Feb. 23, 1943. M. A. ROTE 2,311,872

ANTENNA SYSTEM

Filed April 12, 1941 2 Sheets-Sheet 1

FIG. 1.

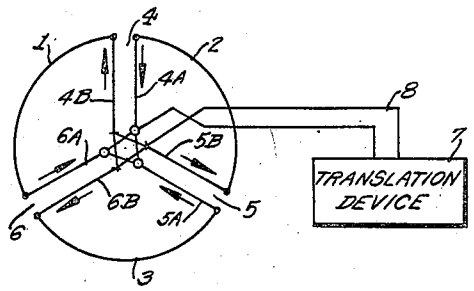
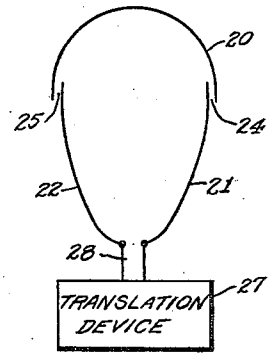


FIG. 2.



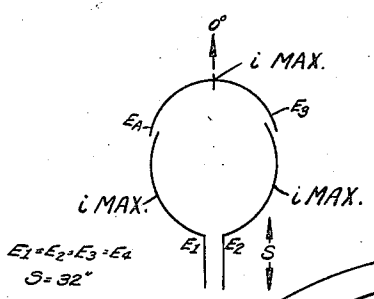


FIG. 4.

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Feb. 23, 1943. M. A. ROTE 2,311,872

ANTENNA SYSTEM

Filed April 12, 1941 2 Sheets-Sheet 2

FIG.3.

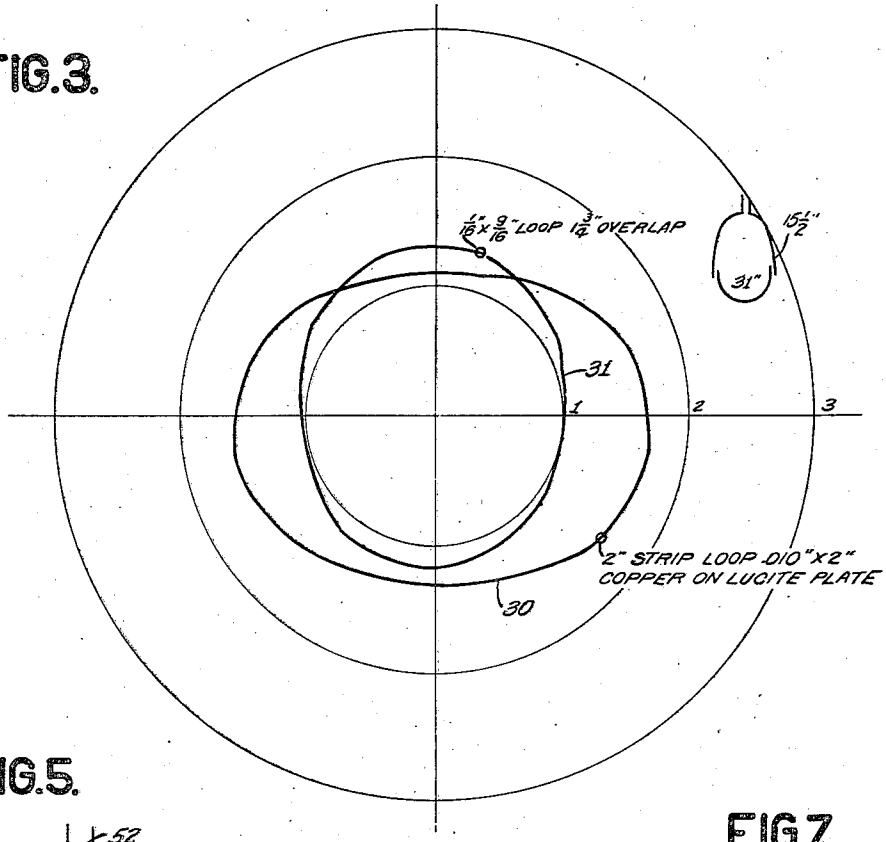


FIG.5.

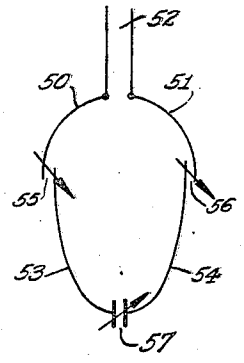


FIG.6.

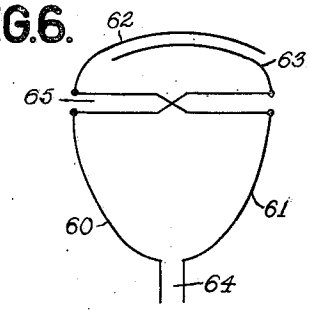
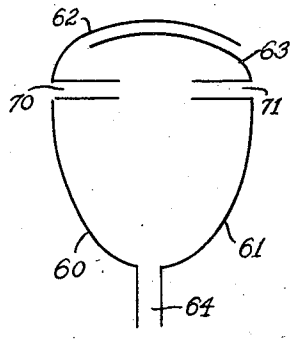


FIG.7.



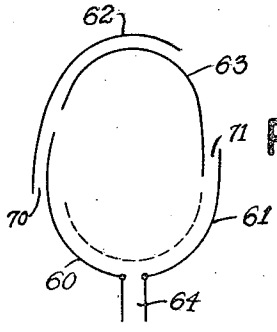


FIG.8.

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2,311,872

ANTENNA SYSTEM

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Application April 12, 1941, Serial No. 388,223

5 Claims. (Cl. 250—33)

This invention relates to improvements in antenna systems and more particularly to antenna systems of the high frequency loop type.

High frequency loop type antennae have been proposed having certain desirable features in simplicity of construction. One such type of high frequency loop antennae is disclosed in the application of Andrew Alford, entitled "Antenna systems," Ser. No. 270,173, filed April 25, 1939, Patent No. 2,283,897, granted May 26, 1942. This high frequency loop antenna particularly when designed to operate with two radiant acting elements suffers from the difficulty that voltage maxima occur at the feeding point of the loop. This loop when applied to aircraft has the voltage maximum points aligned with the longitudinal axis of the craft. Thus, sleet formations tend to detune the loop, being deposited at a relatively high impedance point. This can be partly overcome by providing a covering arrangement around the loop but such covers increase the air drag and are, therefore, undesirable. The construction of the loop does not lend itself readily to mounting if turned at right angles on the craft.

Since these loops have current maxima at laterally disposed points of the craft, they are slightly more effective on the sides of the aircraft than longitudinally. This type of characteristic is not generally desirable since the signals received usually come from the front or rear of the craft.

Furthermore, when such a loop is mounted above the fuselage of the craft the distorting effects of the airplane parts themselves tend to further accentuate the ellipticity of the horizontal characteristic.

It is a principal object of my invention to provide a loop antenna for high frequency energy in which these difficulties are minimized or completely overcome.

In accordance with a feature of my invention a loop of the general character described above but arranged to have more than two current maxima around the periphery thereof is provided so that the characteristic pattern of the antenna in the plane of the loop, is substantially circular or elongated in the direction of the longitudinal axis of an aircraft, or elongated in this axis to compensate the distorting effects of the aircraft.

The objects and features of my invention will be more clearly understood from the particular description of my invention made with reference to the accompanying drawings, in which

Fig. 1 shows diagrammatically one form of my invention;

Fig. 2 is a modified antenna arrangement incorporating the features of my invention;

Figs. 3 and 4 are experimental curves in polar coordinates of the field pattern illustrating the performance of an antenna of the form of Fig. 2;

Fig. 5 is a still further modified embodiment of my invention which has characteristics similar to the arrangement of Fig. 2 when properly adjusted; and

Figs. 6, 7 and 8 are still further modified embodiments incorporating the features of my invention.

In Fig. 1 is shown a loop antenna consisting of three radiant acting members 1, 2 and 3, arranged to form a substantially enclosed peripheral space. These elements are substantially equal in length and are each short with respect to the operating wavelength, preferably in the order of two-tenths of a wavelength long. Connected to the adjacent ends of sections 1, 2; 2, 3 and 3, 1, are non-radiating transmission lines 4, 5, 6. The conductors 4A, 5A and 6A, and 4B, 5B, 6B, may be respectively interconnected and coupled to a common translating device 7 over a transmission line 8. Each of lines 4, 5 and 6 are adjusted to have substantially equal electrical lengths and impedances.

By this arrangement current maxima are produced at the centers of each of the members 1, 2 and 3. The current distribution around the entire periphery of the antenna system is thus maintained fairly constant and a substantially circular radiation pattern in the plane of the loop is produced. Furthermore, the energy radiated or collected by the loop will be polarized with the electric vector in planes parallel to the loop.

In the arrangement of Fig. 1 complications arise because symmetry must be maintained in the radiating members and feeding lines in order to maintain proper balance and secure uniform feeding of the radiating members. Furthermore, the loop of Fig. 1 is not of such construction as to readily lend itself to suitable support on the fuselage of an aircraft.

The structural arrangement shown in Fig. 2 overcomes the disadvantages present in the loop of Fig. 1. In this arrangement the radiant acting portion of the antenna consists of three members 20, 21 and 22, preferably, but not necessarily of equal length, forming a substantially closed periphery. These members need not be symmetrically arranged as in the case of Fig. 1,

Member 20 is coupled at its opposite ends to members 21 and 22, respectively, by means of a capacitive coupling which may comprise merely an overlapping portion of the respective members. This structure, utilizing the inherent capacity of overlapping conductors may be readily availed of when the antenna is made of flat strips, but in the case of other conductor shapes the provision of separate coupling condensers or other constructions permitting suitable capacitive coupling must be provided. In the case of Fig. 2 a translation device 27 is coupled over a transmission line 28 to the free ends of members 21, 22.

This arrangement provides a current maximum at the center of conductor 20 and two current maxima intermediate the ends of conductors 21, 22. By adjusting the coupling capacities between members 20 and members 21, 22, the current maxima in members 21, 22 may be shifted toward or away from the junction point of transmission line 28 with members 21, 22 to vary the distribution in the plane of the loop. By decreasing the capacity at 24, 25, the current maxima are shifted toward transmission line 28 and a field pattern elongated in the plane of symmetry of the loop is achieved. By increasing capacities 24, 25, the current maxima in members 21, 22 are shifted away from transmission line 28 and a more nearly circular pattern is produced.

In Fig. 3 curve 30 shows the field pattern experimentally obtained from a loop antenna of the prior art. It will be noted that curve 30 has its major axis in such a direction that it would be laterally disposed to an aircraft if it were mounted thereon in the conventional way. Curve 31 is a pattern plotted utilizing an antenna of the form shown in Fig. 2 having the dimensions indicated in the small diagram in the plot of the curve. It will be noted that curve 31 has its major axis at right angles to the major axis of curve 30, thus securing a more desirable distribution. These measurements were made for both types of loop at 110 megacycles.

In Fig. 4 curve 40 illustrates another experimental pattern obtained at 110 megacycles using a loop similar to Fig. 2, in which the current maxima are adjusted in members 21, 22 to substantially the midpoints of these members. It will be noted that the pattern here is substantially circular.

It should be further noted that with the antenna structure of Fig. 2 a voltage node occurs substantially mid-way of member 20 and a relatively low voltage may be similarly obtained at the junction point of transmission lines 28 with members 21, 22. Accordingly, when such a loop is mounted in the normal manner on an aircraft fuselage, the troublesome effects of sleet formations at high voltage points is greatly reduced.

The arrangement shown in Fig. 5 is similar to that shown in Fig. 2, except that in place of a unitary member 20, the energy is supplied at this end of the loop necessitating the provision of two sections 50, 51 connected to supply line 52. Two members 53, 54 corresponding to 21, 22 of Fig. 2, are capacitively coupled through capacitances 55, 56 with sections 50, 51, respectively, and a condenser 57 is provided to intercouple the other end of the member 53, 54. In this arrangement, each of the capacitors 55, 56 and 57 may be made adjustable to secure the desired current distribution in the loop. The same distribution of current may be achieved in this arrangement as in the arrangement of Fig. 2. This loop, however, has the advantage that a low impedance line 52 may be used for coupling the loop to a translating device whereas the arrangement of Fig. 2 requires a relatively high impedance transmission line. In addition the use of a low impedance line provides a more efficient transfer of energy without the use of impedance matching elements. Furthermore, the tuning of the loop is less critical with this connection than with the previously described connection.

In Fig. 6 a further modification of my invention in which four current maxima are produced around the periphery of the loop is disclosed. This antenna comprises four radiant acting members 60, 61, 62, 63, arranged to form a substantially closed periphery. A transmission line 64 is connected to members 60, 61, so that coupling to a suitable translator may be made. The other end of members 60, 61, and adjacent ends of members 62 and 63, are interconnected by a transposed tie-line 65 and the other ends of members 62, 63 are arranged in overlapping relation. Thus, the current distribution in conductors 62 and 63 starting from a current minimum at their open ends will be effectively in overlapping relationship, producing by addition current maxima either in the center or on both sides of a plane of symmetry. Similarly, two current maxima will exist in conductors 60, 61, generally located intermediate the ends of these conductors. Adjustment of the current maxima can be made by bridging a tuning element, such as the condenser, across line 65, preferably at its midpoint. Adjustment of this tuning element will serve to shift the maxima considerably in conductors 60, 61, but will have only slight effect on the position of the maxima relative to conductors 62, 63.

Figure 7 illustrates a loop antenna similar to that of Fig. 6, but in place of the tie-line 65, two open ended transmission line sections 70, 71, are provided. This antenna will produce substantially the same type of current distribution as is achieved in the circuit arrangement of Fig. 6. However, the distribution may be readily varied by adjusting the length of lines 70, 71. These lines should, of course, be adjusted the same amount to maintain symmetry of the system.

If desired, transmission line sections 70, 71, may be replaced by coupling condensers, preferably variable condensers.

In Fig. 8 a preferred structural arrangement of the antenna circuit shown in Fig. 7 is illustrated. In this arrangement the transmission line sections 70, 71, are formed by continuing elements 60, 62, and 61, 63 in substantially parallel overlapping relation. This is in effect merely a straightening of the two conductors of transmission lines 70, 71 so that they are substantially aligned with the periphery of the loop. This loop arrangement will produce precisely the same type of field pattern as will the loop of Fig. 7. However, from a mechanical standpoint, particularly for mounting on aircraft, air resistance is considerably reduced by this construction since cross structural elements are avoided.

In each of the arrangements of Figs. 6, 7 and 8, the same advantages with respect to the shaping of the pattern and the avoidance of excessive sleet formation on high voltage points is achieved.

It should be noted that in the various arrangements according to my invention, particularly as disclosed in Figs. 2 to 8, the various radiant acting members are arranged to form a

closed periphery and each of these members is made less than a quarter of a wavelength long at the operating wavelength. The antenna structures are all provided to have a single plane of symmetry and the transmission line for coupling the loop to a translation device, is coupled substantially in this plane of symmetry. Also, means for controlling the current distribution, by use of condensers, by overlapping of the conductors of the antenna or by transmission line sections, to produce a single effective current loop substantially in each of the radiant acting members is provided. At least one of these current loops is produced in a radiant acting member or in the members at a point less than half the length of the particular member or members from this plane of symmetry.

While I have diagrammatically disclosed a number of embodiments of my inveniton, it is clear that various changes in the structural arrangement may be made without departing from the scope of my invention. The loops may be made in substantially any geometric form which will provide a single axis of symmetry with respect to each of the loop constructions.

A preferred structural arrangement for use on aircraft is one in which the loop, as a whole, has substantially a rectangular or square form. This loop is made with the longitudinal members of a bomb shaped streamline form and with the lateral members in the form of streamlined connecting struts, so that the whole structure forms a hollow substantially rectangular arrangement in which all members are streamlined. This construction produces less air resistance than would be produced by a single streamlined housing enclosing the entire loop. Furthermore, such an arrangement is subjected to less strain, upon change of attitude of the aircraft, than a single elevated housing of streamline form about the entire loop. Also, this arrangement still retains the desirable effective height for the antenna which would be lost were a housing of the blister type used.

While I have described specific embodiments of my invention, this description should not be considered as a limitation on the scope of my invention. Various changes and modifications within the scope of my invention will readily be apparent to an expert in the art.

What is claimed is:

1. A loop antenna system for short wave operation comprising at least three radiant acting means arranged to form a substantially closed periphery, said radiant acting means being less than a quarter-wavelength long at the operating frequency and arranged to have a single plane of symmetry, a translating means, a transmission line coupling said translating means to at least one of said members substantially at said plane of symmetry, and coupling means for controlling distribution of energy in said loop to produce a single current loop in each of said radiant acting means, said coupling means being adjusted to produce at least one current maximum at one side of said loop less than half the length of one of said radiant acting means from said plane of symmetry.

2. A loop antenna system according to claim 1, further comprising means for adjusting said distribution to shift the position of at least one of said current loops.

3. A loop antenna according to claim 1 provided with three radiant acting elements as the radiant acting means, one of said elements having its center coinciding with said plane of symmetry, and the other members being arranged with one end of each coupled to said first named member and their other ends substantially in said plane of symmetry, said means for controlling the distribution of current comprising means for effecting said coupling.

4. A loop antenna according to claim 1 provided with three radiant acting elements as the radiant acting means, one of said elements having its center coinciding with said plane of symmetry, and the other members being arranged with one end of each coupled to said first named member and their other ends substantially in said plane of symmetry, said means for controlling the distribution of current comprising means for effecting said coupling, and said transmission line being coupled substantially at the center of said first named member.

5. A loop antenna according to claim 1, provided with four radiant acting members as said radiant acting means, two of said members being connected at one end to said transmission line and at their other ends coupled to one end of the other two members, the other ends of said other two members being arranged in overlapping relation.

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