

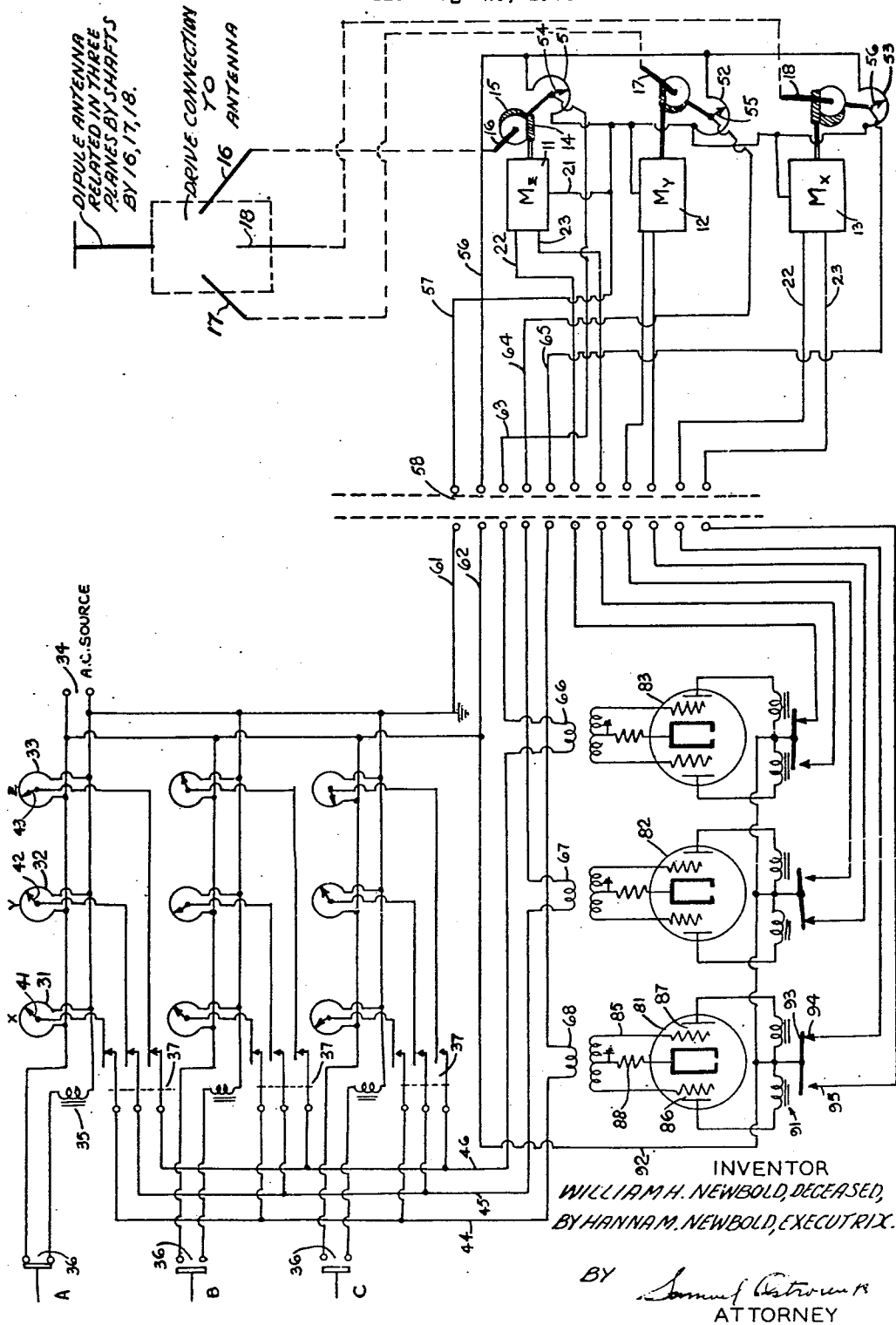
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ANTENNA ORIENTATION CONTROL SYSTEM

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ANTENNA ORIENTATION CONTROL SYSTEM

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This invention relates in general to the field of high frequency signalling systems, and more particularly concerns an automatic antenna array control.

In present day television and frequency modulation reception systems, a dipole antenna or dipole antenna array is generally utilized as the signal receiving element. These antennae are of fixed construction and of fixed orientation and are generally disposed upon the roof of the building housing the receiving apparatus. The installation of these television and frequency modulation antenna systems generally comprises the positioning of the antenna system upon a pole or other suitable support and the determination of orientation which provides optimum signal strength for the bands desired.

In many simple installations of dipole antennae or arrays, the structure is merely aligned in the direction of the transmitting station. In other instances, the antenna orientation is successively adjusted until an operator of the receiving set obtains the desired signal condition.

It has been well understood that this type of antenna structure and installation methods presented several severe disadvantages which made proper reception difficult in many instances. For example, it is understood that a receiving set may be installed at a location central with respect to several transmitting stations. Accordingly, the antenna structure may be adjusted initially for maximum signal strength for only one of the plurality of transmitters. A manual adjustment of the antenna orientation would be required to properly receive signals from the other transmitting stations.

It is also well understood that multi-path propagation of high frequency signals of the type utilized in connection with frequency modulation and television transmission may result in serious distortion. This multi-path transmission is due to the multiple reflections encountered in the propagation of a wave wherever large masses may interfere.

In television reception the receipt of an echo signal results in a double image which is unpleasant and unclear. In frequency modulation reception, echoes may result in acoustical distortion. It has been discovered that for a particular antenna structure there exists an orientation of the system which will provide the most desirable signal condition for a particular station. This optimum position, of course, will be a function of the location of the transmitter and the location of the receiver. This desired orientation

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does not necessarily involve the azimuth alone, but will include the proper antenna positioning with respect to the polarization plane and the vertical directivity.

The choice for any particular transmitted signal will, of course, depend upon the reflections encountered and the presence of interference, as ignition noise and diathermy apparatus. Herefore it has been necessary to manually adjust the antenna structure utilized on a frequency modulation or a television receiver until the optimum condition for a given station was obtained. Thereafter, it was necessary to re-adjust this position for each channel—the adjustment being accomplished by actually moving the antenna structure. In order to avoid this manual adjustment, it has been the practice to install a plurality of antenna structures each oriented for optimum signal strength on a single channel. If the conditions affecting the signal strength and interference were to change, it was necessary to manually re-adjust the entire structure.

This invention contemplates an antenna system through which optimum orientation of ultra-high frequency antennae may be obtained on any channel by purely automatic means. The position of the receiving antenna structure is governed directly by the channel selector switch upon the receiving apparatus. The antenna structure is operative so that all initial adjustments for determining the optimum position for a particular receiving channel may be made by the operator viewing the television picture or listening to the frequency modulation receiver. The adjustment for a particular receiving channel as established by the operator is left fixed upon determination of the most desirable receiving conditions. Thereafter, the proper adjustment is automatically obtained whenever that channel is utilized in the receiving apparatus. The adjustment for each receiving channel on the television or frequency modulation apparatus may be entirely independent of the other channels, and all adjustments remain fixed and invariable after the optimum conditions are determined.

Essentially the antenna control system of this invention comprises a mechanism for proper orienting of an antenna along any of the three axes. The antenna adjustment for each axis may be determined by a source of motive power controlled by apparatus installed in the receiver. The operation of the automatic adjustment for the antenna about the three axes is governed by a plurality of bridge circuits which are automatically balanced immediately after the channel se-

lector switch is operated. Whenever the receiving channel is changed, the automatic system operates to realign the antenna about the three axes until the optimum signal conditions are obtained.

The system to be described for automatically controlling antenna orientation is comparatively simple in operation, and may be directly applied to outdoor or indoor antenna structures.

In addition, the antenna control system is completely self-contained such that it may be made optional for receiver sets; that is, by the inclusion of an additional contact upon the station selector switch of the frequency modulation or television receiver.

It is thus an object of the present invention to provide a novel, fully automatic antenna orientation control system.

Another object of the present invention is to provide a novel automatic system for controlling antenna adjustments for a plurality of channels.

A further object of the invention is to provide a novel high frequency antenna structure, the orientation of which is directly controlled by the station selector switch at a receiver or the like.

A still further object of the present invention is to provide a novel antenna control system for automatically governing the orientation of an antenna structure for optimum signal strength on a plurality of receiving channels.

Still another object of the present invention is to provide a novel automatic antenna orientation system utilizing a plurality of bridge network adjustments.

These and other objects of this invention will now become apparent from the following detailed specification taken in connection with:

The figure, which is a generalized schematic view of the antenna control system of the invention.

The antenna structure to be controlled by the novel automatic system to be described is not an important part of this invention.

As previously mentioned, the antenna structure may be one designed for suitable reception for television or frequency modulation. For best results in television systems, the antenna structure may be a dipole array tuned broadly enough to cover the existing broadcast channels. For very high frequency work, the antenna structure should give the maximum feasible gain. The need for a non-directional design is completely eliminated by the automatic orientation system to be described.

No particular antenna structure is therefore illustrated in the figure. However, the mechanism for orienting the particular system utilized comprises essentially three electric motors 11, 12 and 13; each of which drives a worm such as 14 and a worm gear 15. The worm gear shafts 16, 17 and 18 associated with the three motors 11, 12 and 13, respectively, are coupled to the antenna structure so that each shaft controls the antenna orientation about one of the three axes, X, Y, and Z. The coupling mechanism utilized between the worm gear shafts 16, 17 and 18 and the antenna structure is not illustrated but may comprise a suitable simple mechanical system.

Each of the motors 11, 12 and 13 may be operated upon an alternating current line, and are of the reversing type. As all the motors 11, 12 and 13 are of identical design and wiring, the following description of operation will be restricted to a single unit such as 11. Thus, as illustrated in the figure, a lead 21 from each of the three motors is connected to ground over

conductors 57 and 61 of the electrical system. Two other leads, such as 22 and 23 on motor 11, extend through the control system, through a relay which connects either of these two leads 22 or 23 to the ungrounded side of the power source over conductor 92. In operation, lead 21 is always grounded. When lead 22 is connected through the armature of a relay to be described, to the high potential side of the power source, the motor 11 rotates in one direction. When lead 22 is disconnected and lead 23 is connected through the armature of a relay to the ungrounded end of the power source, the motor 11 runs in the opposite direction.

As will be described below, the three motors 11, 12 and 13 are operated until the shafts 16, 17 and 18 orient the antenna structure into the optimum position as predetermined by a trial and error adjustment. The position of shafts 16, 17 and 18 for any one channel at which the receiver is operative is determined by a plurality of potentiometers, a set of three for each channel.

In the system illustrated in the figure, automatic antenna control is provided for three channels. However, it will be evident that the automatic adjustment provided may be readily extended to any number of antenna channels without altering the basic system. For each of the three channels labelled A, B and C in the figure, three potentiometers, as for example 31, 32 and 33 for channel A, are provided. These three potentiometers are directly connected across the source of alternating current power 34. In series with the alternating current mains extending from terminals 34 are a relay 35 and a contactor 36. The contactor 36 may be directly ganged with the channel selector switch of the television or frequency modulation receiver to which the automatic antenna system is joined.

When the contactor 36 for channel A is closed, as illustrated in the figure, a circuit is completed from the alternating current source 34 through the relay 35. Energization of the relay 35 results in closure of the triple-pole single-throw switch 37. The armature contacts 37 are normally opened as illustrated in the connection for channels B and C which are opened when channel A is closed.

The potentiometers 31, 32 and 33 each comprise essentially $\frac{1}{2}$ of a four-arm Wheatstone bridge. Thus, the central movable taps 41, 42 and 43 respectively, divide the potentiometers into two unequal resistors. When the armature contacts 37 are closed, subsequent to closure of channel selector switch 36, the variable taps 41, 42 and 43 of the potentiometers are connected through the armature contacts 37 of the control circuit to be described, to conductors 44, 45 and 46, respectively. The four-arm bridge circuits including the potentiometers 31, 32 and 33 are completed by potentiometers 51, 52 and 53, which as illustrated are mounted with the antenna orientation system so that the variable taps 54, 55 and 56 are operative from the shafts 16, 17 and 18, respectively. The outer terminals of potentiometers 51, 52 and 53 are connected back through leads 56 and 57 and through a cable connection 58, which joins the movable antenna structure to the receiving set, to the leads 61 and 62 which as illustrated are connected at the terminal 34 across the alternating current power supply.

Essentially, therefore, the potentiometers 31, 32 and 33 are paired with the potentiometers 51, 52 and 53 so that the outer fixed connections of

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the potentiometers form the input end of a Wheatstone bridge, and the variable taps the output circuit thereof. Thus, as illustrated, the variable taps 54, 55 and 56 of the potentiometers 51, 52 and 53 respectively, are connected back through individual leads 63, 64 and 65 respectively, through the cable connection to the control circuit within the receiver. The cable connection 58 again joins each of the leads 63, 64 and 65 to one end of the primary of an output transformer 66, 67 and 68 respectively. The other ends of the three transformers 66, 67 and 68 are returned to the leads 46, 45 and 44 respectively.

It will now be evident that with the channel selector switch 36A closed, potentiometers 31 and 53 are connected to form a four-arm Wheatstone bridge across the power source 34, and the output between variable taps 41 and 56 are connected across the primary of a coupling transformer 68.

Potentiometers 31 and 53 are identical as are the other coupled pairs of potentiometers 32 and 52 and 33 and 51. Accordingly, bridge balance will be obtained when the movable taps such as 41 and 56 of the potentiometers 31 and 53 are in the same relative position. The resultant alternating voltage across the coupling transformers 68 will under these conditions be equal to zero.

In accordance with the invention, the resultant voltage across the transformer primary 68 is operative to cause rotation of motor 13 in that direction which will rotate the variable tap 56 of the potentiometer 53 to the position of bridge balance. Correspondingly, the motors 12 and 11 may be operated automatically to adjust their associated variable potentiometer taps to the identical position of those taps of potentiometers 32 and 33 respectively.

The potentiometers 31, 32 and 33 may be small units suitably disposed upon the automatic antenna control system and adjustable by means of screw driver slots in the drive shaft. These adjustments need not be placed on the receiver panel in that they are semi-permanent—that is to say, after an initial adjustment for a given receiver and antenna location, these adjustments may be considered fixed.

The adjustment of the potentiometer 31, 32 and 33 so that the antenna structure will be oriented in the most desirable conditions for receiving signals on channel A may be initially performed by a skilled operator who may view the television screen or listen to the received frequency modulation signals while adjusting the antenna. The control circuits for all three Wheatstone bridges formed by the opposed potentiometers as described comprise essentially double triode differential amplifiers such as 81, 82 and 83. As these amplifiers and associated circuits are identical for each axis of orientation, the following description will be confined to amplifier 81 which is operative to control the rotation of motor 13.

As previously described, the primary 68 of the coupling transformer is connected across the output circuit of the Wheatstone bridge. The secondary 85 of this transformer has its center tap grounded and its ends connected to the control grids of associated triode amplifiers 86 and 87 which in turn may be confined within a single envelope 81. The cathode of the amplifiers 86 and 87 are joined and connected to ground through a resistor 88. The plates of each amplifier 86 and 87 are each coupled through $\frac{1}{2}$ of a differential relay 91 to the source of alternating current power over leads 92.

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The operation of the differential amplifier comprising double triode tube 81 is well understood in the art. Briefly, the alternating current signal output of the Wheatstone bridge is coupled to the two grids of the double triode tube. The phase of the voltage applied to the grid is of course determined by the direction of unbalance of the Wheatstone bridge formed by the potentiometers 31 and 53. Since the plates are essentially in parallel, the triode plate which will conduct is that one which is positive when its associated control grid is also positive. Thus, when the bridge circuit formed by the potentiometers is off-balance in one direction, the grid of one of the triode elements 86 or 87 will be positive when the plates are positive. If the unbalance is in the other direction, then the grid of the other triode section will correspondingly be positive when its plate is positive.

Therefore, current will flow only in $\frac{1}{2}$ of the differential relay 91 and this current flow is determined by the direction of unbalance of the bridge circuits. As illustrated, the differential relay is provided with its individual pivoted armature 93 which is connected to the high potential source through leads 92 and controls circuit closures selectively over the two contacts 94 and 95 as determined by which section of the differential relay coil 91 is energized.

The leads extending from the contact 94 and 95 pass through the cable connection 58 from the receiver to the antenna structure and comprise the reversing leads for the motor 13 such as the leads 22 and 23 described in connection with motor 11. Since the differential relay 91 connects only one of the contacts 94 or 95 to the high potential source 34, the motor 13 will operate in a direction governed by the direction in which the unbalance of the Wheatstone bridge occurs.

The system is electrically connected so that the differential relay 91 when actuated will cause rotation of motor 13 in that direction which will cause variable tap 56 to restore bridge balance. When this condition occurs, the input voltage at the primary coil 68 of the coupling transformer is essentially zero, and the differential relay contactor 93 is restored to its neutral position whereby neither of contacts 94 or 95 are connected to the high potential source 34. If the potentiometer 31 is adjusted, the bridge balance will be disturbed and the differential relay 91 will operate, and result in rotation of motors 13, and accordingly potentiometer arm 56, to that point where bridge balance is reestablished. In a similar manner, the differential amplifier 82 controls the direction of rotation of motor 12 and the amplifier 83 controls the direction of rotation of motor 11.

Adjustment of the potentiometer 32 will cause operation of the differential amplifier 82 and a corresponding rotation of motor 12 which will restore bridge balance by adjustment of the variable arm 55. This operation is similarly true for the potentiometer 33 and motor 11.

Summarizing the operation of the antenna adjustments, therefore, it is clear that an adjustment of potentiometers 31, 32 and 33 for receiver channel A followed by closure of selector switch 36 will result in a rotation of motors 11, 12 and 13 which will establish bridge balance in all three circuits. This rotation of the three motors may be utilized directly to orient an antenna structure in three dimensions so as to obtain the most desirable reception conditions.

In actual practice, the unit illustrated to the right of cable connection 58 in the figure, may

be mounted wherever best reception may be expected. The control cable is then connected between the antenna unit and the control circuit illustrated to the left of the cable connection in the figure.

A particular channel, as for example channel A, is then tuned in on the television or frequency modulation receiver. For the initial adjustment of the antenna system, a skilled operator may watch the television picture or listen to the frequency modulation reception, and manually adjust the movable arms of potentiometer 31, 32 and 33. The adjustment of these arms will cause corresponding rotation of the antenna orientation motors 11, 12 and 13. This adjustment may be made therefore while the operator is at the receiver itself, and no one need be present at the antenna structure.

The three adjustments are continued until the optimum receiving conditions are obtained as regards the elimination of echoes and other spurious undesirable effects. At this point, the potentiometer arms may be set by suitable means and need not be adjusted again. Similarly channel B may be tuned in, which is accompanied by closure of the switch 36 in channel B and the opening of switch 36 in channel A. The three potentiometers illustrated for channel B are then adjusted until optimum operating conditions are obtained and again set permanently. Correspondingly, any number of tuning channels may be pre-set in this manner by merely arranging a triple potentiometer arrangement illustrated in connection with channels A, B and C.

The vacuum tube differential amplifiers and the antenna structure will remain the same independently of the number of channels to which the set may be tuned. After the initial adjustment is accomplished, it is evident that any operator of the set by merely throwing the channel selector switch will cause antenna rotation to that position giving optimum operating results.

The antenna control system illustrated in the figure is, of course, basic and subject to various modifications. The system illustrated is of course subject to use with most antenna designs. As an additional feature for obtaining optimum reception characteristics, the antenna system may be electrically resonated for each channel. Of course, the three dimensional control systems illustrated may often prove unnecessary. That is to say, for certain suburban installations where interference and reflections are at a minimum, it may be desirable to merely utilize a single dipole and reflector unit which may be rotated in horizontal plane to that position giving best reception. Accordingly a single control motor such as 11 and single differential amplifier and relay could be utilized to provide the necessary control. In other installations, merely two adjustments would be sufficient.

The electro-mechanical system which is not described in great detail herein of course may be subject to many different constructions. Thus, since various modifications of the present invention will be evident to those skilled in the art, it is preferred not to be bound by the specific disclosures set forth above but only by the appended claims.

What is claimed is:

1. In an antenna control system for a radio receiver having a plurality of channels, antenna control mechanism comprising a plurality of bridge circuits, a plurality of pairs of branches of said bridges being located at the receiver re-

mote from said antenna, and a pair of branches common to said plurality of pairs of branches, said common branch being connected to and operated with said antenna being controlled, a source of motive power for adjusting said antenna and said common pair of branches, means for connecting one of said pairs of branches at the receiver to said common pair of branches at the antenna, the antenna position thereupon determining the relative balanced condition of said bridge, and means including circuit connections energized by an unbalanced condition in said bridge for driving said motor to adjust said antenna and said common pair of branches until said bridge is balanced.

2. In an antenna control system for a signaling system having a plurality of radio receiver channels and an antenna system arranged to be oriented in azimuth; switching mechanisms located at the receiver, a plurality of self-balancing bridge mechanisms one for each of said channels, each of said balancing mechanisms being adjustable independently of the other of said balancing mechanisms, said adjustment being at the receiver and remote from said antenna system; and motor means controlled by said balancing mechanisms for effecting a predetermined orientation of said antenna system, the adjustments of each of said balancing mechanisms remaining undisturbed while another of said balancing mechanisms effects orientation of said antenna system.

3. In an antenna control system for a radio receiver having a plurality of channels, antenna control mechanism comprising a plurality of bridge circuits, a plurality of pairs of branches of said bridges being located at the receiver remote from said antenna, and a pair of branches common to said plurality of pairs of branches, said common branch being connected to and operated with said antenna being controlled, a source of motive power for adjusting said antenna and said common pair of branches, a differential amplifier comprising a double triode and a differential relay connected in the output circuit of said bridge, means for connecting one of said pairs of branches at the receiver to said common pair of branches at the antenna, the antenna position thereupon determining the relative balanced condition of said bridge, and means including circuit connections controlled by said differential relay for energizing said motor to rotate said motor in a predetermined direction until said bridge is balanced, said motor being thereupon de-energized.

4. In an antenna control system for a radio receiver having a plurality of channels, antenna control mechanism comprising a plurality of bridge circuits, a plurality of pairs of branches of said bridges being located at the receiver remote from said antenna, and a pair of branches common to said plurality of pairs of branches, said common branch being connected to and operated with said antenna being controlled, a source of motive power for adjusting said antenna and said common pair of branches, means for connecting one of said pairs of branches at the receiver to said common pair of branches at the antenna, the antenna position thereupon determining the relative balanced condition of said bridge, and means including circuit connections energized by an unbalanced condition in said bridge for driving said motor to adjust said antenna and said common pair of branches until said bridge is balanced, the setting of each of said plurality of pairs of branches being pre-set to secure a plu-

ality of predetermined optimum settings of said antenna.

5. In an antenna control system for a radio receiver having a plurality of receiving channels, antenna control mechanism forming part of the radio receiver for automatically adjusting the antenna about a plurality of axes comprising a plurality of bridge circuits, means controlled by each of said bridge circuits for effecting a predetermined alignment of said antenna, switching means for selecting a receiving channel and for simultaneously rendering one of said bridge circuits effective to align said antenna system about the plurality of axes until optimum signals are obtained.

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deceased.*

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