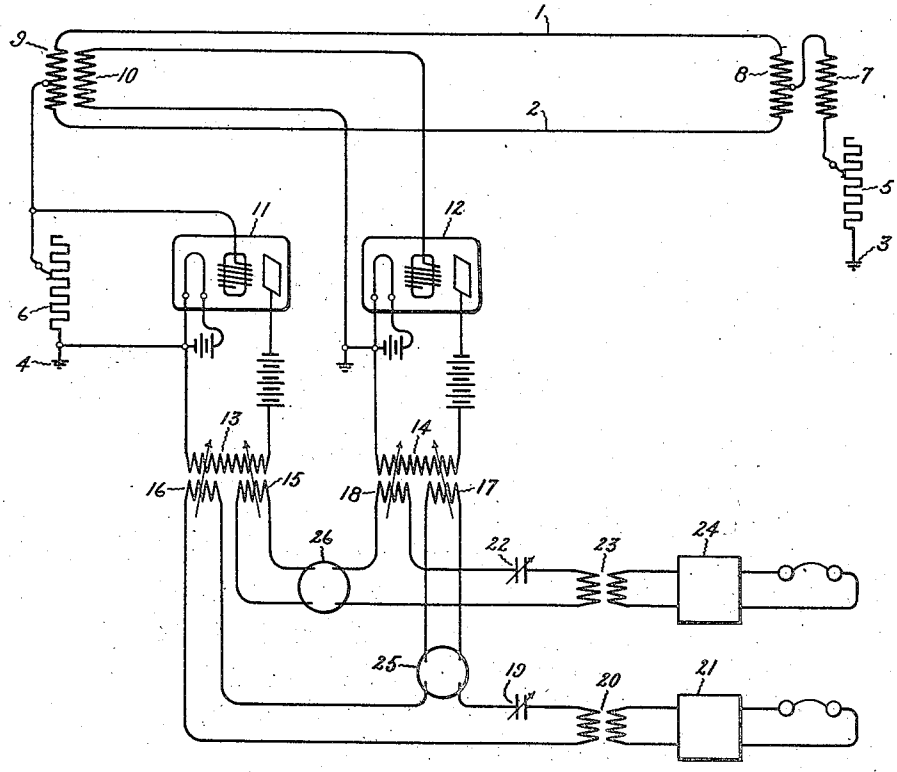
H. H. BEVERAGE.

RADIORECEIVING SYSTEM.

APPLICATION FILED MAY 3, 1921.

1,434,984. Patented Nov. 7, 1922.



Inventor:
Harold H. Beverage,
by Albert G. Davis
His Attorney.

Patented Nov. 7, 1922. 1,434,984

UNITED STATES PATENT OFFICE.

HAROLD H. BEVERAGE, OF RIVERHEAD, NEW YORK, ASSIGNOR TO GENERAL ELECTRIC COMPANY, A CORPORATION OF NEW YORK.

RADIORECEIVING SYSTEM.

Application filed May 3, 1921. Serial No. 466,475.

To all whom it may concern:

Be it known that I, HAROLD H. BEVERAGE, a citizen of the United States, residing at Riverhead, in the county of Suffolk, State of New York, have invented certain new and useful Improvements in Radioreceiving Systems, of which the following is a specification.

My present invention relates to radio receiving systems, and more particularly to a system which permits of the reception of signals coming from more than one direction upon a single antenna.

In my prior application, Serial No. 372,933, filed April 10, 1920, issued June 7, 1921, as Patent No. 1,381,089, I have described and claimed a form of horizontal receiving antenna which is especially adapted for the efficient reception of signals from any desired direction. I have pointed out in that application, but have not claimed a method of operation whereby it is possible to employ the same antenna for simultaneously receiving signals from two different directions.

One of the objects of my present invention is to provide a method of and means for accomplishing the result mentioned; a more specific object of my invention is to provide apparatus whereby the desired reception from two different directions may be accomplished at a single receiving station.

I have pointed out in the above-mentioned application that with a long horizontal receiving antenna extending in the general direction of transmission of signaling waves to be received, signaling currents produced in the antenna by waves coming from one particular transmitting station will be strongest at the ends of the antenna farthest from the transmitting station while currents produced by waves coming from the opposite direction will be a minimum at that point. This permits of the reception of waves coming from opposite directions by connecting the receiving apparatus at opposite ends of the antenna. It will in general, however, be desirable to accomplish the desired reception from the two directions at the same point. In order to accomplish this result I may locate the receiving apparatus at either end of the antenna and utilize the antenna as a transmission line for conveying signaling currents from the opposite end of the antenna to the receiving station. One receiving set will then be operated by means of the currents flowing in the ground connection of the antenna at the receiving station and the other set of receiving apparatus will be operated by means of the currents transmitted over the antenna as a transmission line.

The novel features which I believe to be characteristic of my invention are set forth in the appended claims. The invention itself, however, both as to its organization and method of operation will best be understood by reference to the following description taken in connection with the accompanying drawing in which I have indicated diagrammatically one way in which my invention may be carried into effect.

As indicated in the drawing, I provide a long horizontal receiving antenna made up of two conductors 1 and 2, which are grounded at the ends 3 and 4. If this antenna is constructed with distributed constants of such value that the current wave therein travels at the same velocity or substantially the same velocity as the ether wave, the current wave in the antenna will gradually build up and become a maximum at the end farthest from the transmitting station. Currents produced at the end 3 by ether waves traveling from that end toward the end 4 will have substantially zero value at the end 3 and will increase to a maximum value at the end 4. In the same way currents produced by ether waves traveling from the end 4 toward the end 3 will have a minimum value at the end 4 and a maximum value at the end 3. In order to prevent reflection of the current waves flowing in the antenna from the ends, the ground connections are made through resistances 5 and 6 having a value substantially equal to the surge impedance of the antenna.

While the receiving antenna should preferably have such constants that the current wave travels therein at the same velocity as the ether wave this is not essential for successful results in carrying out my invention. If the velocity of the current wave in the antenna differs somewhat from that of the ether wave then for a certain distance the waves will add and a point will finally be reached where one wave will be so far in advance of the other that the two will be in phase opposition. Interference will then occur and the current wave will start to decrease. In any case, the antenna should be constructed with such constants that the

length at which the current wave becomes maximum will be at least as great as a half wave length of the signaling waves to be received.

In the present case I have indicated the receiving station as being located at the end 4 of the antenna. In order to be able to receive at this point currents produced by waves traveling from the end 4 toward the end 3, the antenna conductors may be employed as a transmission line. In order to accomplish this the currents in the antenna conductors flowing toward the end 3 are caused to flow to ground through the primary winding 7 of the transformer, the secondary 8 of which has its terminals connected to conductors 1 and 2 respectively. As a result the signaling currents flowing to ground at 3 produce currents flowing in opposite directions in the conductors 1 and 2. In other words, the conductors 1 and 2 form the two sides of a transmission line which is completed by means of the primary 9 of the transformer at the end 4 of the antenna. The mid-point of the winding 9 being connected to ground at 4 and the mid-point of the secondary 8 being connected to ground at point 3 substantially no current will be produced at the ground connection 4 by means of the signaling currents conveyed over the transmission line.

The signaling currents produced by waves coming from the two different directions which are caused to flow in the ground connection at 4 and in the secondary winding 10, are impressed upon the input circuits of the two electron discharge amplifiers 11 and 12, of the usual three-electrode type. The output circuits of these amplifiers include coupling coils 13, 14, which are coupled by variable couplings to coils 15, 16, and 17, 18, respectively. Current produced in coil 16 is caused to flow in the resonant circuit connected thereto which is tuned by means of capacity 19 to the frequency of the signaling waves which are to be received and which travel from the end 3 toward the end 4. Currents flowing in this resonant circuit are impressed by means of coupling 20 upon the receiving apparatus 21, which may be of any desired form. Currents produced in the coil 18 are impressed upon a resonant circuit tuned by means of the variable condenser 22 to the frequency of the waves to be received which are traveling from the end 4 toward the end 3 of the antenna, and the currents produced in this resonant circuit are impressed by means of the coupling 23 upon the second receiving set 24. The waves to be received in set 24 may be of the same frequency or a different frequency from those received in set 21.

While a long horizontal antenna such as that employed has decided unidirectional properties, mathematical analysis indicates and experience shows that at the end farthest from the transmitting station small currents will under some conditions be produced by waves coming from the opposite direction even though the end nearest the transmitting station is grounded through a resistance approximately equal to the surge impedance of the antenna so that no reflection occurs. In some cases, also, it may happen that while the antenna is adjusted so that the receiving apparatus is not affected by disturbing waves coming from a direction exactly opposite to that of the desired signal, it is affected by disturbances coming from some other direction, for instance, 160° from the transmitting station and that it is more important to limit the effect of the disturbing waves coming from this direction than those coming from the direction 180° from the transmitting station. In order to eliminate the effect of the undesired waves mentioned, in the receiving set 21, a current component is impressed by means of the coil 17 upon a phase rotator 25 by means of which the phase of this component is adjusted so as to be opposite in phase to the undesired component of the current flowing in the resonant circuit associated with the receiving set 21. This neutralizing component is impressed upon the resonant circuit from the phase rotator 25 and the intensity of this neutralizing component is adjusted to secure the desired neutralization by means of the variable coupling between coils 14 and 17. In the same way undesired currents are neutralized in the receiving set 24 by means of the current component produced by means of the coil 15 and phase rotator 26.

While I have described the preferred embodiment of my invention, it will be apparent that my invention is by no means limited to the precise arrangement shown and that modifications therein may be made without departing from the scope of my invention as set forth in the appended claims. While in general it will be desirable that the receiving antenna be located so that the two sets of signals to be received come from directions 180° apart, or approximately so, the apparatus which I have shown may be successfully employed for receiving signals coming from two directions at an angle much less than 180°.

I have indicated the receiving station as being located at one end of the antenna, but this is not essential in carrying out my invention as the receiving station may be located at any desired point and connected with the desired points in the antenna in such a way that the desired signaling currents may be impressed upon the receiving apparatus in the general manner indicated. While I have indicated the points at which the signaling currents are selected as being located at the two ends of the antenna, and

while in general these points will be the most suitable, the selection of these particular points is not essential to the carrying out of my invention as in some cases it may happen that the signaling currents will be stronger or will have a more favorable stray ratio at some other point along the length of the antenna than the end. When I speak, therefore, of the point where the signaling currents received from a desired station are strongest, it will be understood that I mean either the point where they are of the greatest amplitude, or where the stray ratio is most favorable for desired reception.

While I have shown only a single receiving set for receiving waves coming from each direction the system which I have shown and described may equally well be employed for receiving simultaneously a plurality of signals coming from either direction or from both directions.

What I claim as new and desire to secure by Letters Patent of the United States is:—

1. A receiving system for radio signals comprising a horizontal receiving antenna which is grounded at both ends and has distributed constants of such value that electric waves produced therein by desired signaling waves will be propagated along its length at substantially the same velocity as that at which the desired signaling waves travel along its length in the ether, and means associated with said antenna for selectively receiving signals coming from opposite directions.

2. A receiving system for radio signals comprising a horizontal receiving antenna which is grounded at both ends and has distributed constants of such value that electric waves produced therein by desired signaling waves will be propagated along its length at substantially the same velocity as that at which the desired signaling waves travel along its length in the ether, and means associated with said antenna at one point along its length for receiving signals coming from different directions.

3. A receiving system for radio signals comprising a horizontal receiving antenna which is grounded at both ends and has distributed constants of such value that electric waves produced therein by desired signaling waves will be propagated along its length at substantially the same velocity as that at which the desired signaling waves travel along its length in the ether, and means associated with said antenna at one end thereof for selectively receiving signals coming from different directions.

4. A receiving system for radio signals comprising a horizontal receiving antenna which is grounded at both ends and has distributed constants of such value that electric waves produced therein by desired signaling waves will be propagated along its length at substantially the same velocity as that at which the desired signaling waves travel along its length in the ether, and means associated with said antenna at one end thereof for selectively and simultaneously receiving signals coming from opposite directions.

5. A receiving system for radio signals comprising a horizontal receiving antenna, means for utilizing said antenna as a transmission line for conveying signaling currents from a selected point in said antenna where signaling currents received on the antenna from a desired station are strongest to a distant receiving station located along the length of said antenna, and means associated with said antenna at the receiving station for selectively and simultaneously receiving both the signaling currents thus transmitted, and signaling currents received on the antenna from a direction different from that of the desired station.

6. A receiving system for radio signals comprising a horizontal receiving antenna, means for utilizing said antenna as a transmission line for conveying signaling currents from the end of said antenna where signaling currents received on the antenna from a desired station are strongest to a distant receiving station located along the length of said antenna, and means associated with said antenna at the receiving station for selectively and simultaneously receiving both the signaling currents thus transmitted and signaling currents received on the antenna from a station located in a different direction from the receiving station than that of the first station.

7. A receiving system for radio signals comprising a long horizontal receiving antenna, ground connections at both ends of said antenna, means for utilizing said antenna as a transmission line for conveying signaling currents from a selected point in said antenna where signaling currents received on the antenna from a desired station are strongest to a listant receiving station located along the length of said antenna, a pair of receiving sets, a pair of electron discharge devices having input and output of circuits, means for impressing the signaling currents thus transmitted upon the input circuit of one of said electron discharge devices, means for impressing currents from one of the ground connections of said antenna upon the input circuit of the second electron discharge device, and means for impressing currents from both of the output circuits of said electron discharge devices upon both of the receiving sets.

8. A receiving system for radio signals comprising a long horizontal receiving antenna, ground connections at both ends of said antenna, means for utilizing said an-

tenna as a transmission line for conveying signaling currents from a selected point in said antenna where signaling currents received on the antenna from a desired station are strongest to a distant receiving station located along the length of said antenna, a pair of receiving sets, a pair of electron discharge devices having input and output circuits, means for impressing the signaling currents thus transmitted upon the input circuit of one of said electron discharge devices, means for impressing currents from one of the ground connections of said antenna upon the input circuit of the second electron discharge device, means for impressing currents from both of the output circuits of said electron discharge devices upon both of the receiving sets, and means for regulating the phase and intensity of the currents thus impressed upon the receiving sets.

9. A receiving system for radio signals comprising a horizontal receiving antenna which is grounded at both ends, a transmission line for carrying signaling currents from a selected point in said antenna to a receiving station located at a distant point along the length of said antenna, two receiving sets at the receiving station, means for impressing upon one receiving set currents conveyed over said transmission lines, means for impressing upon the second receiving set currents flowing in the ground connection at one end of said antenna, means for impressing upon the first receiving set from the ground connection currents of equal magnitude and opposite phase to those impressed thereon from the transmission line which are produced by waves coming from a different direction than that of the desired signaling waves to be received by that set and means for impressing upon the second receiving set from the transmission line currents of equal magnitude and opposite phase to those impressed thereon from the ground connection which are produced by waves coming from a different direction than that of the desired signaling waves to be received by the second set.

10. A receiving system for radio signals comprising a horizontal receiving antenna which is grounded at both ends and which has distributed constants of such values that electric waves produced therein by desired signaling waves will be propagated along its length at such a velocity that increments of current produced in the antenna at points along its length by desired signaling waves in the ether will add to the current flowing therein through a distance which is at least equal to a half wave length of the desired signaling wave and means associated with said antenna for selectively receiving signals coming from opposite directions.

11. The method of operating a radio receiving system comprising a horizontal receiving antenna which is grounded at both ends and two receiving sets, which consists in impressing upon one of said receiving sets currents produced in said antenna by signaling waves coming from one direction and impressing upon the other receiving set currents produced in said antenna by signaling waves coming from a different direction.

12. The method of operating a radio receiving system comprising a horizontal receiving antenna which is grounded at both ends and two receiving sets which consists in impressing upon one of said receiving sets desired signaling currents produced in one of said ground connections and impressing upon the other receiving set desired signaling currents produced in the other ground connection.

13. The method of operating a radio receiving system comprising a horizontal receiving antenna which is grounded at both ends and two receiving sets which consists in impressing upon one of said receiving sets desired signaling currents produced in one of said ground connections impressing upon the other receiving set desired signaling currents produced in the other ground connection, and neutralizing the effect in the first receiving set of undesired currents therein by impressing thereon currents of equal intensity and opposite phase derived from the second ground connection.

14. The method of operating a radio receiving system comprising a horizontal receiving antenna which is grounded at both ends and two receiving sets which consists in impressing upon one of said receiving sets desired signaling currents produced in one of said ground connections, impressing upon the other receiving set desired signaling currents produced in the other ground connection, and neutralizing the effect in the first receiving set of undesired currents therein by impressing thereon currents of equal intensity and opposite phase derived from the second ground connection, and neutralizing the effect in the second receiving set of undesired currents therein by impressing thereon currents of equal intensity and opposite phase derived from the first ground connection.

15. The method of operating a radio receiving system comprising a horizontal receiving antenna which is grounded at both ends and two receiving sets which consists in impressing upon one of said receiving sets currents produced in said antenna at a selected point by signaling waves coming from one direction and impressing upon the other receiving set currents produced in said antenna at another selected point by signaling waves coming from a different direction.

16. The method of operating a radio receiving system comprising a horizontal receiving antenna which is grounded at both ends and two receiving sets which consists in impressing upon one of said receiving sets desired signaling currents produced in said antenna at a selected point, impressing upon the second receiving set desired signaling currents produced in said antenna at a second selected point and neutralizing the effect in the first receiving set of undesired currents therein by impressing thereon currents of equal intensity and opposite phase derived from the antenna at the second selected point.

17. The method of operating a radio receiving system comprising a horizontal receiving antenna which is grounded at both ends and two receiving sets which consists in impressing upon one of said receiving sets desired signaling currents produced in said antenna at a selected point, impressing upon the second receiving set desired signaling currents produced in said antenna at a second selected point and neutralizing the effect in the first receiving set of undesired currents therein by impressing thereon currents of equal intensity and opposite phase derived from the antenna at the second selected point, and neutralizing the effect in the second receiving set of undesired currents therein by impressing thereon currents of equal intensity and opposite phase derived from the antenna at the first selected point.

In witness whereof I have hereunto set my hand this twenty ninth day of April, 1921.

HAROLD H. BEVERAGE.