the outer conductive surface of horn 14 and the inner conductive surface of horn 16.

To obtain the various radiation patterns, each horn has a plurality of quadrantally position feeds. Inner horn 12 has two feeds 40 and 42 positioned 90 degrees apart. Intermediate horn 14 has four feeds 44, 46, 48 and 50, and outer horn 16 has four feeds 52, 54, 56 and 58. Each of the feeds is actually a transformer or transition of conventional type, making the transition from a coaxial connection 34 to the wave guide horn. A coaxial conductor 34 extends from each feed at the rear of the antenna, with a coupling 36 for connection to associated transmit or receive apparatus. The specific configurations of the feeds and coaxial connections will depend on the range of frequencies being used, the arrangement and structure being well known.

All the antenna horn sections operate in the TE_{11} mode, rather than the conventional TEM mode. Second and higher order linear modes are prevented by using waveguide sizes which are too small to support them. The modes of interest are TE_{11} and TE_{21} . In TE_{11} mode the cutoff wavelength $\lambda_c = 3.41a$ in a circular guide, and $\lambda_c \approx 4.64a$ in a coaxial guide. In TE_{21} mode the cutoff wavelength $\lambda_c = 2.057a$ in a circular guide, and $\lambda_c = 2.35a$ in a coaxial guide. These cutoff wavelengths correspond to a ratio between outer to inner coaxial diameters of 2:1, and will change only slightly as the ratio is changed.

The operational bandwidth (BW) for a concentric horn is approximated by the ratio of the two cutoff wavelengths. Thus for a circular guide:

$$BW = \lambda_c(TE_{11})/\lambda_c(TE_{21}) = 1.66$$

and for a coaxial guide, the ratio is 1.98

The number (n) of individual horns in a concentric assembly necessary to operate over a total bandwidth (ΣBW), for a coaxial waveguide is:

$$n \approx \text{Log} \Sigma BW / \text{Log } 2$$

Maximum bandwidth for a given number of circularly symmetric horns is achieved with the inner horn operating in the circular guide TE_{11} mode.

Circularly symmetric modes are avoided by the method of excitation, which utilizes a dual coupling technique to ensure a TE_{11} mode excitation. Diametrical feeds in a horn are fed in or out of phase to generate a linearly polarized wave, with either a sum or difference pattern. By connecting two diametrical feeds to a suitable hybrid, an amplitude monopulse pattern can be produced in the plane through the two feed points. A second set of feeds in quadrature relation will provide orthogonal or conjugate linearly polarized modes. With two conjugate modes, any desired polarization can be radiated.

A typical arrangement is illustrated in FIG. 5. Diametrically opposed feeds 54 and 58 of outer horn 16 are coupled through phase shifters 60 and 62, respectively, to a hybrid junction 64, which is connected to an associated signal source. Feeds 52 and 56 are similarly coupled through phase shifters 66 and 68 to a hybrid junction 70, which is connected to a signal source. Feeds 44-50 in horn 14 would be connected in a similar manner. In horn 12, the feed 40 would be excited for horizontal polarization and the feed 42 for vertical polarization.

The signal source may be any suitable microwave transmitter and/or receiver means, operating on a different frequency for each horn. The inner horn operates at the highest frequency and the outer horn at the lowest frequency of the useful range, the coaxial horn arrangement making it possible to have a bandwidth of several octaves. The antenna can be used as a direct radiator or, as illustrated in FIG. 4, can be mounted on a suitable support 72 to illuminate a reflector 74.

With reference to FIG. 5, if feeds 54 and 58 are excited out of phase a vertically polarized wave is radiated. Similarly, if feeds 52 and 56 are excited out of phase, a horizontally polarized wave is radiated. If diametrical pairs 52-56 and 54-58 are fed with equal amplitude in phase quadrature, a circularly polarized wave is radiated.

FIGS. 6a-6d illustrate various specific examples of

radiation patterns with the relative phases of the various feeds indicated by directional arrows. In FIG. 6a, the feeds are in phase in each diametrical pair and the two pairs are in phase, resulting in a vertically polarized radiation pattern. In FIG. 6b, the feeds are in phase in each diametrical pair, but the two pairs are 180 degrees out of phase, resulting in a horizontally polarized radiation pattern.

FIG. 6c indicates that the feeds are 180 degrees out of phase in each diametrical pair, but the two pairs are in phase. This produces a monopulse difference pattern with horizontal polarization in the azimuth plane, and vertical polarization in the elevation plane. In FIG. 6d the feeds are 180 degrees out of phase in each diametrical pair and the two pairs are also 180 degrees out of phase. The result is a monopulse difference pattern with vertical polarization in the azimuth plane and horizontal polarization in the elevation plane.

If only one polarization is required for a specific purpose only diametrically opposed feeds are required, rather than the quadrantal arrangement. The wide band and variable radiation pattern characteristics make the antenna very versatile, and the compact structure makes it adaptable to a variety of installations.

Having described our invention, we now claim:

1. A coaxial horn antenna, comprising:

a plurality of at least three progressively sized tubular horns secured together in coaxial alignment and defining concentric radiating apertures at one end, the innermost horn having a pair of feeds coupled thereto that are spaced 90° and the intermediate and outermost horns having four feeds coupled that are spaced 90°, each of said feeds having means for connection to a signal source,

said horns are axially staggered with the innermost horn extending a preset distance from said one end, and the intermediate horn extending an intermediate distance between the innermost horn and the outermost horn,

each of said feeds includes a coaxial to wave guide transition element coupled to the inner surface of the respective horn,

said means for connection comprising a coaxial conductor to said transition element,

and the ratio of cross sectional size between adjacent horns is approximately 2 to 1.

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