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F. A. KOLSTER

1,828,705

RADIO SYSTEM

Filed May 21, 1928

FIG. 1.

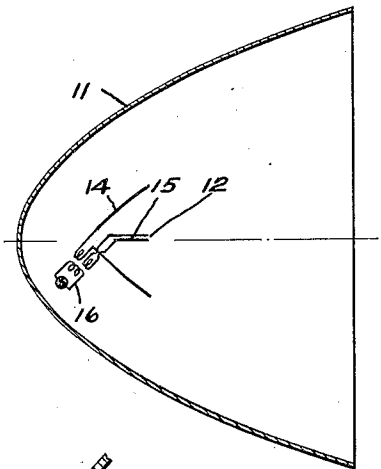


FIG. 2.

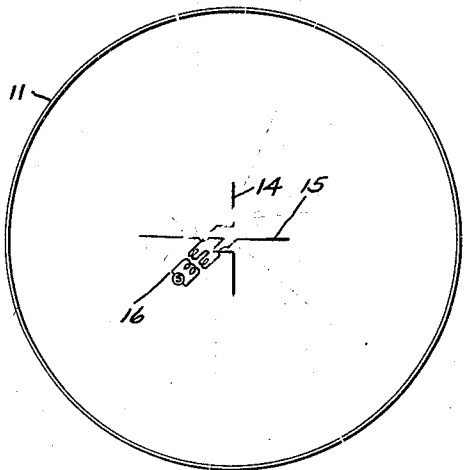


FIG. 3.

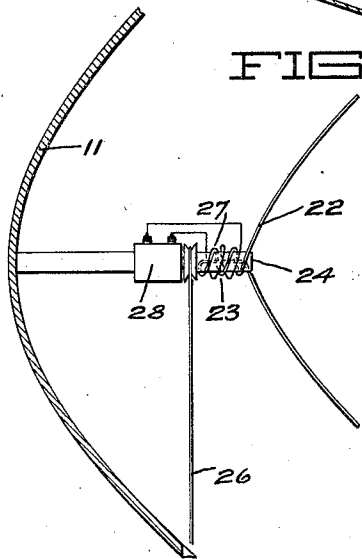


FIG. 4.

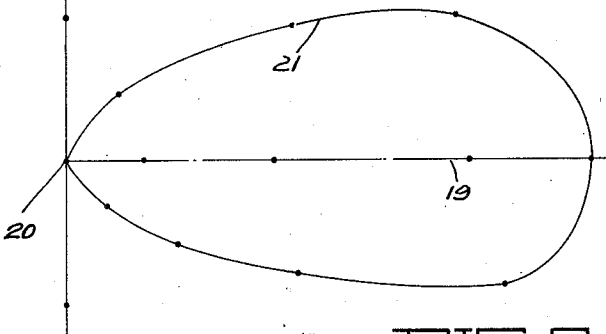


FIG. 6.

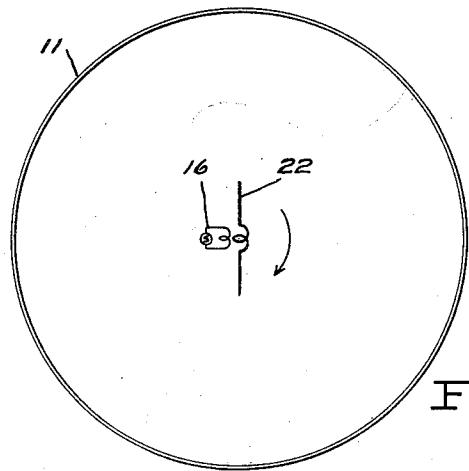
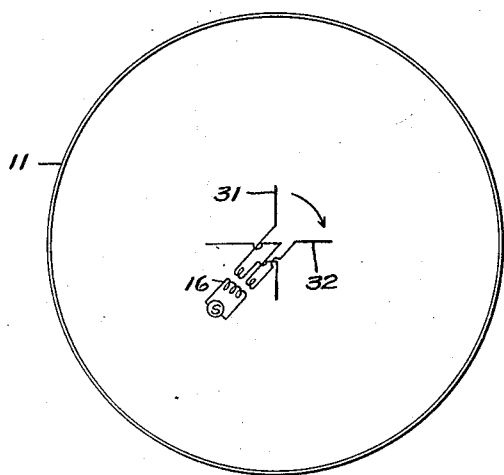


FIG. 5.

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RADIO SYSTEM

Application filed May 21, 1928. Serial No. 279,243.

This invention relates to radio signaling systems and particularly to directive radio communication systems.

A broad object of the invention is to decrease fading and generally increase the reliability of radio signaling under varying atmospheric conditions.

In accordance with the invention the above objects are attained by transmitting waves having both a horizontally and a vertically polarized component, so that even though conditions may be unfavorable for the propagation of a wave polarized in one plane, the component of the wave polarized in another plane may be propagated to successfully transmit the desired signal.

Referring to the drawings:

Figure 1 is a side elevational view in cross section illustrating diagrammatically an apparatus incorporating the principles of this invention.

Fig. 2 is a front view of the apparatus as shown in Fig. 1.

Fig. 3 is a side elevational view in cross section illustrating an apparatus utilizing a rotatable antenna.

Fig. 4 is a curve illustrating the directional characteristics of apparatus such as shown in Figs. 1 and 2.

Fig. 5 is a front view of apparatus such as shown in Fig. 3, with the antenna means and signaling circuit shown diagrammatically.

Fig. 6 is a front view of apparatus utilizing both cross conductors for antenna means, and a rotatable antenna.

My invention may be outlined briefly as incorporated a novel form of antenna and method of operating the same. As to certain features, the invention herein disclosed is an improvement over the apparatus disclosed in the copending application of Kolster and Kruesi, No. 279,244 filed May 21, 1928. In that application there is disclosed a radio system utilizing a reflector having the approximate shape of a paraboloid, and having antenna means arranged near its focal center. With such apparatus, if the antenna means is excited with radio current of a correct wave length and in such a manner as to secure proper current distribution, a true

beam of electromagnetic radiation will be projected from the reflector. The antenna means described in that application is in the form of an extended conductor coupled at its medial portion to a signaling circuit. The conductor is formed so that the direction of current flow is substantially parallel to the reflecting surface, is symmetrical with respect to the axis of the reflector and is arranged so that oscillatory current surges occur back and forth laterally with respect to the reflector axis. With such an arrangement, tho the field is in the form of a true beam, it is polarized according to the position of the antenna conductor. For example if the conductor is arranged in a vertical plane, the plane of polarization is vertical, while if the plane of conductor is arranged in a horizontal plane, the polarization is horizontal. Furthermore because of the position occupied by the single extended conductor within the reflector, the electromagnetic beam produced is not uniform. In other words if the characteristics of such an apparatus employed for transmission were plotted for different planes coincident with the axis of propagation, the characteristic curve along one plane, say the vertical plane would not be the same as the characteristic curve plotted along another plane, say the horizontal.

In this invention I utilize a concentrated field of radiation in the form of a true beam which includes both vertically and horizontally polarized components. Furthermore the field is more uniform than that of the apparatus disclosed in the above noted copending application. To obtain these results there is utilized in accordance with this invention, at the transmitting station end an antenna radiator which extends in two dimensions rather than along a single dimension. It is preferred to arrange this radiator near the focal center of a paraboloidal reflector, as in the case of said copending application. It is also proposed to effect rotation of the antenna structure in order to secure certain desirable effects.

In Figs. 1 and 2 of the drawings there is shown apparatus which is somewhat similar to the apparatus disclosed in the above co-

pending application. This apparatus consists of a reflector 11 in the form of a surface of complete revolution which has at least an approximate focal center. For optimum operation it is desirable to employ a reflector which approximates a true paraboloid. The reflector may be formed of any highly conductive material, such as copper sheathing or copper mesh. The focal center of this reflector has been indicated at 12, at which point there is arranged the antenna means 13 which is employed to absorb or radiate radio energy. As explained above, the conducting material forming the antenna means 13 preferably extends in two dimensions. In the preferred embodiment shown this is made possible by utilizing a plurality of elongated conductors 14 and 15 which cross at their centers and which extend laterally with respect to the axis of the reflector.

The signaling circuit which is utilized, whether the apparatus is employed for transmitting or receiving signals, is coupled to both conductors 14 and 15. For example there is shown diagrammatically a signaling circuit 16 coupled to an inductance 17, and this inductance is coupled to the mid-points of conductors 14 and 15. In Fig. 2 there is shown only two conductors 14 and 15 which are arranged at right angles to each other. Two conductors have given good results and provide a simple structure, although it is obvious that more than two conductors may be employed.

The wave length of energy to be received or supplied by the signaling circuit 16 preferably bears a definite relationship to the focal length of the paraboloid 11. It has been found that best results can be obtained if this wave length is equal to four times the focal length. However the focal length may be any odd multiple of the quarter wave-length. For example if the focal length is one meter, best results can be obtained by operating the signaling circuit 16 upon four meters. However a wave length of $1\frac{1}{2}$ meters may also be employed. In any event the wave length should not materially exceed four times the focal length. In order to reduce and better distribute the capacitance between conductors 14 and 15 and the reflecting surface 11, it is preferred to bend conductors 14 and 15 so that they fall within the surface of a paraboloid similar to the reflector 11 and having its axis coincident therewith. This arrangement is shown in Fig. 1, in which conductor 14 has been shown in a vertical position and conductor 15 horizontal.

Assuming that the apparatus is employed for transmission purposes, when high frequency energy of proper wave length is applied to the conductors 14 and 15 from signaling circuit 16, a true beam of radiation will be projected from the paraboloid reflector 11.

A typical characteristic curve for this beam is shown in Fig. 4. Horizontal axis 19 represents the direction of maximum radiation while the point 20 represents the source of radiation, which in this case is the opening of the reflector. Curve 21 represents in polar coordinates the characteristics of the apparatus substantially as shown in Figs. 1 and 2, and was plotted from field strength measurements made at various points equidistant from the reflector. The distance measured along a straight line from the origin 20 to any point on curve 21, represents the relative quantity of energy radiated in the direction of that line.

An analysis of the characteristics of a transmitting system utilizing the above apparatus, shows that the radiation throughout a cross section of the radiated beam is fairly uniform. If a single linear conductor is employed for a receiver, and this conductor is arranged so that it extends substantially at right angles to the direction of received radiation then as the receiving end is turned about such axis, the intensity of received signals will vary a certain amount but will not reduce to zero for any position. In other words the beam of radiation consists of both horizontally and vertically polarized components, and these components can conjointly affect a receiving antenna, provided of course that the antenna at the receiving station is capable of receiving both horizontal and vertical components. Such a receiver may be had by utilizing apparatus substantially the same as that shown in Figs. 1 and 2, that is, apparatus making use of antenna means having conductive material, extending in two dimensions.

It is believed that a beam of radiation such as is projected from apparatus such as described is more effective for radio signaling than are radio waves polarized in only one direction. Under certain conditions of transmission, one component may not carry through to the receiving station, but in such case the probabilities are that the other component will carry thru to affect the receiver.

In Figs. 3, 5 and 6 there is shown other apparatus capable of being operated in such a manner as to secure more uniform transmission between two stations. In this case the antenna means placed within the paraboloidal reflector 11 is bodily rotated about the axis of the reflector. Thus as indicated diagrammatically in Fig. 5, a simple antenna conductor 22 is arranged near the focal center of the reflector and is coupled to a signaling circuit 16. Suitable means is provided for bodily spinning it about the focal center and the reflector axis. With such an arrangement it is apparent that at any one instant, the radiation field will be polarized in one plane, depending upon the position of the conductor 22, but as this conductor is

rotating, the plane of polarization likewise rotates. The conductor 22 is preferably rotated sufficiently fast to change the plane of polarization at a frequency which is at least high enough to be musical. Assuming that such an apparatus is employed with a receiving antenna polarized chiefly in one plane, the energy received by the antenna varies according to the rotation of conductor 22, and if this rotation is at a sufficient rate, the received energy will vary at a frequency which is at least musical. It is apparent that this makes possible a system in which the received energy is modulated, without however modulating the energy in the signaling circuit 16. The receiving antenna can also be rotated about an axis substantially parallel to the direction of propagation of received radiation. Where the receiving antenna is rotated at the same rate as the transmitting antenna conductor, no modulation effect is produced, but when the receiving antenna is rotated at a rate of rotation other than that of the transmitting antenna, received energy is modulated at a frequency determined by the algebraic difference between the rates of rotation.

In addition to making possible a system of modulation, rotating the antenna means makes possible more uniform transmission under conditions in which waves polarized in one plane may be attenuated to a greater extent than waves polarized in other planes. It has been previously determined by other investigators that when received radio energy has been refracted or reflected to a substantial degree by the Heavyside layer, its plane of polarization is frequently changed. Such polarity changes may cause fading effects and non-uniform reception. In the case where the plane of polarization of the transmitted beam is continually changed there should be no changes in the strength of received signals in response to changes in the plane of polarization caused by the Heavyside layer. The apparatus described with reference to Figs. 3, 5 and 6, can therefore be used to advantage in systems in which the field of radiation is directed upwardly toward the Heavyside layer.

In Fig. 3 there is illustrated a practical apparatus such as indicated diagrammatically in Fig. 5. In this case the antenna conductor 22 is formed with an inductance 23 in its intermediate portion. Conductor 22 is mounted upon a spindle 24, and suitable means such as a belt 26 is provided for effecting rotation of spindle 24 and antenna conductor 22. Inductance 23 is preferably arranged concentric with the axis of rotation, and is coupled to a suitable signaling circuit as by means of another inductance 27. In this particular instance conductor 27 has been shown as connected to a transmitting oscillator located for example within a housing

28. As has been previously specified, the medial portion of conductor 22 is approximately at the focal center of the reflector 11.

In Fig. 6 there is illustrated a slight modification of an apparatus in which the antenna is rotated, and in this case the antenna means consists of a plurality of cross conductors 31 and 32, coupled to the signaling circuit 16 in the manner as explained with respect to Figs. 1 and 2. As has been previously explained when utilizing such crossed antenna conductors, the beam of radiation at any one instant is more uniform. Furthermore at any one instant the polarization is in two dimensions, depending upon the directions of conductors 31 and 32. While the arrangement of Fig. 2 secures a more uniform beam of radiation than is possible by utilizing a single antenna conductor, the arrangement of Fig. 6 carries such uniformity to a greater degree.

The apparatus described above is particularly effective for securing beam transmission of radio waves. It is apparent that when it is employed for transmission purposes, ordinary forms of antennas may be employed at the receiving end. However in order to obtain the greatest benefit from the directional characteristics of the system, it is preferred to employ similar highly directive apparatus at the receiving end. When rotation of the antenna means at the transmitting end is resorted to, the antenna conductor at the receiving end can be stationary or can also be rotated to secure certain special effects. Furthermore it is possible to transmit without a rotating antenna, and to use a rotating antenna at the receiving end.

I claim:

In a radio system, a reflector approximating a paraboloid and formed of conducting material, antenna means disposed near the focal center of the reflector, and means for rotating said antenna means.

In testimony whereof, I have hereunto set my hand.

FREDERICK A. KOLSTER.