

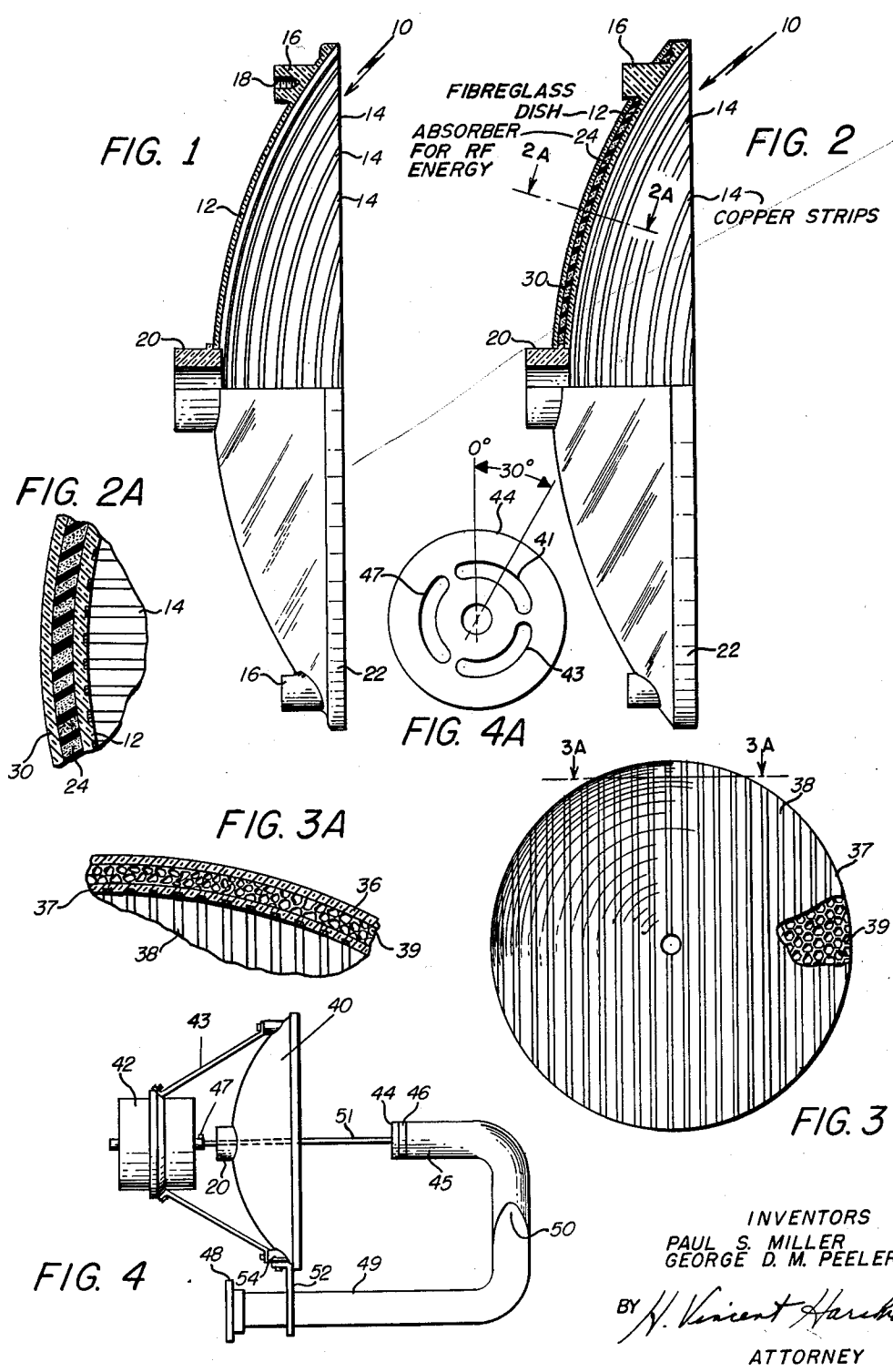
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POLARIZATION FILTER ANTENNA UTILIZING REFLECTOR
CONSISTING OF PARALLEL SEPARATED METAL STRIPS
MOUNTED ON LOW LOSS DISH

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2 Sheets-Sheet 1



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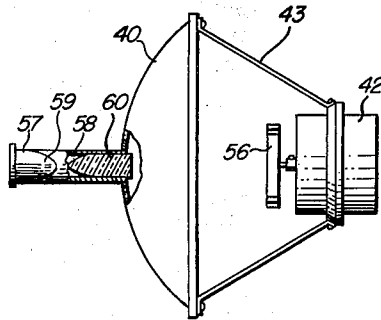


FIG. 5

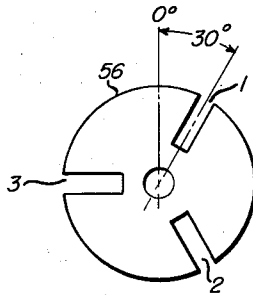


FIG. 5A

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POLARIZATION FILTER ANTENNA UTILIZING REFLECTOR CONSISTING OF PARALLEL SEPARATED METAL STRIPS MOUNTED ON LOW LOSS DISH

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7 Claims. (Cl. 343—756)

This invention relates to directional antennas and more particularly to a parabolic reflector of the polarization-selective type.

In directional antenna systems of the kind employing a parabolic reflector, it is frequently necessary to feed a plane-polarized wave to one or more radiating elements which illuminate the parabolic reflector and to transmit or receive in a given plane of polarization. This procedure is necessary in order to prevent energy which has become depolarized during transmission from interfering with the antenna beam pattern. Polarization selection of this type is particularly useful in connection with tri-element scanning where a rotating tri-element, such as a tri-slot, is rotated about its mechanical center in a polarized microwave energy field to generate an effective conical scan at three times the physical rotational velocity of said tri-element radiator. A scanning device of this character has been disclosed in the United States patent application of Paul S. Miller, Serial No. 656,474, filed April 26, 1957. In this device the rotating tri-slot element senses during rotation energy polarized in a plurality of planes of polarization and, in particular, energy polarized at 45 degrees due to the three-to-one ratio of electrical-to-mechanical scan.

In order to achieve the aforementioned polarization filtering, electromagnetic energy is sometimes polarized by an external grating or filter through which the energy passes before entering the reflector. However, this grating tends to distort the antenna pattern of transmitted energy and results in internal reflections between the grating, the radiating element and the reflector. To counteract this tendency toward internal reflection, an additional absorption filter, constituting a double grating, is usually positioned between the first reflector grating and the antenna assembly. To construct this grating in a manner so as not to impede the passage of energy is often costly and difficult. In numerous applications, therefore, it is desirable to provide a reflector in which the function of reflecting and polarization filtering is obtained in a single operation and by a single reflecting surface.

In accordance with the polarization filter antenna of the invention, a parabolic dish of low-loss material, such as thin fiberglass, is molded with an embedded reflecting surface of a plurality of evenly spaced metallic strips. The parabolic dish or reflector is excited with electromagnetic energy of a fixed polarization. The parallel metallic strips act as a parabolic reflector to the desired polarization, that is, components of energy parallel to the strips. The unwanted cross-polarized components of energy, that is, polarization perpendicular to the strips, propagates through the dish and entirely out of the beam pattern. Whether the energy illuminating the polarized dish emanates from a rotating tri-slot radiator of the direct transmission type as in the aforementioned Miller patent application or from a rotating parasitic tri-element, the dish operates as a selective filter and reflector which eliminates the need for an external or separate polarization filter or grating.

In order to insure that no reflections are introduced from the antenna mounting and associated antenna parts to the rear of the reflector, an electromagnetic energy-absorbent material is applied in the form of a lining or

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coating to the rear surface of the parabolic dish. However, even without the addition of absorbing material, the reflections from irregular metallic surfaces at the rear of the dish are ordinarily sufficiently defocused so as to exert substantially no effect upon the scanning or beam portion of the antenna dish.

In another embodiment of the invention, the aforementioned reflections are cancelled out by providing a fiberglass backplate spaced one-quarter wavelength behind the ribbed fiberglass reflecting-surface and held in parallel alignment by honeycomb fiberglass construction.

Further objects and advantages of this invention will be more apparent as the description progresses, reference being made to the accompanying drawings wherein:

FIG. 1 is a side view, partly in section, of one embodiment of the invention;

FIG. 2 is a side view, partly in section, of a second embodiment of the invention;

FIG. 2A is a section along the line 2A—2A of FIG. 2;

FIG. 3 is a front view, partly in section, of another embodiment of the invention;

FIG. 3A is a section along the line 3A—3A of FIG. 3;

FIG. 4 is a side elevation of the antenna reflector used in a scanning system;

FIG. 4A is a front view of the rotary tri-slot disc which is used to illuminate the paraboloid of FIG. 4;

FIG. 5 is a side view of another embodiment of the invention; and

FIG. 5A is a front view of another tri-slot disc which is used to illuminate the paraboloid of FIG. 5.

Referring now to FIGS. 1 and 2, reference numeral 10 denotes a parabolic reflector of the polarization selective type comprising a parabolic dish of thin fiberglass 12 into which is embedded a plurality of evenly spaced metallic strips 14. These strips are printed or etched approximately three-sixteenths inch apart on the inner side of the parabolic surface and form a polarization filter or grating which reflects all components of radiation aligned parallel to the strips. Fiberglass bosses 16, as shown in FIG. 1, have tapped apertures 18 for mounting the reflector in the path of electromagnetic energy. At the center of the parabolic reflector is a mounting sleeve or ring 20 which may, as shown, consist of fiberglass; or an epoxy resin material can be used. Sleeve 20 is of a size sufficient to receive a waveguide for providing excitation to the reflector. In like manner, an epoxy resin support ring 22 of approximately one-half inch in width extends around the outer circumference of the fiberglass reflector and is bonded thereto by an epoxy resin cement, not shown, to provide a light-weight supporting structure.

While FIGS. 1 and 2 show the ribbed metallic strips, such as copper, embedded into the fiberglass dish, it should be understood that any method of etching or spray-metal technique can be employed to fix these evenly spaced strips to the surface of the fiberglass.

To prevent undesired reflections from re-entering the antenna dish from the antenna mounting structure, FIG. 2 shows a cover of well-known radiation-absorbing material 24 mounted behind the fiberglass reflecting plate 12. For example, this absorbing material may consist of a sheet of lossy rubberized fabric. In order to support the energy-absorbing material 26, a fiberglass backskin or supporting layer 30 is attached to the absorbing material by liquid epoxy cement, not shown. FIG. 2A shows the backskin 30 forming a second fiberglass layer or supporting structure which in no way affects the radiation characteristic of the antenna dish.

Referring to FIG. 3 and FIG. 3A, the aforementioned reflections from the antenna mounting structure at the rear of the reflector are cancelled out by the combination of a fiberglass backplate or backskin 36 spaced substantially one-quarter wave-length behind the ribbed

fiberglass reflecting surface 37. In this embodiment, as shown in FIG. 3A, the ribbed fiberglass reflecting surface 37 and the fiberglass backplate 36 are held in parallel alignment by honeycomb fiberglass material 39 which provides the precise quarter wave-length spacing from the front reflecting surface. This honeycomb material also increases the tensile strength of the antenna dish. The front and rear fiberglass strips are bonded to the honeycomb fiberglass by the application of well-known epoxy resin cement, not shown. By this arrangement, energy which passes between the metallic strips 38 becomes cancelled after entering the quarter-wave cancellation zone.

Referring now to FIG. 4, the polarization-selective dish or reflector 40 is used in connection with a tri-slot radiator of the front transmission-type feed, described in detail in the aforementioned Miller patent application. Here, the novel polarization selective dish 40 is substituted in place of the usual metallic parabolic reflector, thereby eliminating the requirement of an additional external grating or filter. A motor-generator 42 is mounted to the rear of the parabolic dish 40 by means of support brackets 43. A rotating slotted plate or disc 44, as shown in FIG. 4A, is mounted in the end portion of the circular waveguide section 45 and is provided with a rotary joint 46 to permit rotation of the slotted disc while the circular waveguide portion 45 is held fixed. The slotted disc 44 has three half-wave resonant slots, 41, 43 and 47, circumferentially mounted around the center of rotation of the disc. The circumferential slots are directly excited and the offset center of radiation is a direct function of the distance between the feed center and the center of the slots. Generally, the greater the distance from the feed center to the center of the slots, the greater will be the radiation offset. The tri-slot metal disc in this embodiment can be constructed in a variety of shapes and forms, the only limitation being that the three circumferential slots are so constructed and positioned as to make the slots concentric about an axis passing through their center point, and at the same time extend circumferentially about the center point of the metal disc, thereby being symmetrical about the axis of rotation.

In order to rotate the slotted disc 44, a shaft or rod 51 is connected to the center of metal disc 44 and to the shaft of the motor 42 by means of a set screw 47. This shaft extends through an aperture, not shown, in the mounting sleeve 20 at the midpoint of the parabolic reflector 40. Energy is fed by way of flange 48 into the rectangular waveguide section 49 which tapers into circular waveguide section 45, as shown at 50. The parabolic reflector 40 is held rigidly to the rectangular waveguide 49 by means of a bracket 52 which is connected to boss 54 attached to the reflector 40. The rotating disc 44, which contains three slots, preferably resonant, positioned circumferentially in the end portion thereof, is positioned in a manner which during transmission permits energy to be extruded directly toward the parabolic reflector 40. In this manner, the illuminated parabolic reflector reflects energy polarized in the desired plane while the perpendicular components of energy pass through the parabolic dish and entirely out of the reflected beam pattern.

While FIG. 4 shows a tri-slot element used in connection with the novel polarization-selective dish, it should be understood that any tri-element illuminator can be used in connection with this dish to produce an offset conical scan. For example, the motor 42 can be used to rotate the tri-pole radiator described in the copending application of Jesse L. Butler, Serial No. 457,072, filed September 17, 1954, assigned to the assignee of this application and which is now U.S. Letters Patent No. 2,895,131, which issued July 14, 1959. The generator portion of the motor generator 42 is used to give an alternating current reference voltage for determining the position of the tri-pole or tri-slot radiator at any specific time.

FIG. 5 shows the polarization-selective reflector 40

used with a tri-slot radiator of the indirect transmission or parasitic type. The tri-slot disc 56 contains three rectangular radial slots, 1, 2 and 3, as shown in FIG. 5A. In this embodiment, microwave energy is fed into rectangular waveguide 57 which tapers into circular waveguide section 58, as shown at 59. The circular waveguide section 58 contains a low-loss dielectric material 60, which acts as a polyrod feed for the parasitic scanning disc 56. This material is inserted into the waveguide and bonded thereto. The end portion of the dielectric material transfers energy from the waveguide section to the tri-slot element 56 which, in turn, illuminates the polarization-selective reflector 40.

As described in detail in the aforementioned Miller patent application, the power radiated by a given slot depends upon its orientation relative to the dominant E-vector of the feedguide. For example, referring to FIG. 4A, when slot 41 is located along the vertical axis at zero degrees, it receives more excitation than either slot 43 or 47 due to its orientation with respect to the vertically polarized E-vector. Accordingly, the left-right effects of slots 43 and 47 cancel and a resulting offset radiation center in the up direction is obtained.

For position 2, with slot 41 rotated thirty degrees with respect to the vertical axis, as actually shown in FIG. 4A, slot 47 may be considered inactive relative to the E-vector, and the up-down effects of slots 41 and 43 cancel. An offset to the left is obtained by inspection of position 2 which produces a 90-degree rotation of the center of radiation for a 30-degree rotation of the tri-slot disc. In like manner, if slot 41 is rotated to 60 degrees from the vertical axis, the left-right radiation offset, due to slots 41 and 47, cancel, and a downward displacement of the center of radiation is produced due to the greater excitation of slot 43 because of its favorable orientation with respect to the vertical E-vector. A rotation of 180 degrees of the effective center of radiation is thereby obtained for a 60-degree mechanical rotation of the tri-slot disc. In this manner, the scanning antenna system shown in FIG. 4 produces a three-to-one ratio of electrical-to-mechanical conical scan by rotating the disc 44 in the path of microwave energy of fixed polarization. In other words, the tri-slot aperture produces an offset center of radiation that describes a perfect circle about the mechanical center of rotation at a rate which is three times the rate of mechanical rotation.

Referring to FIG. 5, the radiation offset center is in the opposite direction from that obtained with the tri-slot disc of FIG. 4A. For example, as shown in FIG. 5A, slot 3 will now receive maximum excitation due to its orientation perpendicular to the vertical E-vector. The up-down effects of slots 1 and 2 cancel and the effective offset radiation center is to the right.

It should be understood that numerous embodiments of the polarization-selective dish can be used in connection with these tri-scan antennas depending upon the percentage of reflected radiation permitted to enter the antenna beam. Thus, in the usual application, a reflector of the type shown in FIG. 1 can be used without the necessity of the energy-absorbing materials described in connection with FIGS. 2 and 3.

This completes the description of the embodiments of the invention illustrated herein. However, many modifications of the advantages thereof will be apparent to persons skilled in the art without departing from the spirit and scope of this invention. Accordingly, it is desired that this invention not be limited to the particular details of the embodiments disclosed herein, except as defined in the appended claims.

What is claimed is:

1. A polarization reflector comprising a dish of a substantially low loss material, a waveguide adapted to propagate electromagnetic energy of plane polarization feeding said dish, a plurality of strips of conductive material arranged parallel to each other and mounted on the sur-

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face of said dish, said strips arranged in a manner to permit passage therebetween of electromagnetic energy having a direction of polarization other than parallel to said metallic strips, and to reflect electromagnetic energy having a direction of polarization parallel to said metallic strips, and a coating of electromagnetic absorbent material on the side of the dish opposite said waveguide.

2. A polarization reflector comprising a plurality of strips of electrically conductive material mounted on a layer of low loss material, the space between said strips being substantially free from conductive material, a waveguide adapted to direct electromagnetic energy of plane polarization toward said reflector, a rotatable element having a plurality of apertures positioned in the path of said energy and substantially perpendicular to the axis of said path to illuminate said reflector with energy from said apertures, and means for rotating said element.

3. A polarization reflector comprising a parabolic dish of a substantially low loss material, a waveguide adapted to propagate energy of a plane polarization feeding said parabolic dish, a plurality of parallel strips of conductive material arranged parallel to each other and mounted on the surface of said dish, said strips further arranged in a manner to pass electromagnetic energy having a direction of polarization other than parallel to said metallic strips, and to reflect electromagnetic waves having a direction of polarization parallel to said metallic strips, and a coating of electromagnetic absorbent material on the side of said dish opposite said waveguide.

4. In combination, a parabolic dish of a substantially low loss material, a plurality of parallel metallic strips of substantially uniform thickness embedded into the surface of said parabolic dish, said strips adapted to permit passage therebetween of electromagnetic energy having a direction of polarization other than parallel to said metallic strips, and thereby to reflect electromagnetic energy having a direction of polarization parallel to said waveguide, a section of waveguide adapted to support electromagnetic energy, a rotatable metal disc having three slots symmetrically disposed in a plane perpendicular to the axis of rotation, said rotatable metal disc positioned at one end of said section of waveguide and perpendicular to the longitudinal axis thereof, means for rotating said metal disc, means for propagating electromagnetic energy having a fixed polarization along said waveguide toward said slots, said rotatable metal disc positioned in a manner adapted to illuminate said parabolic dish with electromagnetic energy from said slots.

5. In combination, a parabolic dish of a substantially low loss material, a plurality of parallel metallic strips of substantially uniform thickness embedded into the surface of said parabolic dish, said strips adapted to permit passage therebetween of electromagnetic energy having a direction of polarization other than parallel to said metallic strips, thereby to reflect electromagnetic energy having a direction of polarization parallel to said metallic strips, a section of waveguide adapted to support electromagnetic energy, a rotatable

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metal disc having three slots symmetrically disposed circumferentially in a plane perpendicular to the axis of rotation, said rotatable metal disc positioned at one end of said section of waveguide and perpendicular to the longitudinal axis thereof, means for rotating said metal disc, means for propagating electromagnetic energy having a fixed polarization along said waveguide and through said slots, said rotatable metal disc positioned in a manner adapted to illuminate said parabolic dish with electromagnetic energy passing through said slots.

6. In combination, a parabolic dish of a substantially low loss material, a plurality of parallel metallic strips of substantially uniform thickness embedded into the surface of said parabolic dish, said strips adapted to permit passage therebetween of electromagnetic energy having a direction of polarization other than parallel to said strips, thereby to reflect electromagnetic energy having a direction of polarization parallel to said strips, a radiating element positioned adjacent said parabolic dish, said radiating element including a rotatable disc having three radiating apertures symmetrically disposed substantially in a plane perpendicular to the axis of rotation, means for rotating said rotatable disc about said axis, and means for exciting said apertures with electromagnetic energy having a fixed polarization, thereby to illuminate said parabolic dish.

7. In combination, a parabolic dish of a substantially low loss material, a plurality of parallel metallic strips of substantially uniform thickness embedded into the surface of said parabolic dish, said strips adapted to permit passage therebetween of electromagnetic energy components having a direction of polarization perpendicular to said metallic strips, and to reflect electromagnetic energy components having a direction of polarization parallel to said metallic strips, a tri-element radiator having three rotatable elements positioned adjacent to said parabolic dish, means for rotating said elements, and means for exciting said elements with electromagnetic energy of fixed polarization, thereby to illuminate said parabolic dish.

References Cited in the file of this patent

UNITED STATES PATENTS

2,608,659	Korman	Aug. 26, 1952
2,647,256	Heilpern et al.	July 28, 1953
2,680,810	Korman	June 8, 1954
2,682,491	Hahn	June 29, 1954
2,864,083	Butler	Dec. 9, 1958
2,878,471	Butler	Mar. 17, 1959
2,930,039	Ruze	Mar. 22, 1960
3,096,519	Martin	July 2, 1963

OTHER REFERENCES

Society of Plastic Engineers, October 1957, pages 52, 53.

Microwave Antenna Theory and Design, M.I.T. Radiation Laboratory Series, vol. 12, 1st edition, McGraw-Hill Book Co., Inc., New York, 1949. Pages 448-450 TK 6565-A655-c.2.