

June 16, 1936.

R. WEYRICH

2,044,413

TRANSMITTER AND RECEIVER FOR ELECTROMAGNETIC WAVES

Filed Aug. 5, 1931

2 Sheets-Sheet 1

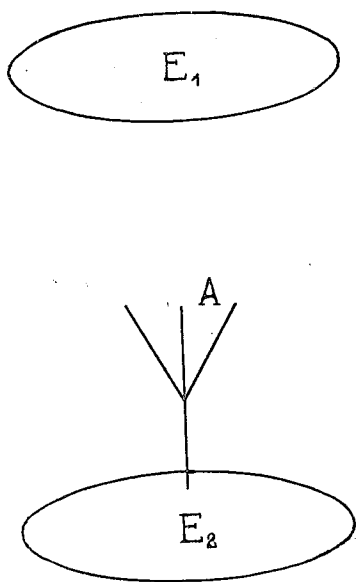


Fig. 1

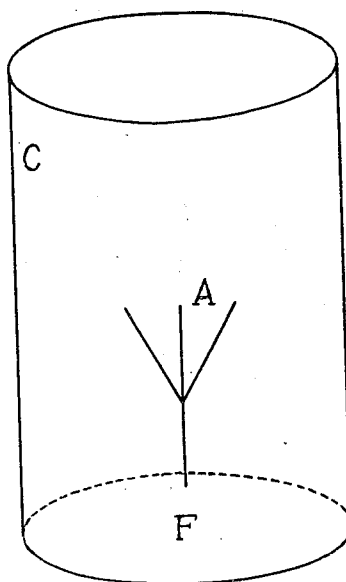


Fig. 3

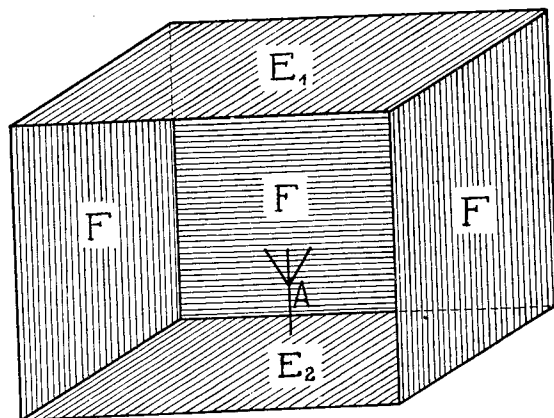


Fig. 2

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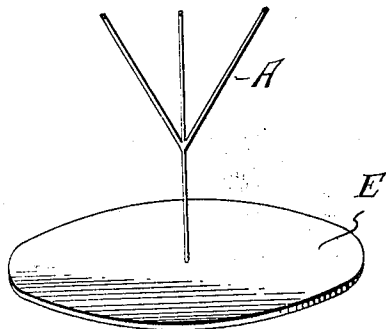
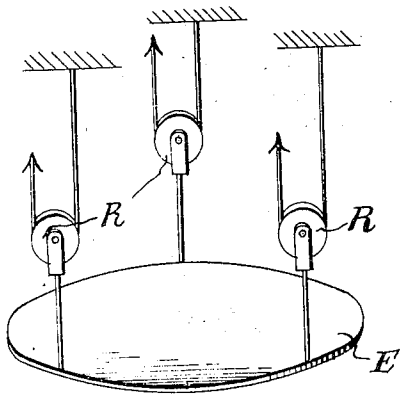


Fig. 1a.

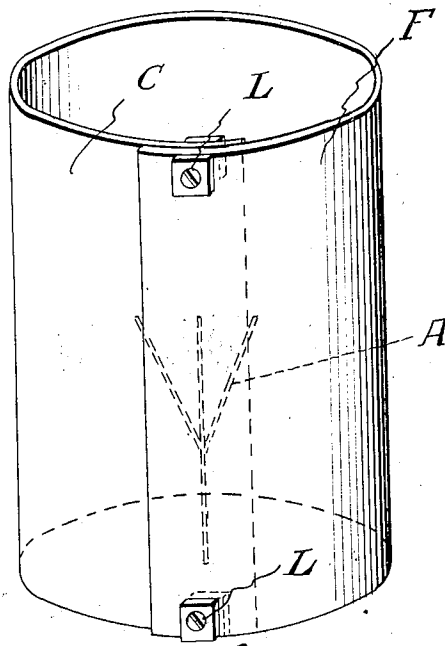


Fig. 3a.

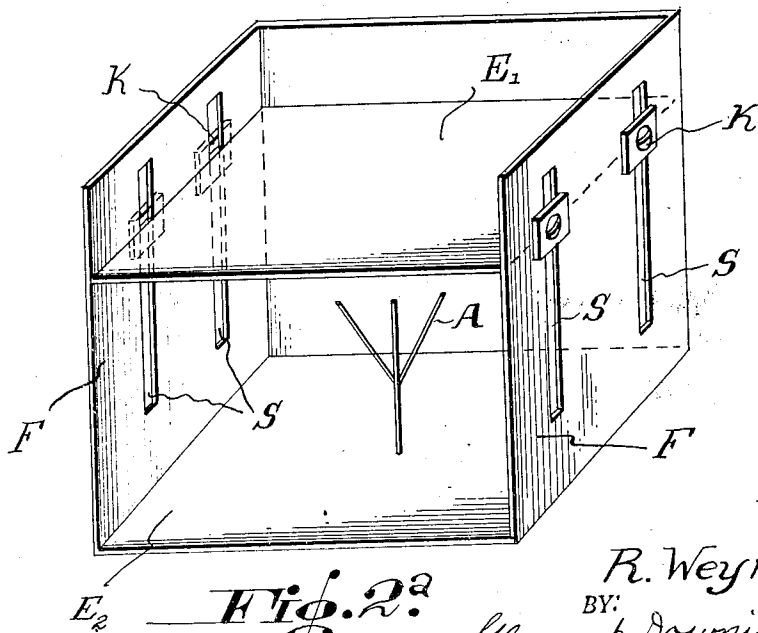


Fig. 2a.

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UNITED STATES PATENT OFFICE

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TRANSMITTER AND RECEIVER FOR
ELECTROMAGNETIC WAVES

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In Germany August 7, 1930

11 Claims. (Cl. 250—11)

It is a known fact in acoustics that the action of a source of sound can be substantially improved by the co-operation of a resonance space and that also the effect of sound waves which are received is increased by the use of resonating spaces. In transmitting or receiving electromagnetic waves use has only been made of devices which are capable of resonating to the extent of using transmitting and receiving circuits with the corresponding aerials, that is, wire systems which are capable of resonating down to the same frequency. It is, however, possible by using spaces which are capable of resonating, which are filled with any semi-conductor or non-conductor preferably with the medium through which the transmission takes place, to obtain similar effects to those known in acoustics. For this purpose it is necessary that these spaces, which must be connected with the outer space, should be limited by surfaces which have different electrical and magnetic constants from the enclosed medium. Preferably these surfaces have a much greater conductivity.

The invention therefore consists in an apparatus for transmitting and receiving electromagnetic waves in which spaces capable of resonating are provided in the immediate surroundings of an apparatus for emitting or absorbing electromagnetic waves which are surrounded by limiting surfaces of suitable material which may consist of compact metal, a wire fabric or other suitable arrangement of wires or in general of a material which differs from the enclosed medium in its electromagnetic properties. These surfaces must have such geometric shape that the space enclosed has fundamental frequencies which can be excited in resonance by an electromagnetic excitation of the same frequency. The existence of such fundamental frequencies can be discovered by obtaining experimentally a resonance curve which shows the amplitudes of the electric vector in the enclosed space as a function of the exciting frequency. Fundamental frequencies are indicated by maxima on this curve. As these maxima are never very sharp the desired action also takes place near to a fundamental frequency so that exact resonance is not always necessary to obtain the effect.

On account of spaces capable of resonating being enclosed the invention differs characteristically from other inventions in which conducting surfaces are arranged near to a transmitting or receiving apparatus which, however, only act as reflectors and are intended to produce a directing effect on the electromagnetic radiation. These known apparatus depend chiefly on the geometrical-optical focusing properties of surfaces of the second order, as for example, parabolic or elliptical cylindrical reflectors. It has been found of advantage to combine the action of spaces

which are capable of resonating with the action of such reflectors where it is technically possible.

Fig. 1 is a diagrammatic view of a pair of planes between which an electrical receiver or aerial is placed,

Fig. 1a is a similar view of a modified form in which means are provided for adjusting the planes relative to one another,

Fig. 2 is a diagrammatic perspective view illustrating reflecting surfaces in the form of a square,

Fig. 2a is a perspective view of a modified form of arrangement shown in Fig. 2 showing another means for adjusting the planes,

Fig. 3 is a diagrammatic perspective view of a cylindrical reflecting surface for enclosing the aerial, and

Fig. 3a is a perspective view of the modified form of the arrangement shown in Fig. 3.

The simplest geometrical configuration of boundary surfaces which enclose a space which can resonate, consists of a pair of parallel planes between which an electromagnetic transmitter or receiver is placed. Such an arrangement is illustrated diagrammatically in Figure 1, in which E_1 and E_2 indicate the two boundary planes and A is an aerial. If E_1 and E_2 are taken as extending indefinitely and completely conducting there is resonance for the Hertz function of the radiation field, if the distance between the planes is an integral multiple of a half wave length in the intervening medium.

When the conductivity is not perfect and the extension of the planes is finite there are corresponding alterations. The surface of the earth may with advantage be used as the plane E_2 in which case when necessary for increasing the effect in the immediate surroundings of A its conductivity is to be increased by suitable measures. Furthermore it is of advantage to make the distance the planes E_1 and E_2 variable so that when the frequency is changed the apparatus can be adjusted. As is shown in Figure 2, it is possible by providing the sides with one or more absorbing or reflecting surfaces F to prevent radiation entering or passing out in undesired directions in which case the reflecting surfaces may be so shaped that they concentrate the radiation in given directions.

These surfaces may also be provided for increasing the capability of resonating of the space between E_1 and E_2 which is desirable because with this configuration in the case of infinitely extended perfectly conducting planes there is resonance actually only for the Hertz function of the radiation field and not for the electric and magnetic field strengths. In spite of the incompleteness of the resonance in this case, this arrangement is noteworthy because, by producing an infinite number of mirror images of the aerial

by means of E_1 and E_2 the effect of an infinitely extended aerial system is obtained. Substantially better resonance effects which apply not only to the Hertz function but also to the field strengths are obtained by enclosing the aerial in a prismatic or cylindrical resonance space with a polygonal or curved cross-section. The cylindrical surface C for enclosing the aerial A as shown in Figure 3, may preferably be closed by a further reflecting or absorbing surface F or the cylinder may be closed on both sides and be in communication with the exterior only through a window. If C is taken as a perfectly conducting circular cylinder the resonance frequencies have a simple relation to the zero values of the Bessel function J_0 .

If r is the radius of the cylinder, c the velocity of light, ω the angular frequency of the electromagnetic oscillations that is, the number of oscillations in 2π seconds, $k\tau$ one of the zero values of the Bessel function J_0 , ϵ the dielectric constant, and μ the permeability of the medium enclosed by the cylinder, in the case of resonance the following relation holds:

$$r\omega\sqrt{\epsilon\mu} = ck\tau$$

It must be pointed out that the spaces capable of resonating may be produced in many other manners, that the boundary surfaces may be spherical, ellipsoidal or of any other shape provided the space enclosed by them has fundamental electromagnetic frequencies and further, that the aerial need not necessarily lie within these spaces and that any kind of transmitting or receiving apparatus can be used. The arrangements described fully above are to be regarded only as special examples employed for explaining the invention. In general also, it is possible to tune the apparatus exactly to resonance or to dispense with sharp resonance, to make the apparatus regulable by making the boundary surfaces adjustable, to obtain special screening or directional effects by providing additional reflecting or absorbing surfaces and to make use of the surface of the earth as a boundary surface.

Figs. 1a, 2a and 3a show constructional examples of resonance spaces with adjustable boundary surfaces. In Fig. 1a the distance between the two plates is altered by means of pulley blocks R . In Fig. 2a the plate E_1 is guided in slots S in the side surface F by means of clamping screws K . In Fig. 3a the cylindrical surface C is adjusted by varying the overlap of the ends and securing by means of the clamping screws L .

What I claim is:

1. In apparatus for signaling by means of electromagnetic waves, the combination of an antenna with reflectors near to the antenna, the reflectors enclosing a space having a natural frequency approximately coinciding with the frequency of the electromagnetic waves.

2. In apparatus for signaling by means of electromagnetic waves, the combination of an antenna with two plane parallel reflectors, one on each side of the antenna, the distance between the reflectors being approximately an integral multiple of the half wave length of the electromagnetic waves.

3. In apparatus for signaling by means of electromagnetic waves, the combination of an antenna with a cylindrical reflector surrounding the antenna, a natural frequency of the space enclosed by the cylindrical reflector being approxi-

mately equal to the frequency of the electromagnetic waves.

4. In apparatus for signaling by means of electromagnetic waves, the combination of an antenna with a cylindrical reflector surrounding the antenna, the dimensions of the reflector agreeing with the formula

$$r\omega\sqrt{\epsilon\mu} = ck\tau$$

where r is the radius of the cylinder, c the velocity of light, ω the angular frequency of the electromagnetic oscillations, $k\tau$ one of the zero values of the Bessel function J_0 , and ϵ the dielectric constant and μ the permeability of the medium enclosed by the cylindrical reflector.

5. In apparatus for signaling by means of electromagnetic waves, the combination of an antenna with a prismatic reflector surrounding the antenna, a natural frequency of the prismatic space enclosed by the reflector being approximately equal to the frequency of the electromagnetic oscillations.

6. In apparatus for signaling by means of electromagnetic waves, the combination of an antenna with reflectors near to the antenna, the reflectors enclosing a space of which a natural frequency is approximately equal to the frequency of the electromagnetic oscillations and with screening surfaces adapted to prevent radiation in certain directions.

7. In apparatus for signaling by means of electromagnetic waves, the combination of an antenna with two plane parallel reflectors on both sides of the antenna, the distance between the reflectors being approximately an integral multiple of the half wave length of the electromagnetic waves and means for adjusting the distance between the reflectors so that it can be adapted to different wave lengths.

8. In apparatus for signaling by means of electromagnetic waves, the combination of an antenna with a plane reflector parallel to the surface of the earth and disposed above the antenna, the distance of the reflector from the surface of the earth being approximately an integral multiple of the half wave length of the electromagnetic waves.

9. In apparatus for signaling by means of electromagnetic waves, the combination of an antenna with reflectors near to the antenna, which reflectors, together with the surface of the earth, enclose a space of which the natural frequency is approximately equal to the frequency of the electromagnetic oscillations.

10. A combination of an antenna with reflectors near to the antenna, which reflectors, together with the surface of the earth, enclose a space of which a natural frequency is approximately equal to the frequency of the electromagnetic oscillations and with conducting surfaces which are adapted to prevent radiation in certain directions.

11. In apparatus for signaling by means of electromagnetic waves, the combination of an antenna with reflectors near to the antenna, the reflectors enclosing a space having a natural frequency approximately coinciding with the frequency of the electromagnetic waves and means for adjusting the space enclosed by the reflectors so that it can be adapted to different wave lengths.

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