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SEARCH ROOM

Oct. 29, 1968 S. H. WALKER 3,408,654

SCANNING ANTENNA

Filed Sept. 29, 1965 2 Sheets-Sheet 1

FIG. 1

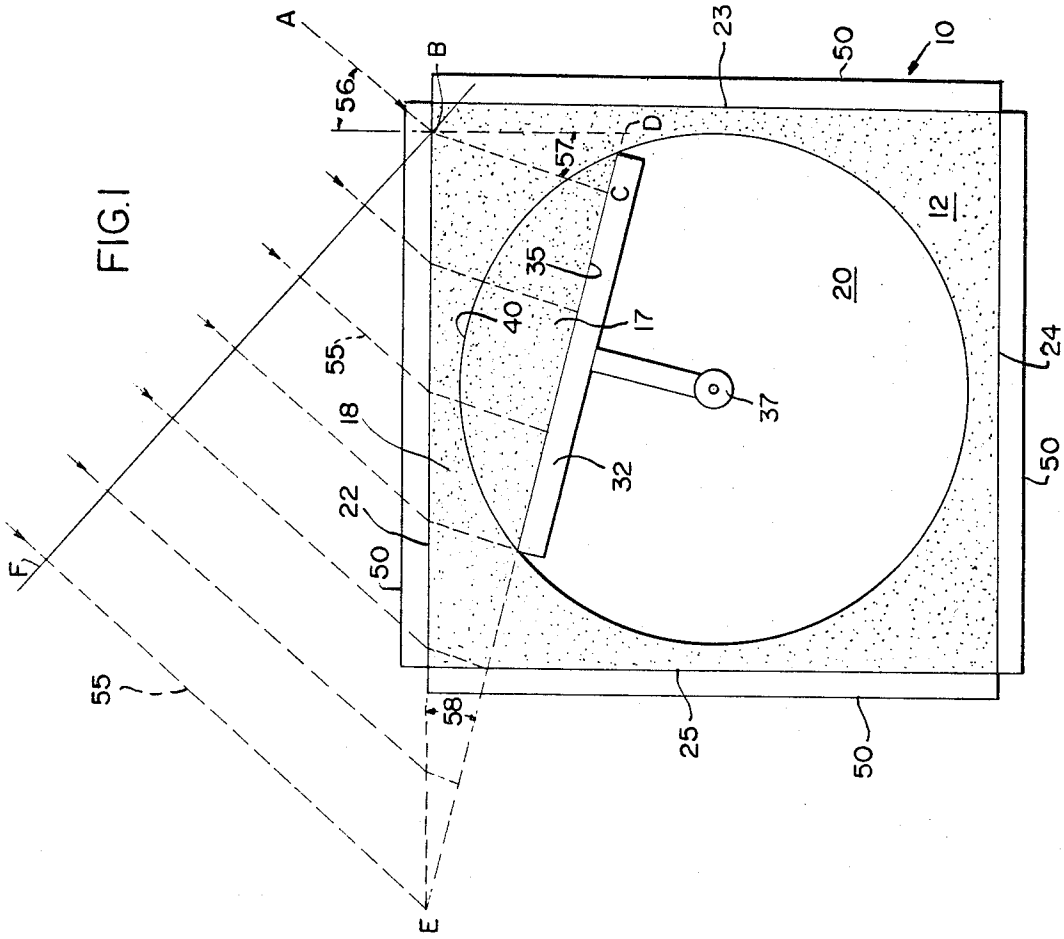
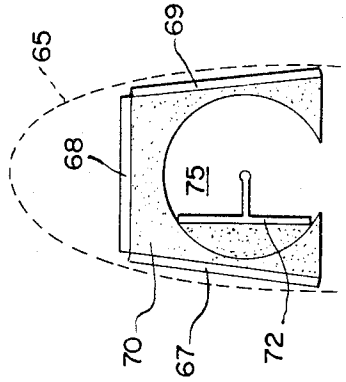


FIG. 5



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SCANNING ANTENNA

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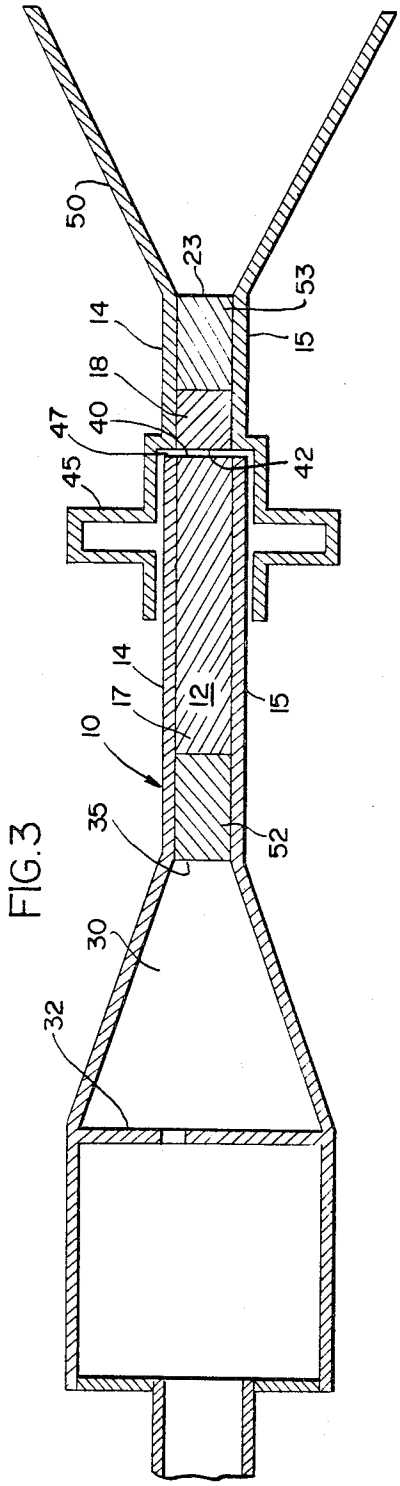


FIG. 3

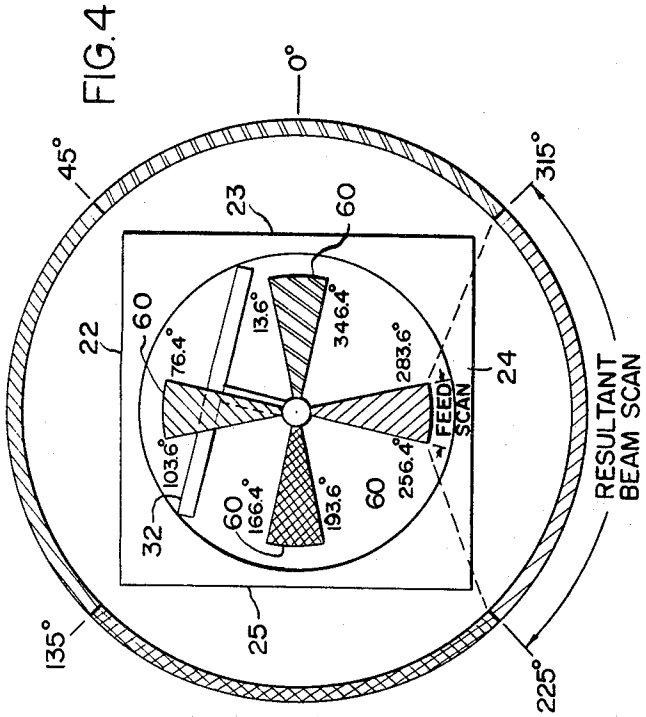


FIG. 4

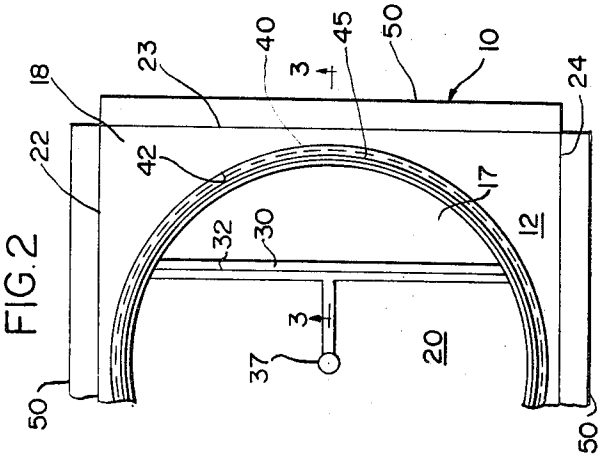


FIG. 2

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SCANNING ANTENNA

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5 Claims. (Cl. 343—754)

ABSTRACT OF THE DISCLOSURE

A beam scanning antenna with a prism having a movable portion secured to a movable input feed waveguide and movable therewith such that the prism shape is effectively changed as the input feed waveguide moves. This action changes the relative position of the prism outer surface with respect to the input waveguide for causing the beam leaving the prism to scan at a greater rate than the movement of the input feed waveguide.

This application pertains generally to beam scanning antennas and more particularly to a movable prism beam scanning antenna.

The need for compact narrow beam antennas to scan through large angular sectors has become increasingly important in modern radar and communication systems. This is particularly true in airborne electronic systems where large, high gain antennas designed using conventional techniques have severely limited the ultimate capability of the systems. Conventional antenna types, in order to achieve wide angle beam scanning without being masked by the aircraft, must be located outside the basic fuselage air frame contour. These protruding antennas cause excessive drag and are aerodynamically unacceptable for supersonic aircraft.

It has been proposed to use two dimensional geodesic lenses as they are capable of 360° scan and provide antenna apertures that can be flush mounted to many vehicles. The circular line apertures of these antennas, however, result in off-axes pattern deterioration which is unacceptable in many applications.

It has also been proposed to employ a number of flush-mounted scanable linear apertures which together can cover the required angular sector. Electronic scanning techniques are commonly considered for such applications but their size, weight and costs limits their useful value. Mechanically scanned linear apertures such as pill boxes have achieved 100 to 120 degrees of scan, but the requirement for three to four such large and heavy structures to achieve greater angular coverage is obviously undesirable.

It is an object of this invention to provide an improved compact linear aperture beam scanning antenna capable of large angular coverage.

It is another object of this invention to provide a highly reliable, variable prism beam scanning antenna that reduces servo power requirements and is simple, lightweight and relatively inexpensive to manufacture.

It is another object of this invention to provide a movable prism beam scanning antenna capable of scanning one or more linear apertures which can be mounted flush with the air frame contour of the vehicle thereby effectively reducing air drag.

One feature of this invention is a linear aperture beam scanning antenna having a rotating structure including a prism and a linear feed movable therewith for refracting the beam between the feed source and air thereby magnifying the angular motion of the rotating feed.

Another feature of this invention is a movable prism beam steering antenna having the prism in two sections with the first section including a combination linear radiating aperture and refraction surface and an arcuate

portion and the second section being shaped as a segment of a circle and mechanically connected and electrically coupled to a linear feed source. The sections are mounted so that the arc of the circle segment is rotatably mounted with respect to the arcuate portion of the first section to form a circular interface therewith which permits variation of the angle of refraction of the beam by rotating the second section of the prism and the linear feed source coupled thereto.

A further feature of this invention is a variable prism scanning antenna having the first section of the prism connecting a plurality of straight line radiating apertures that are mounted to approximate the air frame contour of a vehicle. The second section of the prism is electrically coupled and mechanically connected by a tapered waveguide transition to the feed, and a waveguide choke forms a rotating joint at the circular interface between the first and second sections. The angular motion of the linear feed while scanning the plurality of linear radiating apertures is magnified by the variation of the angle of refraction of the beam at the refraction surface of the prism.

In the drawings:

FIG. 1 is a plan view of the device of this invention showing a wave front impinging one refracting surface of the prism;

FIG. 2 is a partial plan view of the device of FIG. 1;

FIG. 3 is a greatly enlarged cross-section of the device of FIG. 1 taken along the lines 3—3 of FIG. 2;

FIG. 4 is a graph illustrating the operation of this invention; and

FIG. 5 is a plan view of the device of this invention mounted in a flush radome of an aircraft.

In one embodiment of the invention, a prism of dielectric material is interspaced between parallel conducting plates. The prism includes two sections, the first section having an arcuate portion and a portion with a straight edge which is both a refracting surface and linear radiating aperture. The second section of the prism has the shape of a segment of a circle, and that edge represented by the chord of this segment is electrically coupled and mechanically connected through a tapered waveguide transition to a slotted waveguide feed array which is rotated by a servo drive mechanism. The circular segment of the second section of the prism is rotatably coupled with respect to the arcuate portion of the first section by a waveguide choke and forms a circular interface therewith. In operation, the beam between the feed and the air is refracted at the refracting surface of the first section of the prism. As the slot array feed is mechanically rotated, the second section of the prism rotates with the array and with respect to the first section of the prism thereby causing a variation of the angle of refraction of the beam at the refracting surface. The beam is refracted in such a manner that there is angular motion magnification of the array during antenna scanning.

A better understanding of the device of this invention can be had by referring to the figures of the drawings. In FIGS. 1, 2 and 3, can be seen a variable prism scanning antenna **10** capable of scanning 360° in azimuth. The antenna **10** consists of a rectangular prism **12** formed from a dielectric material such as alumina ceramic or other similar ceramic and plastic dielectric materials. The prism **12** is relatively flat and sandwiched between conducting plates **14** and **15**, as shown in FIG. 3, which is a greatly enlarged cross section of the relatively flat prism structure. Prism **12** is built in two sections **17** and **18**. The first section **18** is rectangular in form and has a round opening or hole **20** passing through it. The prism section **18** is bounded by the sides **22**, **23**, **24** and **25** and the hole **20**, and each side forms a straight line radiat-

ing aperture for the antenna **10**. Each quadrant, therefore, includes a straight line aperture and a 90° arcuate portion of the circle **20** as will be described in greater detail subsequently.

The second section **17** of the prism **12** is shaped as a segment of the circle. A tapered waveguide transition **30** electrically couples and mechanically connects straight line source feed array **32**, which in this instance is shown as a slotted waveguide, to the section **17** of the prism **12** at the chord **35** of the circle segment of that section. The straight line array feed **32** is then coupled through a rotary joint **37** to a servo drive motor (not shown) which rotates the feed **32** during antenna scanning, and hence, the second section **17** of the prism **12** which is connected thereto.

The arc **40** of the circle segment of section **17** is rotatably mounted with respect to the circumference or arcuate portion **42** of the circle **20**, in section **18**, by the waveguide choke **45** which suppresses any tendency for the prism to radiate or lose power at the small, but finite gap **47**. The gap **47** is shown exaggerated for illustration purposes in FIG. 4 and is formed at the rotating circular interface between the two sections **17** and **18**.

The conducting plates **14** and **15** are extended beyond the sides **23**, **24** and **25** to form waveguide horns **50**. These horns are used to shape the elevation pattern of the antenna and are not essential to the variable prism device and feed array which control the azimuth pattern and position.

By varying the dielectric constant of the prism **12** at the region adjacent to the straight line apertures **22**, **23**, **24** and **25** and at the region adjacent the chord **35** of the second section **17** of the prism **12**, one-quarter wave transformers **52** and **53** can be constructed. These transformers are used for impedance matching to eliminate signal reflection normally occurring when going from air to a high dielectric region.

The theory and operation of the antenna **10** can be understood by referring to FIG. 1. As a receiving system, a wave front FB is shown impinging on the straight line aperture or refracting surface **22** of the prism represented by EB. Incident rays **55** of the wave FB are at an angle of incidence with respect to the normal BD to the refracting surface. The rays will be refracted upon entering the prism dielectric to a smaller angle **57** because the dielectric constant of the prism is greater than the dielectric constant of air. If the angle **58**, formed by BED, is made to equal the angle of refraction **57** then all refracted rays are perpendicular to the line source feed **32** which lies along the line ED, and a constant phase front will exist along this surface. Alternately, if the feed **32** is phased to generate a beam in the dielectric perpendicular to ED, the beam will be refracted at refraction surface **22** to the angle **56** with respect to the normal BD. Therefore, by having the line source feed **32** and the second section **17** of the prism **12** free to rotate with respect to the refracting surface **22**, the angle **58** of the line source can be varied to control the beam pointing angle **56**. Thus it can be seen that mechanical advantage clearly exists between the rotation of the feed and the scan of the beam which in effect provides an angular motion magnification of the rotational movement of the feed **32**.

This angular motion magnification can be seen more clearly by referring to the graph of FIG. 4. The graph was compiled using a dielectric constant of **9** and clearly illustrates how the configuration of FIG. 1 permits the scanning of the antenna **10** beam over a full 360°. Each side **22**, **23**, **24** and **25** serves as a radiating aperture from which the beam may be scanned 45° from the normal. Therefore, the feed **32** has only to rotate in four 27° sectors to accomplish 360° of scan, i.e., 13.6° actual feed movement on either side of each normal. When the feed array **32** is directed in other than the central shaded position **60**, a deterioration of the resultant beam prevents operation. This deleterious effect is not instantaneous but rather a matter of gradual beam deterioration until total internal reflection in the prism causes complete breakup of the pattern. The scan is, therefore, discontinued between the various mechanical feed quadrants.

A practical embodiment of the invention is shown in FIG. 5. A radome **65** is shown in phantom flush with the fuselage of an aircraft. Horned linear apertures **67**, **68** and **69** are mounted within the radome so that they approximate the air frame contour of the vehicle. The apertures are connected together by the prism **70** constructed in the manner heretofore described. A linear radiating feed **72** is rotatably mounted within the prism. The feed **72** could be a slotted waveguide array as disclosed but other feeds would also find utility. For example, a simple H-plane sectoral horn with a correcting lens could easily be integrated with the dielectric prism, with the dielectric being an extension of the correcting lens, or leaky waveguide structures employing two feed arrays each producing a non-broadside beam could be used.

Although the variable prism antenna **75** mounted in the radome is used for scanning in azimuth over a 270° sector, because of the roll and pitch of the aircraft, limited elevation scanning is necessary. This can be accomplished by varying the angle of the horn plates **50**.

The antenna of this invention provides many important advantages. For instance, the mechanical advantage between the feed rotation and beam scan could be used to reduce servo power requirements, or for a given drive power the beam could be scanned at a higher rate. In addition, because the prism does not focus but merely redirects beam radiation, any technique that can be used with a line source feed can be used with a prism, such as electron scan of the prism feed to achieve an even higher scan rate than with mechanical scan. Furthermore, multiple feeds could be used to permit simultaneous operation at different frequencies or to generate a number of beams simultaneously from either the same prism aperture or combination of apertures.

The antenna structure described, therefore, is a highly reliable, simple, lightweight and relatively low cost variable prism scanning antenna that is capable of large angular coverage. This antenna structure can be mounted flush with the air frame contour of a vehicle thereby effectively reducing drag.

What is claimed is:

1. A beam scanning antenna including in combination, refracting means having relatively movable first and second sections, said first section including a linear radiating aperture and an arcuate portion, said second section having an arcuate shaped portion adopted to mate with said arcuate portion of said first section, means mounting said second section so that said arcuate portion thereof is rotatably positioned with respect to said arcuate portion of said first section to form a circular interface therewith, and feed means mechanically and electrically coupled to said second section, with the positioning of said first and second sections causing a variation of the angle of refraction of the beam coupled to said feed means.

2. A beam scanning antenna including in combination, refracting means having relatively movable first and second sections, said first section including a linear radiating aperture and an arcuate portion, said second section being shaped as a segment of a circle with the arc of said circle being adapted to mate with said arcuate portion of said first section, means mounting said second section so that the arc of said circle segment is rotatably positioned with respect to said arcuate portion of said first section to form a circular interface therewith, and line source feed means mechanically and electrically coupled to said second section, with the positioning of said first and second sections causing a variation of the angle of refraction of the beam coupled to said feed means.

3. A variable prism beam scanning antenna including in combination, a rotatably mounted slotted waveguide feed array, a dielectric prism interspaced between parallel conducting plates and having first and second sections, said first section being rectangular in configuration and being bonded by the sides of said rectangle and a circular opening therethrough, with each of said sides forming a straight line aperture and refraction surface, and said second section being shaped as a circle segment, waveguide transition means electrically and mechanically connecting said second section at the chord of said circle segment to said slotted waveguide, and waveguide choke means rotatably coupling the arc of said circle segment with the circumference of said circular opening of said first section to form a circular interface therewith, with the beam between said slotted waveguide feed array and air during antenna scanning being refracted at said refraction surface of one side of said first section of said prism to provide angular motion magnification of the rotational movement of said slotted waveguide feed array.

4. A variable prism beam scanning antenna for mounting in a vehicle including in combination, linear feed means, a dielectric prism interspaced between parallel conducting plates and having a first section including an arcuate portion and a second section shaped as a segment of a circle, a plurality of linear radiating apertures mounted to approximate the air frame contour of the vehicle, said apertures being connected to said first section of said prism, waveguide choke means rotatably coupling the arc of said circle segment with respect to the arcuate portion of said first section to form a circular interface therewith, and transition means electrically coupling and mechanically connecting said second section to said linear feed means, with the beam between said feed means and air during antenna scanning being refracted by one of said linear radiating apertures to provide angular motion magnification of the rotational movement of said feed means.

5. A variable prism beam scanning antenna including in combination, linear feed means, a dielectric prism interspaced between parallel conducting plates and having a first section including an arcuate portion and a second section shaped as a segment of a circle, a plurality of linear radiating apertures integral with and at the perimeter of said first section of said prism, said linear radiating apertures each forming a refraction surface of said prism, waveguide choke means rotatably coupling the arc of said circle segment with the arcuate portion of said first section to form a circular interface therewith, tapered waveguide transition means electrically coupling and mechanically connecting said second section to said linear feed means, first impedance matching means between air and said first section of said prism, and second impedance matching means between the air of said tapered waveguide transition means and said second section of said prism, said first and second transformer means for impedance matching between air and said dielectric, with the beam between said feed means and air during antenna scanning being refracted at one of said refracting surfaces to provide angular motion magnification of the rotational movement of said feed means.

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