

Feb. 27, 1951

S. D. ROBERTSON
REFLECTING SYSTEM

2,543,130

Filed July 3, 1946

4 Sheets—Sheet 1

FIG. 1A

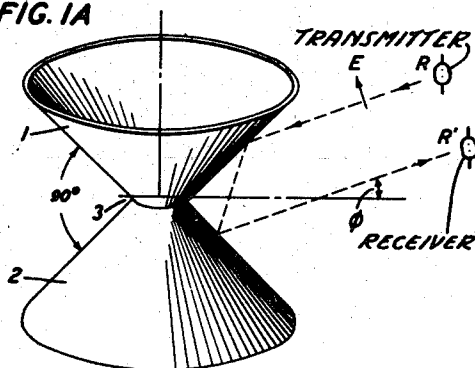


FIG. 1B

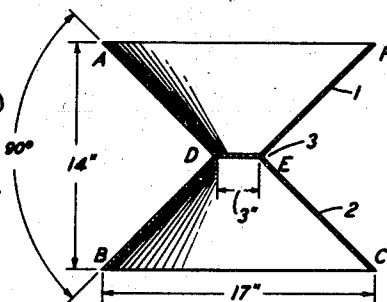


FIG. 2A

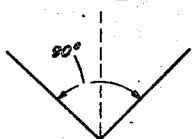


FIG. 2B

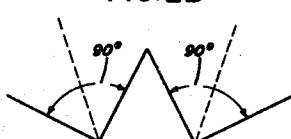


FIG. 2C

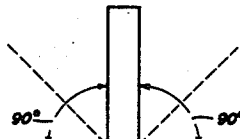


FIG. 2D

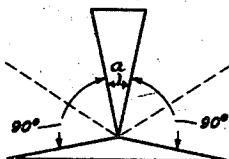


FIG. 2E

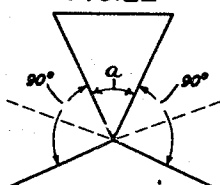


FIG. 2F

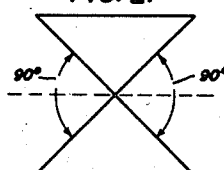


FIG. 3

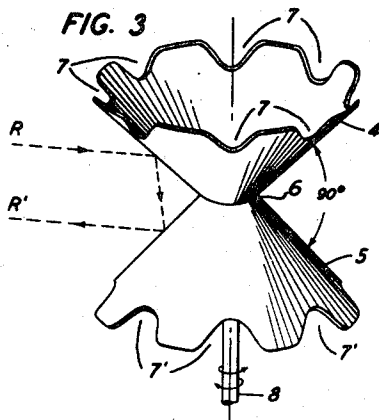
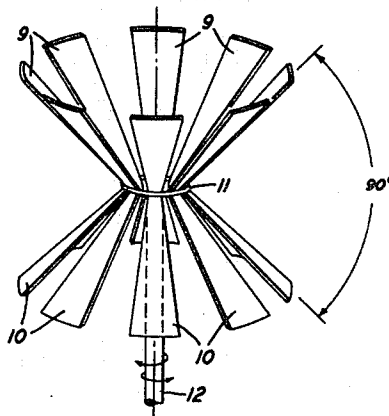


FIG. 4A



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FIG. 4B

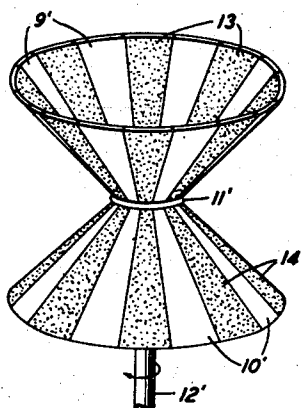


FIG. 9A

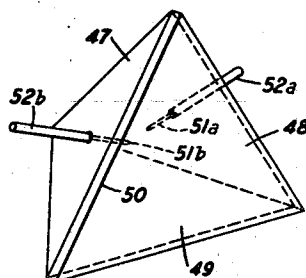


FIG. 9B

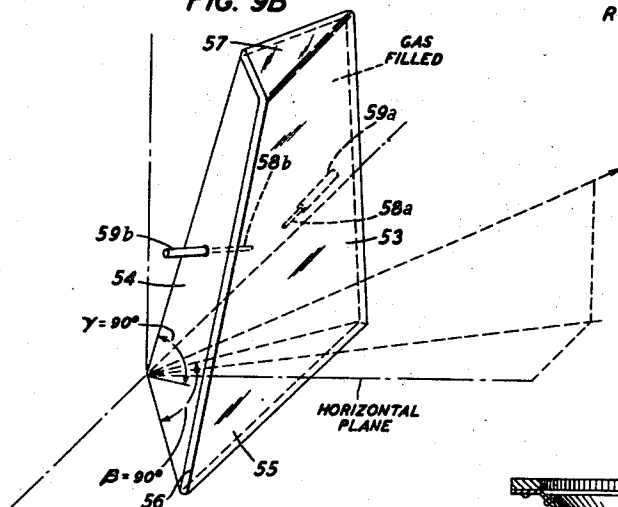


FIG. 10

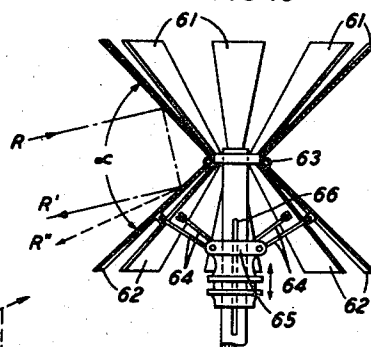
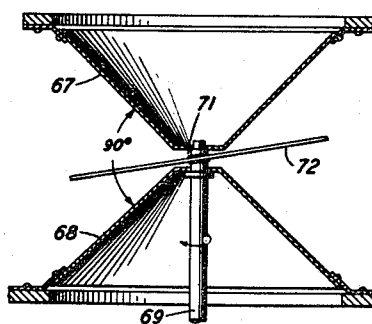


FIG. 11



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FIG. 5A

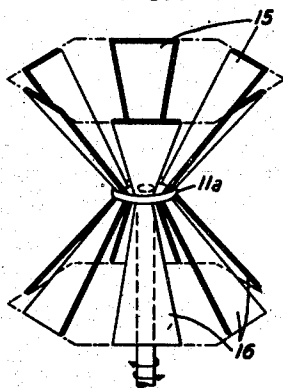


FIG. 5B

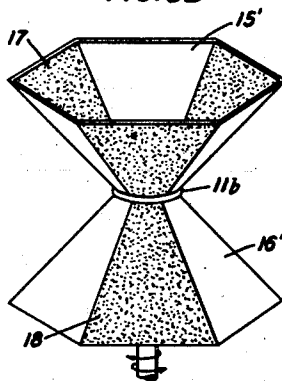


FIG. 6

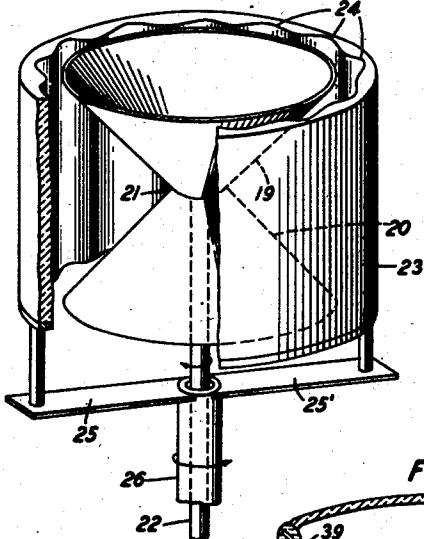


FIG. 7

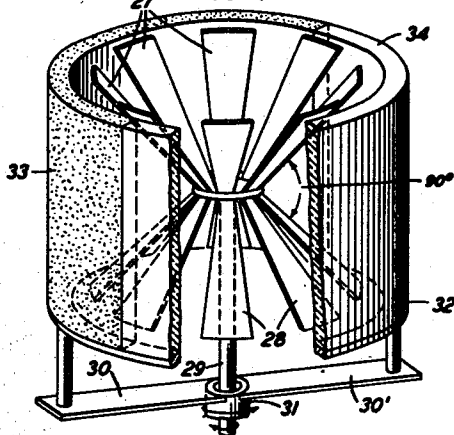
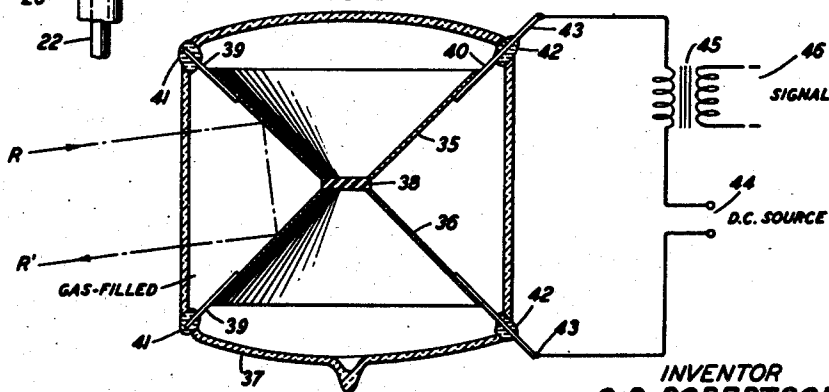


FIG. 8



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FIG. 12

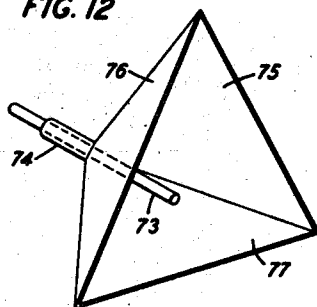


FIG. 13A

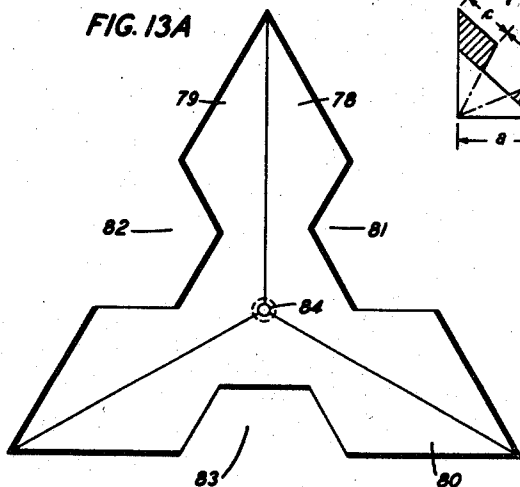


FIG. 13C

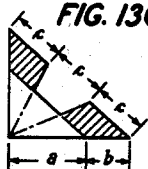


FIG. 13B

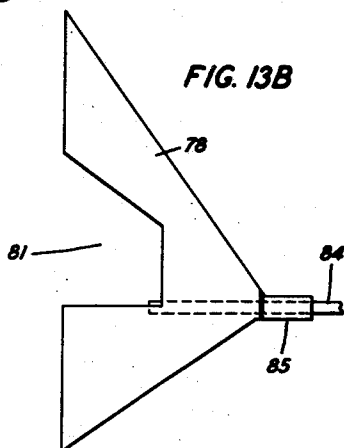


FIG. 14A

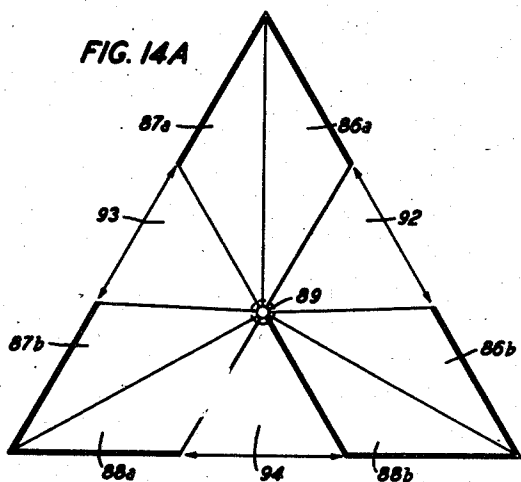
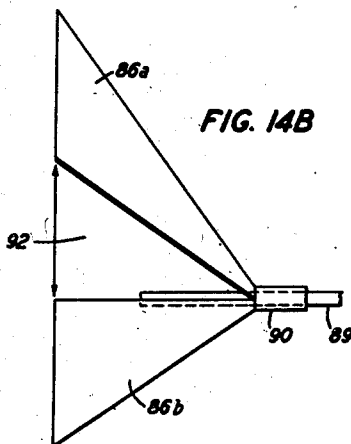


FIG. 14B



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2,543,130

REFLECTING SYSTEM

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Application July 3, 1946, Serial No. 681,201

10 Claims. (Cl. 343—18)

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This invention relates in general to electromagnetic signaling systems. More particularly, it relates to reflector beacons and several modifications thereof which are adapted to simultaneously reflect and modulate microwave signals.

Navigation systems have recently been developed for directing mobile bodies such as ships or airplanes along a predesignated course by means of reflector beacons responsive to microwave energy transmitted from the directed body. Inasmuch as the directed traffic moves in a plurality of directions, it is desirable for such beacons to present a substantially uniform response characteristic over a wide range of aspect angles. Certain prior art structures, such as the trihedral corner reflector, have been developed which are efficient in reflecting a large proportion of the transmitted energy back towards the source, provided that the transmitted wave arrives from a direction which corresponds approximately with the axis of symmetry of the reflecting structure. However, the reflection efficiency of such structures is considerably reduced for waves arriving from off-axis directions.

It is therefore a primary object of this invention to improve the reflection characteristics of reflectors for electromagnetic signals transmitted thereto from a plurality of directions.

It is my discovery that the basic geometric structure which best fulfills the above-stated object comprises a pair of conical surfaces positioned with their vertices directed towards each other and along the same axis, said surfaces intersecting at an angle of substantially 90 degrees. A structure so designed is characterized by a substantially uniform reflected response through 360 degrees in a predetermined plane, and a reasonably broad response in other directions.

A particular feature of this invention is a biconical structure adapted to simultaneously reflect and impress a modulating code on signals transmitted thereto.

In accordance with one such embodiment, modulations are produced by a pattern of notches on the periphery of a rotating biconical reflector; in accordance with a second embodiment, the surface of the rotating reflector comprises spaced segments which may, in accordance with a further modification, comprise alternate segments of materials having different frequency selective reflection properties.

Another device for modulating reflected signals in accordance with the present invention comprises a biconical structure disposed in a rotating hollow cylinder which may alternatively have

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a periphery which is corrugated, or which comprises sections of materials having different transmission factors for the reflected signals.

In accordance with still another embodiment, a mass of inert gas is sealed into a chamber which comprises a portion of the reflecting surface of the biconical structure. The reflected signals are amplitude modulated by ionization changes impressed on the gas through a signaling circuit.

In several additional embodiments of the invention, mechanical devices are utilized to produce modulations in the reflected signals. These comprise a device in which the lower portion of the biconical reflector is hinged to the supporting members attached to a sleeve designed to slide up and down a shaft, whereby the lower portion of the reflector is raised and lowered in the manner of an umbrella; and a device whereby a rotating conducting probe is inserted through the vertex of the biconical reflecting structure.

For the purpose of the present specification and claims "biconical surface" will be defined as comprising a pair of oppositely directed coaxial conical surfaces.

Other objects, features and advantages will be apparent from a study of the specifications as set forth hereinafter and the attached drawings.

Fig. 1A shows a signaling system including in perspective a basic biconical reflector having an angle of 90 degrees between its generatrices;

Fig. 1B shows the structure of Fig. 1A in cross-section;

Figs. 2A, 2B, 2C, 2D, 2E and 2F show in cross-section various modifications of the biconical reflector of Fig. 1;

Fig. 3 shows in perspective one embodiment of a modulating rotating biconical reflector having a pattern of notches on the periphery;

Fig. 4A shows in perspective another embodiment of a modulating rotating biconical reflector wherein the surface comprises spaced segments of reflecting material;

Fig. 4B shows a modification of the structure of Fig. 4A in which alternate segments comprise materials having different reflection factors for signals of different frequency;

Fig. 5A shows a modulating bipyramidal reflector in which the surface is segmented;

Fig. 5B shows a modification of the structure of Fig. 5A in which alternate segments have different reflection factors;

Fig. 6 shows a modulating reflector in which the biconical structure is enclosed within a rotating Plexiglas cylinder having a corrugated periphery;

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Fig. 7 shows another embodiment of a modulating reflector wherein a segmented biconical reflector is enclosed in a rotating outer cylinder having portions with different transmitting properties;

Fig. 8 shows a modulating biconical reflector comprising a sealed gas-filled chamber and means for ionizing the gas in said chamber;

Fig. 9A shows a modified form of the modulating reflector of Fig. 8 in which a trihedral corner reflector includes an ionized gas chamber;

Fig. 9B shows another modification of the modulating reflector of Fig. 8 in which the gas-filled chamber comprises a trihedral corner reflector shaped so as to have an increased response in the direction of the vertical axis;

Fig. 10 shows a modulating biconical reflector hinged at the apex, the lower portion thereof adapted to be raised or lowered in the manner of an umbrella;

Fig. 11 shows a modulating biconical reflector which includes a conducting paddle located at the apex and extending between the conical surfaces at an angle to the horizontal and adapted to be rotated;

Fig. 12 shows a perspective view of a modified form of the modulating reflector of Fig. 11, in which a conducting probe is adapted to be inserted and withdrawn through the vertex of a trihedral corner reflector;

Figs. 13A and 13B show front and side views, respectively, of a modification of the modulating trihedral reflector of Fig. 11, in which a probe is adapted to be inserted and withdrawn through the vertex of a trihedral corner reflector shaped for increased off-axis response;

Fig. 13C shows the relative proportions of one of the sides of Figs. 13A and 13B; and

Figs. 14A and 14B show front and side views, respectively of a modification of the modulating reflector of Figs. 13A and B in which the trihedral corner reflector is designed to give a null response on the axis and increased off-axis response.

As stated hereinbefore, a reflector which is responsive to incident radiation over a full 360 degrees in the horizontal plane and which is also operative over a fairly broad angle in the vertical plane would be useful as a "beacon" or "buoy" for guiding radar-equipped aircraft or ships.

Such a device is embodied in the biconical reflector shown in Figs. 1A and B, which is included as part of a radio signaling system having conventional microwave radio sending and receiving equipment located at a point remote therefrom, as indicated in Fig. 1A. The reflecting element of Figs. 1A and 1B comprises two truncated right-circular conical surfaces 1 and 2 placed in juxtaposition at their planes of smallest cross-section, so that the generatrices of one cone intersect those of the other at right angles. The reflecting surfaces 1 and 2 may comprise any material which readily conducts electricity, such as sheet metal or wood covered with metallic paint. Moreover, a particular type of surface may be dictated by the circumstances of the reflector's use, such as non-corrosive galvanized sheet iron for use near the ocean, or aluminum for airplane use.

Referring to Fig. 1B, which shows the biconical reflector in cross-section, typical dimensions are as follows. The diameters AF and BC of the bases of the cones 1 and 2 equal 17 inches; the altitude of the structure, as represented by the distances AB and FC, equals 14 inches; while the

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diameter of the neck at the junction 3 between the two cones equals 3 inches. The dimensions of the conical frusta and the diameter of their uniting neck are not critical, but preferably should be such that the aperture of the reflector has dimensions which are several times the wavelength. The neck may comprise a wooden collar preferably of negligible thickness, to which the conical metallic surfaces 1 and 2 are attached.

In the structure of Figs. 1A and 1B, a ray of microwaves R from the transmitter striking the conical surface 1 is reflected therefrom to strike the surface 2 from which it is reflected back toward the source in the form of the ray R' which travels to the receiver in a direction parallel to that of the incident ray R. In the biconical reflectors, maximum reflected response occurs in the direction of the bisector of the 90-degree angle between the conical surfaces. This will be referred to in the specification and claims hereinafter as the response axis, and "off axis response" will relate to the reflected response in planes disposed at angles to the plane of the response axis.

Measurements have shown that the vertical response pattern from a biconical reflecting structure designed in accordance with the above specifications is relatively uniform for rays of energy arriving at the surface within an angular range of more than 20 degrees above and below the response axis. Because of the circular symmetry of the biconical reflector, the vertical response is equal for all angles in the horizontal plane. Calculation shows that the echo level from the biconical reflector varies by less than three decibels over a solid angle of 3.25 steradians or 52 per cent of a hemisphere. However, the angle between the generatrices, as represented by the angles ADB and FEC of Fig. 1B, should closely approximate 90 degrees inasmuch as a difference of as little as one degree therefrom has been found to reduce the reflected response at a wavelength of three centimeters by several decibels.

Figs. 2A through 2F schematically indicate the cross-sections of various surfaces of revolution comprising one or more conical sections which are combined to produce reflectors in accordance with the teachings of this invention. Other such combinations within the scope of the present invention will readily occur to those skilled in the art.

Fig. 2A shows a reflector having a maximum vertical response which comprises a conical surface evolved by rotating a 90-degree angle about its vertical bisector.

Fig. 2B shows a reflector comprising a surface generated when a pair of 90-degree coplanar angles having adjacent sides which intersect in an acute angle at a point equidistant from their vertices are rotated about an axis comprising the bisector of the acute angle. Maximum reflected response occurs near the bisectors of the 90-degree angles.

Fig. 2C shows a reflector comprising a right-circular cylinder with the base thereof disposed on a flat plate. Maximum reflected response occurs at an angle of approximately 45 degrees with the surface of the plate. This may be considered as a limiting case of the biconical reflector, in which one cone has a flare-angle of zero degrees, and the intersecting cone has a flare angle of 180 degrees.

Figs. 2D and 2E show two biconical reflectors comprising respective pairs of right-circular cones having different angles of flare. The cones are

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disposed with their bases parallel, their vertices intersecting and a 90-degree angle between their generatrices. The acute angle α in Fig. 2E is substantially larger than the corresponding angle α in Fig. 2D, giving the two structures appreciably different directions of maximum reflected response.

Fig. 2F indicates a surface generated when a pair of lines intersecting at right angles is rotated about an axis which comprises the bisector of one pair of the vertical angles so formed. Assuming the structure to be hollow with both the inner and outer surfaces reflecting, maximum reflected response will be secured in a vertical as well as a horizontal direction.

Although in the structures of Figs. 2D through F, the respective conical surfaces are shown joined at their vertices, the surfaces could alternatively comprise truncated cones joined at their planes of smallest cross-section as shown in Fig. 1.

The usefulness of a reflector beacon is enhanced for navigation purposes if it is capable of impressing a modulating code on the reflected beam, so that a particular beacon may thereby be identified. In accordance with the present invention, several different types of structure are provided for bringing about this desired coded modulation.

As described hereinbefore, a symmetrically constructed biconical reflector having the cones thereof disposed with their bases in parallel horizontal planes produces a substantially uniform reflected response through 360 degrees in a horizontal plane. In order to modify the horizontal response pattern of such a biconical in accordance with a desired code, a pattern of irregularities may be introduced at preselected points on the reflector surface. Modulating biconical reflectors which make use of this device are shown in Figs. 3, 4A and 4B and 5A and 5B of the drawings.

In the embodiment of Fig. 3, the modulations in the reflected signal are produced by means of a spaced pattern of notches in the periphery of the reflector. A pair of conical reflecting surfaces 4 and 5 are disposed as described with reference to Figs. 1A and 1B to include an angle of substantially 90 degrees between their generatrices. In the peripheries of the base portions of the two cones 4 and 5, notches 7 and 7', respectively, are cut out, the notches preferably having dimensions which are several times as great as the wavelength of the microwave signals used. The structure is rigidly fastened on the interior of the neck 6 to the supporting shaft 8, which is connected to a motor or other conventional means for producing rotation.

As the shaft 8 rotates thereby rotating the biconical structure 4-5, the amount of energy reflected in the direction R' in response to an incident microwave beam R fluctuates in accordance with the instant position of the notches 7-7'. Thus, a flashing or coded signal is returned in the direction of the microwave source.

In accordance with the embodiment of Fig. 4A, a similar result is achieved by use of a segmented biconical structure. Corresponding microwave reflecting segments 9 and 10 which lie respectively on the upper and lower surfaces of a pair of cones disposed as described with reference to Figs. 1A and B are attached to a collar 11 which lies at the apex of the 90-degree angle between the upper and lower portions of the reflector. The dimensions of the correspond-

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ing segments 9 and 10, which are shaped as truncated conical sections, are not critical excepting that they should be relatively large compared to the wavelength of the impinging beam in order to prevent diffraction effects. The entire structure is rigidly supported by the rotatable shaft 12 which is attached internally to the collar 11. As in the notched embodiment of Fig. 3, the shaft 12 is attached to conventional means for producing rotation.

The frequency and duration of the intermittent signals flashed back to the source in response to an incident microwave beam is a function of the number and extent of the reflecting segments 9 and 10 and the rate of rotation of the shaft 12.

The embodiment of Fig. 4B is a modification of Fig. 4A in which the conical reflecting segments 9' on the upper portion of the biconical structure are alternated with conical segments 13 comprising a material adapted to absorb microwaves of certain frequencies, and corresponding reflecting segments 10' on the lower portion of the structure are alternated with microwave absorbing segments 14. As in the embodiments described hereinbefore, upper segments 9' and 13 and corresponding lower segments 10' and 14 are attached at their ends of smallest cross-section to the collar 11', the angle between corresponding upper and lower segments being substantially 90 degrees.

In a still further modification of the structure shown in Fig. 4B, alternate pairs of segments 9' and 13 on the upper portion, and 10' and 14 on the lower portion, comprise materials of different frequency selective reflective properties. The frequency selective properties of the respective reflecting and absorbing surfaces may be altered by varying such functions as the dielectric constant, the index of refraction, the loss constant, or the thickness of the film in a manner known in the art to produce a resonant response for specific frequencies or bands of frequencies. The principles according to which such reflecting and absorbing surfaces may be designed are discussed in "Fields and Waves in Modern Radio," Ramo and Whinnery, John Wiley and Sons, 1944, page 270.

When the biconical structure of Fig. 4B is rotated, if the segments 13 and 14 comprise a material which is absorptive for a specific frequency, the modulated echo will appear only in reflected signals of that particular frequency. In accordance with a further modification of the structure of Fig. 4B, alternative ones of the segments 13 and 14 may comprise materials absorptive for two respectively different frequencies, in which case, rotation of the device serves to reflect a modulated signal for each of said frequencies. This principle may be further extended by the construction of a rotating reflector having respective elements absorptive to any number of preselected frequencies, which device is thereby adapted to reflect modulated signals in each of such frequencies.

The structure of Fig. 5A presents another modification of the segmented biconical reflector, in which the conical segments on the upper and lower portions of the reflecting structure are replaced by configurations of flat truncated triangular plates 15 and 16, respectively, disposed to lie on the faces of a pair of truncated pyramids having their polygonal bases disposed in parallel planes and joined at their ends of smallest cross-section where the segments 15 and 16 are at-

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tached to the polygonal collar 11a. As in the other embodiments, a 90-degree angle is included between upper and lower segments.

As in the case of the segmented biconical reflector, the pyramidal reflector may be modified in accordance with the showing of Fig. 5B to comprise alternate pairs of segments, 15' and 17 on the upper body of the structure, and 16' and 18 on the lower body, which have different coefficients of reflection for signals of different frequencies.

The embodiments of Figs. 6 and 7 illustrate a modulating technique in which the basic reflecting element is enclosed in a rotating envelope which has different properties of transmission over different portions.

Fig. 6 shows an embodiment adapted to impress frequency modulations on the signals reflected from the biconical structure. A biconical reflector comprising the upper and lower conical surfaces 19 and 20 disposed in the manner of the structure of Figs. 1A and B is supported on the rotatable shaft 22 which is attached internally at the neck 21. Enclosing the biconical reflector 19-20 and concentric therewith, is a hollow cylinder 23 which may comprise any suitable material relatively transparent to microwaves, having a dielectric constant which is substantially different from that of air and easily moulded in a predetermined shape, such as polystyrene. The cylinder 23 is mounted for rotation on the arms 25-25' which are rigidly attached to the sleeve 26 which is concentric with the shaft 22. The sleeve 26 is attached to conventional means to produce rotation with respect to the shaft 22, whereby the cylinder 23 is adapted to rotate with respect to the biconical reflector 19-20. Variations in thickness are moulded into the wall of the polystyrene enclosing cylinder 23 which may take the form of corrugations 24 on the inner surface thereof. The function of the corrugations 24 is to introduce a time delay in the beam reflected at one instant from a given point on the reflector surface with respect to the beam reflected at a succeeding instant from the same point, thereby producing a "Doppler" effect or a to-and-fro frequency shift at the receiving device. The degree of such frequency shift is a function of the thickness differential between the maxima and minima of the corrugations 24 and the dielectric constant of the material while the frequency of the modulating envelope is a function of the number and spacing of said corrugations, and the speed of rotation of the cylinder 23. The spacing between corrugations should preferably be large compared to the wavelength used.

By means of the embodiment shown in Fig. 7, a code modulation is superposed on the reflected tone modulation produced by a rotating segmented biconical reflector. A biconical reflector comprising a plurality of segments 27 and 28 of similar composition and disposed as described with reference to the structure of Fig. 4A is mounted for rotation on the shaft 29. Concentric with the reflector 27-28 and supported by the arms 30-30' attached to the sleeve 31, which is concentric with the shaft 29, is the hollow cylindrical element 32. The portion 33 of the cylindrical element 32 comprises a material, having such thickness and constants in accordance with the teachings of Ramo and Whinnery, cited hereinbefore, that it either absorbs, reflects or delays in phase waves of certain frequencies or bands of frequencies and transmits all other frequencies with relative efficiency. The remainder of the

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cylinder 32 may either comprise a portion 34 which is uniformly transmissive for all frequencies, or alternatively, this portion of the cylinder 32 may be eliminated entirely, leaving only the absorbing partial cylinder 33. The sleeve 31 and the shaft 29 are connected to conventional means which are geared to produce respectively different rates of rotation therein, whereby the cylindrical envelope 32 is rotated at a slower rate than the segmented biconical reflector 27-28. The tone modulated signal of the biconical reflector 27-28 is therefore code-modulated in accordance with the respective absorbing and transmitting surfaces presented by the cylinder to the incident and reflected waves.

It is obvious that other forms of reflecting elements than the specific embodiments disclosed in Figs. 6 and 7 could be enclosed within the modulating envelopes described without departing from the spirit of the invention.

Figs. 8, 9A and B show embodiments in accordance with another modified form of the invention in which modulations are produced in the signal from a reflector beacon by changes in the ionization of an inert gas enclosed in a chamber of which the reflector forms a part.

Fig. 8 shows an embodiment comprising a pair of metallic conical reflecting surfaces 35 and 36 disposed so that the angle between their generatrices is substantially 90 degrees. The surfaces 35 and 36 are separated by the insulating collar 38, the entire structure being disposed in a gas-tight chamber 37 shown in cross-section, which comprises a material transparent to microwaves, or such other radiations as are utilized in the modulating signaling system. The biconical structure 35-36 is supported in the chamber 37 by means of the metallic supporting members 39 and 40, the members 39 being embedded in the insulating beads 41, and the conducting members 40 being brought through the insulating seals 42 to provide the external electrical contacts 43. The contacts 43 are connected to the direct current source of potential 44 and through the transformer 45 to a source of modulating signals 46.

In operation, the chamber 37 is filled with an inert gas, such as argon or neon. Such a potential difference is maintained between the reflector electrodes 35 and 36 that the gas in the chamber 37 is continuously ionized, the degree of ionization being changed by the impressed voltage signals from the source 46. Thus, because of the absorption of power from the incident beam of microwaves R in passing through the ionized gas in the chamber 37 the amplitude of the reflected beam R' will be modulated in accordance with the degree of ionization of the gas which is varied by the impressed signal from the source 46.

The embodiment of Fig. 9A is a modification of the modulating reflector, Fig. 8, in which a trihedral reflector replaces the biconical reflector. The triangular reflecting surfaces 47, 48 and 49 are positioned so that they intersect in a common apex at angles of 90 degrees to form what is known in the art as a corner reflector. In order to make a gas-tight chamber, the open side of the corner reflector 47-48-49 is sealed with a plate 50 which comprises material transparent to microwaves or other radiations utilized in the reflecting system. Electrodes 51a and 51b are connected through gas-tight seals to the external contact members 52a and 52b, to which a source of direct current voltage and a source of modulating voltage are both connected, as in the

embodiment of Fig. 8 which operates in a similar manner.

It has been discovered that the response pattern of a corner reflector depends on the geometrical configuration of the aperture. In accordance with this concept, the trihedral reflecting element of the ionized gas modulating reflector of Fig. 9B has been modified to improve its vertical response by increasing the height of the vertical faces thereof. Accordingly, the reflecting surfaces 53 and 54 comprise truncated triangular elements having a greater extent in the direction of the vertical axis than in the horizontal plane. The surfaces 53 and 54 are joined together so that the angle β between their base lines is 90 degrees; and they are so joined to the base 55 that the angle γ between their common joint and the base 55 is substantially 90 degrees. As in the embodiment of Fig. 9A, the ionized gas chamber is sealed by means of the microwave transparent plate 56 across the face of the reflector and plate 57 across the top of the reflector. The electrodes 58a and 58b and their respective contacts 59a and 59b perform the same functions as described with reference to previous embodiments. It is apparent that the reflector comprising the surfaces 53, 54 and 55 can be used for reflection purposes independently of the electrode attachments and sealing plates 56—57.

Fig. 10 shows an embodiment of the segmented biconical reflector in which modulations in the reflected beam may be produced by mechanically manipulating the lower conical segments with respect to the upper segments, thereby to change the included angle. The conical segments 61 and 62 are of such material and so shaped as described with reference to the segmented biconical reflector of Fig. 4A. The lower ends of the upper segments 61 are rigidly fastened to the collar 63, while the upper ends of the lower segments 62 are hinged to the collar 63 so that they may be freely rotated in a vertical direction. At some point substantially removed from the collar 63 each of the segments 62 is hinged to one end of a supporting member 64, the other end of which is hinged to the sleeve 65 which is adapted to move slidably up and down the shaft 66 thereby to alter the angle α included between the respective segments 61 and 62.

Thus, if the segments 62 are so positioned that the angle α between them and the upper segments 61 is equal to substantially 90 degrees, the incident beam R is reflected back toward the source in a direction R'. However, if the segments 62 are so positioned that the angle α presented to the oncoming signal R is other than 90 degrees, the reflected signal R' will return in some direction other than that of the source, thereby producing a modulation in the energy received at the source. If the entire structure is rotated by turning the shaft 66, a code-modulated tone will be received at the source in a manner similar to that described in the embodiment of Fig. 7.

Fig. 11 shows another embodiment equipped with mechanical means for producing modulations in a reflected signal. The conical surfaces 67 and 68 comprising reflecting materials of the nature described with reference to Figs. 1A and 1B of the drawings, are disposed with a 90-degree angle between their generatrices, their bases parallel and their ends of smallest cross-section directed towards each other. The upper conical surface 67 is supported on the shaft 69

so that a slight separation 71 occurs between it and the lower conical surface 68 at the apex of the 90-degree angle. The conducting paddle 72 is rigidly attached to the shaft 69 in the space 71 in such a manner that it extends between the conical surfaces 67 and 68 at an angle to the horizontal and can be rotated with respect thereto by means of the shaft 69.

When the paddle 72 rotates, the effective reflecting area between the conical surfaces 67 and 68 is altered thus amplitude-modulating the signals reflected therefrom at a frequency that corresponds with the speed of rotation. This same modulation technique can be applied in connection with any of the several embodiments of biconical reflecting elements hereinbefore disclosed.

Fig. 12 shows a modification of the modulating reflector in which a conducting probe 73 is inserted through the sleeve 74 at the apex of the trihedral corner reflector comprising the reflecting surfaces 75, 76 and 77. When the probe 73 is inserted and withdrawn through the sleeve 74, the "effective area" of the reflector 75—76—77 is thereby changed, producing a modulation in the signals reflected therefrom.

For the purposes of this specification, "effective area" will be defined as the portion of the projected cross-section of a corner reflector which is able to return incident radiation to the source. "Effective area," thus defined, is a function of the aspect, that is, the angle at which the reflector is viewed, as well as of the geometrical configuration.

The embodiments of Figs. 13 and 14 are modifications of the embodiment of Fig. 12, in which the configuration of the sides of the trihedron is specially designed in order to increase the off-axis response of the reflector.

Fig. 13A shows a modified modulating corner reflector as viewed along the axis of symmetry in which the triangular sides 78, 79 and 80 have quadrangular-shaped notches 81, 82 and 83 disposed centrally along the edges thereof. A side view of the reflector is shown in Fig. 13B, the conducting probe 84 adapted to move in and out of the sleeve 85 as described with reference to Fig. 12 above. It is quite apparent that a structure designed in accordance with this disclosure would be utilized for reflection purposes without the attachment of modulating probe 84 and sleeve 85.

In the design of the structure 13A for an optimum reflected response characteristic, it has been found that the ratio of the depth of the indentations 81, 82 and 83 as related to lengths of the respective bases of the triangular sides 78, 79 and 80 is critical. Referring to Fig. 13C, which shows the optimum proportions of any one of the sides 78, 79 or 80, the respective indentations 81, 82 and 83 should be positioned equidistant from the adjacent sides, the base projections c thereof being substantially equal in extent to the unnotched portions on either side. Moreover, in order for the response at an off-axis aspect angle of 30 degrees to equal the axis response of the reflector, the ratio b/a should approximate 1. If the ratio b/a is less than 1, the reflector response for off-axis aspect angles will be only partially corrected; whereas, if the ratio b/a is greater than 1, it will be overly corrected. In the uncorrected reflector with triangular aperture the ratio b/a equals zero.

If the ratio a/b equals infinity, that is, if the quantity a is equal to zero, one would expect to

obtain a response curve having a minimum value on the axis and rising to a maximum on either side. A reflector having these properties is illustrated in Figs. 14A and 14B, which show front and side views of a modified form of the modulating trihedral reflector of Fig. 12 in which triangular notches 92, 93 and 94, having their apices on the axis of symmetry of the coplanar reflector, divide each of the respective triangular sides into two triangular sectors 86a and 86b, 87a and 87b and 88a and 88b, respectively. In accordance with a preferred design, the extent of each of the sectors 86a and 86b along the periphery of one side of the reflector is equal to that of the notch 92 while the other two sides are similar. The conducting probe 89, which is slidably mounted in the sleeve 90 at the apex of the reflector performs the same modulating function as in the designs of Figs. 12 and 13. As pointed out above, however, this reflector, which is designed to give a null response to signals arriving on its axis of symmetry and increased response to off-axis signals, may be used for reflecting purposes without the addition of the modulating probe 89 and the sleeve 90.

Although the invention, as herein disclosed, has been described with reference to certain specific embodiments, other structures than those herein disclosed which embody the principles of this invention will be obvious to those skilled in the art and are intended to be embraced by the appended claims.

What is claimed is:

1. A modulating reflector comprising a biconical surface, the angle between the generatrices of said surface being substantially 90 degrees, means for rotating said surface about an axis, and means comprising a spaced pattern of irregularities in said surface adapted to modulate a reflected signal in accordance with a predetermined code.

2. A reflector in accordance with claim 1 in which said irregularities comprise discontinuities in said biconical surface.

3. A reflector in accordance with claim 1 in which said irregularities comprise alternate zones of absorbing and reflecting material arranged on said surface in accordance with a predetermined pattern.

4. A reflector in accordance with claim 1 in which said irregularities comprise alternate zones of absorbing and reflecting materials having different frequency selective properties and arranged on said surface in accordance with a predetermined pattern.

5. A reflector comprising a series of reflecting elements having different reflection factors for different frequencies, said elements positioned so that the faces thereof lie on a substantially biconical surface.

6. A modulating reflector comprising in combination a biconical reflecting surface, an enclosing envelope wherein said surface is disposed, different segments of said envelope being differently pervious for certain frequencies of electromagnetic radiation, and means for rotating said envelope with respect to said reflecting surface.

7. A reflector comprising a pair of juxtaposed

coaxial reflecting expanses which, in each of a multiplicity of different axial planes, are disposed at right angles to each other so that radio waves incident on the reflector in the direction of any such axial planes are reflected back toward their origin, and in which said reflecting expanses are alternated with expanses of material which are substantially absorptive to said radio waves.

8. A reflector comprising a pair of juxtaposed coaxial reflecting expanses which, in each of a multiplicity of different axial planes, are disposed at right angles to each other so that radio waves incident on the reflector in the direction of any such axial planes are reflected back toward their origin, and in which said reflecting expanses are alternated with expanses of material which is differently absorptive for radio waves of different frequencies.

9. A modulating reflector comprising a biconical surface, the angles between the generatrices of said surface being substantially 90 degrees, means for rotating said surface about an axis, and means including said rotating means operative at said reflecting surface to modulate reflected signals in accordance with a predetermined code.

10. A modulating reflector which comprises in combination a reflecting surface comprising a pair of juxtaposed axially aligned reflecting expanses which, in each of a multiplicity of axial planes, are disposed at right angles to each other, an envelope at least partially enclosing said reflecting surface, said envelope comprising a material designed to transmit electromagnetic radiation of certain frequencies more readily than electromagnetic radiation of certain other frequencies, and means for rotating said envelope with respect to said reflecting surface.

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