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W. W. HANSEN ET AL

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RADIATING ELECTROMAGNETIC RESONATOR

Original Filed Jan. 17, 1938

FIG. 1

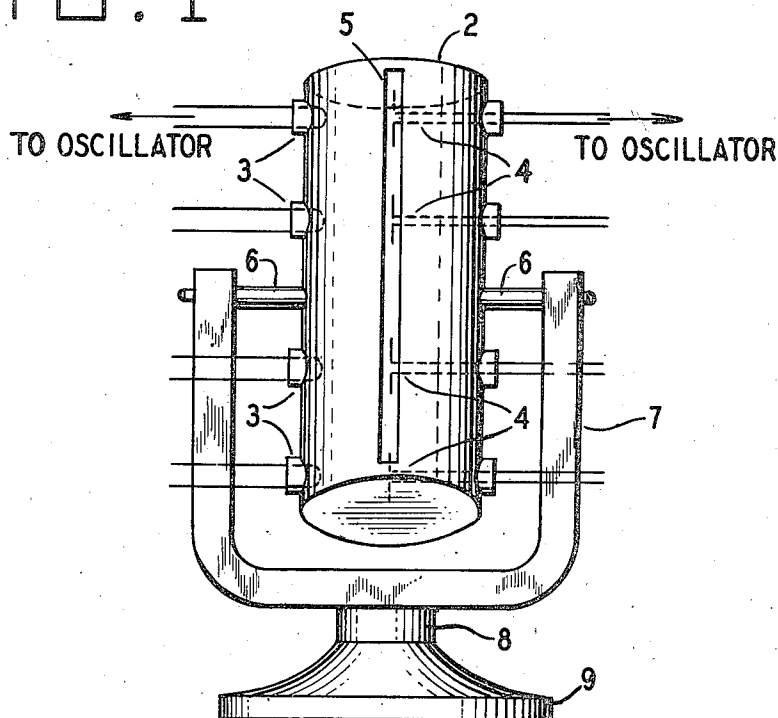
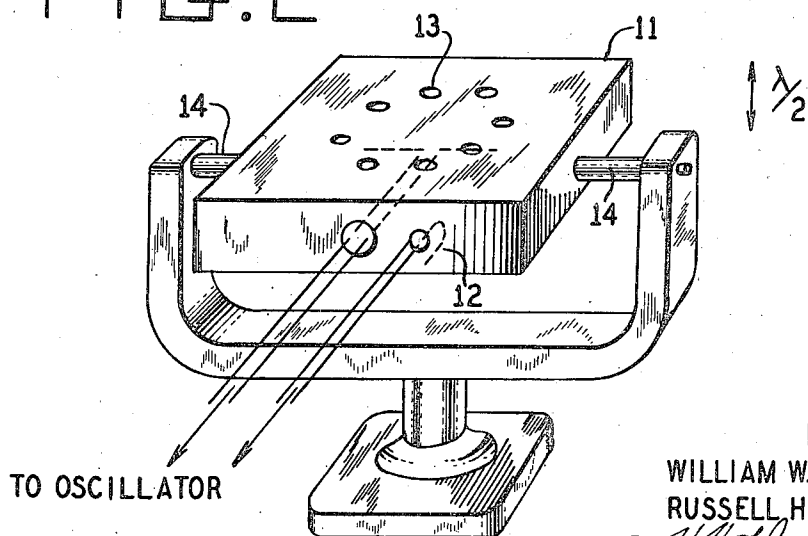


FIG. 2



INVENTORS
WILLIAM W. HANSEN and
RUSSELL H. VARIAN
BY *H. H. Thompson*
ATTORNEY

UNITED STATES PATENT OFFICE

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RADIATING ELECTROMAGNETIC
RESONATOR

William W. Hansen and Russell H. Varian, Stanford University, Calif., assignors to The Board of Trustees of the Leland Stanford Junior University, Stanford University, Calif., a corporation of California

Original application January 17, 1938, Serial No. 185,382, now Patent No. 2,415,094, dated February 4, 1947. Divided and this application November 13, 1940, Serial No. 365,450

10 Claims. (Cl. 250—33.63)

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This invention relates, generally, to the projection of radio waves in the form of a beam, and the invention has reference more particularly to the use of suitably apertured hollow resonators for the accomplishment of this result above mentioned.

The principal object of this invention is to produce simple, compact, and easily portable apparatus for projecting directional radio beams, said beams being suitable, among other things, for guiding aircraft to safe landings under conditions of low or zero visibility.

Another object of the present invention is to provide means for obtaining directive beams of electromagnetic energy of fan-shaped configurations, said beams being especially useful in connection with apparatus for measuring distances and velocities described in co-pending application Serial No. 185,382, filed January 17, 1938, now Patent No. 2,415,094, issued February 4, 1947, of which the present application is a division.

Another object of the present invention is to provide a hollow resonator having suitable radiating means or apertures disposed to produce a desired shape of beam radiation.

Still another object of the present invention is to provide means for orientating said electromagnetic wave radiation apparatus in azimuth and elevation, as for effecting scanning operation and selective reception of radiation emitted or reflected from some remote object.

Other objects and advantages will become apparent from the specification, taken in connection with the accompanying drawings illustrating embodiments of the invention.

In the drawings:

Fig. 1 is a perspective view of an embodiment of the invention with some parts broken away that is adapted to produce a fan-shaped beam, and also capable of directing the projected beams of radiation in any desired azimuthal and elevational angles.

Fig. 2 is a perspective view of an embodiment of an invention that is capable of projecting a columnar beam of radiation.

Referring now to Fig. 1 of the drawings, there is shown one form of radiating resonator, or directive antenna structure, comprising an elongated tubular cavity resonator 2 capable of having standing electromagnetic waves set up and maintained therein by means of one or more inductive loops 3, or by one or more small di-pole antennae 4 supplied through the leads shown, which may be of the concentric line type fed from a suitable high frequency generator or oscillator

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not shown in the drawing. As illustrated in Fig. 1, the antennae 4 may be disposed in alignment and parallel to the longitudinal axis of the tubular cavity resonator 2. Cavity resonator 2 is long compared to the wave length corresponding to the frequency of the standing electromagnetic field therein and is provided with a radiating slot 5 substantially parallel to the axis of the resonator that is also several wavelengths in length. The area of slot 5 is substantially less than the total wave-reflecting area of the cylindrical wall portion of the resonator 2; yet, it is large enough to permit energy emanation there-through. In other words, of the total circumferential distance of tubular resonator 2, slot 5 represents a minor part of 360°. When resonator 2 is excited in the proper mode of oscillation, the wave fronts of the standing electromagnetic waves within the resonator reach all parts of the cylindrical portion of the resonator wall simultaneously and, the emitted radiation through slot 5 will be in phase throughout the length of the slot, and in accordance with the known laws of diffraction, will form a fan-shaped beam of radiation collimated in the plane through the slot and the axis of the resonator, being narrow in this plane and wide in the plane at right angles thereto. The beam of radiation can be orientated in the plane containing the slot and the axis of the resonator by rotating the resonator whose trunnions 6 are rotatably supported by a yoke 7, and the beam can be orientated in the plane at right angles to said plane by rotation about the axis of a shaft 8 attached to yoke 7 and engaging a step bearing in base 9. The beam may be orientated by remote control, if desired. When used as a searching beam, the resonator 2 is elevated to the desired angle by inclining the axis of the resonator from the vertical. The lateral spread of the beam is centered about the radius drawn from the center of the resonator through the center of slot 5. The wavelengths found most useful for scanning purposes are those of the order from 1 to 10 centimeters. For these wavelengths the radius of the resonator 2 is from about 1/3 of a centimeter to about 5 centimeters, or may be much more if the resonator is operated on a harmonic of its fundamental frequency; in other words, the frequency of resonance of the resonator is determined by the depth of the cavity.

Referring now to Fig. 2, (which is an embodiment of an invention disclosed and claimed in our copending application for Radiating electromagnetic resonators, Serial No. 464,614 filed

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November 5, 1944), shown therein is an illustrative form of narrow columnar beam radiator, comprising a hollow resonator 11, approximately square in plan having sides of dimensions large in comparison with the wavelength of the standing electromagnetic waves within said resonator, or a multiple thereof when said resonator is operated on a harmonic of its fundamental frequency. Resonator 11 is shown excited by means of an inductive loop 12 or di-pole energized through leads shown which may be a concentric line. In one face of the resonator, apertures 13 are provided formed by circular openings of a diameter which is small compared to a wavelength, the apertures being distributed over an area covering several wavelengths in various directions, and may conveniently be arranged symmetrically along concentric circles. When cavity resonator 11 is excited to the fundamental mode of oscillation determined by its depth, or to a harmonic thereof when the depth is made substantially to correspond to a multiple of one-half wavelength, the radiation emitted through the various apertures 13 will be in phase, and due to interference, the resultant radiation will be restricted to a columnar beam whose axis is perpendicular to the radiating face of the cavity resonator, and having an angular spread which is a function of the ratio of the wavelength to the dimension of the pattern formed by the radiating apertures. The beam of radiation can be orientated by rotating cavity resonator 11 about trunnions 14, and a mounting similar to that shown in connection with Fig. 1 may also be used to orientate the beam of radiation both in azimuth and elevation.

The directivity achieved by a given radiation antenna structure in transmission is also obtainable for reception of electromagnetic radiations either emitted or reflected from a distant object, in which case a receiver will be used in connection with the apparatus instead of a transmitter.

As many changes could be made in the above construction and many apparently widely different embodiments of this invention could be made without departing from the scope thereof, it is intended that all matter contained in the above description or shown in the accompanying drawings shall be interpreted as illustrative and not in a limiting sense.

What is claimed is:

1. A radiator for projecting a fan-shaped beam of electromagnetic energy, comprising a hollow conducting enclosed resonator, electromagnetic radiating means within said resonator for setting up standing electromagnetic waves therein resonant at a natural frequency thereof, said resonator having a major axis having a length materially longer than the wavelength in free space of the standing waves therein, said radiating means being relatively short compared to the length of the major axis of said resonator, said resonator being apertured along its major axis to provide an electromagnetic wave radiating area, said radiating area being relatively small compared to the total internal wave reflecting area within said resonator.

2. A radiator of electromagnetic waves having a fan-shaped radiation pattern comprising a substantially closed hollow conducting body having enclosing long and short walls providing an interior resonant cavity of a length appreciably greater than its depth, relatively small electromagnetic radiating means within said cavity for

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setting up high frequency standing electromagnetic waves resonant therein at a natural frequency thereof, so that the electric vector of said waves extends throughout and substantially parallel to the length of the cavity and to the long wall thereof, said cavity having a length of a greater order of magnitude than the length of said radiating means, the frequency of said waves being determined by the depth of said cavity, the long wall of said body being arranged for radiating the electromagnetic energy therewithin over an area that has at least one dimension that is long compared to the wavelength of the energy in free space, said radiating area being relatively small compared to the internal wave reflecting area within said body.

3. Means for radiating a directional beam of electromagnetic waves comprising a conducting body having a cavity therein one bounding wall of which is cylindrical, antenna radiating means having a length of a considerably smaller order of magnitude than the length of said body and contained therein for setting up standing electromagnetic waves within said body so that the wave fronts reach all parts of the cylindrical wall simultaneously, and means located within said cylindrical wall for radiating a small part only of the radiation incident on said walls, said last-named means being distributed over a length of said cylindrical wall that extends a distance equal to a multiplicity of wavelengths in free space of the radiation within said cavity.

4. A high frequency antenna having a fan-shaped directivity pattern comprising a hollow conducting enclosed resonator adapted to contain standing electromagnetic waves therein resonant at a natural frequency thereof, electromagnetic coupling means within said resonator for coupling to said standing electromagnetic waves, said resonator having a major axis of a length materially longer than the wavelength in free space of said standing waves, said coupling means being relatively short compared to the length of said major axis, said resonator being apertured along said major axis to provide an electromagnetic wave translating area for translating waves between the interior and exterior of said resonator, said area being relatively small compared to the total wave-reflecting area within said resonator.

5. Directional electromagnetic wave antenna means comprising a conductive body having a cavity therein one bounding wall of which is cylindrical, said body being adapted to contain standing electromagnetic waves therein resonant at a natural frequency thereof, coupling means having a length of a considerably smaller order of magnitude than the length of said body and contained therein for coupling to said standing electromagnetic waves within said body, and means located within said cylindrical wall for translating only a small part of the energy incident on the walls of said cavity, between the interior and exterior thereof, said last-named means being distributed over a length of said cylindrical wall that extends a distance equal to a multiplicity of wavelengths in free space of the electromagnetic energy within said cavity.

6. Directional high frequency antenna means comprising an enclosed cylindrical conducting body adapted to contain electromagnetic waves resonant at a natural frequency of said body and having a length of a higher order of magnitude than the wavelength of said waves in free

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space, coupling means having a length of considerably smaller order of magnitude than the length of said body and contained therein for coupling to said electromagnetic waves within said body, said body having an opening therein extending for a distance corresponding to a multiplicity of wavelengths in free space of said waves for translating electromagnetic energy between the interior and exterior of said body.

7. An ultra high frequency directional antenna comprising a cavity resonator adapted to contain standing electromagnetic waves resonant therein at a natural frequency thereof, said resonator having a cylindrical wall with an axial length of a larger order of magnitude than a wavelength in free space of said energy and having a slot in said cylindrical wall also of a length long compared to the wavelength of said energy in free space, and means within said resonator for coupling to the field therein, said coupling means being relatively small compared to the length of said cylindrical wall.

8. A directional high frequency antenna for defining a fan-shaped directivity pattern, comprising a substantially closed cavity resonator adapted to contain standing electromagnetic waves resonant therein at a natural frequency thereof, said resonator having a dimension long in comparison to the wave length of said waves in free space and being apertured over a length that is long compared to said wavelength, and means, comprising a plurality of coupling means, for coupling to the field within said resonator at a plurality of points thereof, each of said coupling means being short in comparison to the length of said resonator.

9. A high frequency directional antenna comprising a cavity resonator adapted to contain standing electromagnetic waves resonant therein at a natural frequency thereof, said resonator having a cylindrical wall with an axial length

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long in comparison to the wavelength of said waves in free space, said wall having a slot therein extending substantially axially of said cylindrical wall and also of a length long in comparison to said wavelength, the area of said slot being relatively small compared to the total internal area of said resonator, and a plurality of coupling means within said resonator and disposed in a direction parallel to said slot for coupling to the field within said resonator at a plurality of points thereof.

10. Directional antenna means comprising a conducting body having a cavity adapted to contain an oscillating electromagnetic field therein, said cavity having at least one dimension of a length considerably longer than the wavelength of said field in free space, and coupling means for electromagnetically coupling to said body, said body having a continuous slot in the outer wall thereof extending over a distance long compared with said wavelength for translating electromagnetic energy between the interior and exterior of said body.

WILLIAM W. HANSEN.
RUSSELL H. VARIAN.

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