Jan. 6, 1959 H. E. GIHRING 2,867,804

ANTENNA ARRAY AND FEED SYSTEM THEREFOR

Filed Dec. 1, 1954 2 Sheets-Sheet 1

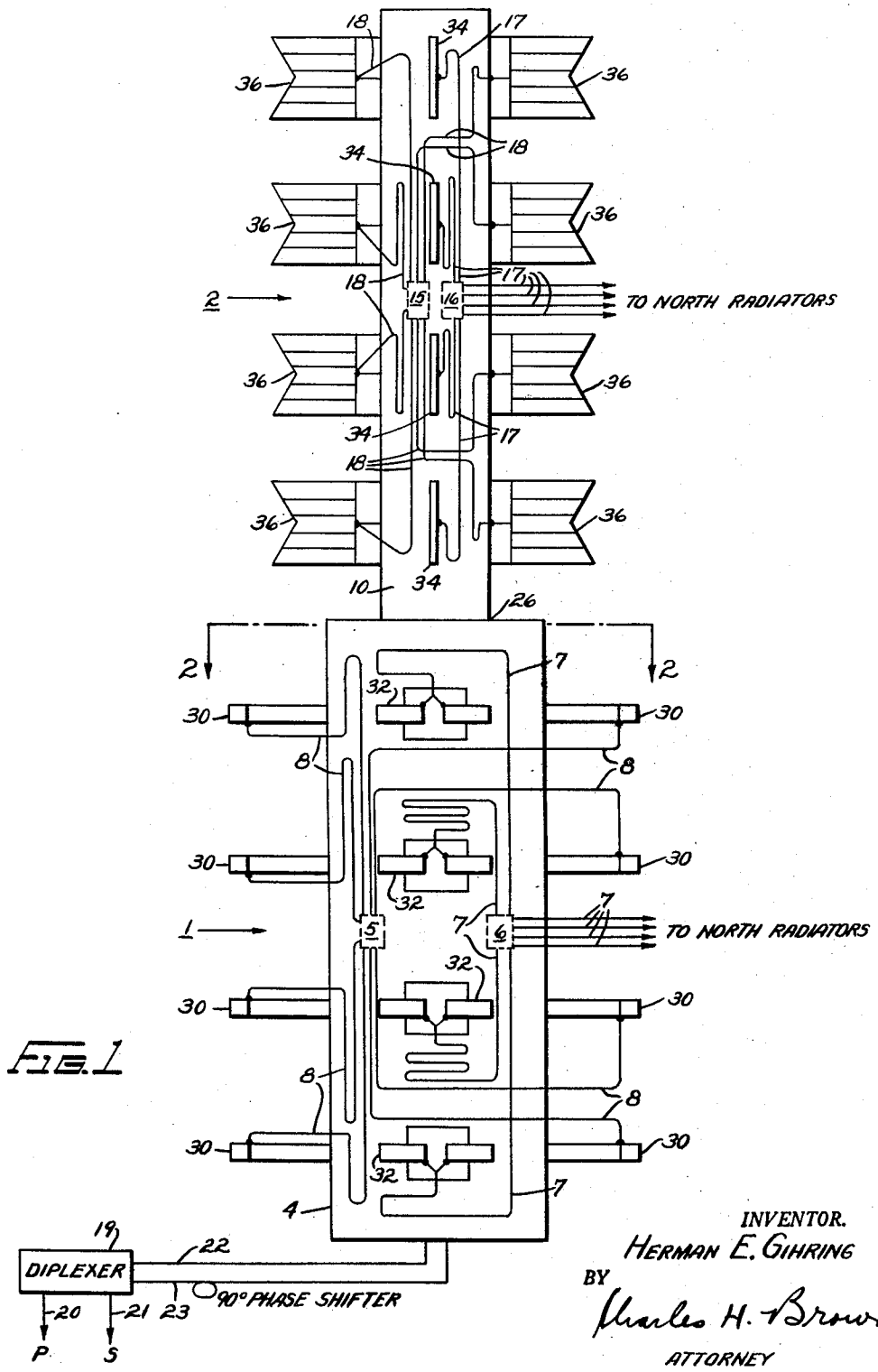


FIG. 1

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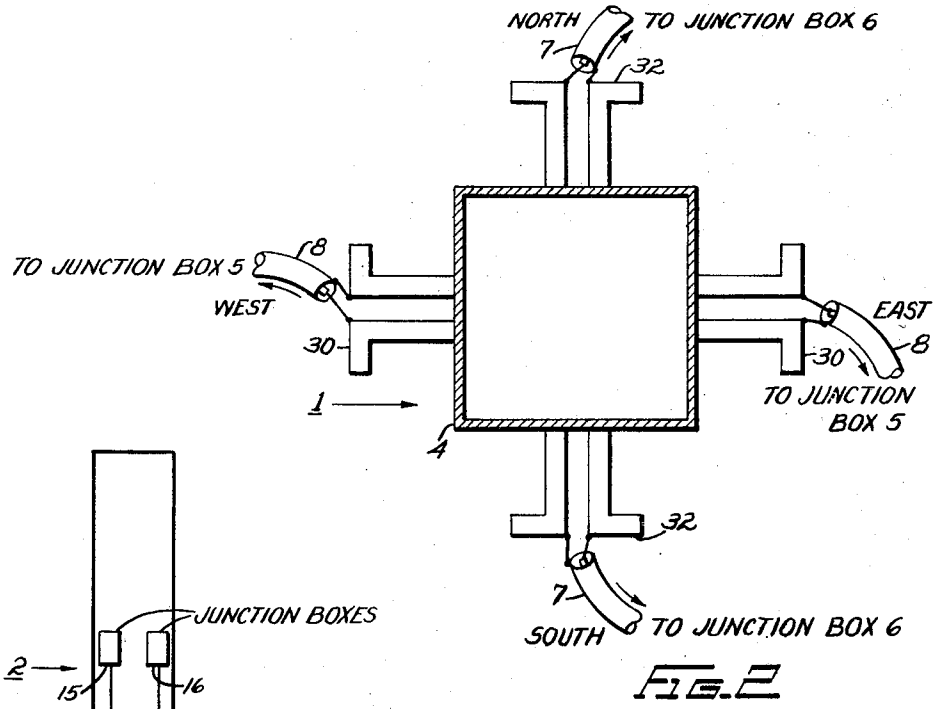


FIG. 2

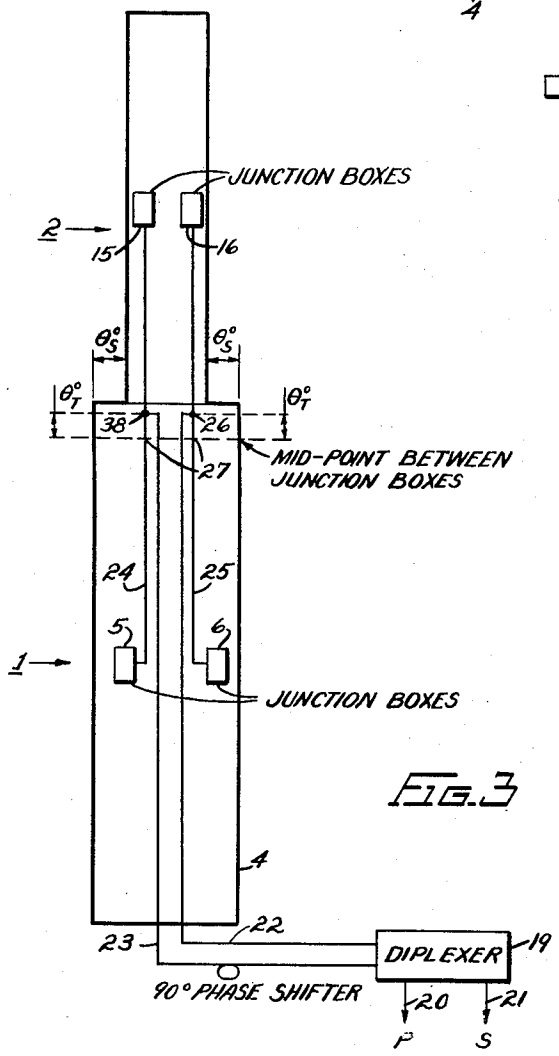


FIG. 3

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ANTENNA ARRAY AND FEED SYSTEM THEREFOR

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Application December 1, 1954, Serial No. 472,465

The terminal fifteen years of the term of the patent to be granted has been disclaimed

10 Claims. (Cl. 343—853)

This invention relates to an antenna array and more particularly to a method of and means for enabling an increase in the maximum gain of an antenna array without discarding or completely altering an existing or available antenna system.

Following the installation of an antenna system for use with a given communication means, it is often discovered that the signal strength of the existing system is inadequate. For example, in commercial television broadcasting stations, the growth in size of a neighborhood or service area requires the station to extend the area covered by its transmission. Such action is necessary on the part of the station in order to properly serve the advertisers who make use of its services and the public who rely on the various programs provided by the station for their entertainment and information. Any increase in the power limit permitted would also make it desirable to increase the signal strength of a station to permit it to provide the additional service to its service area.

In increasing the strength of a signal from an antenna system that is operating at or near maximum output, several courses of action can be taken. A new antenna of the required characteristics could be purchased but it may not be available in time and, if available, might not be economically feasible.

An existing antenna, designed for television broadcasting, while inadequate, is an expensive piece of equipment and the discarding thereof so as to replace it with an entirely new antenna will mean considerable expense to the station over and above the cost of the new antenna. The combining of two known types of antennas, such as a super-turnstile and a super-gain, will be less expensive, and can be done more quickly.

The present invention is directed to an antenna array in which a second antenna system, chosen in accordance with the requirements therefor, is mounted underneath an existing antenna system which is inadequate as to power output, in order to obtain increased signal strength from the resulting array.

An existing antenna is usually designed in such a manner that an additional load cannot be placed upon it. However, a second antenna having a larger cross section can be placed underneath an antenna so that it will support an existing type. In feeding a signal to such an antenna array incorporating two antenna systems, it is necessary to feed the signal so that the phase front of the departing signal will be substantially uniform. The larger dimensions of the second antenna system will serve to adversely distort signals radiated from the over-all antenna array. This is due to the fact that the wave front radiated from the second antenna system will not be uniform and in phase with that radiated from the top or existing antenna system.

An object of the invention is to increase the gain of an existing or available antenna system in a simple and relatively inexpensive manner.

Another object is to modify an existing television antenna system having an array of radiating elements,

which has been operated at or near maximum output, in a novel manner to increase the gain of the array.

Another object is to operate a television antenna array including two normally independent antenna systems having different dimensions in such a manner that the same signal radiated therefrom will not be adversely distorted or altered due to the different structural dimensions of the systems.

A still further object is to attain the above objects with a simple and compact construction.

In accomplishing these objects a second antenna system, chosen in accordance with the requirements therefor, is mounted underneath an existing or available antenna system which could be in use and in operation at or near a maximum output found to be inadequate. The second antenna system is larger in lateral dimension so as, for example, to provide the necessary structural strength to support the existing antenna system which is mounted on the top thereof. A signal is fed from a transmitting means to both antenna systems. The difference in structural dimension of the two antenna systems would normally serve to adversely distort the wave front radiated therefrom due to the fact that the waves radiated from one system would not be uniform and in phase with the waves radiated from the other. The present invention eliminates this difficulty by providing a new and novel means for feeding a signal to a plurality of antenna systems which are incorporated into an antenna array.

Junction boxes are located in each antenna system to which are connected the radiating elements used on the associated antenna systems, the radiating elements of one system being electrically connected to the junction boxes located in that system, and the radiating elements of the other system being electrically connected to the junction boxes located in that system. The junction boxes in one system are connected to those in the other system by electrical conductors. The lead-ins from a transmitting device are in turn connected to the conductors connecting the junction boxes. In order to compensate for the difference in structural dimensions of the two antenna systems, the point at which the lead-ins are connected to the conductors connecting the junction boxes is removed from a point mid-way between the junction boxes to a point whereby the signal fed to both antenna systems will be radiated from each system in an in-phase relationship, presenting thereby a uniform over-all wave front. The exact distance involved will depend upon the particular antenna arrangement which is used and is to be determined by experimentation therewith.

A more detailed description of the invention follows in conjunction with a drawing in which like reference numerals refer to like parts and in which:

Figure 1 shows pictorially one embodiment of the invention, wherein a super-gain antenna system is mounted underneath a super-turnstile antenna system.

Figure 2 is a cross-sectional view of the super-gain antenna system taken immediately below line 2—2 of Figure 1, and

Figure 3 is a diagrammatical view of the antenna array including a top antenna system such as a super-turnstile antenna and a bottom antenna system such as a super-gain antenna, as shown in Figure 1, showing the circuit for feeding a signal to the over-all antenna array.

Referring to Figures 1 and 2, a television broadcasting antenna system is shown. A super-gain antenna **1** is mounted underneath and along the longitudinal axis of a super-turnstile antenna **2**. It is to be presumed that the super-turnstile antenna is an existing antenna that is installed or quickly available. The supports for the two antenna systems may be fastened together at point **26** in any manner known in the art. The lower or super-

gain antenna 1 has a larger lateral dimension than that of the super-turnstile antenna 2, as will be more fully discussed later. The array comprising the two antenna systems, namely the super-gain antenna 1 and super-turnstile antenna 2, is adapted to be vertically mounted on a tower, mountain or building, not shown.

The super-gain antenna 1 comprises a plurality of dipole radiating elements arranged in groups of four in quadrature relationship about the hollow square support 4, each group including a pair of North-South radiators 32 and East-West radiators 30. For the sake of description, there are shown four groups of such dipole arrangements, but it is to be understood that the invention is not so limited and that any number of such arrangements may be used. Two junction boxes 5 and 6 are located inside the support 4. While the wiring for feeding a signal to the radiating elements 30 and 32 would normally be placed inside the hollow support 4 in actual usage, for purposes of description, the wiring has been shown as extending along the surface of the support 4.

Coaxial connecting lines 7 which are of equal length serve to connect one pair of dipoles of each group, for example the North-South dipoles 32, to junction box 6. Coaxial connecting lines 8 which are of equal length serve to connect the other pair of dipoles of each group, for example the East-West dipoles 30, to junction box 5. As is more clearly shown in Figure 2, the coaxial connecting lines 7 and 8 will be coaxially connected to each dipole at each of the groups to provide proper phasing and electrical operation of the antenna array.

The super-turnstile antenna 2 of Figure 1 comprises a plurality of radiators which are arranged in groups of four in quadrature relationship about the outer surface of a support 10, each group including a pair of North-South radiators 34 and East-West radiators 36. For purposes of description, there are shown four groups of radiators, but it is to be understood that any number of such groups may be used. As in the case of the super-gain antenna 1, the wiring of the super-turnstile antenna 2 is shown as extending along the outer surface of the support 10, for purposes of description. Two junction boxes 15 and 16 are located in or on the support 10. Coaxial connecting lines 17 which are of equal length serve to connect one pair of the radiators, for example North-South radiators 34, of each group to junction box 16. Coaxial connecting lines 18 which are of equal length serve to connect the other pair of radiators of each group, for example East-West radiators 36, to junction box 15.

While coaxial connecting lines 17 and 18 in the super-turnstile antenna 2, as well as 7 and 8 in the super-gain antenna 1 have been indicated as being equal in length, a pattern which may be desirable due to the contour of the surrounding land area could be obtained from the antenna array by utilizing different coaxial line lengths to the various radiators.

A source of television picture and sound signals, P and S, respectively, is connected by leads 20 and 21, respectively, to any diplexing means 19. The output of the diplexing means is fed through lead-ins 22 and 23 to the antenna array, lead-in 23 having incorporated therewith a 90° phase shifter.

Referring now to Figure 3, the lead-ins 22 and 23 from the diplexer 19 are inserted into and along the length of the hollow support 4 of the super-gain antenna 1. The junction box 15 located in the super-turnstile antenna 2 is electrically connected to junction box 5 located in the super-gain antenna 1 by means of an electrically conducting lead 24. Junction box 16 also located in super-turnstile antenna 2 is electrically connected to junction box 6 located in the super-gain antenna 1 by means of an electrically conducting lead 25. In the normal feeding of an antenna array, the lead-ins 22 and 23 would be coaxially connected to the mid-point of leads 24 and 25. To compensate for the difference

in lateral dimensions of the super-gain antenna as compared to that of the super-turnstile antenna, the lead-in 22 is connected to lead 25 and lead-in 23 is connected to lead 24 at points 26 and 38, respectively. The points 26 and 38 are removed from the midpoint 27 of the leads 24 and 25 a distance such that the phase angle of the signal, shown as θ^{o}_{time} in Figure 3, is equal to the phase angle of the signal between the plane of radiation of the lower or super-gain antenna 1 and the plane of radiation of the top or super-turnstile antenna 2, shown as θ^{o}_{space} in Figure 3. By so connecting the lead-ins 22 and 23 to the connecting leads 24 and 25, the phase of the signal fed to each of the antenna systems 1 and 2 will differ in such a manner, the signal fed to the super-gain antenna 1 being delayed in phase, that the signals radiated from both antennas will be in substantially the proper phase relationship with one another and a uniform wave front will be presented by the over-all antenna array. The signal transmitted by the antenna array as a whole will, therefore, not be adversely altered due to the difference in lateral dimensions of the two antenna systems incorporated in the antenna array, and will be of greater strength than the maximum output capable of being put out by the top portion 2 alone.

The points 26 and 38 on connecting leads 25 and 24 at which lead-ins 22 and 23 will be connected in the actual installation of an antenna such as is described will be dependent upon the exact physical and electrical differences of the antenna systems and the supporting structures which are used to give a particular combination of antenna array.

It may be seen that an antenna array has been provided capable of large signal strength whereby use may be made of an existing antenna system by properly feeding the signal to be radiated to a plurality of antenna systems incorporated in a single antenna array. The antenna array of the invention is simple and compact in construction and will radiate a uniform wave front which is free of undesired distortion and signal imperfection. When θ^{o}_{s} does not equal θ^{o}_{t} a net tilt in the departing wave front will result, which can be utilized effectively in certain types of service areas where a downward tilt of the departing wave front is desirable. In a special case, when the centers of the antennas are not colinear a varying tilt can be obtained in various azimuthal directions which is highly useful in the situation where the transmitting site is on a plateau overlooking a valley. In this situation, a downward tilt may be desired towards the valley and no tilt or a very small tilt desired along the plateau. When the antennas are not colinear, the value of tilt can be made to vary in various azimuthal directions, as desired, by proper displacement of the upper antenna from the center axis of the lower antenna.

While the invention has been described in connection with an antenna array consisting of super-gain and super-turnstile antenna systems, it is to be understood that the invention is not necessarily limited to such an antenna array. A specific application of the invention is a super-gain antenna of 8 to 10 sections located under a 12 bay super-turnstile antenna. Such a combination can give a gain of about 18 by combining designs. Other ultra-high frequency antennas such as slotted or pylon antennas may be used. Another application of the invention is a large diameter U. H. F. antenna of a gain of the order of 20 which is placed under an existing U. H. F. pylon antenna.

Having described my invention, what I claim is:

1. In a broadcasting system, an antenna array comprising, in combination, first and second antennas of different lateral dimensions located in an end-to-end relationship along the longitudinal axis of said array, means for electrically connecting said antennas, and means for feeding signals to be radiated by said antennas to said connecting means at a point removed from the mid-point between the ends of said connecting means, said point

being located from said mid-point at an electrical distance equivalent to the delay in the wave front of the antenna of smaller lateral dimensions relative to the wave front of the antenna of larger lateral dimensions.

2. A system as defined in claim 1 wherein the antennas are colinear.

3. A system as defined in claim 1 wherein the centers of the antennas are not colinear.

4. In a broadcasting system, an antenna array comprising, in combination, first and second antennas of different lateral dimensions located in an end-to-end relationship along the longitudinal axis of said array, each of said antennas including a plurality of radiators, junction boxes located in each of said antennas, means for electrically connecting said radiators of each of said antennas to the junction boxes located in the antenna of which they are a part, means for electrically connecting each of said junction boxes located in one of said antennas to the corresponding one of said junction boxes located in the other of said antennas, a source of signals to be radiated by said antennas, and means for feeding said signals from said source to said second-mentioned connecting means at a point removed from the mid-point between the ends of said second connecting means an electrical distance equivalent to the delay in the wave front of the antenna of smaller lateral dimensions relative to the wave front of the antenna of larger lateral dimensions.

5. In a broadcasting system, an antenna array comprising, in combination, first and second antennas of different lateral dimensions located in an end-to-end relationship along the longitudinal axis of said array, each of said antennas including a plurality of radiators, junction boxes located in each of said antennas, means for electrically connecting said radiators of each of said antennas to the junction boxes located in the antenna of which they are a part, means for electrically connecting each of said junction boxes located in one of said antennas to the corresponding one of said junction boxes located in the other of said antennas, means for feeding signals to be radiated by said antennas to said second-mentioned connecting means at a point removed from the mid-point between the ends of said second-mentioned connecting means by an electrical distance equal to the electrical distance between the planes of radiation of said antennas, whereby a uniform wave front is radiated from said antenna array.

6. A system as defined in claim 5 wherein the antennas are colinear.

7. A system as defined in claim 5 wherein the centers of the antennas are not colinear.

8. In a television broad casting system, an antenna array comprising, in combination, a super-turnstile antenna and a super-gain antenna system each including a plurality of radiators, said super-turnstile antenna mounted on top of and along the longitudinal axis of said super-gain antenna, said super-gain antenna having a larger lateral dimension than that of said super-turnstile antenna, junction boxes located in each of said antenna systems, means for electrically connecting said radiators of each of said antenna systems to the junction boxes located in the system of which they are a part, means for electrically connecting each of the junction boxes located in one of said antenna system to the corresponding one of the junction boxes located in the other of said antenna systems, a source of television signals, to be radiated by said antenna systems means for feeding said signals from said source to said second-mentioned connecting means, at a point removed from and above the mid-point of said second-mentioned connecting means between said junction boxes at an electrical distance substantially equal to the electrical distance between the planes of radiation of said two antenna systems, so that a uniform wave front is radiated from said antenna array.

9. In a television broadcasting system, an antenna array comprising, in combination, a super-turnstile antenna and a super-gain antenna system each including a plurality of radiators, said super-turnstile antenna mounted on top of and along the longitudinal axis of said super-gain antenna, said super-gain antenna having a larger lateral dimension than that of said super-turnstile antenna, a pair of junction boxes located in each of said antenna systems, means for electrically connecting the North-South radiators of said super-gain antenna to one of said pair of junction boxes located in said super-gain antenna, means for electrically connecting each of the East-West radiators of said super-gain antenna to the corresponding one of said other one of said pair of junction boxes located in said super-gain antenna, means for electrically connecting the North-South radiators of said super-turnstile antenna to one of said pair of junction boxes located in said super-turnstile antenna, means for electrically connecting the East-West radiators of said super-turnstile antenna to said other one of said pair of junction boxes located in said super-turnstile antenna, means for electrically connecting said junction boxes connected to said North-South radiators in said array, means for electrically connecting said junction boxes connected to said East-West radiators in said array, a source of television signals, means for feeding said signals from said source to each of said junction box connecting means, said feeding means being connected to said junction box connecting means at points removed from and above the centers of said junction box connecting means between said junction boxes at an electrical distance substantially equal to the electrical distance between the planes of radiation of said two antenna systems, so that a uniform wave front is radiated from said antenna array.

10. An antenna array adapted to be mounted in a vertical position, said array comprising in combination, first and second antennas each including a plurality of radiators, said first antenna being mounted on top of and along the longitudinal axis of said second antenna, said second antenna having larger lateral dimensions than those of said first antenna, junction boxes located in each of said antennas, means for electrically connecting the radiators of each of said antennas to the junction boxes located in the antennas of which they are a part, means for electrically connecting each of said junction boxes located in said first antenna to the corresponding one of said junction boxes located in said second antenna, means for feeding signals to said second-mentioned connecting means at points removed from and above the centers of said second-mentioned connecting means by an electrical distance equal to the electrical distance between the planes of radiation of said antennas.

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