March 3, 1959

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2,876,448

MULTIPLE DECOUPLED ANTENNAE CONNECTED TO RADIO BY DIFFERENT LENGTH FEEDER FOR IMPEDANCE MIAMATCH REDUCTION

Filed March 30, 1954

Fig. 1.

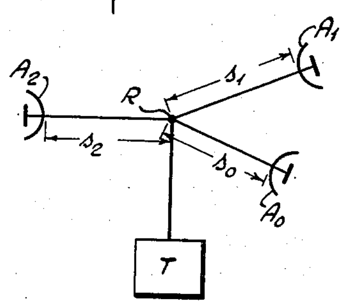


Fig. 2.

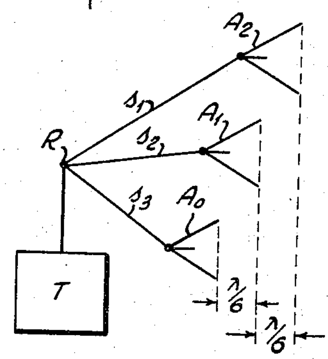
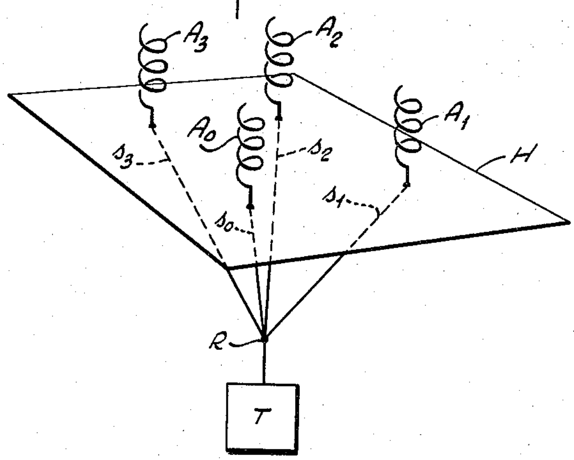


Fig. 3.



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2,876,448

Patented Mar. 3, 1959

2,876,448

MULTIPLE DECOUPLED ANTENNAE CONNECTED TO RADIO BY DIFFERENT LENGTH FEEDER FOR IMPEDANCE MISMATCH REDUCTION

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Application March 30, 1954, Serial No. 419,799

2 Claims. (Cl. 343—853)

The present invention relates to multiple antenna systems for both directional and omni-directional transmission and/or reception of radio signals, more particularly to antenna systems designed for operation in the VHF and microwave range of operating frequencies.

As is well known, great difficulties are experienced in practice in matching the impedance of an antenna with its feeder or transmission lines connecting it to a high frequency transmitter or receiver. In case of an impedance mismatch between the antenna and its feeder, reflections occur which in turn cause losses in the line and often are the result of distortion of the signals being transmitted or received. Furthermore, in case of a transmitting antenna connected to a microwave generator, the reflections have the further effect of unfavorably reacting upon the generator (so-called long line effect). While this reaction can be minimized by a sufficiently loose coupling between the feeder input and the transmitter, this results in a reduction of the power radiated by the antenna.

An important object of the present invention is, therefore, the provision of simple and efficient means in connection with a multiple antenna structure, in particular for use in the VHF and microwave range, whereby the effect of undesirable reflections due to impedance mismatch is practically eliminated or compensated.

The invention, both as to its further objects and novel aspects will be better understood by the following detailed description taken in conjunction with the accompanying drawing the several views of which diagrammatically show various practical embodiments of multiple antennae constructed in accordance with the principles of the invention.

As is well known, the input impedance Z_1 of a loaded transmission line can be determined to a sufficient approximation by the following equation:

$$Z_1=Z_0(1+R\cdot e^{-2\gamma L})$$

wherein Z_0 represents the wave impedance, L the electrical length, $\lambda=\beta+j\alpha$ the transmission constant of the line and R is a magnitude representative of the mismatch between the load and the line.

For very short waves, such as microwaves, the transmission constant may be represented simply by $\gamma=j\alpha$ with sufficient approximation, whereby

$$Z_1=Z_0(1+R\cdot e^{-2\alpha L}) \qquad 1)$$

In accordance with the present invention, the input impedance of a multiple antenna system designed for an operating wavelength λ is rendered independent of the magnitude R representing the mismatch by staggering or varying the electrical length of the feeders for the various antennae by consecutive increments equal to $\lambda/2n$, wherein n represents the number of antennae of the system. The input ends of the feeders are preferably connected in series, but if desirable may be connected in parallel.

In the following the function of the invention is further explained with reference to a simple practical example comprising two antennae with feeders connected in series, such as a pair of dipoles arranged for directional, omnidirectional or any other kind of transmission or reception. It is assumed that the first antenna is connected to a feeder having an electrical length L. Accordingly its input impedance Z_1 is given by the above Equation 1. The second antenna is provided according to the invention with a feeder having an electrical length

$$L+\lambda/2n=L+\lambda/4$$

Accordingly, the input impedance of this feeder is as follows:

$$Z_2=Z_0(1+R\cdot e^{-2j\alpha(L+\lambda/4)})=Z_0(1-R\cdot e^{-2j\alpha L}) \qquad (2)$$

By connecting both lines or impedances Z_1 and Z_2 in series, the resultant total input impedance of the antenna system will be as follows:

$$Z=Z_1+Z_2=2\cdot Z_0 \qquad (3)$$

From the above it is seen that the input impedance of the system as seen from the transmitter or receiver is free from the effect of the magnitude R representing the mismatch or reflection, the system functioning by causing a wave reflected from any of the antennae to consecutively pass through all the feeders, in such a manner as to cancel or compensate its resultant effect upon the common transmitter or receiver.

In a system of the above type it is necessary to have all the antennae substantially decoupled from each other as is usually the case in multiple antenna systems, in particular directional systems used for both transmission and reception.

A multiple antenna system of the type according to the invention may serve for omnidirectional transmission or broadcasting from a single transmitter to a number of receiving stations. Alternatively, the individual antennae may be positioned in proper relative space arrangement to obtain a directive transmission or reception in a preferred axis by causing the waves radiated by the individual antenna to coincide in phase at a desired receiving point, in a manner well known to those skilled in the art. In a simple arrangement the individual antennae of a system according to the invention may be displaced one from the other in the preferred or directional axis by distances equal to $\lambda/2n$.

The invention is especially suited for use in connection with antenna arrangements for transmission or reception of circularly polarized waves. For this purpose two antennae, such as two dipoles, are arranged with their planes of polarization crossing or forming a right angle. With the feeders of the antenna being designed in the manner according to the invention, the effect of mismatch or reflection is practically eliminated.

The invention will be better understood from the following detailed description taken in reference to the accompanying drawing, forming part of this specification and in which:

Fig. 1 is a general diagram of a multiple antenna system embodying the invention;

Fig. 2 is a similar diagram for a directional antenna array; and

Fig. 3 is a diagram of a directional antenna system embodying the invention, comprising a reflector and a plurality of antenna elements.

Like reference characters identify like parts in the different views of the drawing.

Referring to Fig. 1 there is shown an arrangement consisting of three substantially decoupled antennae, A_0, A_1 and A_2 provided with parabolic reflectors and oriented in different directions. The length s_0, s_1 and s_2 of the feeders for the individual antennae to the common junction R is designed to differ from one another by fractional amounts equal to $k\lambda/6$, wherein k represents the ratio between the velocity of propagation of the electric energy and the velocity of light. Since this ratio in the case of electric waves is equal to 1, the difference in the electrical length between the feeders in the example shown is $\lambda/6$. In other words, the reflected oscillations caused by a mismatch of the impedance of one antenna with its feeder and arriving at the common junction R, are displaced in phase relative to one another by amounts equal to $2\pi/3$, in such a manner as to cancel each other in their effect upon the common transmitter T. The same applies in the case of a plurality of receiving antennae connected to a common receiver. More particularly, for this purpose the length of the line s_1 in Fig. 1 is equal to $s_0+k\lambda/6$ and the length of the line s_2 is equal to $s_0+k\lambda/3$ in accordance with the invention. The input ends of the lines s_0, s_1 and s_2 which may be in the form of conventional two-wire (Lecher) transmission lines or coaxial cables, are preferably connected in series with each other and the transmitter T, as pointed out above.

Fig. 2 shows a similar arrangement comprising three conical or V-shaped antenna A_0, A_1 and A_2 arranged to transmit or receive in the same direction and with the electrical lengths of the feeders s_0, s_1 and s_2 again differing one from the other by amounts equal to $\lambda/6$. At the same time the antennae are shown to be staggered in space by distances equal to $\lambda/6$, to obtain a directional axis in line with displacement of the antennae, in a manner pointed out hereinbefore.

Fig. 3 shows an embodiment of an antenna system comprising four helical antennae A_0, A_1, A_2 and A_3 arranged in spaced relation with their axes at right angle to a reflecting plate or screen H. The energization of these antennae is effected through four feeders s_0, s_1, s_2 and s_3, respectively, whose lengths differ one from the other by amounts equal to $\lambda/8$. An arrangement of this type has a directional axis which deviates somewhat from a line perpendicular to the reflector H. Again, the effect of mismatch of any of the antennae with its respective feeder will be substantially compensated or its effect upon the transmitter cancelled or neutralized in substantially the same manner as described hereinabove.

The individual antennae may be in the form of parabolic radiators, single dipoles or dipole groups and the like, as used in conventional antenna systems for both directional and omnidirectional transmission and reception. In other words, the invention applies to any type

of multiple antenna structure comprising more than a single antenna element each connected to a common transmitter or receiver by an individual transmission line or feeder. By the proper staggering of the electrical lengths of the feeders in the manner described by the invention, the effect of any impedance mismatch between the antennae with their respective feeders is automatically compensated by a neutralization or cancellation of the reflected oscillations at the common input or junction.

In the foregoing the invention has been described with specific reference to a few illustrative embodiments thereof. It will be apparent, however, that variations and modifications as well as the substitution of equivalent elements for those shown, may be made without departing from the broader spirit of the invention as defined in the appended claims. The specification and drawing are accordingly to be regarded in an illustrative rather than in a limiting sense.

What is claimed is:

1. A multiple antenna system comprising a plurality of more than two antenna elements and feeders connecting each of said antenna elements with a common junction point, the improved feature consisting in the electric lengths of said feeders being consecutively staggered by amounts equal to $\lambda/2n$ from one to the next antenna element, wherein λ represents the operating wavelength and n the number of antenna elements of said system.

2. A multiple antenna system comprising a plurality of more than two antenna elements being mutually decoupled from one another and individual feeders connecting each of said antenna elements with a common operating circuit, the improved feature consisting in the electric lengths of said feeders being consecutively staggered by relative amounts equal to $\lambda/2n$ between each and the next antenna element, wherein λ represents the operating wavelength and n the number of antenna elements of said system.

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