April 4, 1967 B. F. GREGORY 3,312,976

DUAL FREQUENCY CAVITY BACKED SLOT ANTENNA

Filed July 19, 1965

Fig. 1.

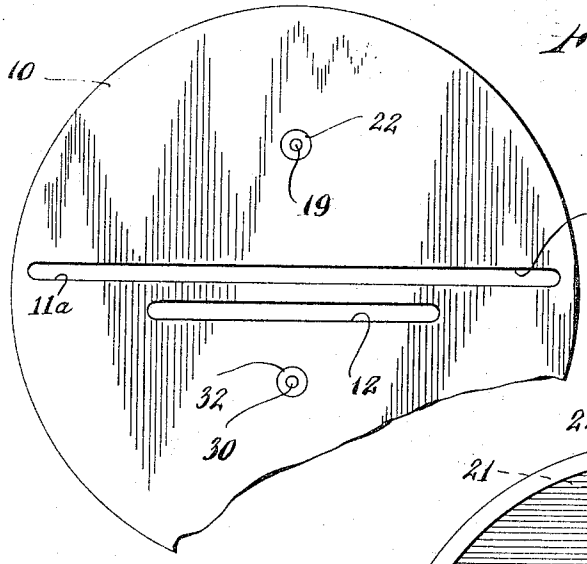


Fig. 2.

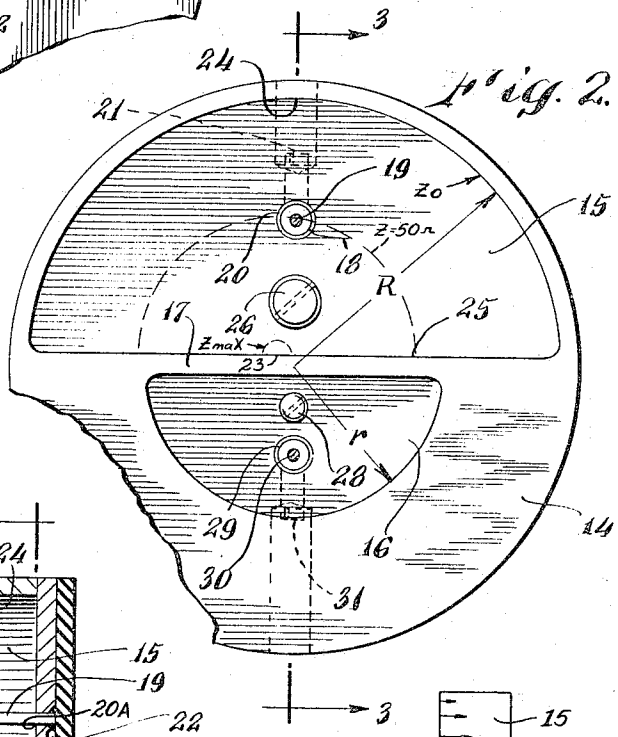


Fig. 3.

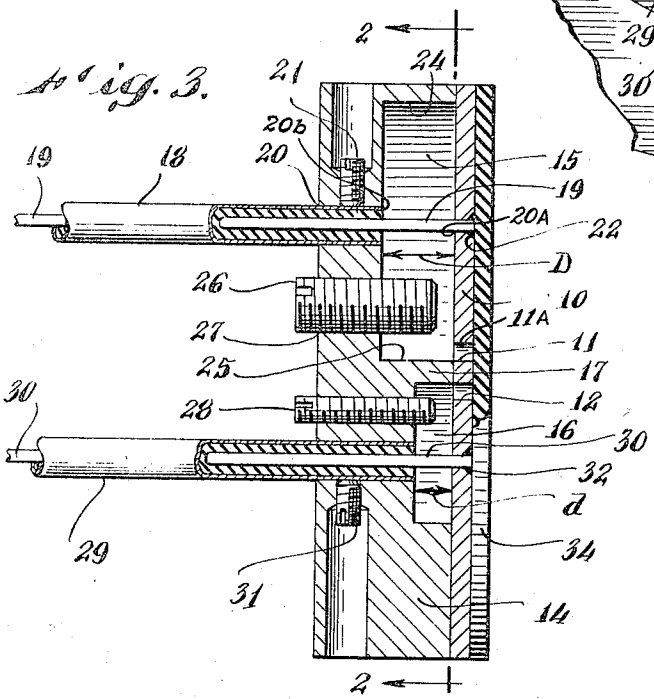
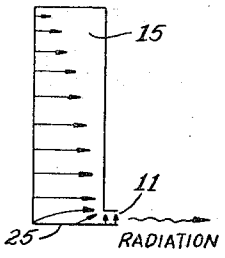


Fig. 3A



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DUAL FREQUENCY CAVITY BACKED SLOT ANTENNA

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9 Claims. (Cl. 343—767)

This invention relates to microwave radiators, and more particularly to a microwave antenna structure for projecting two or more signals of preselected different frequencies in broad beams from the same source of origin.

The problem to which the invention is directed is to provide a small, lightweight, "flashlight" type of microwave radiator capable of being hand held and of projecting beams of invisible microwave energy in much the same manner as an ordinary flashlight projects visible light. Furthermore, the microwave "flashlight" of the invention is capable of projecting two or more beams of different wave lengths and frequency along a common central axis, either independently of each other or simultaneously, or alternately, depending upon various applications for which the device may be employed. The device of the invention is useful for providing a portable source of microwave energy for field testing various types of microwave apparatus.

Accordingly, it is an object of the invention to provide a portable microwave antenna suitable for projecting a unidirectional broad beam of radio frequency energy from a small, hand held, source.

A more particular object is to provide a device of the above character in which the back wave of radiant energy is terminated without absorption or loss of energy from the source.

A further object is to provide a device of the above character in which energy of more than one frequency is radiated with maximum efficiency in a beam along a common axis.

Other objects of the invention will in part be obvious and will in part appear hereinafter.

The invention accordingly comprises the features of construction, combinations of elements, and arrangement of parts which will be exemplified in the constructions hereinafter set forth, and the scope of the invention will be indicated in the claims.

For a fuller understanding of the nature and objects of the invention, reference should be had to the following detailed description taken in connection with the accompanying drawings in which:

FIGURE 1 is a front view of the antenna of the invention with the protective cover removed;

FIGURE 2 is a front view of the antenna structure with both protective cover and cavity cover removed, showing a plan view of the internal construction;

FIGURE 3 is a cross-sectional view of the device taken along the line 3—3 of FIGURE 2, showing internal construction of the antenna, with the protective insulating cover in place;

FIGURE 3A is a diagrammatic representation of the voltage distribution within the cavity 15 of FIG. 3, showing the direction and mode of electromagnetic radiation from the slot 11 thereof.

Referring now in greater detail to the drawings, the antenna structure of the invention comprises a circular front plate 10 of electrically conductive metal, having pierced therethrough two narrow slots 11 and 12, as shown in FIGURES 1 and 3. The lengths of the slots 11 and 12, as shown in FIGURE 1, are each made to be approximately one-half of the wave length of energy to be radiated therethrough.

The front plate 10 is mounted on and supported by

a cylindrical metal block 14, having cut into the front surface thereof two substantially semi-cylindrical cavities 15 and 16, as shown in FIGURES 2 and 3. The slot 11 overlies and opens into the cavity 15, while the slot 12 overlies and opens into the cavity 16. The cavities 15 and 16 are separated from each other by conductive wall portion 17 of block 14. The thickness of wall portion 17 in the preferred embodiment is equal to the space between slots 11 and 12, as shown in FIGURE 3, although this condition is not essential to the invention.

A coaxial RF conductor line 18, having an inner conductor 19, is passed through a hole 20 in the block 14 and is securely held by a recesesd set screw 21 in the sidewall of block 14. The inner conductor 19 extends through the cavity 15 into the front plate 10 where it is electrically connected by a solder well 22. The position of connection 22 is located on the radius of semi-cylindrical cavity 15 normal to the wall 17, at a point where the impedance reflected back into coaxial line 18–19 is fifty ohms. The radius R of cavity 15 is approximately equal to one quarter of the wave length of radio frequency energy fed to the antenna over coaxial line 18–19 for radiation through slot 11. This creates a condition of zero impedance, or short circuit, along the curved wall of cavity 15 at point 24, and maximum impedance at point 23 along the plane surface 25 at the midpoint of straight wall 17. It will be understood that in order to obtain a fifty ohm connecting point 22 at a convenient position approximately in the center of cavity 15, the impedance at point 23 must be substantially greater than fifty ohms. This is accomplished by providing sufficient volume in the cavity 15; the greater the volume, the higher the impedance will be at point 23. The impedance measured between the points 20A and 20B, as shown in FIGURE 3, was empirically determined to increase as the volume of cavity 15 is increased. The maximum impedance of the slotted antenna structure occurs between the surfaces 11 and 11A as shown in FIGURES 1 and 3. While the depth of the cavity 15 is not critical, I have found that a depth D, as shown in FIGURE 3, approximately equal to one sixteenth of the wave length of energy to be radiated, produces a fifty ohm connecting point 22 at the desired position for maximum efficiency of electromagnetic radiation and for minimum reflection of back wave along the coaxial line 18–19.

To enable fine adjustment of cavity 15, for accurate tuning of the antenna to the exact frequency at which microwave energy is to be radiated, I provide a tuning plug 26 threaded through a tapped hole 27 in the rear wall of cavity block 14. A similar, but smaller diameter, tuning screw 28 is threaded through block 14 into the smaller cavity 16, as shown in FIGURE 3 of the drawing.

As cavity 16 is designed to radiate microwaves through slot 12 of a much higher frequency than those from cavity 15 through slot 11, cavity 16 is proportionately smaller than cavity 15. The radius r of cavity 16 is approximately one-quarter wave length at its frequency, the slot 12 is approximately one-half wave length long, and the depth d of cavity 16 is approximately one-sixteenth wave length. Microwave energy of the appropriate higher frequency is fed to the antenna cavity 16 through a second coaxial conductor 29–30 which is secured in cavity block 14 by a set screw 31. The inner coaxial conductor 30 is passed through cavity 16 and soldered to front plate 10 at point 32, to reflect a fifty ohm impedance in the same manner as described above in reference to the connection of coaxial line 18–19 at point 22.

The slots 11 and 12, opening into cavities 15 and 16 respectively, are protected from the intrusion of moisture, or other foreign matter which could affect the tuning of the antenna, by a dielectric cover plate 34 which is fiber glass. The dielectric cover plate 34 is adhered to the face

of conductive plate **10** by any suitable means, such as resin cement.

It will be appreciated that inasmuch as the radiation resistance of free space is approximately three hundred and seventy seven ohms, and the impedance looking into the slots **11** and **12** is also approximately 377 ohms at the frequencies to which the respective cavities **15** and **16** are tuned, by the herein disclosed antenna design I have provided means for effectively coupling microwave energy of two discrete frequencies from conventional fifty ohm lines into space, for efficient radiation in unidirectional beams along a common axis, with minimum back wave reflection.

It will thus be seen that the objects set forth above, among those made apparent from the preceding description, are efficiently attained and, since certain changes may be made in the above construction without departing from the scope of the invention, 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.

It is also to be understood that the following claims are intended to cover all of the generic and specific features of the invention which, as a matter of language, might be said to fall therebetween.

Having described my invention, what I claim as new and desire to secure by Letters Patent is:

1. A unidirectional microwave antenna radiator comprising in combination,

(A) a semi-cylindrical cavity substantially enclosed by electrically conductive material,

(B) a slot opening in to said cavity along the diameter of said cavity and adjacent a high impedance portion of said cavity, and

(C) means for introducing radio frequency energy into said cavity at a selected lower impedance point within said cavity, whereby said radio frequency energy resonates in said cavity and is emitted through said half wave slot in a directional beam.

2. A unidirectional microwave antenna according to claim **1** wherein,

(B) said slot is substantially one half wave length of the energy to be radiated, and

(C) said introducing means is a low impedance coaxial line.

3. The combination of claim **1** including a manually adjustable tuning screw inserted into said cavity for tuning the resonant frequency thereof.

4. The combination of claim **2** including a manually adjustable tuning screw inserted into said cavity for tuning the output frequency of said slot.

5. A multiple radiator microwave antenna comprising, in combination,

(A) a pair of substantially semi-cylindrical cavities formed within an electrically conductive member,

(1) each of said cavities having at least one plane wall lying in a common plane with the other,

(B) a substantially straight conductive wall separating said cavities along their respective diameters,

(C) a pair of narrow slots in said common plane wall adjacent to opposite sides of said separating wall, and passing through said common plane wall,

(1) each of said slots opening into a separate one of said cavities, and

(D) means for introducing radio frequency electromagnetic energy into each of said cavities whereby said energy resonates in said cavities and emanates from said slots in narrow beams normal to said common plane wall.

6. The combination of claim **5** in which:

(A) said semi-cylindrical cavities are formed with different radii, and

(C) each of said slots is of a length equal to approximately one half wave length of the frequency to be radiated.

7. The combination of claim **5** including manually adjustable tuning means in each of said cavities.

8. The combination of claim **5** in which,

(D) said means for introducing radio frequency energy into each cavity comprises separate coaxial lines separately connected with said cavities.

9. A multiple frequency microwave antenna comprising in combination,

(A) a pair of substantially semi-cylindrical cavities formed within an electrically conductive member,

(1) each of said cavities formed with a different radius

(2) each of said cavities having a wall thereof lying in a common plane.

(B) a substantially straight wall of conductive material normal to said common plane and separating said cavities substantially along their respective diameters,

(C) a pair of parallel narrow slots in said common plane adjacent to opposite sides of said separating wall,

(1) each said slot being of a length substantially equal to one half wave length at the frequency to be radiated, and

(2) extending along the diameter of said cavity,

(D) an adjustable tuning screw protruding into each of said cavities for tuning the resonant frequency of each cavity, and

(E) separate coaxial lines connected with each of said cavities,

(1) each of said coaxial lines being connected to its respective cavity at a point of low impedance,

(2) whereby electromagnetic energy of preselected radio frequencies may be introduced into each of said cavities and caused to radiate through said slots in beams perpendicular to the plane of said common plane cavity walls.

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