Sept. 13, 1932. G. G. KRUESI 1,876,694

RADIO SYSTEM AND METHOD

Filed May 21, 1928

FIG. 1.

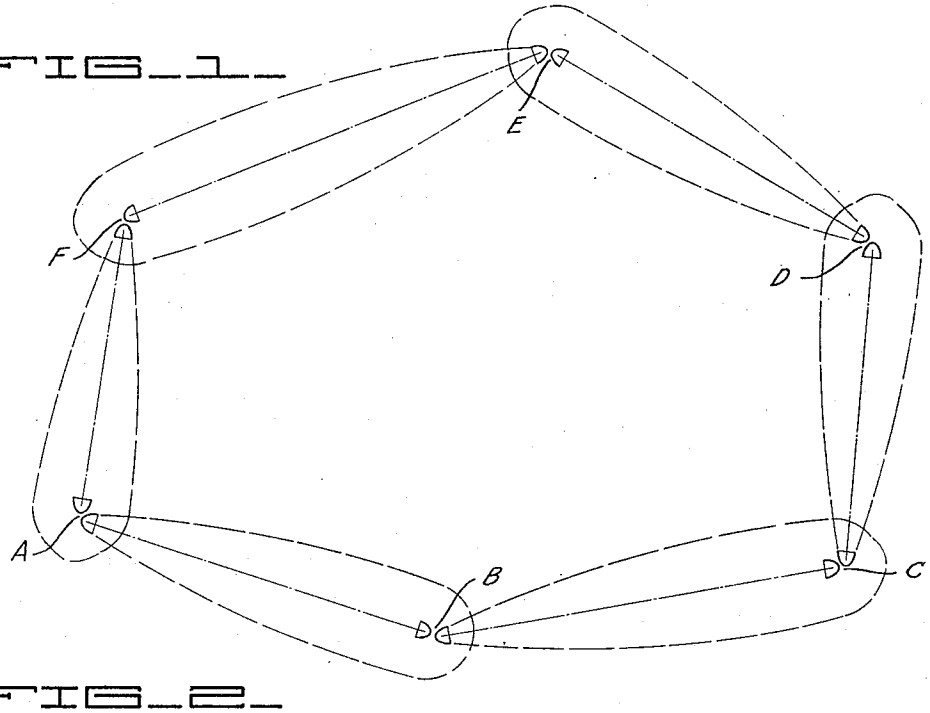


FIG. 2.

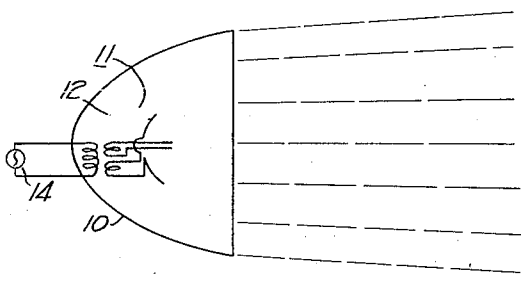
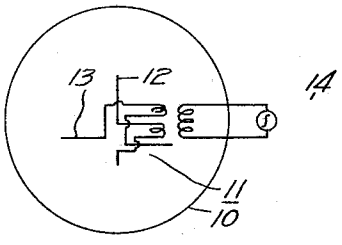


FIG. 3.



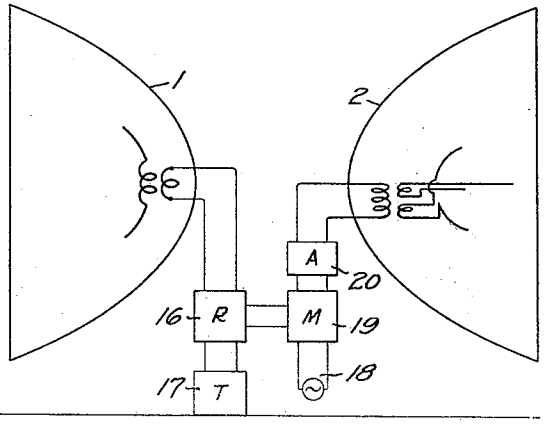


FIG. 4.

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UNITED STATES PATENT OFFICE

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RADIO SYSTEM AND METHOD

Application filed May 21, 1928. Serial No. 279,293.

This invention relates generally to systems and methods of effecting transmission of radio energy between two or more stations. It has particular application to radio signaling systems utilizing directional radio antennæ.

It is an object of this invention to make radio signaling systems more reliable and uniform in operation, and to render them immune from fading effects.

Briefly, the above object is attained by utilizing for the transmission of radio signals that component of the transmitted signal which follows the surface of the earth (commonly termed the ground wave) to the exclusion of the high angle radiation, and reducing the attenuation of the ground wave by transmitting a wave having both horizontally and vertically polarized components.

Referring to the drawing:

Figure 1 illustrates diagrammatically a plan view of a radio network incorporating the principles of this invention.

Fig. 2 is a side elevational view illustrating diagrammatically a transmitting apparatus for producing ground waves.

Fig. 3 is a front view of the apparatus shown in Fig. 2.

Fig. 4 is a diagram illustrating schematically transmitting and receiving apparatus for one of the stations of the network shown in Fig. 1.

Experiments have indicated that the energy radiated from the usual antenna divides into two parts, one of which is commonly termed the "ground wave" and which spreads out horizontally from the source of radiation and is propagated immediately above the surface of the ground, while the other consists of radiations which are reflected upward from the earth's surface toward the Heavyside layer. In ordinary radio systems, communication is effected by the energy of the reflected waves, that is waves which at the transmitted end are directed upward from the ground surface toward the Heavyside layer and which are probably reflected one or more times from the Heavyside layer before being received. It is a commonly accepted fact that with the usual present day radio systems, reception is not always reliable and is subject to frequent fading. The theory has been advanced that this fading is due to shifting of the Heavyside layer due to changing climatic and atmospheric conditions. The ground waves which are sent out from the present day transmitting antennæ, generally die out within the short distance of from 10 to 20 miles, and therefore are not received unless the receiving station happens to be comparatively close to the transmitting station.

As disclosed in copending application No. 279,244 filed in the joint names of Kolster and Kruesi, which is assigned to the assignee of this application, is it possible to concentrate radio waves in the form of a true beam by the proper use of a paraboloidal reflector. I have made the discovery that radio ground waves, which were previously considered to be of little value for radio communication between remote points, can be transmitted considerable distances by utilizing a paraboloidal reflector to concentrate substantially all the radiated energy along the surface of the ground. I have also found that when properly polarized, the concentrated radio waves follow the surface of the ground and are not reflected toward the Heavyside layer to any extent.

In Fig. 2 of the drawing I have shown diagrammatically a transmitting apparatus somewhat similar to that shown in the above copending application. This apparatus consists of a paraboloidal reflecting surface 10 made of conducting material such as sheet copper, and having an antenna radiator 11 placed at its focal center. The radiator in this case consists of crossed antenna conductors 12 and 13, which have their midpoints coupled to a suitable signaling circuit 14. With such an apparatus, assuming that the signaling circuit 14 supplies oscillatory energy of the proper frequency to the radiator 11, which preferably is of a frequency four times the focal length of the reflector, a true beam of electromagnetic radiation is projected from the reflector. If the radiator 11 consists of a single conductor arranged in a vertical plane, then the polarization of the waves is vertical, and similarly if it consists

of a single conductor in a horizontal plane, the polarization is horizontal. By utilizing two conductors 12 and 13 extending in different planes, one in this case being horizontal and the other vertical, the transmitted wave consists of both horizontally and vertically polarized components. By directing the axis of the reflector along the surface of the ground, the radiated waves can be propagated parallel to the ground surface so as to transmit intense ground waves in any desired direction.

In order that the ground waves may effectively be transmitted comparatively great distances, the radiation field should have a horizontal component, as vertically polarized waves are quickly absorbed by the ground. However a certain vertical component is to be desired. Therefore for the method of my invention, I prefer to employ apparatus such as that described above which propagates waves having a horizontally polarized component and at least an appreciable vertically polarized component.

As has been previously explained, with the apparatus described, ground waves of great intensity may be propagated for comparatively great distances and they can be readily received at distances of from 200 to 500 miles from the transmitter. Such ground waves are entirely independent of conditions of the Heavyside layer, and therefore continuous and reliable communication can be had between a transmitting and receiving station, irrespective of changing climatic conditions, without experiencing fading effects.

At the receiving station I prefer to employ apparatus somewhat similar to the transmitting apparatus shown in Fig. 2. In other words I prefer to employ a paraboloidal reflector having antenna means positioned adjacent its focal center. No particular form of antenna means is essential except that it should be constructed so as to receive vertically polarized waves. A receiving apparatus utilizing a paraboloidal reflector with its axis horizontal is desirable since the reflector tends to shield the antenna means from interfering waves reflected down from the Heavyside layer.

In Fig. 1 I have shown a complete network utilizing the method described above. As the ground waves which I employ will not carry over great distances such as are now covered by radio systems, I preferably utilize a network consisting of a number of relay stations which receive and retransmit ground waves. For example I have shown a network consisting of spaced stations A, B, C, D, E, and F, which are each located sufficiently close together, say from 300 to 400 miles apart, so that any one station can receive ground waves from a preceding or succeeding station. Assuming that only one way transmission is to be effected throughout this network, each station is provided with a ground wave receiving and transmitting apparatus, and signals received upon ground waves may be retransmitted upon ground waves.

A diagrammatic arrangement of apparatus for such a relay station is shown in Fig. 4. Thus I have shown a reflector type of receiving apparatus 1 capable of receiving ground waves such as I employ in the method of this invention, and having its antenna means coupled to a suitable receiver 16. Signal energy detected by this receiver is applied to a local translator 17. A transmitting apparatus 2 similar to that previously described is also provided, and is supplied with energy from a suitable signaling circuit consisting for example of the oscillator 18, modulator 19, and power amplifier 20. A connection is shown directly between the receiver 16 and modulator 19, so that signals may be directly relayed and retransmitted upon ground waves.

It will be apparent that while the method of this invention will not permit direct transmission of signals between two stations located extreme distances apart as with other radio systems, it will make possible systematic radio networks which will operate as reliable as present day wire networks.

I claim:

1. The method of signaling over long distances by radio signal energy comprising generating radio waves at one station, concentrating said waves in one direction substantially entirely in the form of ground waves, receiving energy of said ground waves at a remote point, relaying the received signal energy by retransmitting ground waves similar to said first ground waves, and receiving energy of said retransmitted waves at a remote station.

2. A radio communication system comprising a transmitting and a receiving station, a paraboloidal reflector having its axis substantially tangent to the earth's surface with radiating means mounted therein having both a horizontal and vertical component at the transmitter, and a paraboloidal reflector at the receiver having its axis substantially tangent to the earth's surface and having therein as the sole essential absorbing element, a conductor lying in a vertical plane intersecting the transmitter and receiving stations.

In testimony whereof, I have hereunto set my hand.

GEOFFREY GOTTLIEB KRUESI.