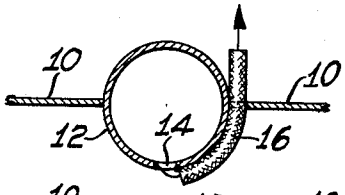
Aug. 11, 1953 R. W. MASTERS 2,648,769

WIDE ANGLE RADIATION ANTENNA

Filed June 28, 1949

Fig. 2



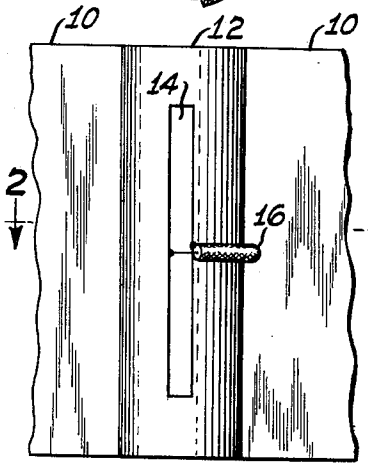
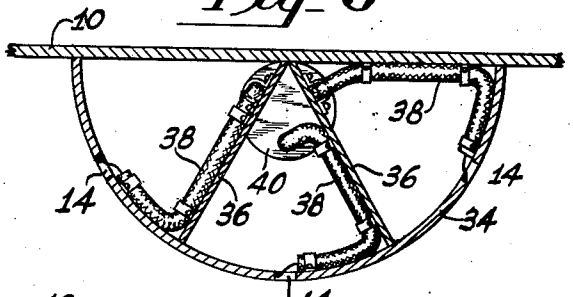


Fig. 1

Fig. 5



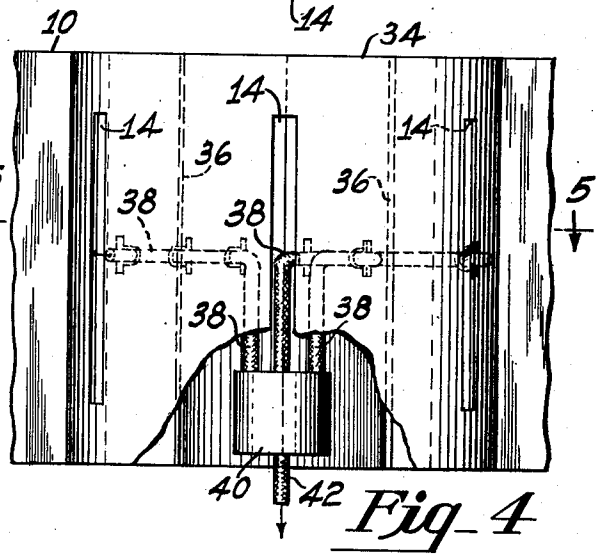


Fig. 4

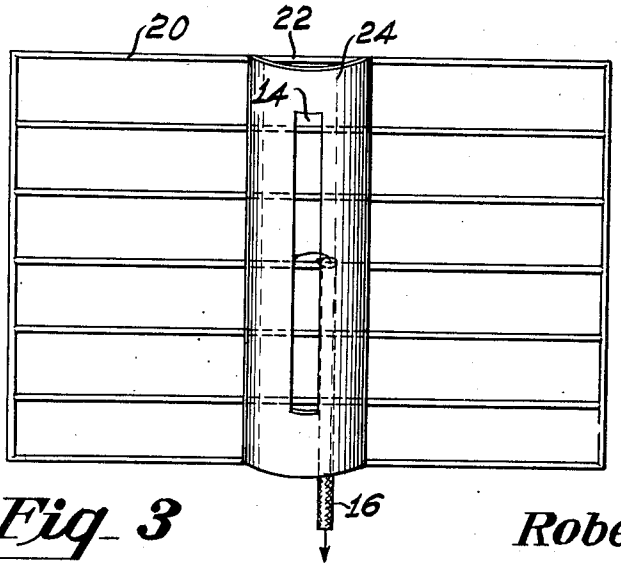


Fig. 3

INVENTOR
Robert W. Masters
BY Harry Tunick
ATTORNEY

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WIDE ANGLE RADIATION ANTENNA

Robert Wayne Masters, Erlton, N. J., assignor to Radio Corporation of America, a corporation of Delaware

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7 Claims. (Cl. 250—33)

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The invention relates to antennas and particularly to an antenna for television and FM broadcasting of substantially uniform signal strength throughout a wide angle, especially an angle of substantially 180°.

The prior art antennas are usually considered from the standpoint of directivity as being of two classes, namely, omnidirectional and bidirectional; the unidirectional antenna being a special form of bidirectional antenna with radiation in one direction suppressed.

There are applications, however, where a substantially uniform radiation pattern over a wide but definitely limited angle of radiation is desired. Such an antenna is particularly useful in providing general coverage in areas having many tall buildings which would otherwise hinder the propagation of wave energy. With the use of several antennas having uniform field strength over a sector of 180° judicially placed throughout the area, substantially complete coverage can be obtained without going to the expensive installations which might otherwise be required. Such an installation is contemplated for use in police and fire department communication systems and the like, although it is equally applicable to many other services, such as program broadcasting.

It is an object of the invention to provide a simple, rugged antenna having an essentially constant field strength pattern throughout a wide azimuth angle.

It is another object of the invention to provide an ultra high frequency antenna of simple and economic construction providing uniform field strength over an angle of substantially 180°.

It is a further object of the invention to provide an antenna having substantially constant coverage throughout a large angle which can be readily and simply coupled to various transmission lines differing rather widely in characteristic impedance.

These and other objects which will appear as the specification progresses are attained according to the invention by means of an antenna comprising a conductive member of relatively large area constituting a ground plane of effectively infinite dimensions and a generally cylindrical member arranged thereon to form a cavity resonator in cooperation with the conductive member, the resultant resonator having at least one centrally located slot short-circuited at its extreme ends and disposed parallel to the axis fo the cylinder, and means to couple a transmission line across the slot intermediate its ends

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at points providing a substantially proper impedance match between the antenna and the transmission line.

The invention will be described in detail with reference to the accompanying drawing forming part of the specification and in which:

Figs. 1 and 2 illustrate a construction according to the basic principles of the invention;

Fig. 3 illustrates a preferred arrangement according to the invention; and

Figs. 4 and 5 illustrate an alternate embodiment of the preferred arrangement according to the invention.

Referring to Figs. 1 and 2, there is shown in plan and cross-sectional views an arrangement according to the invention comprising a ground plane element of finite dimensions constituted by a conductive sheet member 10 having a cylindrical conductive member 12 interposed therein, the cylindrical member 12 having a narrow slot 14 shorted at the ends and disposed parallel to the axis of the cylindrical member. The radius of cylindrical member 12 may be quite small in terms of the operating wavelength, a diameter about $\frac{1}{12}$ of the wavelength having been used with success in one particular embodiment. Although the smaller diameter appears to have certain advantages, there is no reason why the diameter must necessarily be less than a wavelength. The small size used in the particular embodiment shown in Fig. 1 obviates the necessity of driving the circumference of the cylinder at more than one point and this is especially true for cylinders up to a quarter wavelength in diameter where departure from a circular radiation pattern is not permissible. Cylinder 12 may be left open at the ends or capped as desired with a cap of either conducting or non-conducting material. Slot 14 may be of arbitrary length, although slots lying between one-half and one wavelength are to be preferred for various reasons, some of which will be discussed in greater detail hereinafter. It should be pointed out here that the velocity of propagation in the cavity is different from that of free space and the length of the slot should be measured accordingly. The antenna thus far described is energized by coupling a coaxial or a two wire transmission line 16 across the edges of the slot. Preferably the characteristic impedance of the transmission line is such that it is matched to the impedance offered by the slot when it is connected at or very near the center thereof. However, it is an important feature of the invention that transmission lines of different

impedances can be coupled to the slot by connecting them at points other than the midpoint, the impedance of the slot being maximum at the midpoint and tending toward zero at the ends of a slot which is a half wavelength or less in length. For slots over a half wavelength long, the impedance variation may not follow the simple law just stated but it will be possible to predict the impedance of points within a quarter wavelength of the slot with considerable accuracy and other impedances may be easily determined experimentally. With the arrangement shown, radiation in the direction behind the slot is prevented by the sheet member 10. The electrical behavior of the antenna is similar to that of a loop. Due either to small size of the cylinder or by providing a multiplicity of feed points if a cylinder of the diameter of the order of a wavelength is used, the current magnitude around the periphery of any cross section of cylinder 12 is constant for all practical purposes. The currents in the conductive sheet 10 are so distributed as to simulate an image of the rear half of the cylinder, thus completing a radiator which radiates in a 180° sector only, except perhaps for small diffraction effects at the extreme limits of the radiation pattern.

As might be expected, the voltage distributed along slot 12 excites a cylindrical sheath of current around cylinder 14 and so causes a directivity factor normal to the axis of cylinder 12 to be introduced. This directivity due to the length of slot 12 is a desirable quality since more than one section of the antenna as described may be stacked end on to obtain further gain with little or no coupling between sections. The gain of this particular antenna is about three times that of a half wave dipole.

An important application of the subject antenna lies in its use in congested areas wherein the antenna may be mounted on the side of a tall building whose roof may not be available for use as an antenna mounting. In such an installation it is often quite desirable that there be no obstructions on the near side of conductor 10 to prevent the antenna from being mounted flat against a building. A preferred embodiment of the invention providing this advantageous feature is shown in Fig. 3, wherein the ground plane is constituted by a conductive member comprising a grid 20 upon which is mounted a semi-circular conductive member 24 having disposed along its axis a slot 14 which is excited in the same manner as slot 14 of the arrangement of Fig. 1. The portions 22 of grid 20 behind member 24 may be constituted by a solid conductive sheet if that form is more convenient to use as either a grid or a solid sheet will be equally effective. Semi-cylindrical member 24 and portion 22 merely form a cavity resonator equivalent to that afforded by cylinder 12 of the arrangement of Figs. 1 and 2 and the same physical requirements are present. It has been found that the conductive plane member need not be in the form of a solid metallic sheet but may have apertures therein and preferably is made up as a grid because this form of construction provides the electrical equivalent of the solid sheet together with the further advantage of light weight and the possibility of use over air ducts, windows, etc., without serious interference with the normal functions thereof. Theoretically, the sheet member 20 should extend to infinity but practically there are finite dimensions for each case which will provide the desired results. Such a finite

dimensioned element is sometimes termed a "semi-infinite" element, although the term is not widely used. The sheet member 20 should extend at least a quarter wavelength at the operating frequency on either side of the member 24 and preferably sheet member 20 is at least several half wavelengths wide whereby the actual pattern more clearly approaches the theoretical.

While a semi-circular member 24 has been shown, it is equally possible to use a polygonal configuration having a number of flat sides, e. g., two flat sides forming a triangular shaped member, three flat sides forming a square, etc. It is believed that the shape of member 24 may affect the bandwidth of the antenna but this is not definitely known. The radiation pattern obtained should approach the theoretical pattern for larger and larger ground planes. Small ground planes are apt to affect the circularity of the field in desirable or undesirable manner depending on the actual effect for which the designer is looking.

In Figs. 4 and 5 there is shown an alternate embodiment of the antenna according to the invention wherein a plurality of cavity resonators are formed by means of conductive plane wings 10, semi-cylindrical member 34, and internal vanes 36, each of which cavities has a slot 14. Each of the slots 14 in the latter arrangement is excited in exactly the same manner and preferably are connected together by transmission lines 38 of equal length terminating in a junction box 40 at which they are connected in known manner to a single transmission line 42 of characteristic impedance equal to the resultant characteristic impedance of the number of branch transmission lines 38 and leading to the transducer apparatus to be associated with the antenna.

In certain circumstances where an angle of considerable size but definitely not 180° is required, the conduction plane 10 or grids 20 may be formed at substantially the required angle with regard to each other rather than being flat as shown in the drawing.

It should be understood that while the subject antenna has been described from the viewpoint of its adaptability to transmitting radiation, it is clearly capable of receiving radiation as well and can be employed for that purpose without material alteration and modification.

While the invention has been described in terms of express embodiments, it is to be understood that obvious modifications thereof will be suggested to those skilled in the art without departing from the spirit and scope of the invention.

I claim:

1. An antenna for substantially uniform wide angle radiation, including a hollow conductive semi-cylindrical element having at least one slot therein arranged longitudinally of the cylindrical axis thereof, a conductive surface member arranged behind said slot in conductive relationship to said semi-cylindrical element along substantially the entire lines of intersection therewith and extending radially and outwardly therefrom, and means to couple a transmission line across the edges of said slot at points intermediate the ends thereof.

2. An antenna providing substantially uniform radiation over a straight angle comprising a substantially plane conductive surface element, a hollow semi-cylindrical conductive member having at least one slot arranged therein longitudinally of the cylindrical axis, said conductive

member being arranged on one side of said conductive surface element substantially at the center thereof and in electrical contact substantially entirely throughout the lines of intersection therewith, and a transmission line having two conductors individually terminating on opposite sides of said slot intermediate the ends thereof.

3. An antenna providing substantially uniform radiation over a straight angle comprising a substantially plane conductive surface element, a hollow semi-cylindrical conductive member having a plurality of slots arranged therein longitudinally of the cylindrical axis, said conductive member being arranged on one side of said conductive surface element substantially at the center thereof and in electrical contact substantially entirely throughout the lines of intersection therewith, and a plurality of transmission lines each having two conductors individually terminating on opposite sides of one of said slots intermediate the ends thereof.

4. An antenna providing substantially uniform radiation over a straight angle comprising a conductive surface element, a hollow semi-cylindrical conductive member having at least one slot arranged therein longitudinally of the cylindrical axis, said semi-cylindrical conductive member being arranged on one side of said conductive surface element substantially at the center thereof and in electrical contact substantially entirely throughout the lines of intersection therewith, and a transmission line having two conductors individually terminating on opposite sides of said slot substantially at the center thereof.

5. An antenna providing substantially uniform radiation over a straight angle comprising a conductive surface element constituted by a plurality of parallel elongated conductors spaced apart substantially in a single plane, conductive elements interconnecting corresponding ends of said conductors, a hollow semi-cylindrical conductive member having a slot arranged therein longitudinally of the cylindrical axis and terminating short of the ends of said member, the axis of said semi-cylindrical member being substantially normal to the length of said conductors, said conductive member being arranged on one side of said conductors substantially at the center thereof and in electrical contact at substantially all points of intersection therewith, and a transmission line having two conductors individually terminating on opposite sides of said slot substantially at the center thereof to build up a potential difference across said slot.

6. An antenna providing substantially uniform radiation over a straight angle, including a substantially plane conductive surface element having a width of a multiple including unity of half-wavelengths and comprising spaced unidirectionally disposed elongated conductors, a hollow semi-cylindrical conductive member having at least one slot arranged therein longitudinally of the cylindrical axis, said conductive member being arranged on one side of said conductive surface element normal to said elongated conductors and substantially at the center thereof and in electrical contact substantially entirely throughout the lines of intersection therewith, and means to couple the conductors of a two-conductor transmission line individually to opposite edges of said slot intermediate the ends thereof.

7. An antenna for substantially uniform wide angle radiation including a hollow conductive semi-cylindrical element having at least one slot therein arranged longitudinally of the cylindrical axis thereof, and substantially plane conductive surface members connected along given edges thereof to said cylindrical element on both sides of said slot in conductive relationship to said cylindrical element and extending radially and outwardly therefrom, said semi-cylindrical element being arranged on one side of said plane surface members, and means to couple a transmission line across the edges of said slot at points intermediate the ends thereof.

ROBERT WAYNE MASTERS.

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