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Fig. 1.

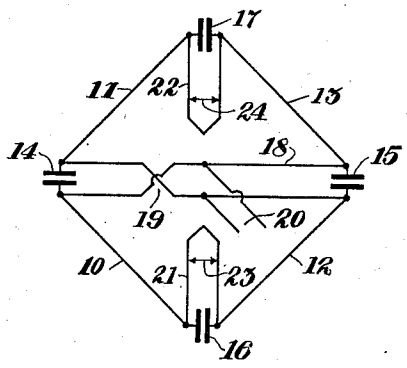
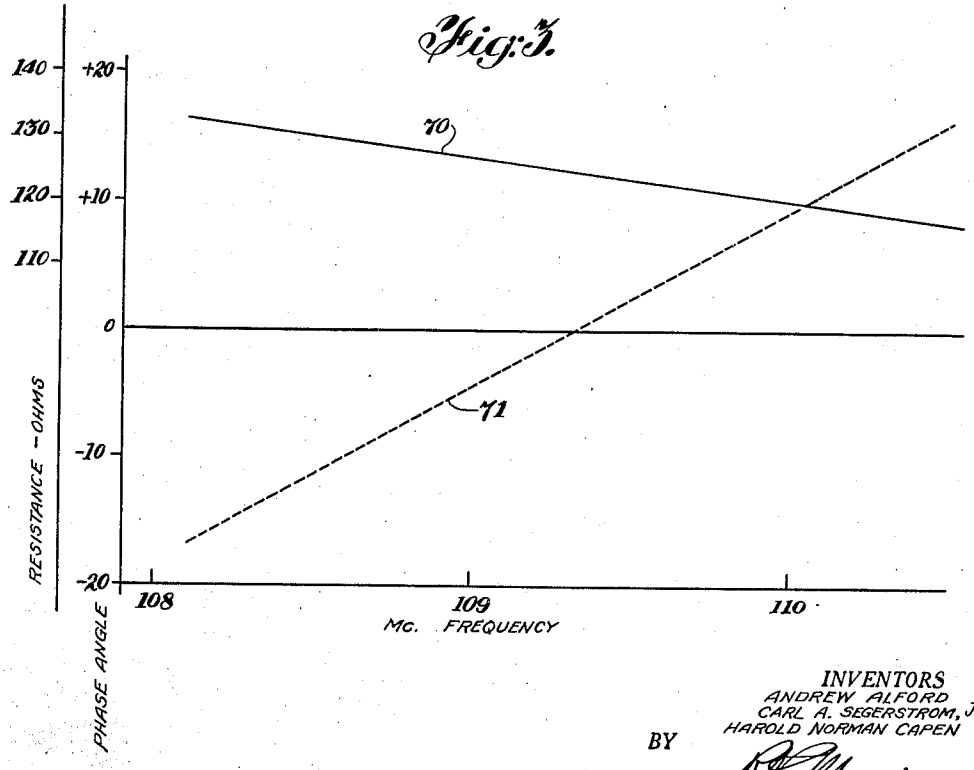



Fig. 3.




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Fig:2.

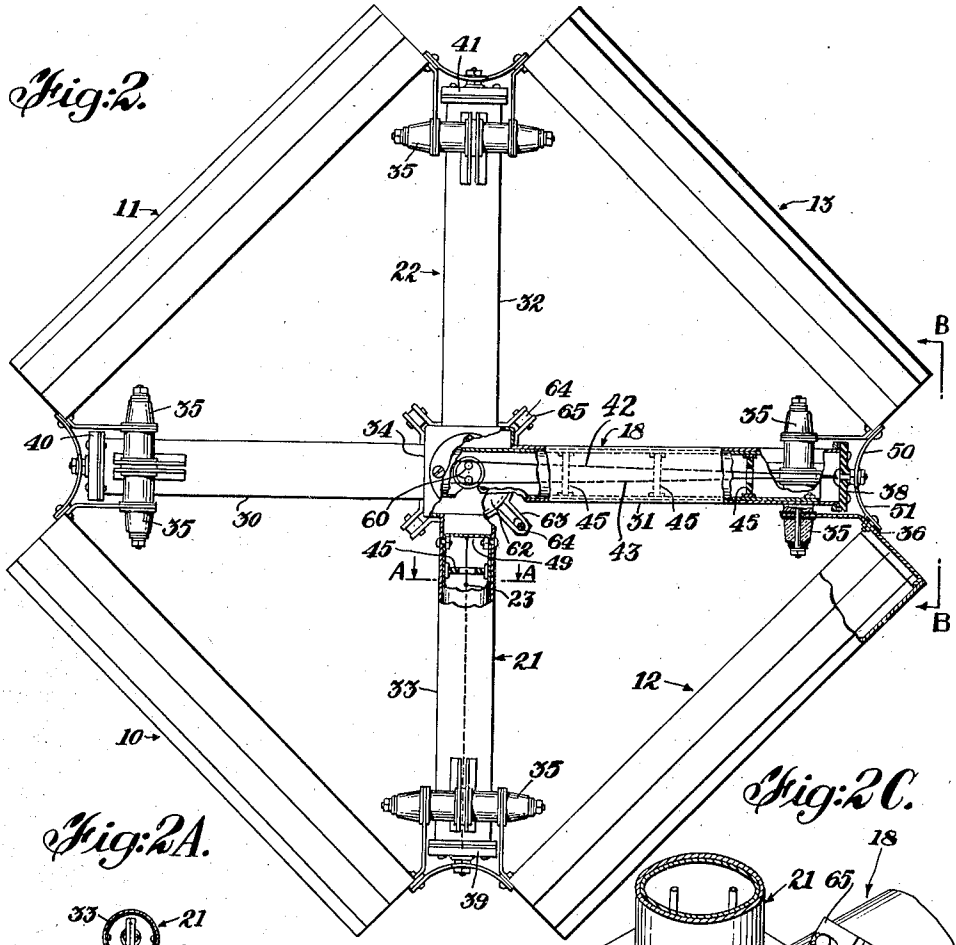



Fig:2A.




Fig:2B.

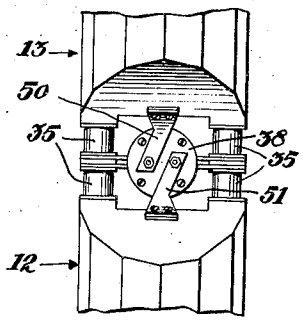
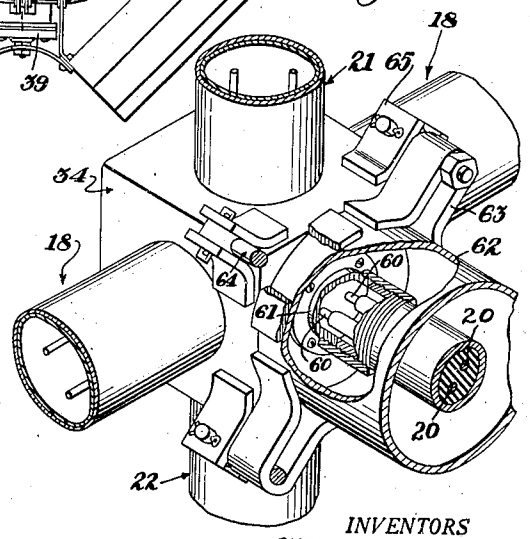



Fig:2C.




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# UNITED STATES PATENT OFFICE

2,372,651

## ANTENNA

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Application March 18, 1943, Serial No. 479,624

11 Claims. (Cl. 250—33)

This invention relates to antennas and more particularly to horizontal loop antennas made up of a plurality of separately coupled arms.

Loop antennas have been proposed in which the radiant acting elements comprise a plurality of radiant acting arms each short with respect to operating wave-length and capacitively coupled together, the loops being fed at two corners of the resulting closed pattern. This type of loop requires sufficient coupling between the adjacent arms to assure that the current loop occurs substantially at the mid-point of each radiating arm. In the patent of Andrew Alford, Patent No. 2,283,897, issued May 26, 1942, an example of this type of loop is given. This type of loop, however, in general, if designed for one particular frequency, may not operate efficiently at other frequencies. It is often desired to have a radio antenna which will operate efficiently over a relatively wide band of frequencies.

It is an object of our invention to provide a loop antenna structure for operating over a relatively wide frequency band which is well shielded and rugged in construction.

It is a still further object of our invention to provide an antenna system wherein the feeding conductors coupled to the elements of the system are properly related to effect a substantial matching of impedances over a relatively wide frequency band.

According to a feature of our invention, we provide an antenna system in which the radiant acting elements are relatively massive and are capacitively coupled together to position properly the current loops along each element. Subordinate transmission lines are provided interconnecting two of the coupled points, these transmission lines being of such length and of such impedance value as substantially to transform the impedance at the coupling points as seen from the end of the lines to a lower value of real impedance. At the junction point of the transmission lines is coupled a feeder line which has an impedance substantially equal to the parallel impedance of the two parts of the subordinate transmission line. This structure then provides an antenna which is substantially completely impedance matched at the mid-frequency of the operating frequency band and which maintains a relatively good matching over a range of frequencies on either side of the mid-point.

A better understanding of our invention and the objects and features thereof may be had by reference to the particular description made with reference to the accompanying drawings, in which:

Fig. 1 is a circuit diagram of a loop made in accordance with our invention used to explain the operation thereof;

Fig. 2 is a plane view partially in section of a practical embodiment of our invention showing a structural feature;

Fig. 2A is a section taken along the line A—A of Fig. 2;

Fig. 2B is a fragmentary end view looking toward Fig. 2 along the line B—B;

Fig. 2C is a fragmentary bottom perspective view of the antenna of Fig. 2 showing further structural features thereof; and

Fig. 3 is a curve showing the antenna resistance end phase angle plotted against frequency for a loop antenna of the type shown in Fig. 2.

Turning first to Fig. 1, the loop antenna comprises four radiant acting arms 10, 11, 12 and 13 arranged in a substantially closed pattern. The arms 10, 11, 12 and 13 are coupled together by condensers 14, 15, 16 and 17. The capacity of condenser couplings 16, 17 should be sufficiently great so that the energy is distributed along each radiant acting member so that a current loop occurs substantially mid-point along the length thereof. Each of the members 10 to 13, inclusive, are preferably made short relative to the operating frequency, for example, between $\frac{1}{10}$ and ¼ of a wavelength. Between coupling points represented by condensers 14, 15 is provided a subordinate transmission line 18 in which there is a transposition 19 so that these diagonally opposite points are coupled together in phase opposition. Mid-way along, line 18 is coupled in the feeder line 20.

Since it is not possible readily to design a loop without having an excessive capacity as at 14, 15, 16 and 17, the impedance at these points is generally relatively high and has a considerable capacitive component. For example, if we take arms 10, 11, 12 and 13 as each being in the order of $\frac{3}{10}$ of a wavelength long at the mid-frequency, the impedance at the junction point of the arms may be in the order of 800 ohms and largely capacitive. The two branches of line 18 are each in the order of $\frac{3}{10}$ of a wavelength long. If, now, this line is designed to have a 400 ohm characteristic impedance, each of the branches of line 18 will serve as an impedance transformer transforming the partially capacitive impedance at the coupling points into a 200 ohm real impedance, that is, resistance impedance. If line 20 is therefore designed to have a 100 ohm charac-

terstic impedance, a complete impedance match at the mid-frequency will be achieved. Likewise, the antenna will operate over a relatively wide frequency band on either side of this mid-frequency without introducing an excessive mismatch.

The other diagonally related corners of the square represented at capacities 16 and 17, however, still have considerably capacitive reactance. It is, therefore, preferable to arrange across each of these junctures, impedance elements which are inductively reactive to compensate for the capacitance effect. These impedances may take the form of transmission line sections 21 and 22 provided with short-circuiting bars 23 and 24 adjusted to provide the desired impedance compensation.

A better idea of the structural features of the antenna in accordance with our invention may be had by reference to Figs. 2, 2A, 2B and 2C. The radiant acting elements of the antenna are made in the form of hollow substantially semi-cylindrical elements 10, 11, 12 and 13. Four supporting bars 30, 31, 32 and 33 are provided extending from the junction point of the radiant acting members to a central junction box 34. These arms are each made hollow and are fastened to the respective radiant acting arms by means of insulators 35 and clamping means 36. In order that the structure may be able to withstand considerable shock, two insulators 35 are provided at each of the corners, one above and one below the corresponding supporting arm. The supporting arms are closed by means of insulating caps 38, 39, 40 and 41 in order to prevent moisture from entering therein and for the purpose of providing a support for transmission line terminals. Within hollow arms 30 and 31 are provided the conductors of transmission line 18 shown at 42 and 43. These lines are coupled together within junction box 34 and are fastened therein to plug elements 60 and by means of said elements are electrically connected to conductors of line 20. Insulating spacers 45 are provided to give to lines 18 a suitable twist to provide the phase inversion. The two conductors of each line 42, 43 are brought out through their respective insulating caps 38, 40 to terminals 50 and 51, Fig. 2B, which are fastened firmly to the corresponding arms such as 12 and 13 of Fig. 2B. Thus is provided a completely shielded transmission line for feeding the radiant acting elements.

The line 20 is preferably a flexible line and may, for example, be a shielded two-conductor flexible line of known make. This line is arranged to contact with the plug elements 60, Fig. 2C, and is held in place in a known manner on threaded sleeve 61. The support for the antenna may comprise a tubular metallic structure 62, for example, which may hold the loop in place by means of lugs 63 cooperating with pins 64 mounted on extensions 65 fastened to the junction box 34. This makes a readily demountable structure for portable antenna units. The junction points of units 11, 13, 10 and 12 are preferably provided with terminal connections similar to those shown in Fig. 2B, which are connected to the separate conductors of lines 21, 22 in a manner similar to the terminal arrangement for subsidiary lines 42, 43. Short-circuiting bars 23 and 24 are provided across the lines and these bars are adjusted to provide the desired inductive reactance to compensate for the existive capacities. In order to hold lines 21, 22 in position, a plate 49 may be provided to which the ends of this transmission line are anchored.

With the antenna of this construction, the capacities at the corners of the loop may be properly adjusted so that the impedance at the midpoint of the subsidiary line becomes real for the particular antenna system. Any value of real impedance between certain limits may be set in accordance with the size of the loop and the practical limits of the corresponding connecting subsidiary line. In an actual antenna, the capacity values are provided by the inherent structure of the supports and this capacity cannot be reduced to too small a value without reducing the mechanical strength of the loop below the safety point. For this reason, the compensating line sections are provided. This compensation also provides an adjustment to take care of many quantities occurring in manufacturing of the loop.

In Fig. 3 is disclosed two curves 70 and 71 illustrating the resistance and phase angle of an actual loop structure incorporating the features of our invention. It will be seen that this loop is precisely matched in impedance at 109.3 megacycles and is operative over a band of about 108 to 111 megacycles. At the mid-point of the band the impedance is about 125 ohms and at either side from the mid-point this impedance increases or decreases dependent upon the direction of departure of the mid-frequency.

It should be distinctly understood that this particular antenna structure shown herein is given merely by way of example. The arms of the antenna may be made in many other forms without departing from the spirit of our invention. Likewise, the details of the supporting structure may be varied within the limits of our invention as desired by those skilled in the art.

While we have described above the principles of our invention in connection with specific apparatus, and particular modifications thereof, it is to be clearly understood that this description is made only by way of example and not as a limitation on the scope of our invention as set forth in the objects of our invention and the accompanying claims.

What is claimed is:

1. An antenna system coupled to a main transmission line of given impedance, comprising a plurality of relatively short radiant acting elements capacitively coupled together end-to-end to provide a substantially closed pattern, the radiant acting elements at their coupling points presenting an impedance relatively high with respect to the impedance of said transmission line, at least two subsidiary lines coupling certain of said elements at their coupling points with said main transmission line, said subsidiary lines being dimensioned so that they act as impedance transformers, the parallel impedance of which substantially matches the impedance of said transmission line to said antenna at the mid-frequency of the operating frequencies of said antenna system whereby said system will be satisfactorily operated over a relatively wide frequency band.

2. An antenna system according to claim 1 further comprising inductive reactive means coupled between said radiant elements other than those coupled to said subsidiary lines, to compensate for the capacitive reactance between said elements.

3. In an antenna system of the type comprising relatively massive radiant acting members which are short with respect to the wavelengths at the operative frequencies and are capacitively coupled

together at their ends to provide a substantially closed pattern, and a feeder line of given impedance, the impedance at the junction points of said radiant acting members being high relative to the impedance of said feeder line and predominately capacitive, the combination of connections for rendering said antenna system efficiently operative over a relatively wide frequency band, comprising subsidiary lines coupling certain of said junction points to said feeder line, each of said subsidiary lines being dimensioned to provide an impedance transformation of such value that the parallel impedance of said coupled junctions is transformed to a real impedance substantially equal to said given impedance at the coupling point of said feeder line at the mid-frequency of said band, and inductively reactive elements coupled across the remaining junction points of said elements to compensate the capacitive reactance of said couplings.

4. An antenna system according to claim 3 wherein said feeder line and said subsidiary lines are each shielded transmission line pairs.

5. An antenna system according to claim 3 wherein said inductively reactive elements comprise short-circuited sections of two conductor transmission lines.

6. A wide band antenna system comprising four relatively massive radiant acting elements each of said elements being in the order of two-tenths wavelengths long at the mid-frequency of said band, said four elements being capacitively coupled together at their ends to provide a substantially closed pattern, said elements having substantial current loops at their centers, the impedance at the coupling points being relatively large and capacitively reactive, two conductor feeder lines interconnecting two diagonally opposite coupling points in phase opposition, said lines each being in the order of three-eighths wavelengths long at said mid-frequency and having a characteristic impedance lower than the impedance at said coupling points, whereby the capacitively reactive impedance of each line at the junction point of said two lines is reduced to a lower real impedance, and a third two conductor line coupled to said junction point, said third line having a characteristic impedance substantially half said lower real impedance.

7. A wide band antenna according to claim 6 wherein each of said transmission lines comprises a two conductor shielded transmission line.

8. A wide band antenna system comprising four relatively massive radiant acting elements each of said elements being in the order of two-tenths wavelength long at the mid-frequency of said band, said elements being capacitively coupled together at their ends to provide a substantially closed pattern, said elements having substantial current loops at their centers, the impedance at the coupling points being relatively large and capacitively reactive, two conductor feeder lines interconnecting two diagonally opposite coupling points in phase opposition, said lines each being in the order of three-eights wavelengths long at said mid-frequency and having a characteristic impedance lower than the impedance of said coupling points, whereby the capacitively reactive impedance of each line at the junction point of said two lines is reduced to a lower real impedance, a third two conductor line coupled to said junction point, said third line having a characteristic impedance substantially half said lower real impedance and inductive reactive means coupled across the other diagonally opposed coupling points to compensate the capacitative reactance thereof.

9. A wide band antenna according to claim 6 wherein said inductive reactive means comprise sections short-circuited two conductor shielded transmission line.

10. In an antenna system of the type comprising four radiating arms each short relative to a half wavelength at the operating frequencies arranged end-to-end substantially in the form of a hollow square, the adjacent ends of said arms being capacitively coupled together, said antenna at said coupling points presenting a relatively high impedance, means for rendering said antenna system operative over a relatively wide band of frequencies, said means including a line section across one diagonal of said square coupling together in phase opposition diagonally opposite ends of said arms and a feeder line coupled substantially at the mid-point of said line section, said line section of an impedance such as to transform the high partially capacitive impedance at said diagonally opposite corners to a lower substantially real impedance at the center of said line over said frequency band, said transmission line being of an impedance substantially half said transformed impedance, and means for inductively compensating the excess capacity at the other two corners of said square.

11. An antenna structure comprising four radiant acting arms each short relative to the operating frequency, capacitive means coupling said arms together at their ends to define a substantially closed planar pattern, four tubular supporting arms insulatingly fastened at one end to respective ends of said radiant acting arms and extending toward the center of said closed pattern, a junction box at the center of said closed pattern to which the other ends of said tubular supporting arms branch, two-conductor transmission lines within each of two of the oppositely extending supporting arms, each line fastened at one end to the ends of corresponding radiant acting arms, said lines coupled together within said junction box at their other ends in phase opposition, a two conductor feeder transmission line terminal connected to said conductor transmission lines at their junction point and provided with terminal means for connection to a feeder cable, and antenna supporting means mechanically fastened to the outer surface of said junction box.

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