Aug. 25, 1931. G. G. KRUESI 1,820,571

RADIOANTENNA SYSTEM

Filed March 27, 1928

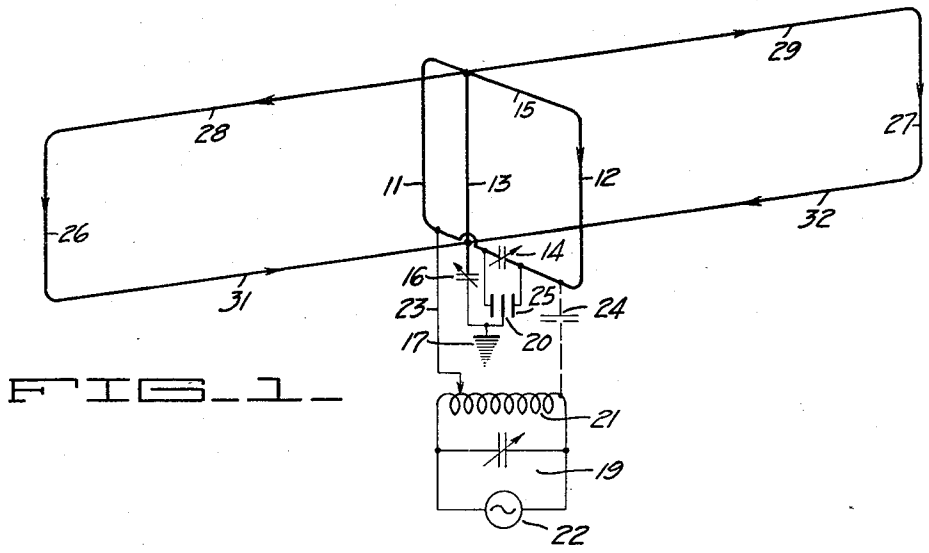


FIG. 1.

FIG. 2.

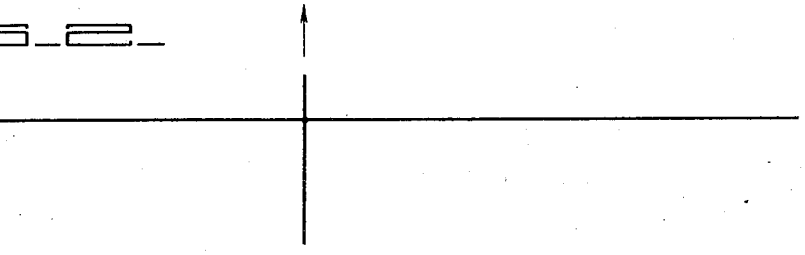
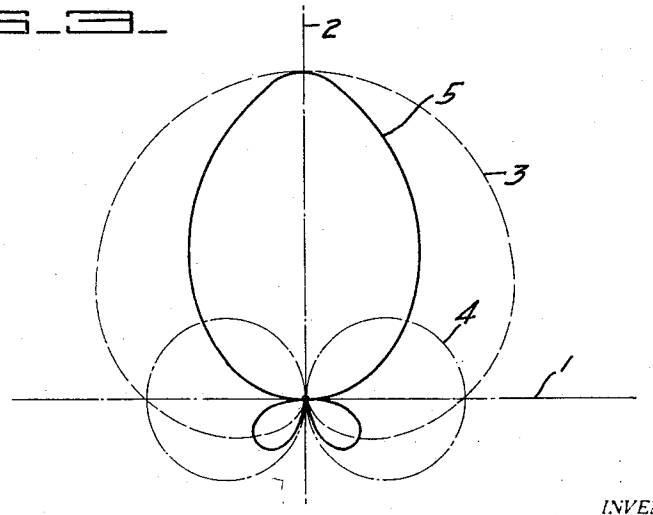


FIG. 3.



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UNITED STATES PATENT OFFICE

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RADIOANTENNA SYSTEM

Application filed March 27, 1928. Serial No. 265,029.

This invention relates to directional wave signaling systems and has for its principal object to obtain, without the use of reflectors, a sharply directional characteristic—and particularly a degree of sharpness more pronounced than that commonly represented by the well known cardioid figure.

A further object is to achieve the above described result with compact and preferably inexpensive equipment.

Referring to the drawings:

Figure 1 is a perspective view illustrating the antenna system of my invention.

Fig. 2 is a plan view of the antenna system shown in Fig. 1.

Fig. 3 illustrates the individual characteristics of the two antennæ forming the system shown in Figs. 1 and 2, and also shows the resulting characteristics of the system.

In the co-pending application of Kolster and Kruesi, Serial No. 255,888 filed February 21, 1928 there is disclosed and claimed a uni-directional radio antenna in which the conductors are arranged within a relatively compact space. The directional characteristics of such a system have been found to approximate a cardioid. Although an antenna having directional characteristics corresponding to a cardioid is sufficiently directional for many purposes, it is desirable in some instances to utilize antenna systems having more accentuated directional characteristics. In accordance with this invention I propose to accentuate the directional characteristics of an antenna system, by employing an antenna having substantially unidirectional characteristics, as for example an antenna of the kind disclosed in the above copending application which has the characteristics of a cardioid, together with another bilaterally directional antenna.

Referring to the drawings for a detailed description of my system and method, I have shown a unidirectional antenna of the type disclosed in my copending application No. 255,888 which may be outlined briefly as comprising a plurality of antenna conductors 11 and 12. In order to obtain a desired distribution of energy in these conductors, they are preferably included as opposite sides of a single looped conductor, the loop being tuned by means of a capacitance 14 connected across its terminals. The loop construction provides a conductor 15 interconnecting conductors 11 and 12. Extending across the loop, and in spaced relationship to conductors 11 and 12, is a third antenna conductor 13 which is connected to conductor 15 at a point intermediate of conductors 11 and 12, and which preferably extends substantially parallel with respect to antenna conductors 11 and 12.

The lower end of conductor 13 is connected to ground, or other point of neutral potential with respect to the loop, through a phase shifting device such as variable capacitance 16. It is evident that the current in any one of the conductors 11, 12, or 13 is equal to the vector sum of the current in any of the other two conductors, and, that the relative phase displacement between the current in different conductors may be varied to a certain extent by adjusting condenser 16.

Coupled to the antenna system is a suitable signaling circuit shown conventionally at 19, which may be a radio receiver or a source of oscillations. As my system has been particularly effective for transmission of radio signals, I have shown the signaling circuit 19 as comprising a tuned inductance 21 or other suitable oscillatory circuit, supplied with energy from an oscillation generator 22. The oscillatory circuit of the generator is preferably coupled to the loop in such a manner as to secure a non-symmetrical distribution of current in the several conductors. To secure this result I have shown the high potential side of inductance 21 connected to one side of the loop by means of the conductor 23, the other side of the loop being coupled to the oscillatory circuit of the oscillation generator by means of its distributed capacitance, represented by the capacitance 24.

The current distribution in the loop is preferably adjustable, as by suitable means, such as a central electrode 20 capacitatively related and adjustable with respect to elec-

trodes 25, these electrodes 25 being connected to the loop ends. Electrode 20 is likewise connected to a point of neutral potential, such as the ground 17.

With a proper distribution of current in the loop, a nodal point will not fall at the point of connection between conductors 13 and 15, and therefore current flow occurring thru antenna conductor 11 will branch and part will flow thru antenna conductor 12, while another part will flow thru the third antenna conductor 13. These currents, which I may identify as I_1, I_2, and I_3, corresponding respectively to the currents in conductors 11, 12 and 13, preferably have their phase angles adjusted with respect to each other so that the antenna has substantially unidirectional characteristics. The phase angle of current I_3 is adjusted as by means of variable condenser 16 and when operating under conditions of proper current distribution and phase angles, the characteristics of the antenna will approximate a cardioid.

In my work with antennæ of the kind described above, I have found that a loop of a given size will operate best upon one given wave-length. I have also found that for a given wave-length, the total length of the loop should be slightly less than one-quarter of that of the wave to which the loop is tuned. I also prefer to space conductors 11 and 12 a distance apart equal to about $\frac{1}{10}$th to $\frac{1}{15}$th of the wave-length which it is desired to employ.

In Fig. 3 I have shown a curve 3 plotted upon polar axes 1 and 2, which curve approximates a true cardioid and represents the characteristics of the antenna described above. Substantially all of the energy transmitted is concentrated in one direction, represented by the axis 2. As a means for obtaining a more sharp directional system, I have shown another pair of antenna conductors 26 and 27 which are arranged on opposite sides of the plane containing antenna conductors 11 and 12. In order to cooperatively associate these conductors 26 and 27 with the signaling circuit, I preferably couple the same directly to conductor 13. Conductors 26 and 27 are therefore shown as connected to the junction between conductors 13 and 15, by means of conductors 28 and 29, while the other ends of antenna conductors 26 and 27 are connected to the other end of antenna conductor 13, by means of conductors 31 and 32. Conductors 26 and 27 are preferably arranged in a plane with conductor 13, and this plane is preferably arranged substantially at right angles to the plane of conductors 11 and 12. Each of the conductors 26 and 27 may be considered as forming portions of two separate loops, completed by conductor 13 in common. Since conductors 26 and 27 are connected in shunt with conductor 13, assuming a downward flow of current in conductor 13 corresponding to an upward flow of current in conductor 11, and a downward flow of current in conductor 12, corresponding downward flows of current will occur in both conductors 26 and 27.

As is well known, if two antenna conductors are excited by currents in phase and are spaced apart one-half a wave length, the combined effect is to concentrate the radiated energy in two opposite directions along an axis at right angles to the plane of the conductors. Theoretically the characteristics of such a system approximate a figure 8. Therefore assuming that conductors 26 and 27 are spaced apart a distance equal to one-half the wave length of the exciting energy, then their combined effect may be represented by a figure 8 as shown by curve 4 of Fig. 3.

In Fig. 3 curve 4 is plotted along an axis at right angles to the axis of cardioid 3. Ordinarily as explained above the effect of conductors 26 and 27 would be represented by a curve having its axis of maximum directional strength at right angles to the plane of spaced conductors 26 and 27. However in my system conductors 26 and 27 are coupled to conductor 13 and are therefore excited by current out of phase with the current in conductors 11 and 12. Accordingly the energy radiated from conductors 26 and 27 is out of phase with the energy radiated from the remainder of the system as represented by cardioid 3, the amount of phase difference being actually in the neighborhood of 90 degrees. This difference in phase can be conveniently represented by plotting curve 4 on an axis arranged at an angle of 90 degrees with respect to the axis of curve 5. The resultant characteristic curve 5 of the combined system is obtained by subtracting curve 4 from the cardioid 3. This result characteristic curve is more accentuated along the direction of axis 2, thus indicating that less energy is being transmitted in directions other than parallel to axis 2.

Theoretically the best directional effects can be obtained by placing conductors 26 and 27 approximately one-half wave length apart. In practice however to avoid structural difficulties, I prefer to position conductors 26 and 27 somewhat closer together. The combined characteristics of conductors 26 and 27 taken alone will then be bilaterally directional but will be a modified figure 8. For all practical purposes such a modified figure 8 is sufficient to secure the desired results of this invention. Whatever spacing is employed between conductors 26 and 27, I prefer to arrange the same symmetrically upon opposite sides of the plane of conductors 11, 12 and 13, except where they

may be shifted to an unsymmetrical position to distort the resultant characteristics.

It is apparent that the antenna may be built of a self supporting structure of rigid metal rod or tubing. It may also be mounted upon a rotatable and tiltable support in order to facilitate interchange of signals between any two stations.

My invention may be embodied in a wide variety of antenna systems and the particular construction shown and described can be materially simplified. For example I can dispense with tuning condenser 14 and can rely upon the capacitance between electrodes 25 for tuning the loop. Likewise the system will operate without the ground connection 17 and with condenser 16 connected to electrode 20.

I claim:

1. In an antenna system, an antenna comprising a pair of spaced conductors forming opposite sides of a loop, a third conductor extending in the general direction of said pair of conductors, phase shifting means associated with said third conductor, another antenna comprising a pair of spaced conductors arranged in a plane at an angle to the plane of said pair of conductors and on opposite sides thereof, means for combining said antennæ, and a signaling circuit cooperatively associated with both said antennæ.

2. In an antenna system, an antenna comprising a pair of spaced conductors forming opposite sides of a loop, a third conductor extending in the general direction of said pair of conductors, phase shifting means associated with said third conductor, another antenna comprising a pair of spaced conductors arranged in a plane at an angle to the plane of said pair of conductors and on opposite sides thereof, means for coupling said last named conductors to said third conductor, and a signaling circuit cooperably associated with the antennæ.

3. In an antenna system, an antenna comprising a loop, a conductor extending across said loop, phase shifting means associated with said conductor, a pair of conductors arranged on opposite sides of the general plane of the loop, means for coupling said last named conductors to said first named conductors, and a signaling circuit associated with said antennæ.

In testimony whereof, I have hereunto set my hand.

GEOFFREY GOTTLIEB KRUESI.