May 26, 1942. P. S. CARTER 2,283,914

ANTENNA

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Fig. 1

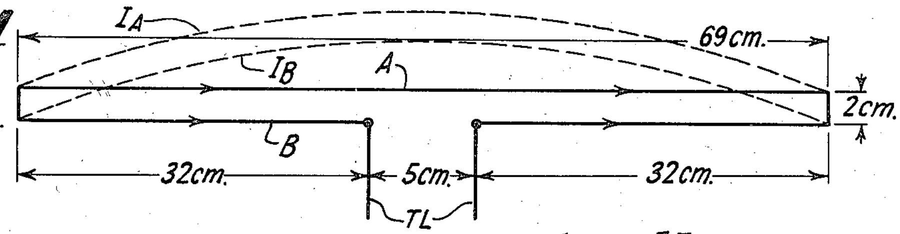


Fig. 1a

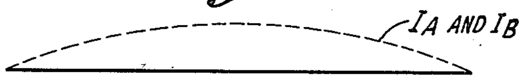


Fig. 1b

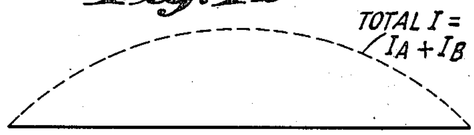


Fig. 4

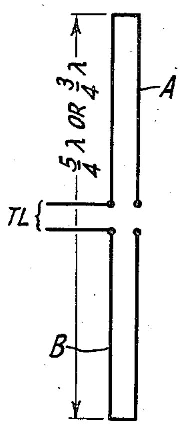


Fig. 5

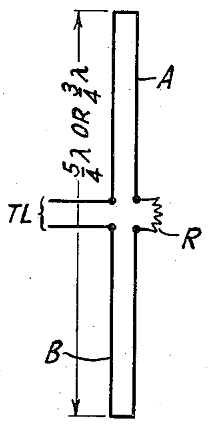


Fig. 6

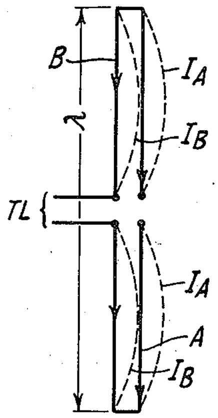


Fig. 7

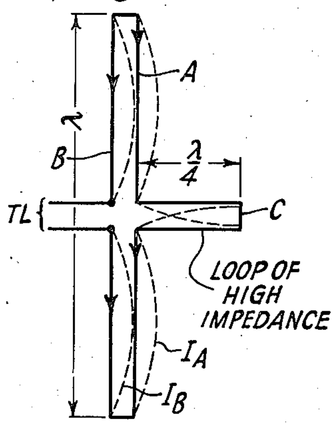


Fig. 2

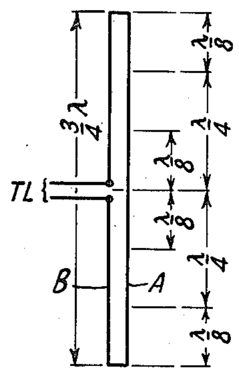


Fig. 2a

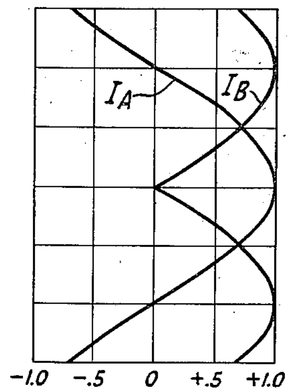
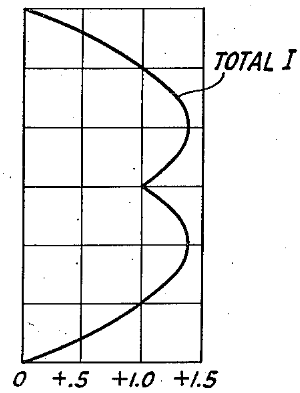


Fig. 2b



INVENTOR
P. S. CARTER
BY H. S. Grover
ATTORNEY

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P. S. CARTER

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Fig. 3

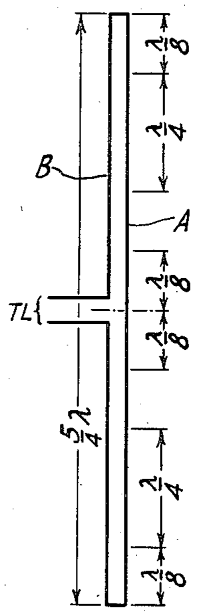


Fig. 3a

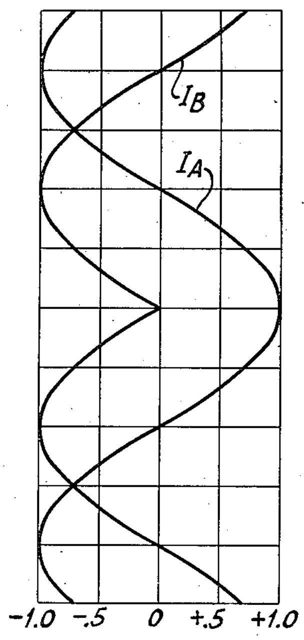


Fig. 3b

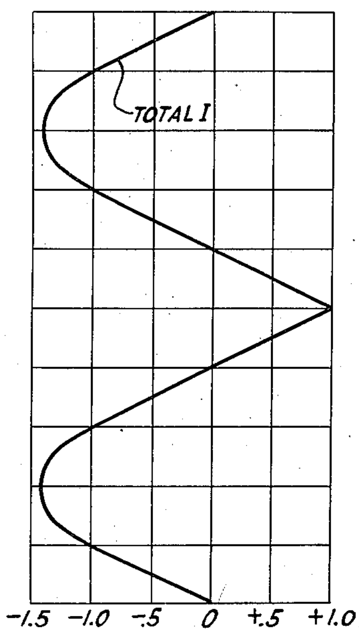


Fig. 8

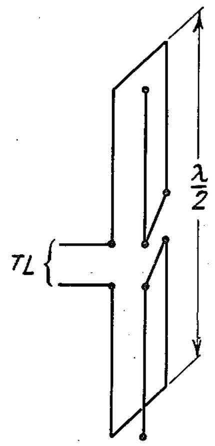


Fig. 9

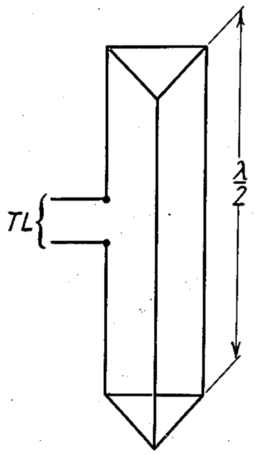
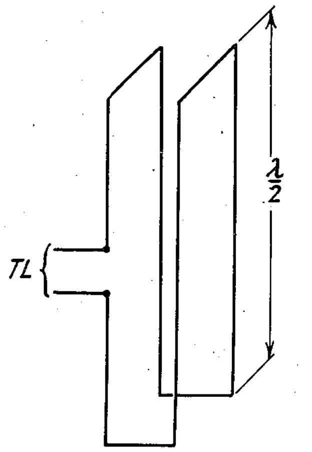


Fig. 10



INVENTOR
P. S. CARTER
BY H. S. Grover
ATTORNEY

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Fig. 11

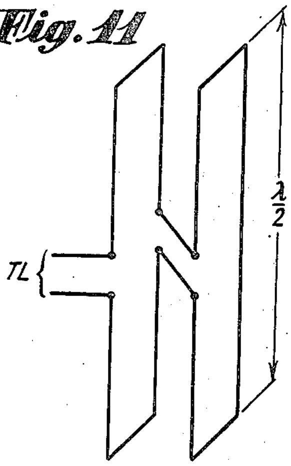


Fig. 12

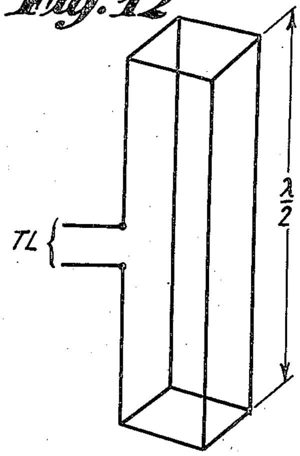
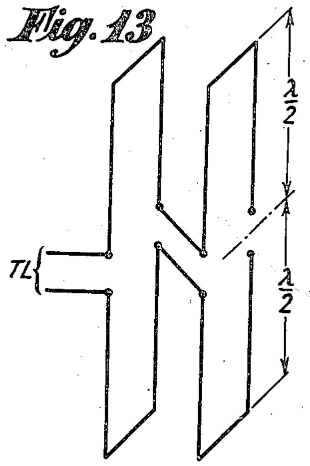


Fig. 13



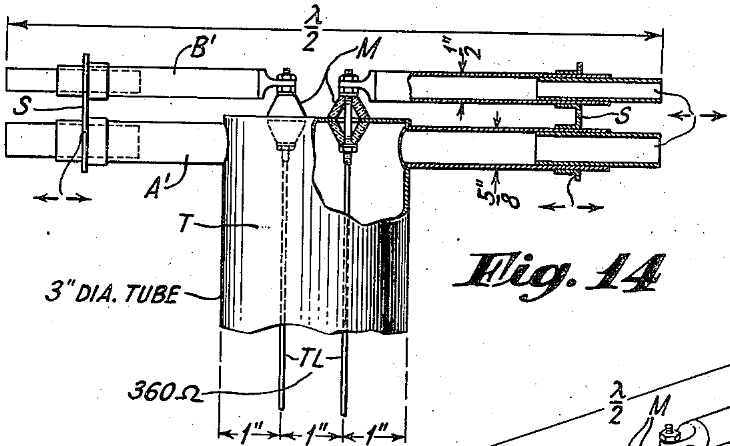


Fig. 14

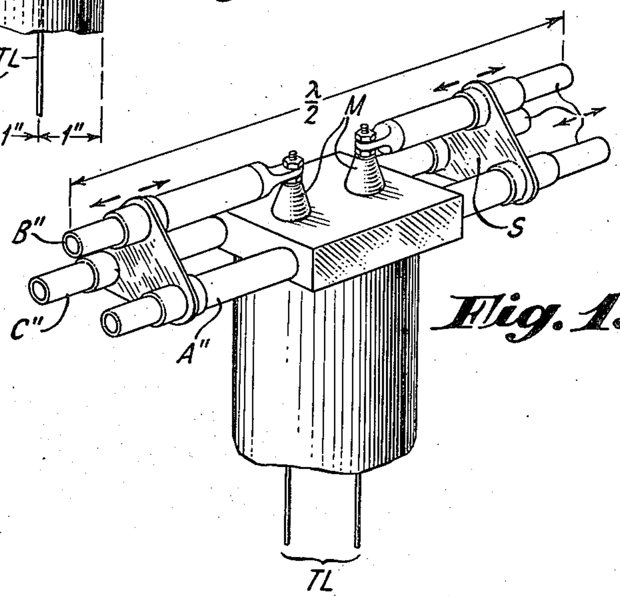


Fig. 15

INVENTOR
P. S. CARTER
BY H. S. Grover
ATTORNEY

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UNITED STATES PATENT OFFICE

2,283,914

ANTENNA

Philip S. Carter, Port Jefferson, N. Y., assignor to Radio Corporation of America, a corporation of Delaware

Application July 24, 1937, Serial No. 155,385

17 Claims. (Cl. 250—33)

The present invention relates to antennas, and more particularly to antennas for use with wide band television transmission and reception.

The primary object of the present invention is to provide an antenna system which will have an extremely broad tuning range when directly connected to a transmission line of ordinary impedance characteristic (for example a two-wire line having impedances from 300 to 600 ohms, or a pair of concentric lines having less impedance). Stated in another way, it is desired to provide such an antenna which when directly connected to the transmission line has a flat impedance versus frequency characteristic over a broad range, as seen looking toward the antenna from the transmitter or receiver terminals.

A secondary object is to provide an antenna system which requires no special impedance matching circuit between the antenna and the feeder line in order to match the surge impedance of the line to the impedance of the antenna.

It has heretofore been proposed to use a half wave dipole for wide frequency band communication. Although the dipole has a sufficiently broad tuning characteristic to give satisfactory transmission and reception over a band of frequencies such as may be used in television, it has been found that when this type of half wave antenna is matched to the transmission line in any of the known ordinary ways (as by the use of shunt impedance elements, or fanning and tapping of the transmission lines, or by the use of the quarter wave section of line) the tuning characteristic of the dipole is made very much narrower and is insufficient for the band of frequencies now generally used for television purposes. As a result of tests made on half wave dipoles, the conclusion was reached that the desired flat impedance versus frequency characteristic over a broad range must be obtained without the use of the usual impedance matching circuits between the antenna and the transmission line.

The above mentioned difficulty in using the half wave antenna is overcome and the foregoing objects achieved in accordance with the present invention, generally, by providing a multiple dipole system, the component elements of which are effectively arranged in parallel, and by breaking and feeding one of the dipole elements at the center. Although it has just been stated that the component elements of the multiple dipole are effectively in parallel, it should be understood that by the term "effectively" it is deemed that all the dipole elements radiate in parallel or receive in parallel (depending upon whether the antenna is used for transmission or reception), while in practice from a direct current standpoint the dipole elements may, if desired, be actually connected in series.

A better understanding of the invention will be had by referring to the following detailed description, which is accompanied by drawings wherein:

Figs. 1 to 15, inclusive, illustrate various embodiments of the present invention;

Figs. 1*a*, 2*a*, and 3*a* illustrate the individual current distributions in the conductors of the antenna systems of Figs. 1, 2 and 3, respectively; and

Figs. 1*b*, 2*b*, and 3*b* illustrate the distribution of the total current in the antenna systems of Figs. 1, 2 and 3.

The theory underlying the present invention will now be given, particularly with reference to Fig. 1. While this theory is believed to be an approximately correct explanation of the principles underlying the present invention, further investigation may lead to some modification of this theory. It is to be understood, of course, that the invention is independent of any theory which may be advanced to account for the results obtained.

Fig. 1 shows, in effect, a double dipole comprising two half wavelength conductors A and B of equal length, except for the break in the center of conductor B for connection to the transmission line TL, in turn extending to a suitable transmitter or receiver (not shown). Conductors A and B are very closely spaced from one another, perhaps a distance of one one-hundredth of a wavelength, and are electrically connected at their ends. The currents flowing in the two conductors will be in the same direction in space, although in opposite directions within the antenna circuit due to phase reversal at the ends. The arrows indicate the direction of current flow in the conductors. Consequently the arrangement will be almost identical in its radiation characteristic with that of a single wire half wave dipole antenna. With such close spacing, the mutual impedance, that is, the coupling between the two conductors, is almost equal to the impedance of one wire. For example, with a spacing of one one-hundredth of a wavelength the mutual impedance has been computed as 73 ohms resistance and 38.5 ohms inductive reactance, whereas the self-impedance of a single wire half-wavelength dipole is 73.2 ohms resistance and 42.5 ohms inductive reactance. It will thus be seen that two conductors A and B of the antenna are very closely coupled by their mutual impedance as well as having an electrical connection at their ends removed from the transmission line. The dotted lines I_A and I_B illustrate the current distributions in the two conductors A and B, respectively.

If we are to assume that the antenna system of a single half wavelength dipole is in free space and that the total current in the antenna is one ampere at the center thereof, it will be found that the power radiated is 73 watts and the radiation resistance is approximately 73 ohms. The effective resistance of the single wire antenna facing the transmission line TL will then be equal to

$$\frac{\text{Power (in watts)}}{I^2}$$

where I is the current in the antenna, in turn equal to

$$\frac{73}{I}=73 \text{ ohms}$$

Assuming the total current in Fig. 1 to be the same as in the single wire antenna first discussed, then the current in each of the wires A and B will be one-half the total current, and the power in both antennas will be equal. The effective resistance of the antenna of Fig. 1, however, at the terminals of the conductor B connected to the transmission line TL, will now be

$$\frac{\text{Power (in watts)}}{(\text{Current in conductor B})^2}$$

or

$$\frac{73}{\left(\frac{I}{2}\right)^2}$$

which is equal to 73×4=292 ohms. It will thus be seen that by means of the antenna system of Fig. 1, by connecting the transmission line in series with only one wire which carries half the total current, that we will have obtained a radiation resistance which is equal to four times the radiation resistance of the single wire dipole, without the use of any special impedance matching circuit between the antenna and the transmission line. This resistance of 292 ohms is of the order of the surge impedance of the transmission line used, and consequently we thus have an antenna system of extremely flat impedance versus frequency characteristic over a broad range.

In a practical embodiment of an antenna system of the type shown in Fig. 1, having the dimensions appearing on the drawing, and using a wavelength of approximately 1.35 meters, the measured resistance of the antenna of Fig. 1 as seen by the transmission line was 424 ohms, which would correspond to a single wire radiation resistance of one-fourth of this value, or 106 ohms. The surge impedance of the transmission line used was 443 ohms. It will thus be observed that by means of the present invention we are able to obtain an antenna system wherein the surge impedance of the transmission line very closely matches the resistance of the antenna. The 106 ohm value of resistance in the practical embodiment given above is somewhat higher than the radiation resistance which might be expected from an antenna placed at the height above ground used in these tests. At the risk of stating an obvious conclusion, it should be observed that the difference between the 73 ohm radiation resistance of a single wire antenna assumed above in the theoretical case, and the 106 ohm value just mentioned, is caused mainly by the fact that in the theoretical instance the antenna was assumed to be in free space, whereas in the practical case the antenna was placed at a finite distance above ground. It should be noted that although a wavelength of 1.35 meters was used in the practical case of Fig. 1, the lengths given for the wires A and B from end to end is 69 cm., which is equivalent to a half wave at 1.38 meters. This difference of 3 cm. between a true half wave at 1.35 meters and a half wave at 1.38 meters is believed to be due to various complex factors, such as may be due to the bolts and insulators used. At this time it should also be noted that the wavelength of 1.35 meters employed was the medium wavelength corresponding to the center of an extremely wide band of wavelengths.

Fig. 1*a* illustrates the current distribution in each of the conductors A and B of the antenna of Fig. 1. Fig. 1*b* illustrates the total current of the antenna of Fig. 1.

Figs. 2 and 3 illustrate two other embodiments of the double dipole arrangement of the present invention wherein the lengths of the conductors A and B are greater than one-half wavelength, in the one case three-fourths of a wavelength, and in the other case five-fourths of a wavelength. Both of these antenna systems give a higher impedance to the transmission line TL than does the system of Fig. 1.

Fig. 2*a* illustrates the current distribution in the individual wire conductors A and B of the antenna of Fig. 2, while Fig. 2*b* illustrates the total current of the antenna of Fig. 2.

Similarly, Fig. 3*a* illustrates the current distribution in the conductors A and B of the antenna of Fig. 3, while Fig. 3*b* illustrates the total current in the antenna. The current distributions of Figs. 2*a*, 2*b*, 3*a* and 3*b* are theoretical, assuming, of course, the presence of sine wave distribution throughout the conductors. In practice, however, the current may differ somewhat from the actual graphical illustrations shown in these figures. In practice, it is believed that the current distribution at the terminals of the transmission line TL connected to the antenna will differ from that shown in the drawings due to complex factors. It will be evident from an inspection of the current distributions of Figs. 2*a*, 2*b*, 3*a* and 3*b* that the overall effective current in the antennas of Figs. 2 and 3 is the same as that for a single wire of the same length from end to end.

Fig. 4 illustrates a system of the same type as shown in Figs. 2 and 3, with the conductor B open at the center. The transformation effect of Fig. 4 and the current distributions will now be reversed from that of Figs. 2 and 3.

Fig. 5 illustrates the same arrangement of Fig. 4 with a resistance R placed in series at the center of conductor B. This resistance gives a traveling wave effect along the conductors A and B and provides a wider frequency characteristic for the antenna than that obtained in the systems of Figs. 1, 2, 3 and 4. At this time it should be noted that the currents in the antenna systems of Figs. 1, 2, 3 and 4 will be standing waves while that in Fig. 5 may be given a traveling wave effect by means of resistance R, depending, of course, upon the value of this resistance.

Fig. 6 illustrates an arrangement similar to Fig. 4 except that the length of the conductors from end to end is now a full wavelength. The current distributions are indicated in dotted lines and the currents in the four legs of the conductors are all in the same directions, as indicated by the arrows. It will be evident from plotting the current distributions that if the break in the center of the conductor A were closed to provide a single continuous straight wire, the currents in the two conductors would be equal and opposite and the radiation resistance would be negligibly small.

Fig. 7 shows an arrangement similar to Fig. 6, except that a quarter wavelength loop C of high impedance is now inserted at the open terminals of conductor A. The length of this loop is one-fourth of the mean wavelength, corresponding to the center frequency of the band of frequencies to be transmitted or received.

The antennas of Figs. 6 and 7 give the same directive gain as a full wavelength single wire dipole as compared with a half wavelength dipole, and are equivalent in effect to a simple single wire antenna a full wavelength long.

Although Fig. 1 illustrates an arrangement wherein there is obtained an impedance transformation ratio of 4:1, and the other figures illustrate antennas giving different impedance transformation ratios, occasions may arise where it is desired to obtain an arrangement giving a transformation ratio of 9:1. Figs. 8 and 9 illustrate two antenna arrangements wherein there are provided three conductors spaced along the sides of a triangle for giving such a transformation ratio. The individual conductors of these two figures are each one-half wavelength long, and each take one-third of the total current. The triangle may or may not be equilateral in form. The system of Fig. 8 differs somewhat from that of Fig. 9 in that the third wire has its ends electrically open, the continuity of the second and third wires of Fig. 8 being broken at the center. These conductors are, like the conductors in the previous figures, closely spaced with respect to one another.

Figs. 10, 11 and 12 illustrate antenna arrangements for obtaining an impedance transformation ratio of 16:1. In these three figures, four closely spaced conductors are employed, each conductor taking one-fourth of the total current.

Fig. 13 illustrates a still further embodiment wherein there are employed four closely spaced conductors each effectively one wavelength long from end to end for the medium wavelength of the band to be transmitted or received. In this figure each of the conductors is broken at the center to provide two legs extending in the same straight line, each leg being one-half wavelength long, the last leg being open. Current distribution in each conductor of the system of Fig. 13 is substantially the same as that shown in the conductors of Figs. 6 and 7. The impedance transformation ratio of Fig. 13 is also 16:1 as compared to a single wire antenna one wavelength long. As mentioned before in connection with Fig. 6, if the last dipole conductor of Fig. 13 were closed, the currents in the conductors would be of opposite phase and the radiation resistance would be negligibly small.

In the antenna system illustrated in Figs. 1 to 13, inclusive, it has been assumed that the conductors of the multiple dipoles are all of the same diameter. This does not have to be the case, however, and, if desired, the conductors of the multiple dipole may have different diameters, particularly in cases where it is desired to depart, above or below, from an even 4:1, 9:1, or 16:1 etc. transformation ratio. When conductors of different diameters are employed in the antenna systems of the invention, it will be found that the conductor of larger diameter will carry the larger current. The difference in the amount of current carried by the conductors of different diameters results in a different transformation ratio from the case where conductors are all of the same diameter. If the conductor which is directly fed by the transmission line is made to have a smaller diameter than the other conductor or conductors of the antenna system, the transformation ratio will be larger than the ratio for an antenna having conductors of the same diameter and, by the same token, if the conductor of the antenna which is directly fed by the transmission line has a larger diameter than the other conductors of the antenna system, the transformation ratio will be less than that of a similar antenna system wherein the conductors are all of the same diameter. The reason the larger diameter conductor carries a greater current than the smaller diameter conductor in the antenna system of the invention is due to the fact that the larger diameter conductor has less series reactance per unit of length than the smaller diameter conductor.

Figs. 14 and 15 show two different antenna arrangements actually tried out in practice wherein the conductors of the antenna system have different diameters. The similarity of the system of Fig. 14 to that of Fig. 1, and the similarity of the system of Fig. 15 to that of Fig. 9, will be appreciated from an inspection of these figures.

In the system of Fig. 14 the conductor B′ is of less diameter than conductor A′, each of these conductors consisting of telescoping rods (as shown) for obtaining the desired length. The ends of the conductors B′ and A′ are made of smaller lengths than the main portions, and are slidable within the main portions of the conductors for tuning purposes. In addition, metallic short circuiting tuning sliders S, S are provided at both ends, the sliders making contact with both conductors A′ and B′ and being adjustable in both directions over the lengths of the conductors B′ and A′ for making small adjustments in impedance. These sliders also serve to support the upper conductor B′ from the lower conductor A′. The lower conductor A′ is mounted on a hollow metallic tubular conductor T which contains within it a transmission line TL extending from suitable transmitting or receiving apparatus (not shown) to the conductor B′ through insulators M. Conductor B′ is here shown, by way of example, as being a one-half inch hollow conductor while conductor A′ is five-eighths of an inch in diameter. The two legs of conductor A′ are effectively connected together through the outer surface of metallic conducting tube T. In this particular antenna system the transformation ratio was purposely made greater than 4:1 in order to match the surge impedance of line TL which was equal to 360 ohms. Similarly, by suitable choice of dimensions there may be obtained, within reason, any desired antenna resistance to match the impedance of the transmission line. By reversing the order of the diameters of conductors A′ and B′, that is, by making the diameter of conductor A′ smaller than that of B′, a transformation ratio less than 4:1 can be obtained. The tubular conductor T in this case merely serves as a transmission line shield for the entire length of the tube, and also as a support for the conductors A' and B'.

Fig. 15 illustrates a multiple dipole antenna system of the three-conductor type employing telescoping rods A'', B'' and C'' with metallic sliders in the same manner as these features are employed in Fig. 14. In Fig. 15, however, the three conductors are of the same diameter, although, if desired, they may have different diameters in accordance with the principles set forth above. The same reference numerals have been used in both Fig. 14 and Fig. 15, except for the difference in prime designations, to designate corresponding elements.

It will be appreciated, of course, that when desired the principle of using different diameters for the conductors A' and B' may be incorporated in any of the systems illustrated in Figs. 1 to 13, inclusive. Although the systems of Figs. 14 and 15 are the only ones illustrating tuning sliders S, S and telescoping rods, it will be obvious that these features are equally applicable to the antenna systems illustrated in the other figures.

What is claimed is:

1. An antenna system operative over a wide range of frequencies comprising an aerial conductor having a pair of separated arms arranged end to end and providing terminals at the adjacent ends of said arms, another aerial conductor arranged parallel to said first conductor and spaced very close thereto relative to the length of the operating wave, connections between the ends of said last conductor and points on said arms removed from the adjacent ends of said arms, whereby the impedance of said antenna system at said terminals is increased over that of a single conductor dipole, and a two-wire open feeder line having a predetermined impedance directly connected to said terminals, the impedance of said antenna at said terminals being of the order of the impedance of said two-wire open feeder line, whereby said antenna system has an extremely flat impedance versus frequency characteristic over said range of frequencies.

2. An antenna arranged to operate as a simple dipole having a driving point impedance so increased over that of a single conductor dipole as to permit direct matching of the impedance of the antenna to that of a two-conductor transmission line, comprising a plurality of parallel aerial conductors spaced very close compared to the wavelength, connected together at points oppositely disposed relative to their midpoints, and carrying currents in phase, the total effective current for the production of radiation at any point in the antenna being substantially greater than the current at the corresponding point of a simple dipole for a given input current, whereby the radiated power for a given input current is substantially increased as compared to that of a simple dipole with a consequent increase in the radiation resistance to a value capable of direct matching to said two-conductor line, said antenna having a pair of terminals intermediate the ends of one of said aerial conductors, and a two-conductor transmission line having a predetermined impedance directly connected to said terminals, the impedance of said antenna at said terminals being of the order of the impedance of said transmission line.

3. An antenna system operative over a wide range of frequencies comprising an aerial conductor having a pair of separated arms extending in the same straight line and providing terminals at the adjacent ends of said arms, another aerial conductor arranged parallel to said first conductor and spaced very close thereto relative to the operating wavelength, means for connecting the ends of said arms removed from said terminals to the ends of said other aerial conductor, whereby the impedance of said antenna system at said terminals is increased over that of a single conductor dipole, and a two conductor transmission line having a predetermined impedance directly connected to said terminals, the impedance of said antenna at said terminals being of the order of the impedance of said transmission line, whereby said antenna system has an extremely flat impedance versus frequency characteristic over said range of frequencies.

4. An antenna system comprising a conductor having a pair of separated arms arranged end to end, another conductor arranged parallel to said first conductor and closely spaced therefrom, means for connecting said arms to said other conductor at points removed from the adjacent ends of said arms, said conductors having different diameters, whereby the impedance of said antenna system at said adjacent ends is increased over that of a single conductor dipole, and a two-conductor transmission line having a predetermined impedance directly connected to the adjacent ends of said arms, the impedance of said antenna system at said adjacent ends being of the order of said transmission line.

5. An antenna system comprising a first conductor having a pair of separated arms arranged end to end, another conductor arranged parallel to said first conductor and closely spaced therefrom, means for connecting said arms to said other conductor at points removed from the adjacent ends of said arms, said first conductor having a smaller diameter than said other conductor, whereby the impedance of said antenna system at said adjacent ends is increased over that of a single conductor dipole, and a two-conductor transmission line having a predetermined impedance directly connected to the adjacent ends of said arms, the impedance of said antenna system at said adjacent ends being of the order of said transmission line.

6. An antenna system in accordance with claim 5, characterized in this that said conductors are each approximately one-half wavelength long at a particular frequency in the band to be transmitted or received.

7. An antenna system operative over a wide range of frequencies comprising an aerial conductor having a pair of separated arms arranged end to end and providing terminals at the adjacent ends of said arms, another aerial conductor arranged parallel to said first conductor and spaced very close thereto relative to the length of the operating wave, connections between the ends of said last conductor and points on said arms removed from the adjacent ends of said arms, whereby the impedance of said antenna system at said terminals is increased over that of a single conductor dipole, said connections being adjustable over the lengths of said conductors, and a two conductor feeder line having a predetermined impedance directly connected to said terminals, the impedance of said antenna at said terminals being of the order of the impedance of said feeder line, whereby said antenna system has an extremely flat impedance

versus frequency characteristic over said range of frequencies.

8. An antenna system operative over a wide range of frequencies comprising an aerial conductor having a pair of separated arms arranged end to end and providing terminals at the adjacent ends of said arms, another aerial conductor arranged parallel to said first conductor and spaced very close thereto relative to the length of the operating wave, connections between the ends of said last conductor and points on said arms removed from the adjacent ends of said arms, whereby the impedance of said antenna system at said terminals is increased over that of a single conductor dipole, and a two conductor feeder line having a predetermined impedance directly connected to said terminals, the impedance of said antenna at said terminals being of the order of the impedance of said two conductor feeder line, whereby said antenna system has an extremely flat impedance versus frequency characteristic over said range of frequencies, said other conductor being electrically open at its center.

9. An antenna system operative over a wide range of frequencies comprising an aerial conductor having a pair of separated arms arranged end to end and providing terminals at the adjacent ends of said arms, another aerial conductor arranged parallel to said first conductor and spaced very close thereto relative to the length of the operating wave, connections between the ends of said last conductor and points on said arms removed from the adjacent ends of said arms, whereby the impedance of said antenna system at said terminals is increased over that of a single conductor dipole, and a two conductor feeder line having a predetermined impedance directly connected to said terminals, the impedance of said antenna at said terminals being of the order of the impedance of said two conductor feeder line, whereby said antenna system has an extremely flat impedance versus frequency characteristic over said range of frequencies, said conductors each having a length from end to end approximately equal to one wavelength, said other conductor being electrically open at its center.

10. An antenna system operative over a wide range of frequencies comprising an aerial conductor having a pair of separated arms arranged end to end and providing terminals at the adjacent ends of said arms, another aerial conductor arranged parallel to said first conductor and spaced very close thereto relative to the length of the operating wave, connections between the ends of said last conductor and points on said arms removed from the adjacent ends of said arms, whereby the impedance of said antenna system at said terminals is increased over that of a single conductor dipole, and a two conductor feeder line having a predetermined impedance directly connected to said terminals, the impedance of said antenna at said terminals being of the order of the impedance of said two conductor feeder line, whereby said antenna system has an extremely flat impedance versus frequency characteristic over said range of frequencies, and a metallic tubular shield surrounding the conductors of said feeder line and serving to support said conductors of said antenna system.

11. An antenna system for transmitting or receiving a wide band of frequencies comprising a first conductor having a pair of separated arms extending in the same straight line, second and third conductors arranged parallel to and closely spaced from said first conductor, said three conductors being arranged in a triangle, and means for connecting said arms to said second and third conductors at points removed from said adjacent ends, whereby the impedance of said antenna system at said adjacent ends is increased over that of a single conductor dipole, and a two-conductor transmission line having a predetermined impedance directly connected to the adjacent ends of said pair of arms, the impedance of said antenna system at said adjacent ends being of the order of said transmission line.

12. An antenna system for transmitting or receiving a wide band of frequencies comprising a first conductor having a pair of separated arms extending in the same straight line, second, third and fourth conductors arranged parallel to and closely spaced from said first conductor, said four conductors being arranged in a quadrangle, and means for connecting said arms to said second, third and fourth conductors at points removed from said adjacent ends, whereby the impedance of said antenna system at said adjacent ends is increased over that of a single conductor dipole, and a two-conductor transmission line having a predetermined impedance directly connected to the adjacent ends of said pair of arms, the impedance of said antenna system at said adjacent ends being of the order of said transmission line.

13. An antenna system operative over a wide range of frequencies comprising an aerial conductor having a pair of separated arms arranged end to end and providing terminals at the adjacent ends of said arms, another aerial conductor arranged parallel to said first conductor and spaced very close thereto relative to the length of the operating wave, connections between the ends of said last conductor and points on said arms removed from the adjacent ends of said arms, whereby the impedance of said antenna system at said terminals is increased over that of a single conductor dipole, and a two conductor feeder line having a predetermined impedance directly connected to said terminals, the impedance of said antenna at said terminals being of the order of the impedance of said two conductor feeder line, whereby said antenna system has an extremely flat impedance versus frequency characteristic over said range of frequencies.

14. An antenna system operative over a wide range of frequencies comprising an aerial conductor providing terminals intermediate the ends thereof, another aerial conductor arranged parallel to said first conductor and placed close thereto relative to the length of the operating wave, connections between the ends of said last conductor and the ends of said first conductor, whereby the impedance of said antenna system at said terminals is increased over that of a single conductor dipole, and a two conductor feeder line having a predetermined impedance directly connected to said terminals, the impedance of said antenna at said terminals being of the order of the impedance of said two conductor feeder line, whereby said antenna system has an extremely flat impedance versus frequency characteristic over said range of frequencies.

15. An antenna system operative over a wide range of frequencies comprising an aerial conductor providing terminals intermediate the ends thereof, another aerial conductor arranged par-

allel to said first conductor and spaced very close thereto relative to the length of the operating wave, connections between points at or near the ends of said last aerial conductor and points on said first aerial conductor removed from the terminals, whereby the impedance of said antenna system at said terminals is increased over that of a single conductor dipole, said connections being adjustable over portions of the lengths of said conductors, and a two-conductor feeder line having a predetermined impedance directly connected to said terminals, the impedance of said antenna at said terminals being of the order of the impedance of said feeder line, whereby said antenna system has an extremely flat impedance versus frequency characteristic over said range of frequencies.

16. An antenna system comprising an aerial conductor having terminals intermediate the ends thereof, another conductor arranged parallel to said first conductor and closely spaced therefrom, means for connecting said first aerial conductor to said other aerial conductor at points removed from the terminals of said first conductor, said aerial conductors having different diameters, whereby the impedance of said antenna system at said terminals is increased over that of a single conductor dipole, and a two-conductor transmission line having a predetermined impedance directly connected to said terminals, the impedance of said antenna system at said terminals being of the order of said transmission line.

17. An antenna system operative over a wide range of frequencies comprising an aerial conductor providing terminals intermediate the ends thereof, another aerial conductor arranged parallel to said first conductor and spaced very close thereto relative to the length of the operating wave, connections between the ends of said last conductor and points on said first aerial conductor removed from the terminals, whereby the impedance of said antenna system at said terminals is increased over that of a single conductor dipole, and a two conductor feeder line having a predetermined impedance directly connected to said terminals, the impedance of said antenna at said terminals being of the order of the impedance of said two conductor feeder line, whereby said antenna system has an extremely flat impedance versus frequency characteristic over said range of frequencies, said other conductor being electrically open at its center.

PHILIP S. CARTER.