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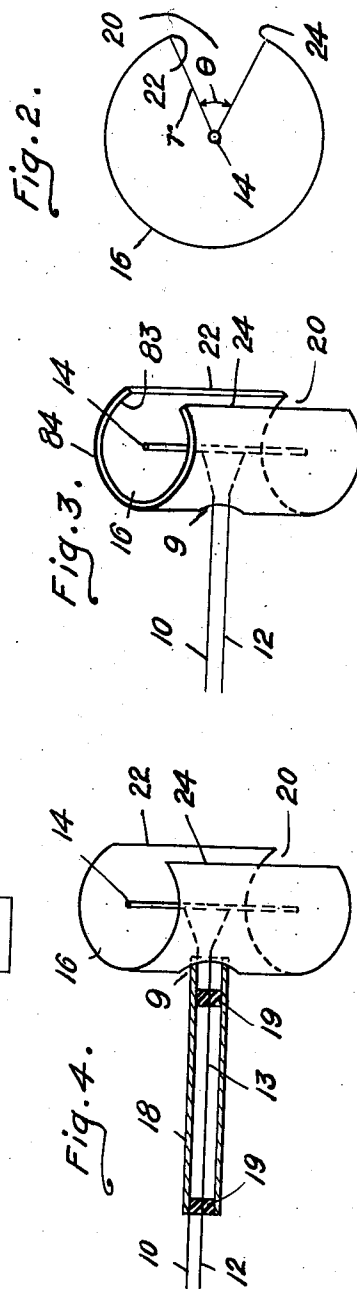
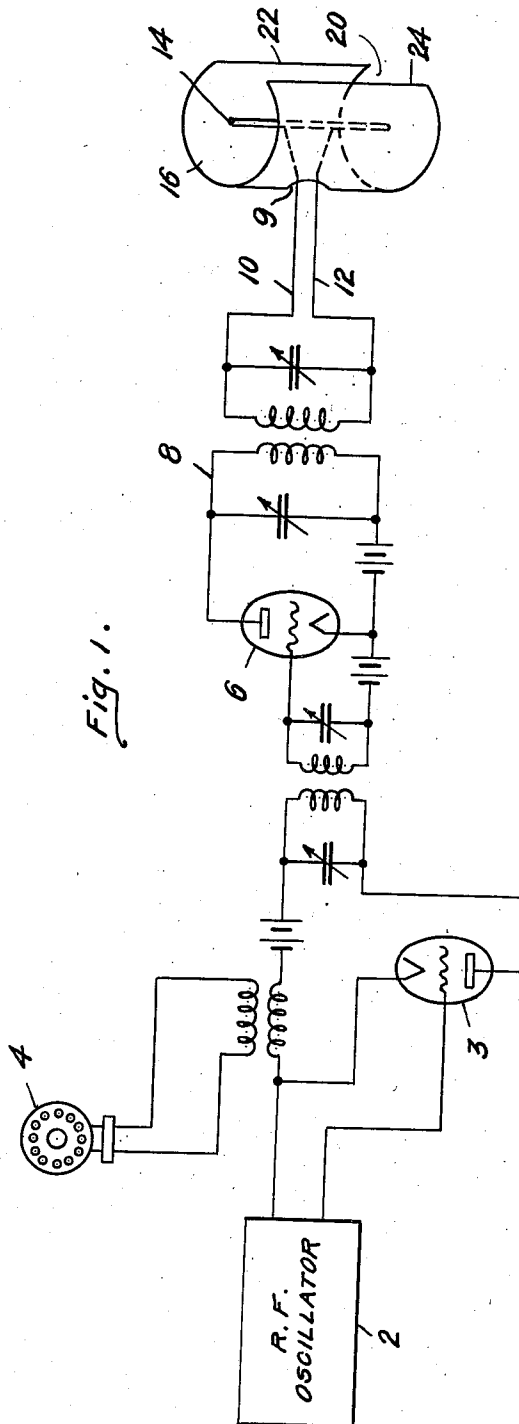
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2,253,501

RESONANT ANTENNA SYSTEM

Filed Sept. 10, 1937

2 Sheets-Sheet 1



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Fig. 5.

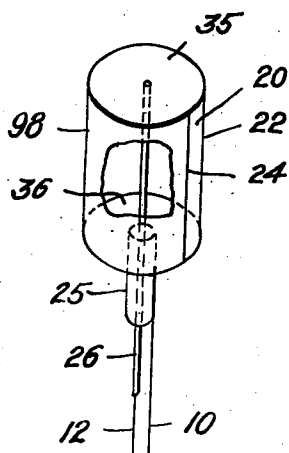


Fig. 6.

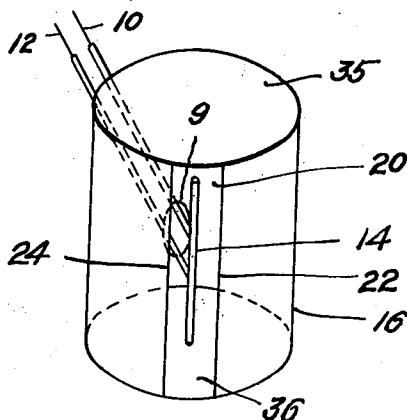


Fig. 7

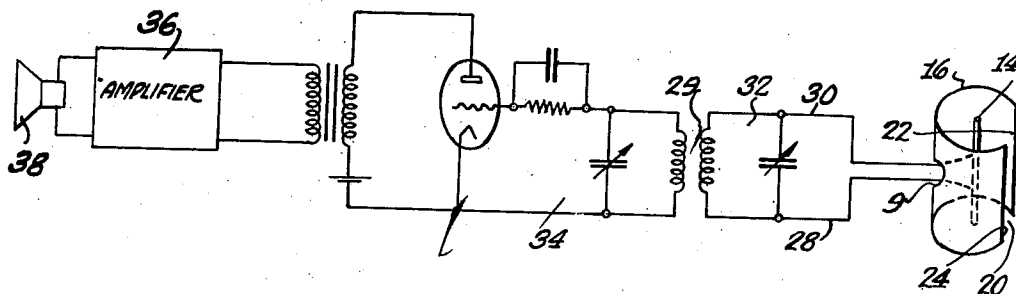
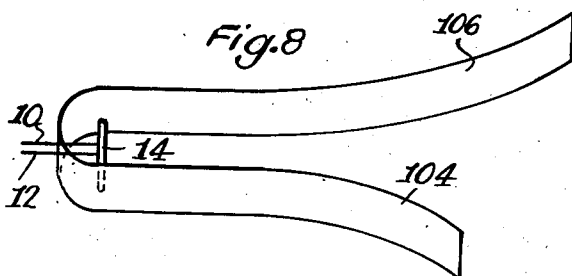


Fig. 8



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RESONANT ANTENNA SYSTEM

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6 Claims. (Cl. 250-11)

The present invention relates to electric communication, and more particularly to directive radio communication, particularly at ultra-high frequencies, or very short waves.

An object of the invention is to provide a new and improved electric system for transmitting and receiving intelligence over long distances at ultra-high frequencies.

Another object is to provide a new and improved directive reflector for ultra-high-frequency waves in free space.

A further object is to provide a new and improved hollow space-resonant cavity or chamber, particularly a chamber or cavity with cylindrical walls.

Still another object is to utilize the walls of the said space-resonant cavity or chamber to reflect ultra-high frequency waves.

Other and further objects will be described hereinafter and will be particularly pointed out in the appended claims.

The invention will now be explained more fully in connection with the accompanying drawings, in which Fig. 1 is a diagrammatic view of a transmitting system embodying the invention, the reflector being shown in perspective; Fig. 2 is a diagrammatic plan of the cylindrical reflector, with explanatory symbols; Figs. 3 to 6 are views of modifications; Fig. 7 is a view similar to Fig. 1 of a receiving system; and Fig. 8 is a view of a further modification.

The radio-transmitting system diagrammatically shown for illustrative purposes in Fig. 1 comprises a radio-frequency oscillator 2, connected with a modulator 3, and which may be modulated in any desired way, as by means of a microphone 4. The modulated output may be fed to a radio-frequency amplifier 6 that may be coupled to a circuit 8 having parallel-line output leads 10 and 12. Sending apparatus will be connected to the biconductor leads 10 and 12. The leads 10 and 12 are shown connected to an exciting linear rod antenna 14, disposed in and substantially along the axis of a hollow resonant cylindrical chamber or cavity 16 of substantially circular cross section and the walls of which are constituted of suitable wave-reflecting material, as hereinafter described. The wires 10 and 12 are shown extending into the cylinder 16 through an opening 9. The sending apparatus will be adjusted to excite in the antenna 14 modulated ultra-high-frequency electromagnetic waves of a frequency corresponding to the resonant frequency of the chamber. These waves will have

electric lines of force substantially parallel to the axis of the cylinder.

The cylinder 16 may be constituted of sheet metal, such as copper or aluminum, or it may be constituted of other material if its inner wall is otherwise rendered a conductor of the said waves, so as to reflect them. The cylinder may be constituted of a thin-walled dielectric pipe 83 the outer surface of which is constituted of conducting material, such as the metal deposit 84 of Fig. 3. The chief purpose of the dielectric 83 here is to support the metal deposit 84. In some cases, indeed, the cylinder 16 may be constituted wholly of dielectric material, though the effect is less pronounced than when conducting cylinders are employed. The interior of the cylinder 16, being open to the atmosphere, is naturally a non-conductor.

Modulated electromagnetic waves will be produced by the exciting rod 14. The walls of the cylinder will, by reflection concentrate the energy upon the linear antenna 14 to produce linearly polarized standing waves in the chamber or cavity within the cylinder 16. A condition of linearly polarized space resonance will thus be produced in the cylindrical reflector that will materially alter the radiation resistance of the antenna, thus introducing a change in the impedance of the antenna, since it depends upon the nature and the conditions of the medium surrounding the cylindrical-reflector system. The space-resonance effects in the cylinder will depend upon the phase relations between the original and the reflected waves within the cylinder, with the consequent production of a directional pattern for the radiation field. Considerable of the linearly polarized wave energy of the said resonant frequency will be directly radiated out of the chamber into space through an opening 20, produced by cutting a section out of the cylindrical wall of the chamber or cavity 16, along sides 22 and 24 substantially parallel to the axis of the cylinder. The space-resonance effects between the antenna and the cylindrical reflector 16 increase the strength of the radiation. The cylindrical chamber or cavity thus constitutes a directive electromagnetic radiator of the electromagnetic energy transmitted to the antenna 14. Not all of the energy is so radiated into space, because of reflections from the said opening, and because of the standing waves that are set up in the cylinder.

Similar action will take place for absorption of such waves, in reception. A modulated space

radio wave may be caused to impinge upon the cylinder 16 and to be reflected by the walls of the cylinder upon the absorbing rod antenna 14. The circuit 8 may then be replaced by a suitable portion of a receiving circuit 32, connected by conductors 28 and 30 of a bi-conductor system to the rod antenna 14, and coupled, by means of a transformer 29, to a detector circuit 34 for demodulating the received and reflected waves. The detector is coupled to a suitable amplifier 36 that, in turn, is connected to a loud speaker 38.

The term "hollow resonant conducting chamber," or its equivalent, will be used in this specification to denote a substantially non-conducting space within a conducting cylindrical shell of substantially circular cross section, the cross dimension of the cylindrical shell being about equal to or greater than one-half of the free-space wavelength of the oscillations in the non-conducting space, and the dimension parallel to the axis of the cylindrical shell, which is the dimension substantially parallel to the electric lines of force of the oscillatory waves within the cavity, being of any desired suitable value. In the drawings, this last-named dimension is parallel to the exciting rod 14.

The exciting rod 14 may be supported in the cylinder in any desired way, as by means of an insulating member or members (not shown, for clearness).

The resonant chamber or cavity of the present invention may thus be connected to free outside space, and the antenna 14 to sending or receiving apparatus, for purposes of either radiating waves into, or absorbing them from, space. The said resonant modulated high-frequency electromagnetic-wave energy may be taken from the antenna 14 and radiated to outside space, or it may be received from outside space and delivered to the antenna 14 for demodulation by the receiving system.

The invention may also be employed with concentric or coaxial-line systems, as in Figs. 4 and 5. As illustrated in Fig. 4, one of the wires, as the wire 10, may be connected to the tubular portion 18 of the coaxial system, and the other wire, as the wire 12, may be continuously extended axially into the tubular portion 18, as illustrated at 13. The conductor 13 is shown supported in and spaced from the walls of the tube 18 by insulating members 19. The tubular portion 18 will constitute the outer tubular conductor of the coaxial line and the conductor 13 the inner conductor. The members 18 and 13 are connected to the antenna 14 in the same way as the conductors 10 and 12 of Fig. 1.

Because of spurious radiation from the parallel-wire transmission line, and because energy was taken off from this line to form spurious currents on both the outside and the inside surfaces of the reflector 16, which spurious currents caused unwanted radiation, the radiation pattern was somewhat distorted. The coaxial line 18, 13 was found to be more satisfactory than the parallel-wire feeder, illustrated at 10, 12 of Fig. 1; it minimized this spurious radiation and distortion from the feeder line and the reflector 16, resulting in more regular radiation patterns and improved performance of the resonant radiating system.

The resonant cylindrical chamber or cavity 98, as illustrated in Fig. 5, may be closed at its ends, and the exciting rod 26 and its cooperating tube 25 of the coaxial line may be disposed substantially axially of the cylinder 98. The conditions

of space resonance produced by the standing waves in the closed chamber will be rendered manifest in a corresponding change in load on the section of the concentric line 25, 26, with marked effect on the radiation or absorption of the radio waves.

The closed ends of the cylinder may be provided also with the arrangement illustrated in Fig. 1, as shown at 35 and 36 in Fig. 6.

The field pattern around the cylindrical reflector and system, that is, the magnitude and the direction of the field at any point in space produced by the radiating antenna 14 (and similar considerations apply for reception), will vary with the angle θ subtended at the axis of the cylinder by the opening 20.

The oscillator 2 should be capable of producing a reasonably strong field at a wave length low enough so that the physical size of the reflector 16 shall not be economically prohibitive. The wave transmitted or received may be in a wave band from between less than a meter to ten meters, in order to keep the dimensions of the apparatus small. The antenna 14 may be any desired length. It may be small compared to the wave-length, it may be a half wave-length, or it may be longer, if desired, but it should extend throughout the major portion of the axis of the cylinder, in order that substantially all parts of the inner walls of the cylinder may cooperate to return the radiations of the rod antenna back upon the rod antenna.

If the wave length is about two meters, for example, with the radius r of the reflector 16 also about two meters, the antenna 14 and the height of the reflector 16 may be about one meter or one-half wave-length. The radiation from the outside surface of the cylinder 16 itself should be eliminated, or reduced to a minimum, as by preventing the occurrence of capacitance between the cylinder 16 and the transmission line, and also by matching the impedance of the line to the antenna.

The angle θ will enter as a factor in determining the characteristics of the field pattern because of the phenomenon of diffraction around the edges 22 and 24 of the opening 20, the dimensions of which opening 20 may be comparable to a wave length of the oscillations from the antenna 14. The diffraction pattern of the field will thus vary with the width of the opening 20, or with the angle θ . It is because of the fact that the dimensions are comparable to the length of the electromagnetic wave that the radiation pattern produced has directive characteristics.

It was found that, for angles θ less than about 60 degrees, the radiation field outward through the opening 20 is less intense than fields to the right and the left thereof, which latter are presumably caused by diffraction. As the angle θ was increased, there appeared to be a critical angle, less than about 80 degrees, at which the radiation from the system assumed the shape of a wide central beam, with the said diffraction lobes very much smaller. For all angles above about 80 degrees, the radiation gradually assumed the shape of one main central beam, with the said small diffraction lobes at the sides decreasing in intensity. The main beam was not sharp, but rather broad. For large angles θ , however, practically the total radiated energy was found to be in this single beam. The field pattern was found to be substantially the same with a large variation of the radius r , including values of r equal to one-eighth, one-quarter and three-eighths

wave length. Most satisfactory results, however, were obtained with the one-quarter wave-length radius, the field being then strongest, and more of the energy then appearing in the radiated beam.

The variation of the radius may be effected by using different sizes of cylinders 16, or by bending the cylinder to a new radius. The chamber or cavity may be rendered adjustable or tunable in other ways also to vary its resonant characteristics.

The resonant cylindrical cavity may be joined to two oppositely disposed conducting flaring electro-magnetic wave-guiding sides or extensions 104 and 106, one extending from each side of the opening 20, substantially parallel to the axis of the cylinder, as shown in Fig. 8. Radiating systems of this kind can produce a beam which is more or less confined in the plane in which the flaring occurs, without materially affecting the directivity in the plane at right angles to this plane.

It will be understood that the invention is not limited to the exact embodiments thereof that are illustrated and described herein, but that further modifications may be made by persons skilled in the art without departing from the spirit and scope of the invention, as defined in the appended claims.

What is claimed is:

1. An electric system comprising a hollow resonant cylindrical chamber of substantially circular cross section provided in its wall with an opening the sides of which are substantially parallel to the axis of the cylinder, a rod antenna disposed in the chamber substantially along the axis of the cylinder and extending throughout the major portion of the length of the cylinder, and means for exciting or absorbing in the antenna electromagnetic waves of a frequency corresponding to the resonant frequency of the chamber and having electric lines of force substantially parallel to the axis of the cylinder to produce, by reflecting from the walls of the cylinder, linearly polarized standing waves in the cylindrical chamber to create a condition of linearly polarized space resonance therein, whereby linearly polarized energy of the said resonant frequency will be directly radiated out of the chamber or absorbed into the chamber through the opening.

2. An electric system comprising a hollow resonant cylindrical chamber of substantially circular cross section closed at its ends and provided in its wall with an opening the sides of which are substantially parallel to the axis of the cylinder; a rod antenna disposed in the chamber substantially along the axis of the cylinder and extending throughout the major portion of the length of the cylinder, a coaxial-line system connected to the chamber and to the rod antenna, and means for exciting or absorbing in the antenna electromagnetic waves of a frequency corresponding to the resonant frequency of the chamber and having electric lines of force substantially parallel to the axis of the cylinder to produce, by reflection from the walls of the cylinder, linearly polarized standing waves in the cylindrical chamber to create a condition of linearly polarized space resonance therein, whereby linearly polarized energy of the said resonant frequency will be directly radiated out of the chamber or absorbed into the chamber through the opening.

3. An electric system comprising a hollow res-

onant cylindrical chamber of substantially circular cross section provided in its wall with an opening the sides of which are substantially parallel to the axis of the cylinder, an absorbing rod antenna disposed in the chamber substantially along the axis of the cylinder and extending throughout the major portion of the length of the cylinder, means for absorbing from space in the antenna modulated ultra-high-frequency electro-magnetic waves of a frequency corresponding to the resonant frequency of the chamber and having electric lines of force substantially parallel to the axis of the cylinder to produce, by reflection from the walls of the cylinder, linearly polarized standing waves in the cylindrical chamber to create a condition of linearly polarized space resonance therein, and means for demodulating the absorbed and reflected waves.

4. An electric system comprising a hollow resonant cylindrical chamber of substantially circular cross section provided in its wall with an opening the sides of which are substantially parallel to the axis of the cylinder, sending apparatus, an exciting rod antenna disposed in the chamber substantially along the axis of the cylinder and extending throughout the major portion of the length of the cylinder, and means for connecting the sending apparatus to the rod antenna to excite in the antenna modulated ultra-high-frequency electromagnetic waves of a frequency corresponding to the resonant frequency of the chamber and having electric lines of force substantially parallel to the axis of the cylinder to produce, by reflection from the walls of the cylinder, linearly polarized standing waves in the cylindrical chamber to create a condition of linearly polarized space resonance therein, whereby linearly polarized modulated ultra-high-frequency energy of the said resonant frequency will be directly radiated out of the chamber through the opening.

5. An electric system comprising a hollow resonant cylindrical chamber of substantially circular cross section closed at one end and provided in its wall with an opening the sides of which are substantially parallel to the axis of the cylinder, a rod antenna disposed in the chamber substantially along the axis of the cylinder and extending throughout the major portion of the length of the cylinder, and means for exciting or absorbing in the antenna electromagnetic waves of a frequency corresponding to the resonant frequency of the chamber and having electric lines of force substantially parallel to the axis of the cylinder to produce, by reflection from the walls of the cylinder, linearly polarized standing waves in the cylindrical chamber to create a condition of linearly polarized space resonance therein, whereby linearly polarized energy of the said resonant frequency will be directly radiated out of the chamber or absorbed into the chamber through the opening.

6. An electric system comprising a hollow resonant cylindrical chamber of substantially circular cross section provided in its wall with an opening the sides of which are substantially parallel to the axis of the cylinder, a rod antenna disposed in the chamber substantially along the axis of the cylinder and extending throughout the major portion of the length of the cylinder, and means for exciting or absorbing in the antenna electromagnetic waves of a frequency corresponding to the resonant frequency of the chamber and having electric lines of force sub-

stantially parallel to the axis of the cylinder to produce, by reflection from the walls of the cylinder, linearly polarized standing waves in the cylindrical chamber to create a condition of linearly polarized space resonance therein, where-
by linearly polarized energy of the said resonant frequency will be directively radiated out of the

chamber or absorbed into the chamber through the opening, the chamber being provided with two oppositely disposed electromagnetic-wave-guiding extensions, one extending from each side of the opening substantially parallel to the axis of the cylinder.

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