H. H. BEVERAGE.
RADIORECEIVING SYSTEM.
APPLICATION FILED APR. 10, 1920.

1,381,089. Patented June 7, 1921.

Fig. 1

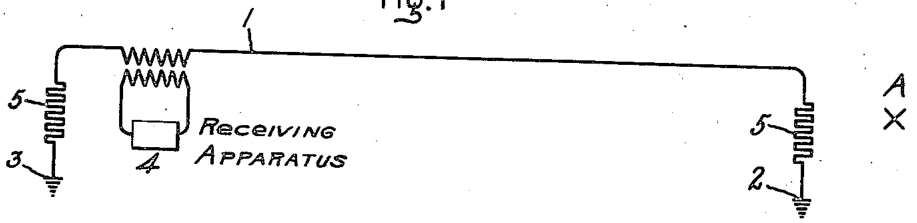


Fig. 2

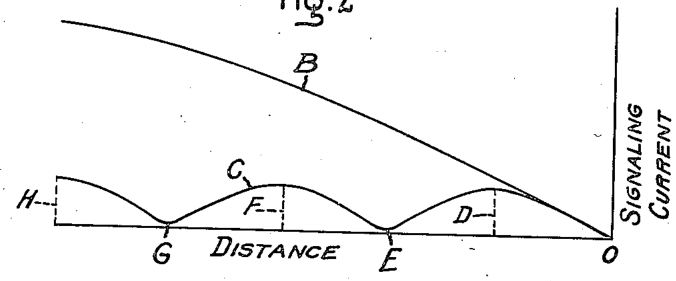


Fig. 3

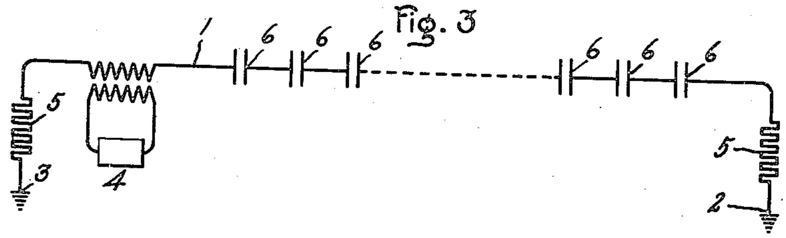
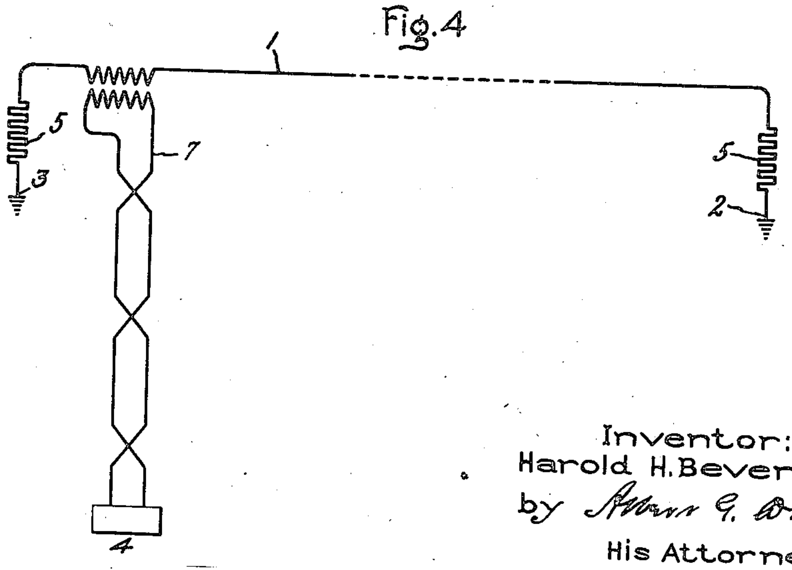


Fig. 4



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UNITED STATES PATENT OFFICE.

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RADIO RECEIVING SYSTEM.

1,381,089. Specification of Letters Patent. Patented June 7, 1921.

Application filed April 10, 1920. Serial No. 372,933.

To all whom it may concern:

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

My present invention relates to radioreceiving systems and more particularly to an improved arrangement of an antenna for receiving purposes.

The object of my invention is to provide a receiving antenna which will have highly directive properties, which will be very efficient in its operation and which will also be highly selective.

In carrying my invention into effect I make use of a horizontal preferably aperiodic antenna extending in a direction parallel to the direction of transmission of the signals to be received. This antenna is constructed with distributed capacity inductance and resistance of such values that the currents produced therein by the desired signals increase progressively from the end of the antenna nearest the transmitting station becoming in the preferred case, the maximum at the end farthest from the transmitting station.

The novel features which I believe to be characteristic of my invention are set forth with particularity in the appended claims. My invention itself however, both as to its organization and method of operation, together with ways in which the particular objects thereof may be attained will best be understood by reference to the following description taken in connection with the accompanying drawing in which Figure 1 illustrates diagrammatically one way in which my invention may be carried into effect; Fig. 2 shows typical curves illustrating variations in signal strength along the length of the antenna, and Figs. 3 and 4 illustrate diagrammatically two other modifications of my invention.

Consider first a simple horizontal receiving antenna 1 as indicated in Fig. 1, which extends from the receiving station at end 3 of the antenna toward the transmitting station A from which the desired signals are coming and which is grounded at both ends. The operation of such an antenna in receiving signals may be explained as follows: Assume that the signaling waves in space are traveling from station A in the direction of the antenna, then at the end 2 of the antenna a small current will be induced which will be propagated as a wave along the antenna toward the end 3. If the velocity of this small current wave in the antenna is equal to the velocity of the signaling wave in space, this current wave will grow as it approaches the end 3 by continuously absorbing small additional amounts of energy from the ether waves since the two waves are traveling along in phase with each other. From this analysis it appears that, if the constants of the antenna are such that the current wave travels at the same velocity as the ether wave, the longer the antenna the greater the current which will be received thereby. There will of course be a maximum length beyond which nothing will be gained because of the losses in the antenna. The lower these losses the greater the length of antenna which can be used to advantage. If, however, the velocity of the current wave in the antenna is not quite the same as that of the ether wave, then for a certain distance the two waves will add, but 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 decrease to zero and then a new wave will be started and built up. Under these conditions the strength of the signal which will be received at the end 2 of the antenna will be weak, and as the receiving apparatus is moved along the antenna in the direction in which the waves are moving, the signal strength will gradually increase to a maximum, then decrease to a minimum, and increase again to a second maximum having the same strength as the first maximum. The distance along the antenna between maximum and minimum will depend upon the relative difference in the velocity of the electric wave on the antenna and the ether wave surrounding it in space. If the velocities differ very little a long receiving antenna can be used to advantage, but if the velocities are considerably different there may be no advantage in using a greater length of antenna than that which will give the first maximum for the desired signal frequency. This length should preferably be at least as great as a half wave length of the signaling waves to be received.

Fig. 2 illustrates the variation in current strength in the antenna under the two different conditions of operation which I have described. In this figure the ordinates represent signal strength and the abscissæ represent distance along the antenna. Curve B shows the increase in current strength along the length of the antenna when the current wave and the ether wave travel at the same velocity. This shows that the current increases along the length of the antenna quite rapidly at first, then more slowly and finally the current curve flattens out when the end of the antenna farthest from the transmitting station is reached. It is assumed that the distance represented by this curve is the maximum length of the antenna which can be used to advantage and this maximum length may be equal to several wave lengths. Curve C shows the variation in current strength along the length of the antenna for one case when the current wave and the ether wave travel at different velocities. Here the current increases until a maximum is reached at the point D; then decreases to a minimum at point E; increases to a second maximum at point F; decreases again to a minimum at point G, and increases to a third maximum at point H. Since these maximum points are all of the same value it is apparent that nothing will be gained in signal strength by using a greater length of antenna than that represented by distance O—D. In either case, however, the receiving apparatus 4 may be located at the end 3 of the antenna farthest from the transmitting station and the best results possible with that particular length of antenna will be obtained.

For signaling waves traveling in the opposite direction, the currents will build up in the same manner. If there is no reflection from the ends the same antenna may be employed for receiving signals from opposite directions by installing receiving apparatus at both ends. The method of and apparatus for accomplishing this result is described in my pending application, Serial No. 466,475, filed May 3, 1921. Reflection may be avoided by grounding the ends through non-inductive resistances 5 of a value equal to the surge impedance of the antenna; that is, having a value equal to $\sqrt{\frac{L}{C}}$ where L and C are the inductance and capacity of the antenna per unit length. In case the antenna has fairly high attenuation the losses therein may be so great that the use of means for preventing reflection may be unnecessary; in other words, the losses in the antenna may be so high that any wave which might be reflected will be practically damped out before it reaches the receiving apparatus. In certain cases where a line of low impedance is used the natural resistance at the grounding point may be sufficient to practically eliminate reflection. In some cases also the ground resistance may be sufficient to largely reduce reflection and the losses may then be sufficient to damp out the small amplitude waves which are reflected.

In accordance with theoretical considerations, if an antenna were to be freely suspended and if the surface of the earth constituted a perfectly conducting parallel plane, current waves would travel through the antenna conductor at a velocity equal to the velocity of light. In practice this theoretical condition may be difficult to obtain because of ground resistance and because of the necessity of providing supports for the antenna. The effect of these supports may be to add shunt capacity to the antenna without causing any compensating change in the other line constants. The effect of the excess shunt capacity may be neutralized for continuous waves of a particular frequency by inserting condensers in series with the antenna which neutralize part of the series inductance and increase the wave velocity. Such series condensers should be inserted in the antenna at suitable intervals (in no case more than $\frac{1}{\pi}$ wave length apart) to give substantially the effect of distributed series capacity for the frequency which is to be received. By choosing proper values for the condensers the wave velocity on the line for continuous waves of any specified frequency may be made equal to or greater than the velocity of light.

In Fig. 3 I have illustrated diagrammatically an antenna, which is provided with series condensers 6, for this purpose.

In some cases it may not be convenient to locate a receiving station at a point along the length of the antenna. In such a case I have found that a transmission line running in a different direction from the main antenna may be employed between the antenna and receiving station. I have indicated in Fig. 4 such an arrangement. The transmission line 7 in this case is transposed at suitable intervals in order to neutralize the effect of currents received thereon. The directivity of the receiving system will therefore be unchanged by the use of this transmission line irrespective of its direction. This feature of my invention is described and claimed in my copending application, Serial No. 438,552, filed January 20, 1921, which is a continuation in part of the present application.

It will be apparent to those skilled in the art that my invention is by no means limited to the precise arrangements shown and described as many modifications in the arrangement and structure of the instrumentalities employed may be made without departing from the scope of my invention, as set forth in the appended claims.

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

1. A horizontal receiving antenna having distributed constants of such values 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.

2. An aperiodic horizontal receiving antenna having distributed constants of such values 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.

3. A horizontal receiving antenna which is grounded at both ends and having distributed constants of such values 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.

4. A horizontal receiving antenna having distributed constants of such values 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 for impressing upon receiving apparatus signaling currents received upon said antenna, said means being located at such a point along the length of said antenna that the effect upon the receiving apparatus of signaling currents produced by the desired waves will be a maximum.

5. A horizontal receiving antenna which is grounded at both ends and having distributed constants of such values 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 for impressing upon receiving apparatus signaling currents received upon said antenna, said means being located at such a point along the length of said antenna that the effect upon the receiving apparatus of signaling currents produced by the desired waves will be a maximum.

6. A horizontal receiving antenna having natural distributed constants of such values that electric waves produced therein by desired signaling waves would be propagated along its length at a velocity less than that at which the desired signaling waves travel along its length in the ether, and means for increasing the velocity at which electric waves produced therein by desired signaling waves will be propagated along the length of the antenna.

7. A horizontal receiving antenna having natural distributed constants of such values that electric waves produced therein by desired signaling waves would be propagated along its length at a velocity less than that of light and means for increasing the velocity at which electric waves produced therein by the desired signaling waves will be propagated along the length of the antenna to a velocity substantially the same as that of light.

8. A horizontal receiving antenna having natural distributed constants of such values that electric waves produced therein by desired signaling waves would be propagated along its length at a velocity less than that at which the desired signaling waves travel along its length in the ether, and condensers in series with said antenna of such value and located at such intervals as to give the antenna effective distributed constants of such values that the 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.

9. A horizontal receiving antenna which is grounded at both ends and having natural distributed constants of such values that electric waves produced therein by desired signaling waves would be propagated along its length at a velocity less than that at which the desired signaling waves travel along its length in the ether, and condensers in series with said antenna of such value and located at such intervals as to give the antenna effective distributed constants of such values that the 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.

10. A horizontal receiving antenna having 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.

11. A horizontal receiving antenna which is grounded at both ends and having distributed constants of such values that elec-

tric 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 the 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.

12. A receiving system for radiosignals comprising a horizontal antenna extending in a direction substantially parallel with the direction of transmission of signaling waves to be received and having effective distributed constants of such values that electric waves produced therein by desired signaling waves increase in amplitude progressively from the end nearest the desired transmitting station to the opposite end, said antenna being of such length and having such properties that waves coming from a direction opposite to that of the transmitting station will produce substantially no effect at the end of the antenna farthest from the transmitting station.

13. A receiving system for radiosignals comprising a horizontal antenna extending in a direction substantially parallel with the direction of transmission of signaling waves to be received and having effective distributed constants of such values that electric waves produced therein by desired signaling waves increase in amplitude progressively from the end nearest the desired transmitting station to the opposite end, said antenna being of such length and having such attenuation that waves coming from a direction opposite to that of the transmitting station will produce substantially no effect at the end of the antenna farthest from the transmitting station.

14. A receiving system for radiosignals comprising a horizontal antenna extending in a direction substantially parallel with the direction of transmission of signaling waves to be received and having effective distributed constants of such values that electric waves produced therein by desired signaling waves increase in amplitude progressively from the end nearest the desired transmitting station to the opposite end, said antenna being grounded at both ends and having such ground resistance and attenuation that waves coming from a direction opposite to that of the transmitting station will produce substantially no effect at the end of the antenna farthest from the transmitting station.

In witness whereof, I have hereunto set my hand this 8th day of April 1920.

HAROLD H. BEVERAGE.