

March 29, 1960

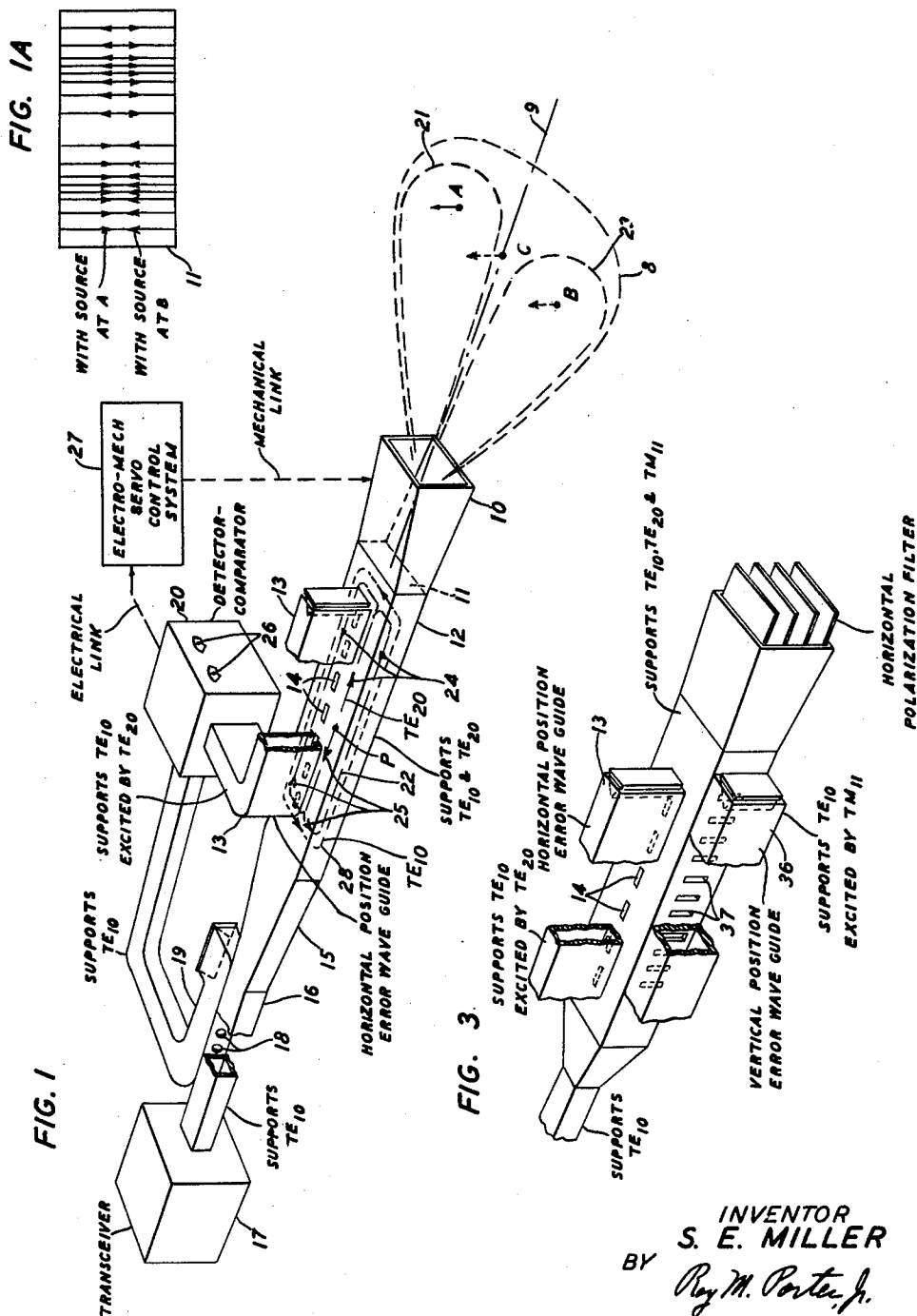
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2,931,033

MULTI-MODE AUTOMATIC TRACKING ANTENNA SYSTEM

Filed July 19, 1955

2 Sheets-Sheet 1



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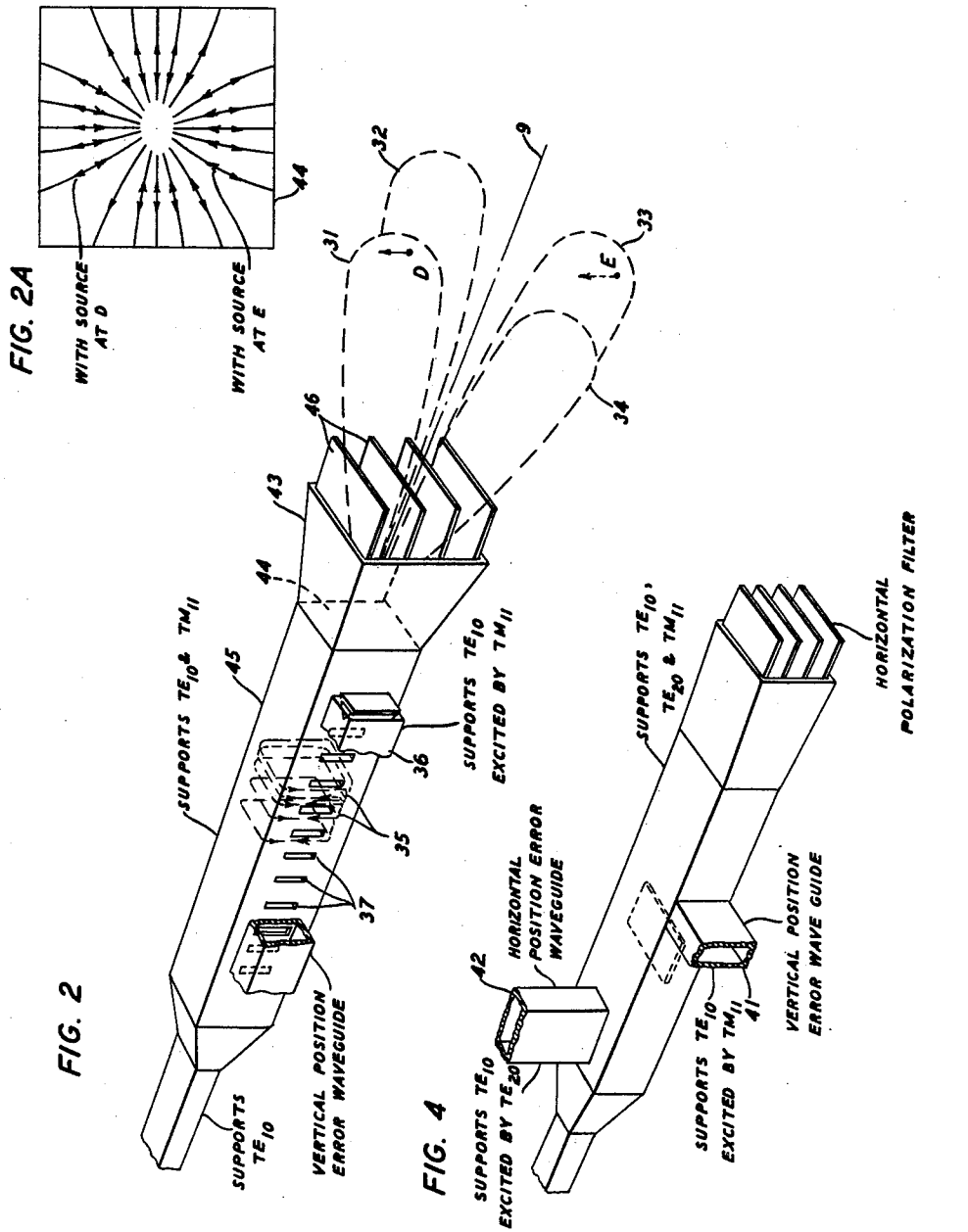
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2 Sheets-Sheet 2



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2,931,033

MULTI-MODE AUTOMATIC TRACKING ANTENNA SYSTEM

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20 Claims. (Cl. 343—703)

This invention relates to microwave communication systems, and, more particularly, to an antenna system capable of automatically positioning its radiation receiving horn, in bearing and elevation, relative to the position of a source of electromagnetic energy located in the antenna's radiation pattern.

It is an object of this invention to automatically position an electromagnetic wave antenna relative to a source of wave energy by deriving positioning information from various modes of wave energy propagation and their characteristic radiation reception patterns.

Another object of this invention is to position an antenna along more than one coordinate by utilizing modes of higher order than the dominant mode as control channels associated with the coordinates.

It is a further object of the invention to perform automatic antenna positioning without interrupting or effecting the normal flow of primary intelligence in the communication system.

In accordance with the invention, it has been recognized that when a source of dominant mode wave energy is located in space somewhere along the extension of the longitudinal axis of an antenna reception horn, every portion of the wave front from the source arrives at the horn in the same time phase. With the source displaced from the axis, the wave front arrives at the horn at an angle; consequently the time phase of the wave front varies across the aperture plane of the horn. Now, in an antenna comprising a horn and wave guide proportioned to support a plurality of modes, only the dominant mode is excited therein when the dominant mode source is located on the axis. It has been discovered, however, that with the source in an off-axis position a wave pattern is excited in the antenna which may comprise, in addition to the dominant mode, components of other modes which the antenna is proportioned to support, due to the time phase variation across the received wave front with reference to the horn aperture. As a consequence, the Off-On position of the source relative to the axis is readily ascertainable, i.e., when components are present in addition to the dominant mode, it is clear that the source is off-axis; if the field pattern is a pure dominant mode the source is on-axis. Which of the modes will be additionally present as components of the field pattern excited in the antenna depends upon the precise position of the source relative to the axis.

Effectively, then, each mode excitable in the antenna defines a radiation reception pattern in free space, convergent at the horn, which is peculiar to that mode. For example, the dominant mode TE_{10} radiation pattern is characterized by a single lobe whose longitudinal center axis is an extension of the longitudinal center axis of the wave guide; the TE_{20} mode is characterized by two lobes located within the boundary of the TE_{10} lobe but whose two lobes respectively are on opposite sides of the center axis. For illustrative purposes, consider a source of electromagnetic wave energy located in a region common to a lobe of each of the two above-mentioned patterns and directed towards the radiation reception horn. Since the

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source is in both radiation patterns, the electromagnetic field pattern excited in the wave guide will be a resultant field comprising both modes. But one of the patterns is double lobed and the polarization of the excited TE_{20} mode associated therewith, relative to the polarization of the dominant mode, will depend upon which of the two lobes of the TE_{20} mode is active, i.e., in which lobe the source is located. Consequently, inspecting the polarization of the higher order mode to ascertain whether it is in or out of phase with the dominant mode results in determining which is the active lobe; thus on which side of the center axis the source is located. With this information, the radiation reception horn may be moved in the proper direction to bring the center axis to bear directly on the source. The dominant mode, associated with the single lobe, remaining unaffected by this process, propagates its wave impressed with intelligence from the source along the guide to be utilized by a receiver. The positioning information thus obtained is clearly with respect to one coordinate.

By standard methods, each component mode may be isolated by coupling it from the main wave guide to the exclusion of the other component modes. Therefore, each mode may be utilized as a separate communication channel. A third mode and thus a third communication channel may be used to provide positioning information with respect to the coordinate perpendicular to that defined by the TE_{20} mode. In this manner two-dimensional positioning information is available.

These and other objects and features, the nature of the present invention and its various advantages, will appear more fully upon consideration of the various specific illustrative embodiments shown in the accompanying drawings and described in the following detailed description.

In the drawings:

Fig. 1 is a perspective view of a one coordinate automatic positioning antenna system operative in the TE_{10} and TE_{20} modes;

Fig. 1A, given for purposes of explanation, is a plane cross sectional view of the TE_{20} electric field pattern;

Fig. 2 is a perspective view of a one-coordinate positioning antenna operative in the TE_{10} and TM_{11} modes;

Fig. 2A, given for purposes of explanation, is a plane cross sectional view of the TM_{11} electric field pattern;

Fig. 3 is a perspective view of a two-coordinate positioning antenna operative in the TE_{10} , TE_{20} and TM_{11} modes; and

Fig. 4 is a perspective view of an antenna as in Fig. 3 using an alternative type of coupling for the various modes.

Where an element is common to more than one figure, it is designated by the same number in the drawings.

Referring more specifically to Fig. 1, an example of a two-way transmission and radiation system in accordance with a first embodiment of the invention is presented for purposes of illustration in which positions of an emitting source of electromagnetic waves located either on a center-axis 9 or to the right or left thereof may be detected. Center-axis 9, which is the extension in space of the longitudinal axis of the antenna's main wave guide 12 and its radiation reception horn 10 contiguous to guide 12, is the frame of reference for the radiation reception patterns characteristic of the modes that the main guide may support. Accordingly, center-axis 9 is the axis of the dominant mode lobe 8; it is also the dividing line between the two lobes 21 and 23 of the TE_{20} mode, with lobe 21 being on the right of axis 9 when facing in the direction of horn 10 and lobe 23 on the left thereof. Both lobes 21 and 23 are encompassed by lobe 8. Although these are three-dimensional lobes, in this illustrative embodiment of the

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invention we are only concerned with their position right and left of axis 9. Dominant mode energy received by the antenna system from the source when it is located in a region common to the characteristic radiation patterns of both modes will simultaneously excite in rectangular radiation reception horn 10 and rectangular wave guide section 12 both the TE_{10} and TE_{20} modes. The wide dimension of guide 12 must be at least one wavelength for guide 12 to support the TE_{20} mode; if it were less than one but more than a half wavelength only the dominant mode could be excited therein.

These two component modes are then isolated from each other in the antenna by structure now to be described. Contiguous to the top wide dimensioned wall of rectangular guide section 12 and disposed along the wall's longitudinal center line is the narrow-dimensioned wall of a rectangular wave guide 13. Penetrating these adjacent walls along the common longitudinal center line thereof are a series of rectangular coupling apertures 14 whose wide dimensions are parallel to the center line. By means of aperture 14, TE_{20} energy excited in guide 12 may be launched in guide 13, to the exclusion of any other mode in guide 12, in the form of the TE_{10} mode in a manner hereinafter to be more fully described. Energy thus launched in guide 13 is the horizontal error signal. In order to isolate the TE_{10} mode from the TE_{20} energy remaining in guide 12, a section of wave guide 15 which commences at the end of guide 12 opposite to horn 10 tapers in the horizontal plane joining guide 12 to a narrower rectangular guide 16. Tapered section 15 precludes the TE_{20} mode receptively excited in guide 12 from entering guide 16 while readily allowing the passage of the TE_{10} mode in that direction; the TE_{10} mode being then received by transceiver 17 which is coupled to guide 16 at its other end. Contiguous to one of the narrow-dimensioned walls of guide 16 and coupled thereto by a plurality of small apertures 18 disposed along the longitudinal center line of the wall is a similarly dimensioned rectangular wave guide 19. This arrangement functions to perform directional coupling between guides 16 and 19 whereby a sample of the TE_{10} mode energy in guide 16 is introduced in guide 19; this directional coupler is well known in the art and is described in several standard textbooks on the subjects such as Southworth, "Principles and Application of Waveguide Transmission," D. Van Nostrand, 1950. One end of guide 19 is terminated with an appropriate energy dissipative material as is also the case with one end of the horizontal error signal wave guide 13 mentioned above. The opposite ends of guides 13 and 19, however, are coupled to a detector-comparator device which functions to detect the possible presence of a horizontal error signal in guide 13 and also to compare the phase of the TE_{10} mode in guide 19 with the phase of the TE_{10} mode error signal which may be present in guide 13. This function provides the desired information concerning the location of the emitting source relative to center-axis 9; it will hereinafter be more fully explained.

In the operation of Fig. 1 it may be noted that the dominant mode TE_{10} is the vehicle or channel for propagating the normal intelligence in the communication system, while the TE_{20} mode is the channel for the horizontal coordinate positioning information. Consider a source of vertically polarized dominant mode wave energy located at some point A in lobe 21 of the TE_{20} double-lobed reception pattern; the vertical electric-field vector orientation of the wave emitted at A, at a given point in time, being represented by the associated solid arrow. The electromagnetic field pattern excited in the antenna by the wave energy will include a component which is the TE_{20} mode; this being due to the time phase variation across the mouth of horn 10 caused by the arrival of the wave front at an angle to the plane of the horn's mouth. The component TE_{20} electric-field pattern excited in the antenna at a given point in time and at a given point in space, as is well known, will appear as schematically

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represented in Fig. 1A. Referring to Fig. 1 again, a portion of the TE_{20} magnetic field pattern excited in guide 12 and associated with the aforementioned electric field will representationally appear in a given small region as two rectangular loops 22 oriented horizontally with their long dimensions parallel to the longitudinal axis of guide 12 and adjacent to each other along that axis or center line. Using the electric field pattern of Fig. 1A as the reference and applying the "right hand rule" it is clear that the magnetic field pattern 22 has a specified sense represented by the solid arrowheads 24 appearing on the loops. The center line passing through point P, which is the side common to both loops, represents a region of maximum magnetic field intensity. Since coupling apertures 14 are disposed along this region the magnetic field will be coupled to guide 13 on the basis of its geometry alone. However, apertures 14 are dimensioned and disposed to enhance the coupling effect beyond that which would be achieved simply by geometric balance. This improved coupling based on the principle of "mode velocity discrimination," is the subject of my copending application Serial No. 245,210, filed September 5, 1951, which matured into United States Patent 2,748,350, on May 29, 1956, which provides a detailed theoretical and structural description thereof. Guide 13, being proportioned to support the dominant mode and having the coupling apertures 14 in its narrow wall, will be excited in the dominant mode by the portion of the TE_{20} magnetic field coupled from guide 12. The sense of the dominant mode magnetic field pattern thus excited in guide 13 will of course be dependent upon the sense of the TE_{20} magnetic field pattern in guide 12; with the source of wave energy in lobe 21 this sense in guide 12 is, as above mentioned, represented by the solid arrowheads 24.

Consider, now, the source of dominant mode energy to be in the other lobe 23 at point B; the vertical direction and upward sense of the electric-field vector at the emitting source at B being the same as at A but represented by the dashed-line arrow. The electric field pattern excited in the antenna due to the wave from the source in reception lobe 23 will have a sense opposite to that excited by the source in lobe 21. As a consequence, the magnetic field pattern in guide 12 represented by loops 22 will have a sense represented by the dashed-line arrowheads 25 which is opposite to that of the solid arrowheads 24 associated with the source in lobe 21. Clearly, then, the dominant mode field pattern excited in the error guide 13 due to the source in lobe 23 will have a sense opposite to that associated with lobe 21.

Should the source, however, be located anywhere along center-axis 9 which is between lobes 21 and 23 or perhaps on their common boundary, say for example at point C, then the TE_{20} mode will not be excited at all in the antenna system, and as a consequence no energy will be coupled into error guide 13. The absence of the TE_{20} mode in this circumstance is understandable. Since the source is on axis 9 its emitted wave front will be transverse to axis 9 but parallel to the mouth of horn 10. Consequently, every portion of the wave front will travel the same distance to reach the mouth of horn 10, there thereby being a constant time phase across the mouth of the horn with each successive wave front. This being the case, and since the wave energy is propagating in the dominant mode, only a pure dominant mode is excited in the antenna which cannot induce as signal in horizontal error guide 13.

Accordingly, the horizontal position of a source with respect to center-axis 9 may always be ascertained by inspecting the energy or lack of it in guide 13, i.e., an absence of energy means that the source is on the center-axis; energy polarized in one sense indicates source on one side of line 9, and energy 180 degrees out of phase with that sense indicates source on the other side. However, the phase of a wave function is a relative concept since

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the wave equation always includes both time and position as parameters. Utilizing the fact that the TE_{10} mode is excited in the antenna whether or not the source is located on axis 9, a constant reference is always available against which the phase of the error signal in guide 13 may be related. It is more accurate to say, therefore, that if the error signal is in phase with the dominant mode excited in guide 12, the source is located in one of the two lobes associated with the TE_{20} mode, while if it is out of phase with the dominant mode the source is located in the other lobe.

This phase comparison is performed in the detector-comparator 20, as hereinbefore mentioned, by sampling at coupling apertures 18, the dominant mode energy isolated in guide 16 and propagating toward transceiver 17; this energy sample then propagates along guide 19 to detector-comparator 20. Here the phase comparison is made with the error signal in guide 13, and also the magnitude of the error signal power is detected. This information may be displayed as analog information at meters 26 mounted on detector-comparator 20 for possible use by a human operator, and/or may be electrically transmitted to a conventional electromechanical servo-mechanism control system, represented by block 27, which has a mechanical linkage, schematically represented, to the antenna for physically controlling the radiating horn's direction in accordance with the error signal.

It may be noted from the above-operative description of the system that at no time during the operation need the transmission of information from the source to transceiver 17 be interrupted. Another point of interest is that even though both the dominant TE_{10} and the TE_{20} modes may be simultaneously excited in guide 12 only the TE_{20} mode carrying the error information may excite error guide 13; in this coupling arrangement the TE_{10} mode in guide 12 cannot substantially excite error guide 13. This may be understood by considering the well-known magnetic field pattern of the dominant mode and the position of coupling apertures 14. The longitudinal components of the field pattern for this mode are maximum at the boundaries of the wide wall of the guide but are zero along the center line (as depicted by rectangular loop 28). Since the coupling apertures 14 are disposed along the center line, which corresponds to the null region of TE_{10} magnetic lines of force, no coupling action can occur. Consequently the error signal in guide 13 cannot be contaminated by the TE_{10} mode in guide 12.

It may be further noted that the embodiment of the invention of Fig. 1 has been discussed in its capacity as a receiving antenna system. It may also function as a transmitting antenna, in which case TE_{10} energy may be radiated from it; a representative illustration of such a type of application of the subject embodiment is to be later discussed. In this connection, it may be seen that although a sample of the TE_{10} mode propagating through guide 16 towards transceiver 17 will be launched in guide 19 via apertures 18, this is a directionally selective coupling action; thus for the TE_{10} propagating in the reverse direction energy coupled into guide 19 will be dissipated at the resistive termination.

Regardless of the mode of operation of the subject embodiment of the invention, at no time need TE_{20} mode energy be radiated in space from the antenna system. It is non-contributive to antenna positioning operation of the invention or to any other operation. In this connection it may be seen that tapered section 15 performs, in addition to its mode isolating function previously discussed, the function of passing TE_{10} energy, which may be generated by transceiver 17, from guide 16 to guide 12 without the creation of the TE_{20} mode or other higher order modes that ordinarily develop at an abrupt impedance discontinuity.

Although the embodiment of the invention in Fig. 1 is illustrated in a manner whereby the error detection and correction is with respect to positions of the source right

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and left of center-axis 9, positional error detection above and below the axis may be obtained in lieu thereof by physically rotating the entire antenna system by 90 degrees about center-axis 9. In this position, lobes 21 and 23 will be vertically oriented but otherwise operation is the same, assuming of course that the source generates horizontally polarized waves rather than vertical waves as required in the illustration of Fig. 1.

Fig. 2 represents an embodiment in accordance with the invention, given by way of illustration, of another type of one-coordinate positional error detection system in which a mode of higher order than the TE_{20} is utilized as the channel for positional error information. The illustrative embodiment of Fig. 2 is arranged to perform vertical error detection. The terminal equipment comprising transceiver, servo system and detector-comparator, illustrated in Fig. 1 is not reproduced in Fig. 2, its existence and relation thereto being implicitly understood when considering an entire antenna system.

The operation of this embodiment depends upon the recognition that, in addition to the TE_{20} mode, various other modes of order greater than the dominant may be excited in an antenna wave guide by a source of dominant mode energy in an off-axis position. The TM_{11} mode is utilized in this embodiment as the position error information channel; its transverse electric-field pattern, well known in the art and appearing in standard textbooks such as Southworth, supra, is for purposes of illustration, represented in Fig. 2A as it would appear at aperture 44 which is common to square horn 43 and square wave guide 45. The four sections or domains of this transverse pattern have associated therewith and define a radiation reception pattern characterized by four lobes; two vertically oriented lobes 31 and 33, that is lobe 31 above center-axis 9 and 33 below, and lobes 32 and 34 on either side of axis 9 respectively. Both the vertical and horizontal sides of square wave guide 45 are at least one wavelength dimensionally, so that both the TM_{11} and TE_{10} modes may be supported.

Restricting attention to the vertical error lobes 31 and 33, consider first an emitting source of vertically polarized dominant mode electromagnetic wave energy located in lobe 31. The electric-field pattern excited in aperture 44 thereby is, as previously indicated, represented in Fig. 2A. Since the sense of the electric-vector of the wave at the emitting source in lobe 31 is upward, as depicted by the solid arrow at D, the sense of the field pattern in aperture 44 will be radially outward from the geometric center of the cross sectional square as shown by the solid arrows in Fig. 2A. The TM_{11} magnetic field pattern excited in guide 45, associated with the electric-field pattern in aperture 44, can be represented by a succession of transverse rectangular loops 35 whose planes are perpendicular to the axis of guide 45. The loops as shown are not intended as a definitive picture of the TM_{11} magnetic field pattern in the guide, but are merely a qualitative indication of the pattern by representation in a small region. As in the case of Fig. 1, the error wave guide is contiguous to the main guide, and is coupled thereto by a series of rectangular apertures along the longitudinal center line of the common wall. In this case, however, the wide dimensions of the coupling apertures 37 are transverse to the longitudinal axis of the wave guides since the magnetic lines of force in guide 45 are transverse. Therefore, the vertical error rectangular wave guide 36 which has its wide dimension vertical and is appropriately proportioned, will have TE_{10} mode energy excited in it by the error information carrying TM_{11} mode in guide 45. The polarization of the wave in the error guide will depend upon the polarization of the TM_{11} mode, which is represented by the solid arrowheads on loops 35 for the case in which the source is in top lobe 31. Now if the source is moved down to point E in bottom lobe 33, it is clear that the sense of the electromagnetic field pattern in guide 45 will be reversed, as repre-

sented by the dashed-line arrowheads, and as a consequence the polarization of the error signal induced in guide 36 will be 180 degrees out of phase with the signal induced by the source in top lobe 31. As is the illustration of the embodiment of Fig. 1, inspection of the phase of the error signal in the error guide relative to the phase of the general information carrying dominant mode gives the answer as to which of the lobes contains the emitting source. Should the emitting source be located on center-axis 9, then, as previously explained with respect to Fig. 1, there will be no excitation of the TM_{11} mode, and as a consequence there will be no error signal in error guide 36.

Side lobes 32 and 34 have been omitted from the discussion thus far. It may be seen that location of a source emitting horizontally polarized waves in either of these side lobes will cause the antenna system to be excited in the same manner as discussed above with respect to a source emitting vertically polarized waves located in top or bottom lobes 31 and 33. Thus, in order for the error signal to be an unambiguous indication of position, excitation due to the side reception lobes must be precluded. This is readily accomplished by using one of the several lenses of the type known in the art that filter out horizontally polarized waves; unwanted in this situation. A lens of this type is depicted in Fig. 2, located in front of horn 43 and transverse to the path of wave propagation. The lens however may appropriately be located in the throat of the horn. It comprises an array of thin parallel plates 46 of highly conductive metal; each plate disposed horizontally and spaced one from the next at some convenient distance less than half a wavelength. Vertically polarized waves pass through this structure undisturbed while horizontally polarized waves are totally reflected.

As discussed above, the embodiment using the TM_{11} mode in Fig. 2 is arranged so as to provide error detection and correction information for the vertical coordinate. This embodiment is versatile, however, in that it may perform its function for horizontal errors by executing a 90-degree rotation about the center-axis of the entire antenna structure, including the parallel plate polarization filtering lens 46, whereby vertical polarization rather than horizontal will be eliminated. As a result lobes 32 and 34, presently located respectively to the right and left of center-axis 9, would be the active lobes.

In applications requiring only one coordinate direction finding the embodiments of Figs. 1 and 2, individually, are particularly appropriate. Many applications, however, require a system to be operative with respect to both the vertical and horizontal coordinates, this being the most general automatic positioning requirement. This requirement readily falls within the capabilities and scope of the invention. Since Fig. 1, as illustrated, provides horizontal error information and Fig. 2, as illustrated, vertical error information, the two embodiments may be combined in a single antenna system providing two-dimensional error information.

Fig. 3, as illustrated, is exactly such a combination. The horizontal error guide 13 and its associated coupling apertures 14 in Fig. 3 are analogous and homologous to their counterparts in Fig. 1, i. e., they are structurally the same and perform the identical function as is also the case with vertical error guide 36 and coupling apertures 37 with respect to Fig. 2. Although both error guides are coupled to the same main wave guide in Fig. 3, there is no "cross-talk" between them. The reason for their isolation one from the other may be understood by considering the magnetic field patterns, above discussed, of their respective exciting modes and the relation of the dimensions of their respective coupling apertures to these field patterns. In each case it may be seen that the wide dimension of the coupling apertures, selected in accordance with my copending application hereinbefore mentioned, is parallel to its proper exciting magnetic lines of

force while perpendicular to the magnetic field pattern defining the undesired mode. As a consequence, the apertures will couple their appropriate mode but will appear as a conductive boundary to the others.

Fig. 4 represents an illustrative embodiment in accordance with the invention that also functions as a two-coordinate error positioning system operating in a manner substantially analogous to the embodiment of Fig. 3. However, the coupling structures are of the lumped branching type familiar in the art and disclosed in my copending application Serial No. 263,600, filed December 27, 1951, which matured into United States Patent 2,748,352, on May 29, 1956, as well as in copending application of A. P. King, Serial No. 260,137, filed December 6, 1951, which matured into United States Patent 2,682,610, on June 29, 1954. They are particularly suitable when the overall system requirements may be satisfied by coupling based solely upon the geometries of the mode field patterns. Because of these geometries, hereinbefore discussed in detail, it is readily evident that the TM_{11} mode will excite the dominant mode in vertical error guide 41 while the TE_{20} mode will excite the dominant mode in horizontal error guide 42.

The modes used as error information carrying channels in all the above-discussed embodiments are examples presented for illustrative purposes. Various other transverse electric and transverse magnetic modes of different orders may obviously be utilized by one skilled in the art within the spirit and scope of the invention.

The invention is readily conducive to use in many important applications. In a microwave radio relay system it may be the case that a receiving antenna may be required to service, that is receive from, a multiplicity of transmitters that are positioned fairly close to each other in azimuth but at varying distances. A signal from any one of the transmitters would actuate the automatic positioning system disclosed in Fig. 1; as a consequence the receiver would automatically and instantaneously commence aligning the center-axis of its reception pattern with the center-axis of the transmitter's pattern.

Radio communication systems involving sharp antenna beams on unstable platforms (such as is frequently the case aboard ships) could advantageously utilize appropriate embodiments of the invention in order to enable the receiving antenna to track the incoming signal.

Similarly automatic tracking radar systems are in the area of application. In the discussion of the embodiments of the invention above, an emitting source of electromagnetic wave energy located in one of the active lobes was the error system actuating agent. However, this source need not be a primary source; a source of reflected energy such as a radar target is also appropriate.

Since radar operates on a pulse, time division basis, the antenna system of Fig. 3 or 4 with the appropriate terminal equipment of Fig. 1 may serve not only as a two-coordinate automatic tracking receiver but also as a transmitter of the radar pulses. In this connection consider Fig. 1 as a one-coordinate system illustration. Transceiver 17 may generate a dominant mode pulse which is radiated in space in the characteristic dominant mode radiation pattern. Energy reflected back from the target located somewhere in the higher order mode reception pattern will excite both the dominant mode and the higher order mode; the dominant mode propagating back to the transceiver with target distance information, and the higher order mode generating the error signal which actuates the servo-system for automatic tracking. The cycle then repeats with another pulse from the transceiver.

In all cases it is understood that the above-described arrangements are illustrative of a small number of the many possible specific embodiments which can represent applications of the principles of the invention. Numerous and varied other arrangements can readily be devised in accordance with these principles by those skilled in

the art without departing from the spirit and scope of the invention.

What is claimed is:

1. An instantaneous directional error correcting antenna system comprising solely a single electromagnetic wave radiation element receptively excitable in a secondary mode of propagation having at least two radiation reception lobes in space and defining a secondary communication channel, said element additionally excitable in a principal mode of propagation having a single radiation reception lobe in space and defining a principal communication channel, a first utilizing means for said principal channel, means selectively coupling said principal mode to said first utilizing means whereby said principal channel is coupled to said first utilizing means, a second utilizing means for said secondary channel, means selectively coupling a portion of the wave energy propagating exclusively in said secondary mode to said second utilizing means whereby said secondary channel is coupled to said second utilizing means, and means for selectively coupling said principal mode to said second utilizing means.

2. A combination as described in claim 1 wherein said radiation receiving element comprises a conductively bounded wave supportive section, said conductive boundary of said secondary mode coupling means comprises a series of spaced apertures in said radiation receiving element, a wave guide means supportable of a mode of the same electromagnetic field configuration as said principal mode having a conductive wall common to said reception element in the region of said coupling apertures for launching said secondary mode in said wave guide in the form of said principal mode energy.

3. A combination as described in claim 2 wherein said second utilizing means comprises means for comparing the phase of said principal mode launched in said wave guide means with the phase of said principal mode in said radiation receiving element, and an indicating means displaying an analog representation of said phase relationship.

4. A combination as described in claim 3 wherein said second utilizing means includes a servo-mechanism system responsive to the output of said phase comparison means, means for directionally orienting said radiation receiving element, and means coupling said servo system to said orienting means.

5. A combination as described in claim 3 wherein said second utilizing means includes means for detecting the magnitude of energy present in said wave guide means and indicating means displaying an analog representation of said energy magnitude.

6. A combination as described in claim 1 wherein said secondary mode is of the TE_{20} type.

7. A combination as described in claim 1 wherein said secondary mode is of the rectangular guide TM_{11} type having four reception lobes, and means located in front of said radiation reception element and transverse to the propagation path of received electromagnetic wave energy for filtering out waves having a polarization characteristic of two of said four lobes.

8. A combination as described in claim 1 wherein said primary mode is the TE_{10} , dominant mode.

9. A tracking antenna system comprising solely a single electromagnetic wave radiation element receptively excitable in a secondary mode of propagation having at least two distinct reception lobes and simultaneously receptively excitable in a principal mode of propagation having a single reception lobe, said radiation means susceptible to radiating electromagnetic wave energy in space in said principal mode, a first utilizing means for said received principal mode, a first coupling means selectively coupling said principal mode to said first utilizing means, a second utilizing means responsive to wave energy derived from said secondary mode, a second coupling means selectively coupling a portion of the

wave energy propagating exclusively in said secondary mode to said second utilizing means, and a means selectively coupling a portion of energy associated with said principal mode to said second utilizing means.

10. A combination as defined in claim 9 wherein a source of electromagnetic wave energy conforming to said principal mode electromagnetic field pattern feeds said radiating element via said first coupling means.

11. A combination as defined in claim 10 wherein said source generates said electromagnetic wave energy in pulse form.

12. A combination as defined in claim 9, wherein said last-named selective coupling means is a directionally selective wave guide coupler responsive to said principal mode propagating in the reception direction and non-responsive to said principal mode propagating in the reverse direction.

13. A combination as defined in claim 9 wherein said radiation element is receptively excitable in a third mode of propagation having at least four reception lobes simultaneously with said principal and secondary modes, a third utilizing means coupled to wave energy derived from said third mode, and a means selectively coupling a portion of energy associated with said principal mode to said third utilizing means.

14. In an instantaneous directional error correcting antenna system, an electromagnetic wave transmission means comprising solely a single radiation element receptively excitable simultaneously in a plurality of electromagnetic field patterns of propagation, each said pattern being characterized by a radiation reception pattern in space peculiar to it alone, a plurality of selective coupling means for isolating respectively at least a portion of the energy associated with each of said field patterns, and means coupled to two of said coupling means for comparing the phase of said portions of energy isolated by said two coupling means.

15. An instantaneous directional error correcting antenna system, comprising an electromagnetic wave radiation element receptively excitable in a resultant electromagnetic field pattern consisting of a plurality of component electromagnetic modes of propagation, said resultant field varying in component mode content with variation of the angular orientation in at least one of two perpendicular planes of said radiation element relative to received plane-wave fronts of electromagnetic wave energy, a plurality of mode selective coupling means for respectively isolating a portion of energy associated with each of said component modes to the exclusion of all others, a plurality of utilizing means for said plurality of isolated portions of mode energy, and a directionally selective coupling means for coupling a portion of one of said plurality of component modes to all of said utilizing means.

16. A combination as described in claim 15 wherein said radiation element comprises a rectangular cross section metallic wave guide having a wide dimension at least one wavelength of the operating frequency.

17. A combination as described in claim 15 wherein said radiation element comprises a square cross section metallic shield wave guide having a side dimension at least one wavelength of the operating frequency.

18. An instantaneous directional error correcting antenna system comprising an electromagnetic wave radiation element receptively excitable in a secondary mode of propagation having at least two radiation reception lobes in space and defining a secondary communication channel, said element additionally excitable in a principal mode of propagation having a single radiation reception lobe in space and defining a principal communication channel, means for converting a portion of said secondary mode energy into said principal mode, a phase comparison means for comparing the phase of said principal mode with the phase of said converted principal mode, means for coupling said principal mode to said comparison means

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and means for coupling said converted principal mode to said comparison means.

19. In an instantaneous directional error correcting antenna system, an electromagnetic wave transmission means comprising a single undivided rectangular electromagnetic wave radiation horn, a section of rectangular cross section wave guide having the end of each of its sides contiguous respectively to each side of said horn at its throat aperture, said rectangular wave guide and said throat aperture having a wide dimension at least one wave length of the operating frequency whereby said transmission means is receptively excitable simultaneously in a plurality of electromagnetic field patterns of propagation, a plurality of selective coupling means for isolating a portion of energy associated with each of said field patterns, a phase comparison means for comparing the phase of one of said field patterns with at least one other of said plurality of field patterns.

20. In an instantaneous directional error correcting antenna system, an electromagnetic wave transmission means comprising an electromagnetic wave radiation horn, a section of square cross section wave guide contiguous

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to said horn at its throat aperture, said square cross section wave guide having a side dimension at least one wavelength of the operating frequency, said transmission means being thereby receptively excitable in at least three electromagnetic field patterns of propagation characterized by single, double and quadruple radiation lobes in space, at least three selective coupling means for isolating respectively a portion of energy associated with each of said field patterns, and means coupled to said wave transmission means for limiting the receptivity of said transmission means to wave energy polarized solely in a single given plane of polarization.

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