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Dec. 5, 1944.

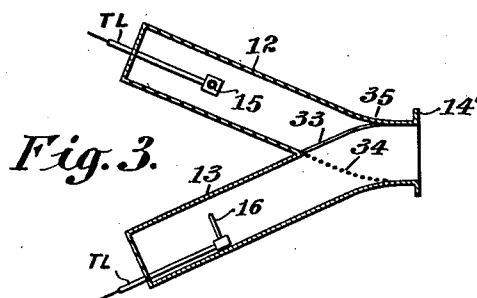
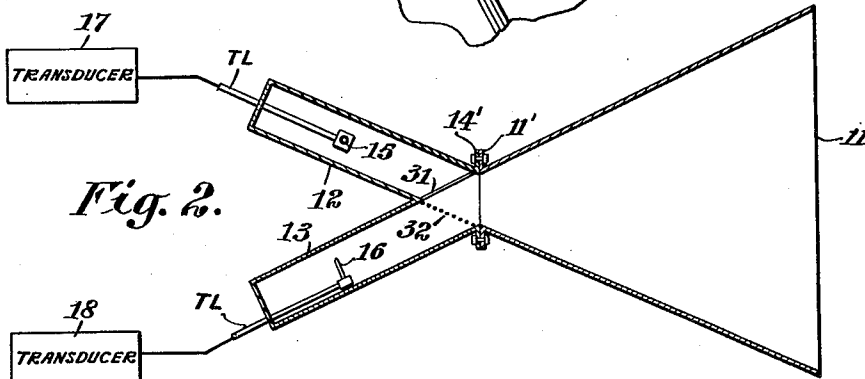
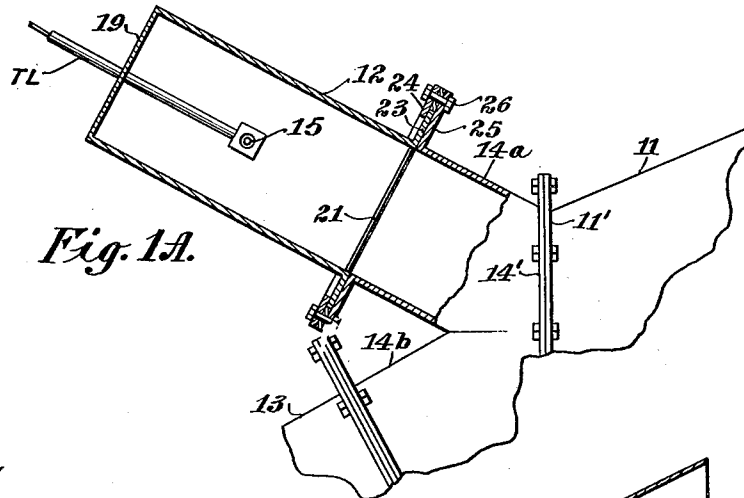
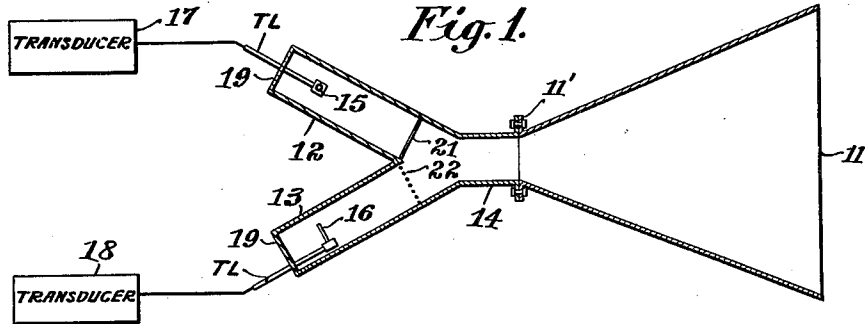
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2,364,371

DOUBLE POLARIZATION FEED FOR HORN ANTENNAS

Filed Aug. 31, 1940

2 Sheets-Sheet 1



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2 Sheets-Sheet 2

Fig. 4.

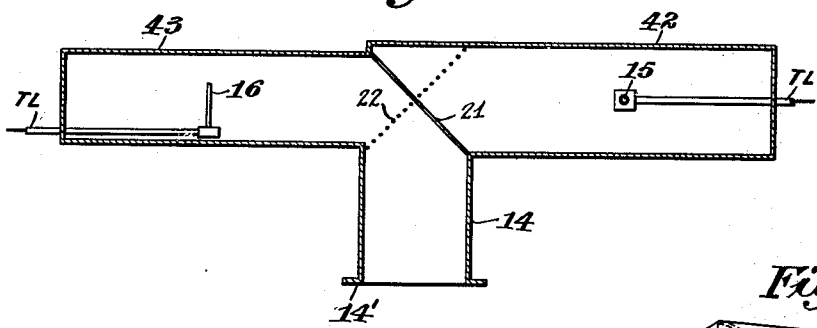


Fig. 5A.

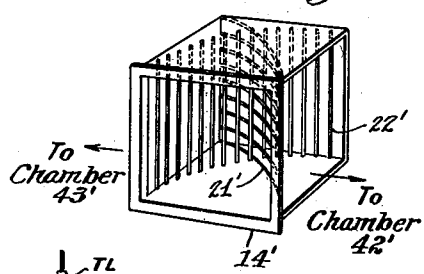


Fig. 5.

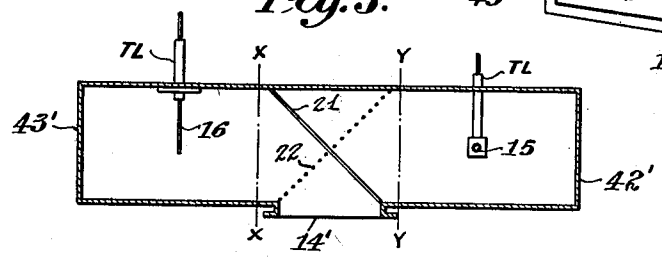
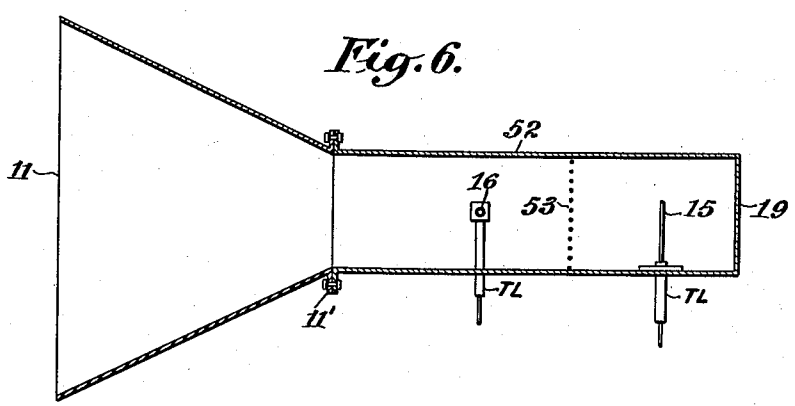


Fig. 6.



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DOUBLE POLARIZATION FEED FOR HORN ANTENNAS

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13 Claims. (Cl. 250—11)

The present invention involves ultra-short-wave horn radiators and, more particularly, means for energizing said radiators to simultaneously radiate vertically and horizontally polarized waves.

An object of the present invention is to provide duplex ultra-short-wave communication with a single horn radiator.

Another object of the present invention is to provide simultaneous transmission and/or reception of ultra-short-wave radiant energy with a single directive horn structure.

Another object of the present invention is to provide a single horn radiator for the simultaneous transmission and/or reception of separate intelligence bearing signals of the same frequency.

Still a further object of the present invention is the provision of means for simultaneously energizing wave guide structure with two separate signals of different polarizations without interaction therebetween.

In general, in employing the present invention rectangular wave guide sections, hereinafter called resonant chambers, are used to couple the energizing antennas to a further wave guide structure of rectangular cross section for transmission of the combined energy from the antennas to a desired location. In accordance with one aspect of the present invention, the further wave guide section may be in the form of a flaring horn for radiating the combined energies in the form of a directive beam. The wave guide and resonant chambers may be circular or elliptical in section if desired. The mouth or large opening of the horn and, similarly, the throat or small opening of the horn may be either square or rectangular, as desired. Also, the horn may be circular or elliptical in cross section, if desired. As a rule, if the same frequency is to be used for both waves, it will usually be desirable to make the horn square in cross section. In order to provide linearly polarized radiated waves the horn may be fed with either $H_{0,1}$ or $H_{1,0}$ waves, that is, either vertical or horizontal polarization of the electric field intensity, respectively, or both simultaneously.

The waves used as indicated by the identification above have a component of magnetic force in the direction of propagation. The first subscript denotes the number of half sine waves in the distribution of electric field intensity in the direction parallel to the vertical axis and at right angles to the direction of propagation, while the second subscript indicates the number of half sine waves in the distribution of field intensity in the

direction parallel to the horizontal axis and at right angles to the direction of propagation. The subscript 0 denotes that the field intensities are independent of the corresponding direction.

5 It will be seen, therefore, that the $H_{0,1}$ wave results in a vertically polarized radiation while the $H_{1,0}$ wave results in horizontal polarization. For the $H_{1,0}$ wave which yields horizontal polarization the vertical dimension of the feed pipe which couples the energizing means to the radiating horn must be larger than the critical dimension, which is determined by the operating frequency. That is, the vertical dimension of the feed pipe must be greater than a half wavelength at the operating frequency. The horizontal dimension of the feed pipe may be arbitrarily chosen. Similarly, the $H_{0,1}$ wave, which yields a vertically polarized radiation, requires that the horizontal dimension of the feed pipe must be larger than the critical dimension, which is a half wavelength at the operating frequency. For this wave the vertical dimension of the feed pipe may be arbitrarily chosen. Therefore, if, for example, a square horn is coupled to a square feed pipe and both horizontal and vertical polarizations are received by the horn simultaneously, then the hollow square feed pipe will contain both $H_{0,1}$ and $H_{1,0}$ waves. If the hollow feed pipe is tapered down in the horizontal dimension to a value less than the critical dimension for the propagation of $H_{0,1}$ waves, then these waves will be suppressed and only $H_{1,0}$ waves will continue on past the taper. Similarly, a tapering of the hollow feed pipe in the vertical dimension down to a value below the critical dimension for the propagation of $H_{1,0}$ waves will allow only $H_{0,1}$ waves to pass. Now, if the hollow square feed pipe is divided into two branches and then one of these branches is tapered vertically while the other branch tapers horizontally, an arrangement is obtained for separating horizontal from vertical polarization, thus allowing the simultaneous reception or transmission of both polarizations.

A further development of the present invention contemplates the insertion of a grid of parallel wires or bars in each of the two branches mentioned above. In one branch the wires are horizontally arranged and in the other vertically. The horizontal wires absorb horizontally polarized waves and, similarly, the vertical wires absorb the vertically polarized waves.

A further modification of the present invention contemplates the provision of means for rotating these grids about the axes of their respective feed chambers in order to compensate for any

small angular difference between the vertical planes at the transmitting and receiving station locations which would otherwise tend to increase cross-talk between the two channels.

Further objects, features and advantages of the present invention will be more clearly understood by reference to the following detailed description which is accompanied by a drawing in which Figure 1 illustrates in horizontal section an embodiment of the present invention; Figure 1a illustrates a modification of the form of the invention shown in Figure 1, while Figures 2 and 3 illustrate further modifications; Figures 4 and 5 illustrate still further modifications of the form of the invention shown in Figure 1 which may be more conveniently useable in some locations, especially where a saving of over-all length of the structure is desirable, while Figure 5a shows a further modification of a part of Figure 5, and Figure 6 illustrates a simplified embodiment of the present invention which may be desirable in some cases.

Figure 1 of the drawings shows a directive horn 11 which is preferably of a square cross section. The horn may be used either for receiving or transmitting, or both simultaneously. It is tapered from the large mouth opening to a smaller throat opening in accordance with the principles of horn design which are not involved in the present application and will, therefore, not be discussed at the present time. To the small end or throat of the horn is connected, by a flange 11', a section of wave guide 14. The wave guide 14 is also preferably square in cross section and is preferably of sufficient length to allow the orientation of the $H_{0,1}$ and $H_{1,0}$ waves to be clearly established before they reach the throat of the horn. At the other end of the wave guide section 14 are connected the exciting chambers 12 and 13. In some cases it may be desirable to locate the exciting chambers in immediate proximity to the source of wave energy and the horn radiator in a comparatively remote location. In this case the wave guide 14 will be of considerable length.

Within the exciting chamber 12 is located a small antenna 15 which is coupled by means of transmission line TL to a transducer 17. For transmission the antenna, of course, establishes the desired wave in the chamber while in reception it is responsive to the wave arriving there from a distant location. Since chamber 12 is designed for a vertically polarized radiation, that is, the $H_{0,1}$ wave component, the antenna 15 is vertically disposed within the chamber. The horizontal dimension of chamber 12 must be at least a half wavelength in order to sustain the desired wave but the vertical dimension may be any convenient amount since it has no influence on the character of the wave for which antenna 15 is provided. As pointed out above, it is contemplated, in accordance with the principles of the present invention, to make this dimension less than the critical dimension, thereby discriminating against waves of other than the desired polarization. The far end of the chamber 12 is closed by a conducting plate 19 which is spaced from the antenna 15 a distance of the order of a quarter wavelength, the exact distance being determined by considerations of impedance matching. It is preferably so chosen that the resultant impedance of the exciting antenna 15 is equal to the surge impedance of transmission line TL whereby reflections of energy along the

transmission line to the transducer 17 are avoided.

At the junction of the chamber 12 with the wave guide section 14, is provided a grid 21 of horizontal wires or rods. The horizontal wires prevent the passage of any horizontal component of wave energy either from wave guide 14 into chamber 12 or in the opposite direction.

A second chamber 13 is coupled to wave guide 14 in the same way as chamber 12. The second chamber 13 has arranged therein a horizontal antenna 16. In this chamber it is only the vertical dimension which controls the propagation of horizontally polarized waves, that is, it must be at least of the order of a half wavelength while the horizontal dimension may be smaller. The far end of chamber 13 is closed by a metal plate 19 which acts in the same way as described with reference to chamber 12. A grid of vertical wires 22 is placed at the junction between chamber 13 and wave guide section 14, preventing the passage of any vertical component of wave energy either from guide 14 to chamber 13 or in the opposite direction. While antennas 15 and 16 have been shown as linear antennas, it is within the scope of my invention to use other antenna forms such as cones, spheroids, etc., with an axis of symmetry in the desired direction transverse to the exciting chambers. The axis chosen is that which is parallel to the direction of travel in the antenna of the exciting energy therefor.

A modification of the previously described structure contemplated within the scope of the present invention is shown in Figure 1a. The form and operation of each of the parts previously described with reference to Figure 1 is the same in Figure 1a and will, therefore, not be repeated. However, between chamber 12 and an intermediate wave guide section 14a is provided means for rotating grid 21 and/or the resonant chamber 12 about the axis of the feed chamber 12. Rotation of the chamber and/or grid is provided for by arranging a disc 23, fastened to the walls of chamber 12, between ring 24 and disc 25 which are fastened to the intermediate wave guide section 14a. Disc 23 is firmly clamped in place between disc 25 and ring 24 by means of clamping bolts 26. Chamber 12 and grid 21 may, because of this construction, be rotated to place the antenna 15 truly vertical with respect to the incoming waves and the grid 21 exactly at right angles to the waves which it is desired to have pass therethrough.

The vertical grid between chamber 13 and the intermediate wave guide section 14b is similarly arranged and has, therefore, not been shown in detail in this figure. In Figure 1a the intermediate wave guide section 14 of Figure 1 has been omitted since it may not, in all cases, be necessary. The common portion of wave guide sections 14a and 14b is directly clamped to the flange 11' at the mouth of horn 11 by a flange 14'.

The modification of Figure 1 shown in Figure 2 differs therefrom in that the grids 31 and 32 are placed along the continuation of the side wall of the other feed pipe so that the grid forms a continuous conducting wall for waves of polarization suppressed by the grid. In this way the waves find a substantially uniform and continuous feed pipe to or from the antennae 15, 16.

Figure 3 is similar to Figure 2, except that the grids 33 and 34 are curved into the throat of the horn (not shown) whereby any abrupt change in direction of the waves is prevented thus reducing the possibility of reflections being set up.

In the further modification of the present invention shown in Figure 4, the coupling structure has the form of a T. The leg of the T is formed by a section of rectangular hollow pipe 14 having the same cross sectional dimensions as the throat of the horn radiator to which it is coupled. A flange 14' may be used to make the connection. The cross arm of the T houses the two feed antennas 15, 16, one on each arm thereof. Arm 42, which contains the vertical exciting antenna 15, has a horizontal dimension equal to at least a half wavelength at the operating frequency and a lesser vertical dimension. Similarly, the arm 43, which contains the horizontal antenna 16, has its vertical dimension equal to at least a half wavelength at the operating frequency, while the horizontal dimension is less than the critical dimension. Due to this form of construction any slight amount of vertically polarized energy introduced into chamber 43 is suppressed and, likewise, any small amount of horizontally polarized energy finding its way into chamber 42 is likewise suppressed. If desired, the transition between the differing dimensions of chambers 42 and 43 may be gradual instead of abrupt, as shown. At the junction between the top of the T and the leg are placed grids 21 and 22. Each grid is placed in a plane perpendicular to the bisector of the angle between the axis of leg 14 of the structure and the chambers 42 or 43 with which it is associated. The vertical grid 22, associated with chamber 42, reflects the waves from the vertical exciting antenna 15 into the horn while preventing the transmission of energy from the vertical exciting antenna into the chamber 42 housing the horizontal antenna. The horizontal grid 21, associated with chamber 43, similarly reflects the radiation from the horizontal antenna 16 into the horn while blocking the passage of radiation from the horizontal antenna 15 into the vertical chamber 43.

Figure 5 shows a modification of the form of the invention shown in Figure 4 in which the top member of the T is fastened directly to the throat of the horn by means of flange 14'. In this figure the leg 14 of the T is omitted, since it may not be found necessary in all cases. The grids 21 and 22 may, instead of being flat as shown in Figure 5, be curved as shown at 21' and 22' in Figure 5a wherein only the combining section of the wave guide structure is shown. The portion shown may be substituted for the portion between dotted lines X, X and Y, Y of Figure 5.

A further feed arrangement for simultaneously energizing the horn with vertically and horizontally polarized energy is shown in Figure 6. Here both the horizontal antenna 16 and the vertical antenna 15 are placed in a hollow pipe chamber 52 which is coupled at one end to the horn 11. The other end is closed in the same way as described with reference to previous figures by a conducting plate 19. A grid of wires 53 is placed between the two antennas, parallel to the antenna 16 more remote from the back of the chamber and, therefore, at right angles to the vertical antenna 15 nearest the back of the chamber. This arrangement allows waves from the vertical antenna 15 to freely pass through the grid 53 and on out into the horn 11, while at the same time effectively forming a totally reflecting wall for the radiation traveling back from the forward horizontal antenna 16. Since horizontal antenna 16 is at right angles to the electric component of field from the vertical antenna it is not affected thereby. Due to the conductors of grid 53 being parallel to the antenna 16 the grid is substantially

as effective a reflector of radiation from 16 as the solid plate 19 is with respect to the radiation from vertical antenna 15. It is, of course, not necessary for the portion of the chamber 52 which surrounds the vertical antenna 15 to be the same height as the portion which surrounds the horizontal antenna 16 since the horizontal dimension is the only critical dimension. The vertical dimension may, therefore, be reduced in order to act as an additional discrimination against horizontally polarized waves from antenna 16. Furthermore, grid 53 may be provided with means to rotate it about the axis of the chamber so that no component of radiation parallel to the forward antenna is allowed to pass from the rear antenna thus keeping cross-talk between the two antennas at a minimum. The means for rotating the grid may be similar to that shown in Figure 1a with respect to grid 21.

In each of the heretofore described embodiments of the present invention the wave guides and exciting chambers have been indicated as having substantially straight walls. If desired, any or all of the guides may be spiralled about their axes to rotate the plane of polarization through any desired angle.

While I have particularly shown and described several modifications of my invention, it is to be distinctly understood that my invention is not limited thereto but that improvements within the scope of the invention may be made.

I claim:

1. Means for coupling a pair of independent transducer means to a horn antenna comprising a pair of elongated resonant chambers each closed at one end, an antenna mounted within each of said chambers and having an axis of symmetry transverse to said chambers, said antennas lying in mutually perpendicular planes and adapted to operate on substantially the same frequency, the dimensions of each of said chambers transverse to the axis of the antenna therewithin being at least a half of the operating wavelength and the dimension of each of said chambers parallel to the axis of the antenna therewithin being substantially less than a half of the operating wavelength, and means for coupling the open ends of said chambers to said horn.

2. Means for coupling a pair of independent transducer means to a wave guide comprising a pair of elongated resonant chambers each closed at one end, an antenna mounted within each of said chambers and having an axis of symmetry transverse to said chambers, said antennas lying in mutually perpendicular planes the dimensions of each of said chambers transverse to the axis of the antenna therewithin being at least a half of the operating wavelength and the dimension of each of said chambers parallel to the axis of the antenna therewithin being substantially less than a half of the operating wavelength of the other of said antennas, said wave guide having an open end thereof in operative relationship with the open ends of said chambers.

3. A high frequency energy system comprising a pair of elongated resonant chambers each closed at one end each forming an arm of a Y, an antenna having an axis parallel to the direction of travel of energy in said antenna mounted transversely within each of said chambers, said antennas lying in mutually perpendicular planes, the dimensions of each of said chambers transverse to said antenna axis being at least a half of the operating wavelength and the dimension of each of said chambers parallel to the axis of

the antenna therewithin being substantially less than a half of the operating wavelength of the other of said antennas, and means for coupling the open end of said chambers to an elongated wave guide so arranged that the axis of said guide lies along the leg of said V, and means at the junction of said chambers for preventing interaction between said antennas.

4. Means for coupling a pair of independent transducer means to a horn antenna comprising a pair of elongated resonant chambers each closed at one end, a linear antenna mounted transversely within each of said chambers, said antennas lying in mutually perpendicular planes and adapted to operate on substantially the same frequency, the dimensions of each of said chambers transverse to the antenna therewithin being at least a half of the operating wavelength and the dimension of each of said chambers parallel to the axis of the antenna therewithin being substantially less than a half of the operating wavelength, means for coupling the open end of said chambers to said horn and means at the junction of said chambers for preventing interaction between said antennas.

5. Means for coupling a pair of independent transducer means to a horn antenna comprising a pair of elongated rectangular resonant chambers each being closed at one end, said chambers forming the arms of a V with their open ends adjacent, a linear antenna mounted transversely within each of said chambers and mutually at right angles with respect to each other, the dimension of each of said chambers transverse to the antenna therewithin being at least a half of the operating wavelength and the dimension of each of said chambers parallel to the axis of the antenna therewithin being substantially less than a half of the operating wavelength of the other of said antennas and means at the junction of said chambers for coupling said chambers to the throat of said horn.

6. Means for coupling a pair of independent transducer means to a horn antenna comprising a pair of elongated rectangular resonant chambers each being closed at one end, said chambers forming the arms of a V with their open ends adjacent, an antenna having an axis parallel to the direction of travel of energy in said antenna mounted transversely within each of said chambers and mutually at right angles with respect to each other, means at the junction of said chambers for coupling said chambers to the throat of said horn and means at said junction for preventing interaction between said antennas, said last mentioned means comprising a grid across the end of each of said chambers, each grid being conductive only in a direction to prevent the passage of wave energy of a polarization other than that for which the antenna within said chamber is arranged, each of said chambers being so dimensioned in the direction of the axis of the antenna therewithin as to prevent passage of waves polarized parallel to the axis of said antenna.

7. Means for coupling a pair of independent transducer means to a horn antenna comprising a pair of elongated rectangular resonant chambers each being closed at one end and having their open ends adjacent, a linear antenna mounted transversely within each of said chambers and mutually at right angles with respect to each other, the dimension of each of said chambers transverse to the antenna therewithin being at least half of the operating wavelength

and the dimension of each of said chambers parallel to the axis of the antenna therewithin being substantially less than a half of the operating wavelength of the other of said antennas and means at the junction of said chambers for coupling said chambers to the throat of said horn and means at said junction for preventing interaction between said antennas, said last mentioned means comprising a grid across the end of each of said chambers, each grid being conductive only in the direction normal to the antenna within its associated chamber, said grids being arranged in intersecting planes, the plane of each grid lying normal to the bisector of the angle between the axis of its associated chamber and the axis of said coupling means.

8. Means for coupling a pair of independent transducer means to a horn antenna comprising a pair of elongated rectangular resonant chambers each being closed at one end, said chambers forming the arms of a V with their open ends adjacent, an antenna mounted transversely within each of said chambers and mutually at right angles with respect to each other, the dimensions of each of said chambers being so arranged as to support the propagation of a wave of the operating frequency of only a single polarization, means at the junction of said chambers for coupling said chambers to the throat of said horn and means at said junction for preventing interaction between said antennas, said last mentioned means comprising a grid across the end of each of said chambers, each grid being conductive only in the direction normal to the antenna within said chamber, each of said grids being arranged to form a continuation of a wall of the other of said chambers whereby a smooth transition between said chambers and said horn is attained.

9. Means for coupling a pair of independent transducer means to a horn antenna comprising a pair of elongated resonant chambers each being closed at one end and having their open ends adjacent, an antenna having an axis parallel to the direction of travel of energy in said antenna mounted transversely within each of said chambers and mutually with their axes at right angles with respect to each other, the transverse dimension of each of said chambers being at least a half of the operating wavelength, and the dimension of each of said chambers parallel to the axis of the antenna therewithin being substantially less than a half of the operating wavelength of the other of said antennas and means at the junction of said chambers for coupling said chambers to the throat of said horn and further means at said junction for preventing interaction between said antennas, said means comprising a grid across the end of each of said chambers, each of said grids being conductive only in the direction normal to the axis of the antenna within its associated chamber.

10. Means for coupling a pair of independent transducer means to a horn antenna comprising a pair of elongated rectangular resonant chambers each being closed at one end and forming the arms of a V with their open ends adjacent, a linear antenna mounted transversely within each of said chambers and mutually at right angles with respect to each other, said antennae being adapted to operate on substantially the same frequency, the dimension of each of said chambers transverse to the antenna therewithin being at least a half of the operating wavelength, the other transverse dimension of each of said chambers being less than half of the operating

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wavelength, the junction between said chambers being directly connected to the throat of said horn and means at said junction for preventing interaction between said antennas, said last mentioned means comprising a grid across the end of each of said chambers, each grid being conductive only in the direction normal to the antenna within its associated chamber and being arranged to form a smooth continuation of the wall of said horn into the other of said chambers. 10

11. Means for coupling a pair of independent transducer means to a horn antenna comprising a pair of elongated rectangular resonant chambers each being closed at one end and having their open ends adjacent, a linear antenna 15 mounted transversely within each of said chambers and mutually at right angles with respect to each other, the dimension of each of said chambers transverse to the antenna therewithin being at least a half of the operating wavelength, and the dimension of each of said chambers parallel to the axis of the antenna therewithin being substantially less than a half of the operating wavelength of the other of said antennas and means at the junction of said chambers for coupling said chambers to the throat of said horn 20 and further means at said junction for preventing interaction between said antennas, said means comprising a grid across the end of each of said chambers, each of said grids being conductive only in the direction normal to the antenna within its associated chamber, said grids being arranged in intersecting planes, the plane of each grid lying normal to the bisector of the angle between the axis of its associated chamber 25 and the axis of said coupling means. 35

12. Means for coupling a pair of independent transducer means to a horn antenna comprising a pair of elongated rectangular resonant chambers each being closed at one end and having their open ends adjacent, a linear antenna mounted transversely within each of said chambers, said antennae being adapted to operate on substan-

tially the same frequency, the dimension of each of said chambers transverse to the antenna therewithin being at least a half of the operating wavelength, the other transverse dimension of each of said chambers being less than half of the operating wavelength, means for coupling said chambers to the throat of said horn and means for preventing interaction between said antennas, said last mentioned means comprising a grid across the end of each of said chambers, each of said grids being conductive only in the direction normal to the antenna within its associated chamber, and means for rotating each of said chambers and its associated grid about the longitudinal axis of said chamber. 15

13. Means for coupling a pair of independent transducer means to a horn antenna comprising a pair of elongated rectangular resonant chambers each being closed at one end and arranged in an end to end relationship with their open ends adjacent, a linear antenna mounted transversely within each of said chambers and mutually at right angles with respect to each other, the dimension of each of said chambers transverse to the antenna therewithin being at least a half of the operating wavelength and the dimension of each of said chambers parallel to the axis of the antenna therewithin being substantially less than a half of the operating wavelength of the other of said antennas, a wave guide section having its axis at right angles to the axis of said chambers connected to the junction of said chambers for coupling said chambers to the throat of said horn and means within said junction for preventing interaction between said antennas, said means comprising a pair of grids mutually at right angles with one another and normal to the bisectors of the angles between said chambers and said guide section, each of said grids being conductive only in the direction normal to the antenna within its associated chamber. 20 25 30 35

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