July 13, 1937. G. H. BROWN 2,086,976

ANTENNA SYSTEM

Filed Sept. 20, 1935 2 Sheets-Sheet 1

Fig. I.

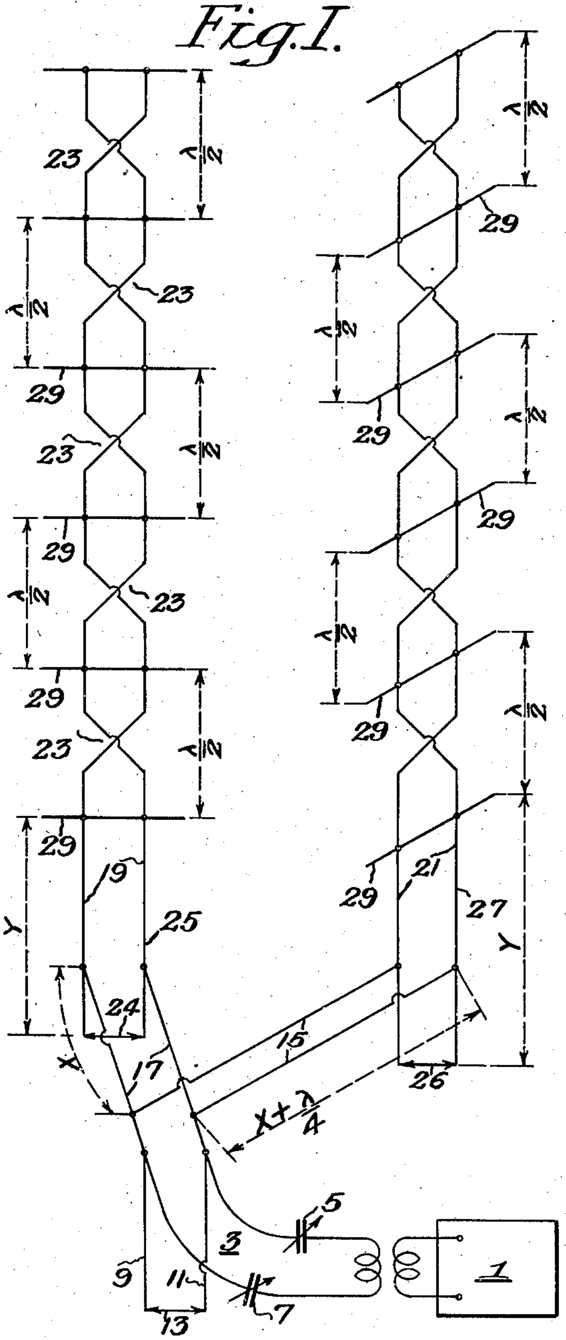


Fig. II.

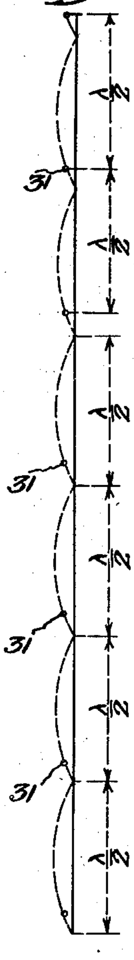
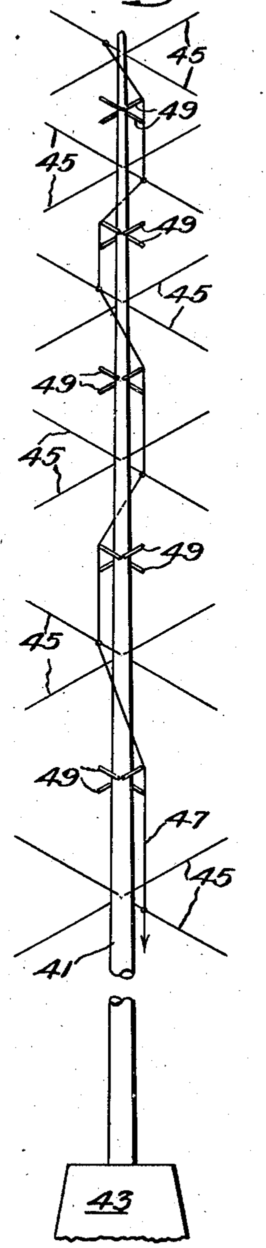


Fig. III.



Witnesses

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Fig. IV.

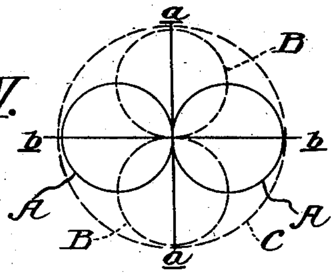


Fig. V.

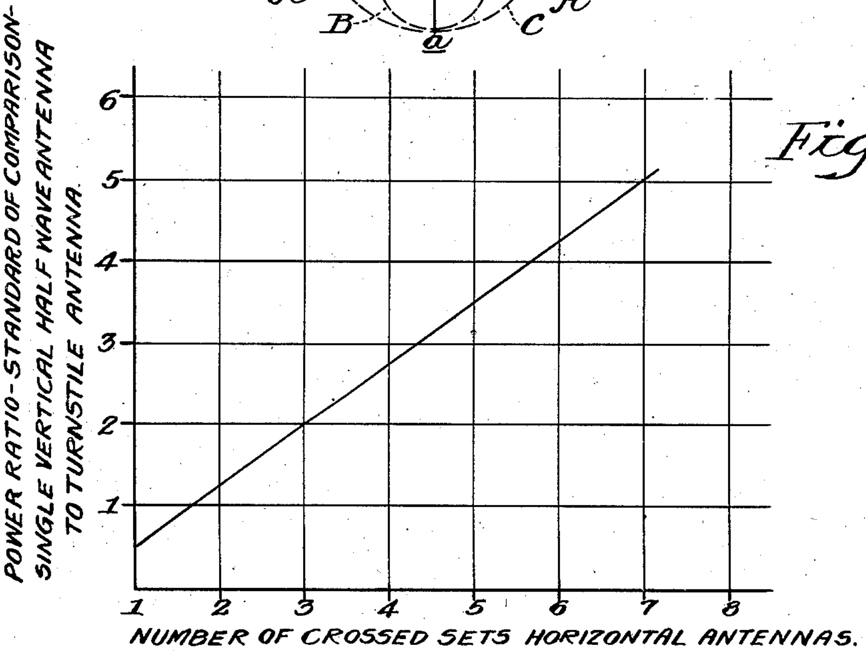
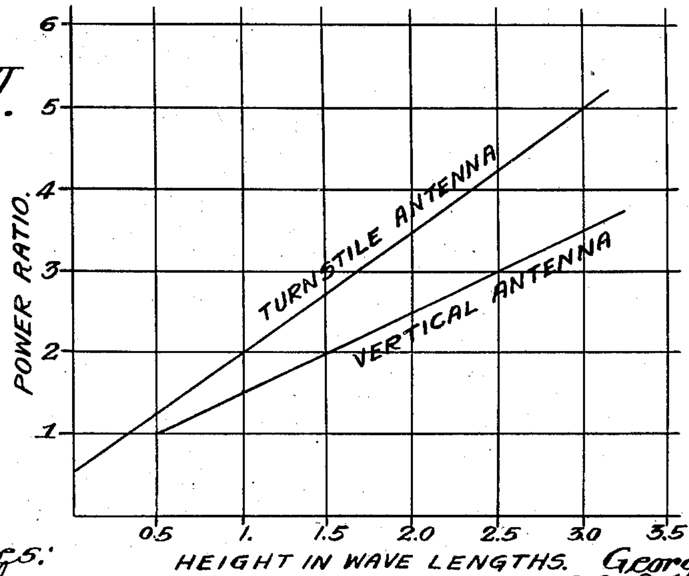


Fig. VI.



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UNITED STATES PATENT OFFICE

2,086,976

ANTENNA SYSTEM

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Application September 20, 1935, Serial No. 41,349

11 Claims. (Cl. 250—33)

My invention relates to antennas. Specifically, my invention relates to a short wave transmitting antenna.

I am aware that vertical antenna systems of a height not exceeding a half wave length may be used for horizontal radiation. Such systems are satisfactory for long wave lengths but are defective for short waves. It has been proposed to reverse phases between alternate half wave sections and thereby permit a plurality of half wave length sections to be employed. An antenna system of several half wave sections offers practical difficulties in the matter of separately insulating the sections. It has also been proposed to employ horizontal antenna elements with insulated masts and phase adjusting circuits, but such systems offer serious structural and electrical difficulties. The novel arrangement which I propose may be used to overcome these difficulties and at the same time improve the radiating efficiency.

One of the objects of my invention is found in the design of an efficient transmitting antenna.

Another object is to secure uniform radiation in all directions in a horizontal plane about the antenna.

Another object is to secure uniform radiation in all directions by a novel arrangement of horizontal antennas.

A further object is in a practical antenna design which permits a plurality of horizontal antenna sections to be conductively supported by a single metallic support.

Additional objects will be found in the accompanying specification and appended claims.

Figure I is a schematic diagram of one embodiment of my invention,

Figure II is a curve showing the approximate voltage distribution in a part of the antenna arrangement,

Figure III is a perspective view of an antenna system embodying my invention,

Figure IV is a curve illustrating the radiational field pattern about an antenna similar to Figure III,

Figure V is a graph showing the relative power ratio of an antenna embodying my invention and a single vertical half wave antenna, and

Figure VI is a graph showing the relative power ratio of a turnstile antenna and a vertical antenna system of similar height.

In Figure I a source 1 of radio frequency power is coupled to a transmission line 3 which may be tuned by one or more variable capacitors 5—7. A pair of conductors 9—11 are connected across the transmission line 3. A bridging conductor 13, connected across the pair of conductors 9—11, may be adjusted to prevent the generation of standing waves on the transmission line 3. At a convenient point beyond the bridging conductor, the transmission line is divided into a pair of lines 15—17. One of these pairs of transmission lines may be of any convenient length but the other line should be a quarter wave length longer. Each of these pairs of lines terminates in pairs of vertically arranged transmission lines 19—21.

The vertical transmission lines are composed of a plurality of sections 23 of a length equal to one-half the length of the transmited wave. The lowermost section 25—27 of each of the vertical transmission lines 19—21 has shunted across it an adjustable bridging member 24—26. The position of the bridging member, and the relative points at which the pair of transmission lines join the vertical transmission lines, are arranged to avoid reflections by a proper terminating impedance.

Every half wave length section 23 of each of the vertical transmission lines is transposed. When the vertical lines are energized, standing waves will be set up. Potential nodal points separated by a half wave length will be established. Each of the anti-nodal potential points on one side of the vertical transmission line will be of the same phase, because of the transposition of the line. Since one of the pair of connecting transmission lines is one-quarter wave length longer than the other, and since the terminating impedances of the vertical lines may be adjusted, currents in one vertical transmission line 21 may be established in quadrature phase relation with respect to the currents in the other vertical line 19.

A series of horizontal antenna elements 29, preferably less than a half wave length long, are connected across points of similar voltage and opposite phase near the potential nodal points of each vertical line. The voltage distribution and the relative position of the horizontal antenna elements is indicated in Figure II. The heavy dots 31 represent the horizontal antenna elements 29.

In Figure I, for convenience of illustration, each vertical transmission line with its connected horizontal antenna elements has been shown as separated. The vertical lines, per se, are separated but the corresponding horizontal elements of each vertical section are actually arranged to intersect at their centers. The intersection should be at right angles if uniform circular radiated fields are desired. Although my invention may be adapted to radiate waves of several patterns, I shall describe an antenna whose radiational characteristic will establish uniform fields at uniform horizontal distances from the antenna. This type of antenna employs horizontal antenna elements in the form of a symmetrical cross. The arrangement may be characterized as a turnstile antenna.

Since the centers of the plurality of horizontal antenna elements are symmetrical with respect to the four conductors of the vertical transmission lines, they are at neutral voltage points and may be conductively connected to a common supporting member, which may be made of metal or any suitable material. Such an arrangement is illustrated in Figure III. A metallic pipe or mast **41**, preferably self-supporting, is erected on a suitable foundation **43**. A number of crossed horizontal antenna elements **45** are fastened to the mast by any suitable method, such as threading, clamping or welding. The horizontal elements are spaced from each other by substantially a half wave length; i. e., the horizontal elements are spaced at half wave length intervals on the vertical transmission line but the sections of the transmission lines are slightly longer than the distance between the horizontal elements. The vertical transposed transmission lines **47** are symmetrically arranged to spiral around the mast and are connected to the horizontal elements at points about one-twentieth of a wave length from the surface of the supporting pole. Stand-off insulators **49** may be used to prevent the conductors of the transmission lines from contacting the supporting pole or from contacting each other. In Figure III, a single conductor of one of the four transmission conductors has been shown. The other conductors have been omitted to avoid confusion in the illustration.

It may be shown that the field of radiation at a distant point with respect to the antenna varies with the angle with the angle θ which is the angle between the one series horizontal antenna elements and a line from the center of the antenna to the distant point and is

$$\text{(I)}\quad F_1 = I_1 \sin\theta \sin\omega t$$

The corresponding field of radiation at a distant point for the other series of vertical antenna elements with 90° phase relation will be

$$\text{(II)}\quad F_2 = I_2 \cos\theta \cos\omega t$$

The sum of these Equations (I and II) is

$$\text{(III)}\quad F_1 + F_2 = I_1 \sin\theta \sin\omega t + I_2 \cos\theta \cos\omega t$$

But since the currents I_1 and I_2 flowing in both series of horizontal antenna elements are equal, the Equation (III) may be rewritten as

$$\text{(IV)}\quad F_1 + F_2 = I_1 (\sin\theta \sin\omega t + \cos\theta \cos\omega t)$$

The expression within the brackets of Equation IV bears the relationship of

$$\sin\theta \sin\omega t + \cos\theta \cos\omega t = \cos(\omega t - \theta)$$

and permits writing the equation as

$$\text{(V)}\quad F_1 + F_2 = I_1 \cos(\omega t - \theta)$$

The Equation (V) indicates that the field will rotate around the antenna at a speed proportional to the frequency of the source, and that the field will have a uniform strength at all points equally distant from the antenna in a horizontal plane. That is, the radiated waves will travel outwardly in a circular pattern.

The radiational characteristic may be illustrated graphically in Figure IV. In this illustration one series of horizontal antenna elements is represented as lying in a plane represented by a line *a*. The other series of horizontal elements is represented as lying in a plane represented by a line *b*. The radiation from the elements in the plane *a* will have a figure **8** characteristic shown as A; while that from *b* may be shown as B. The fields rotate at a 90° phase relationship which gives a resultant field C which is a circle. The circle C represents uniform field strengths at uniform horizontal distances from the antenna.

The turnstile antenna of my invention is more efficient than vertical half wave antennas. In Figure V I have compared the power ratio of an antenna embodying my invention to a single vertical half wave antenna. It will be seen that for turnstile antennas of two or more crossed sets of horizontal elements the power ratio shows that the turnstile antenna is more effective than the vertical half wave antenna. I am aware that a vertical antenna of several half wave lengths may be used by proper phase reversals between the half wave sections. An antenna of several vertical half wave sections offers serious constructional difficulties in matters of insulation and support which are not present in an antenna embodying my invention. Even if the practical difficulties are overcome, the power ratio is very much in favor of the turnstile antenna. The relative power ratios for varying heights of antennas of both types are illustrated by the graphs of Figure VI.

Although I have shown by way of example, one embodiment of my invention I do not intend to thereby limit my invention. Various modifications within the scope of my invention will occur to those skilled in the art. I only intend to limit my invention as required by the prior art and by the appended claims.

I claim:

1. In an antenna system of the character described, a pair of vertical transmission lines, means for creating standing waves on said vertical lines, means for establishing a quadrature phase relation between the currents in said lines, and a plurality of pairs of crossed horizontal antenna elements each of said pairs having a common conductive junction connected to potential points of similar voltage on each of said pairs of lines.

2. In an antenna system of the character described, a pair of vertical and symmetrically disposed transmission lines, means for creating standing waves on said vertical lines, means for establishing a quadrature phase relation between the currents in said lines, and a plurality of pairs of crossed horizontal antenna elements each of said pairs having a common junction connected to potential points of similar voltage on each of said pairs of lines.

3. In an antenna system of the character described, a pair of vertical transmission lines, means for creating standing waves on said vertical lines, means for establishing a quadrature phase relation between the currents in said lines, and a plurality of crossed horizontal antenna elements, each of said elements having a common conductive intersection, connected to potential points of similar voltage on each of said pairs of lines.

4. In an antenna system of the character described, a pair of vertical and symmetrically disposed transmission lines, means for creating standing waves on said vertical lines, means for establishing a quadrature phase relation between the currents in said lines, and a plurality of crossed horizontal antenna elements, each of said elements having a common conductive intersection, connected to potential points of similar voltage on each of said pairs of lines.

5. In an antenna, a pair of vertical transmission lines, means for creating standing waves on said vertical lines, means for transposing said vertical lines so that the waves on one side of said lines are in the same phase, means for establishing a quadrature phase relation between the currents flowing in said lines, a plurality of crossed horizontal antenna elements, each of said elements having a common conductive junction, connected to similar potential points in one of said lines, and a plurality of similar horizontal elements positioned at right angles to the first mentioned horizontal elements and connected to the other of said transmission lines at potential points bearing quadrature phase relation to the first mentioned potential points.

6. In a device of the character described, a conductive mast, two sets of crossed antenna elements positioned at half wave length intervals on said mast and conductively connected thereto, one transmission line connected to one of said sets of elements, another transmission line connected to the other of said sets of elements, means for transposing alternate sections of each of said pair of lines, and means for impressing alternating currents on said pair of lines of equal magnitude and quadrature phase.

7. A transmitting antenna comprising two series of horizontal antenna elements disposed in vertical planes which intersect at right angles at the centers of said elements, a conductive mast for conductively supporting said antenna elements, a first transmission line connected to one series of said elements at points of similar potential and similar phase, a second transmission line connected to the other of said elements at points of similar potential and similar phase, and means for impressing alternating currents on said transmission lines of equal magnitude and quadrature phase.

8. In an antenna system of the character described, a pair of vertical transmission lines, means for creating standing waves on said vertical lines, means for establishing a quadrature phase relation between currents in said lines, a plurality of horizontal antenna elements of the order of one-half wave length long connected to potential points of similar voltage on each of said pairs of lines, and a conductive mast for conductively supporting said antenna elements.

9. In a device of the character described, a metallic mast, two series of horizontal antenna elements disposed in vertical planes which intersect at right angles at the centers of said elements, said mast conductively supporting said elements at said centers, a pair of vertical conductor wires connected to points on the horizontal elements equally distant from the surface of the mast and transposed between each of said elements, a similar pair of conductors connected in similar manner to the other set of horizontal elements, and means for impressing high frequency oscillatory currents differing by quadrature phase on each of said pairs of conductors.

10. A device of the character described in claim 9 including means for establishing standing waves on each of said pairs of conductors.

11. A device of the character described in claim 9 and including means for connecting the pairs of conductors on the horizontal elements at a distance of about one-twentieth of a wave length from the surface of the metallic mast.

GEORGE H. BROWN.