E. W. KELLOGG AND C. W. RICE.

RADIORECEIVING SYSTEM.

APPLICATION FILED APR. 27, 1921.

1,435,009. **Patented Nov. 7, 1922.**

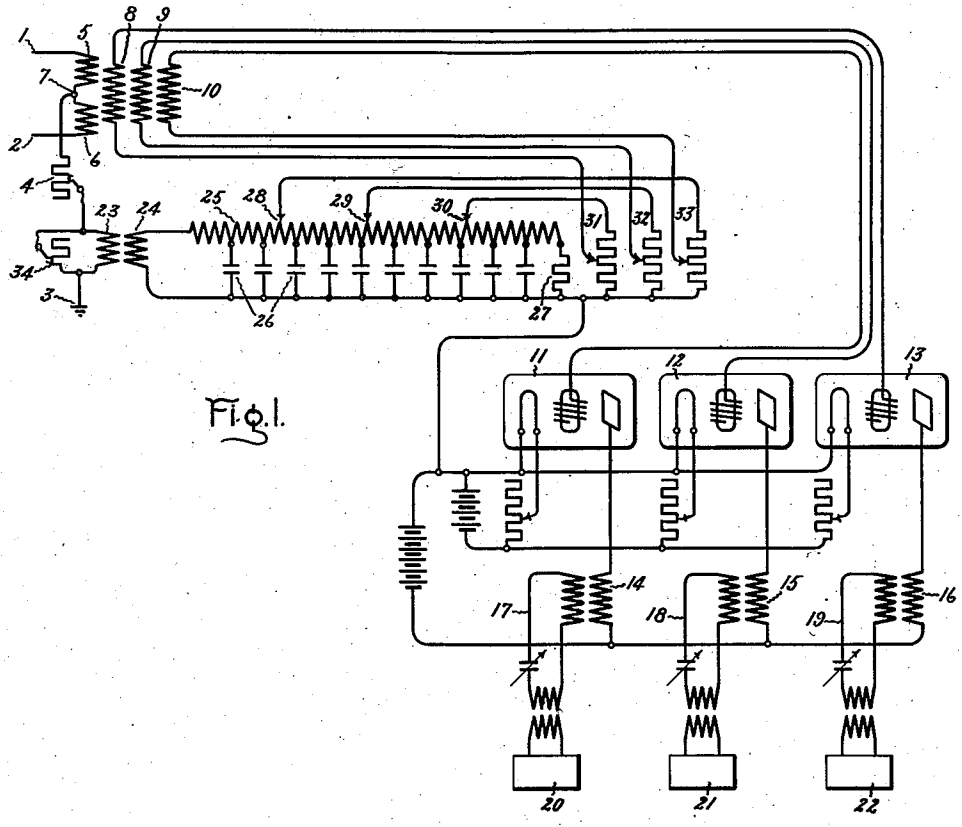
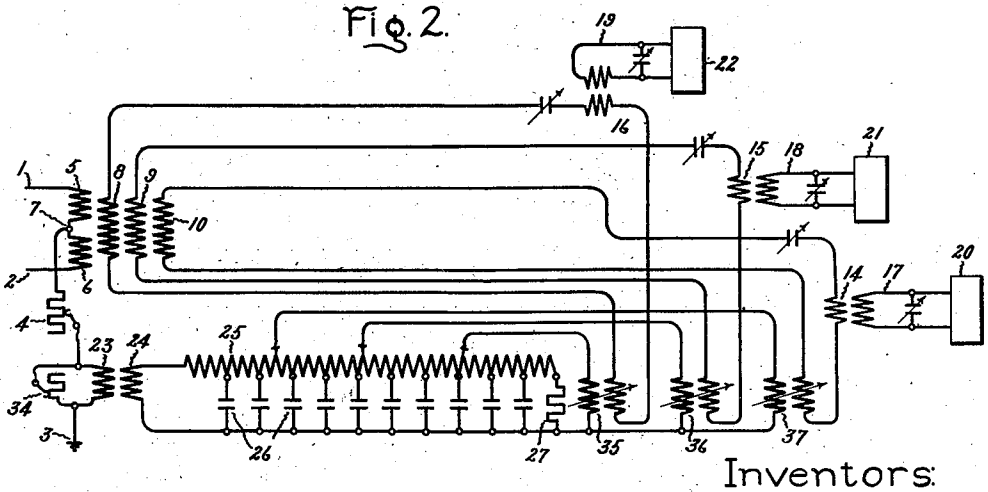


Fig. 1.

Fig. 2.



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UNITED STATES PATENT OFFICE.

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RADIORECEIVING SYSTEM.

Application filed April 27, 1921 Serial No. 464,787.

To all whom it may concern:

Be it known that we, EDWARD W. KELLOGG and CHESTER W. RICE, citizens of the United States, residing at Schenectady, in the county of Schenectady, State of New York, have invented certain new and useful Improvements in Radioreceiving Systems, of which the following is a specification.

Our present invention relates to radio receiving systems, and more particularly to a system which permits of the simultaneous reception of a plurality of signals at a single receiving station.

In our prior application, Serial No. 372,938, filed April 10, 1920, we have described a form of horizontal receiving antenna which is especially adapted for the efficient reception of signals.

The object of our present invention is to provide a method of and means for utilizing an antenna of the form described in our prior application for the simultaneous reception of a plurality of signals of different wave lengths. We have pointed out in the above mentioned application that with a long receiving antenna extending in the general direction of transmission of the signaling waves to be received, signaling currents produced in the antenna by waves coming from any particular transmitting station will be strongest at the end 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. The antenna described is preferably aperiodic so that the strength of the signaling currents produced therein is substantially independent of the wave length.

In carrying out our invention, we utilize an antenna of this type and impress from the antenna upon the input circuits of a plurality of electron discharge amplifiers potentials produced in the antenna at a selected point. In order to improve the reception, we also provide means for impressing upon each of these input circuits a current selected from another point in the antenna which will be of the proper intensity and phase to neutralize in each receiving set disturbing currents produced therein either by interference from undesired waves or by strays. Each of the output circuits of the amplifiers has associated therewith a resonant circuit which is tuned to the frequency of one of the signaling waves which it is desired to receive, and these resonant circuits are associated with the respective receiving sets.

The novel features which we believe to be characteristic of our invention are set forth in the appended claims, the invention itself, however, both as to its organization and method of operation, together with further objects and advantages thereof, will best be understood by reference to the following description taken in connection with the accompanying drawings in which Figs. 1 and 2 show diagrammatically two different circuit arrangements whereby our invention may be carried into effect.

In carrying out our invention, we make use of a long horizontal receiving antenna made up of two conductors 1 and 2 which are grounded at the ends. In the drawings we have shown only one end of these conductors with the ground connection 3 at that end. If this antenna is constructed with distributed constants of such value that the current wave therein travels at 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. 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 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 start to decrease. In any case, the antenna should preferably 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 wave to be received. Currents produced at the end 3 by ether waves traveling from that end to the opposite end will have substantially a zero value at the end 3 and will increase to a maximum value at the opposite end. In the same way currents produced by ether waves traveling from the opposite end toward the end 3 will have a minimum value at the opposite end 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 may be made through resistances having a value substantially equal to

the surge impedance of the antenna. In the present case we have indicated such a grounding resistance 4 at the end 3 of the antenna. A similar grounding resistance may be used at both ends of the antenna if desired.

In Figs. 1 and 2 we have indicated the receiving station as being located at the end 3 of the antenna. In order to be able to receive at this point currents produced by waves traveling from the end 3 toward the opposite end, which consequently are a maximum at the opposite end, the antenna conductors may be employed as a transmission line for transmitting signaling current from the opposite end of the antenna to the receiving apparatus. The manner in which this may be accomplished is described and claimed in a copending application of Edward W. Kellogg, Serial No. 438,544, filed January 20, 1921. The conductors 1 and 2 form the two sides of a transmission line which is completed at the end 3 of the antenna by means of the two coils 5, 6. The point 7 between the two coils 5 and 6 being connected to ground at 3 and the midpoint of the secondary of the transformer at the opposite end of the antenna by means of which the signaling currents are impressed upon the transmission line, being also connected to ground, substantially no current will be produced in the ground connection at 3 by the signaling currents conveyed over the transmission line from the opposite end.

The windings 8, 9 and 10 which are inductively related to the coils 5 and 6, are included in the input circuits of electron discharge amplifiers 11, 12 and 13. Windings 14, 15 and 16 are included in the output circuits of the amplifiers and are associated with resonant circuits 17, 18 and 19, these resonant circuits being tuned to the frequencies of different waves which it is desired to receive. Each of these resonant circuits selects the particular signaling wave which it is desired to receive in that circuit without interfering with the selection of the desired waves by any of the other receiving circuits. Signaling currents thus selected are impressed upon the respective receiving apparatus 20, 21 and 22, which may be of any desired type.

The distributed inductance and capacity of the antenna do not remain constant, but change more or less with frequency. This may be due to lesser depth of penetration into the earth at higher frequencies. It may also happen that the antenna will be partially unbalanced to signals and strays coming from the side except when the antenna length bears a definite relation to the wave length. If, therefore, the reception of several signals is to be carried on simultaneously, and if these signals differ greatly in wave length, an adjustment of the damping resistance 4 may render the antenna perfectly unidirectional for only the wave length for which the damping resistance is adjusted. While when properly adjusted the antenna 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 ground resistance is properly adjusted to prevent reflection. For these reasons it is desirable in order to secure the best results to balance out in the receiving circuit undesired currents produced by these different factors. This balancing action may be accomplished in the arrangements shown by connecting in series with the ground connection at 3 the primary winding 23 of a transformer the secondary winding 24 of which is connected to an artificial transmission line made up of series inductance 25 and shunt capacities 26. The currents flowing to ground at 3 and impressed upon the artificial line, are currents built up on the antenna conductors in parallel by the ether waves traveling from the opposite end toward the end 3. This artificial line is closed at the end opposite the transformer winding 24 through a resistance 27, equal approximately to the surge impedance of the line so that no appreciable reflection can occur. The desired currents for neutralization purposes in the respective receiving circuits are impressed upon the input circuits of the amplifiers 11, 12 and 13 from this artificial line. The phase of the neutralizing currents selected may be adjusted by varying the connections 28, 29 and 30. The intensity of these neutralizing currents may also be adjusted by means of the potentiometers 31, 32 and 33. Since the input circuit of these amplifiers takes practically no current there will be substantially no load upon these potentiometers or upon the secondary windings 8, 9 and 10. This makes it possible to use poteniometers of such a high resistance in comparison with the impedance of the transmission line that the potentiometers represent a negligible load on the transmission line. The sliding contacts 28, 29, 30 can under these conditions be placed anywhere along the transmission line without affecting the potential at other points and thus disturbing the adjustment of the other receiving sets. Winding 23 is shunted by a variable resistance 34 and the impedance of the input of the artificial line is practically independent of the frequency and equivalent to a simple resistance. This makes it possible to adjust the resistance 4 to approximately the surge impedance of the antenna for different frequencies and reduce to a minimum the residual currents which must be balanced out.

In the arrangement shown in Fig. 2, the potentiometers 31, 32 and 33 and the amplifiers 11, 12 and 13, are replaced by couplers 35, 36 and 37 having high impedance primary windings so as to constitute a small load on the transmission line. In this case the circuits which include the secondaries 8, 9 and 10, and the secondaries of these couplers 35, 36 and 37 are tuned to the respective frequencies to be received, and these separate circuits each select the particular signaling current to be received therein without interfering with the proper selection of the signaling currents by the other circuits.

While we have shown and described the preferred embodiments of our invention, it will be apparent that it is by no means limited to the particular circuit arrangements shown as many modifications in the arrangement of the circuits, the location of the receiving apparatus and the type of apparatus employed may be made without departing from the scope of our invention as set forth in the appended claims.

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

1. The combination in a radio receiving system of an aperiodic receiving antenna, a plurality of receiving sets, means for impressing desired signaling currents of a plurality of different frequencies received upon said antenna upon said receiving sets, an artificial transmission line associated with said antenna and means for impressing upon each of said receiving sets a current derived from said artificial line of the proper intensity and phase relation to neutralize the effect of undesired currents in said receiving sets.

2. The combination in a radio receiving system of an aperiodic receiving antenna, a plurality of receiving sets, means for impressing desired signaling currents of a plurality of different frequencies received upon said antenna upon said receiving sets, an artificial transmission line associated with said antenna, means for impressing upon each of said receiving sets a current derived from said artificial line, and means for separately adjusting the phase and intensity of the currents impressed from the artificial line upon each of said receiving sets.

3. The combination in a radio receiving system of a receiving antenna, a plurality of receiving sets, an artificial transmission line associated with said antenna and means for impressing upon each of said receiving sets a current derived from said artificial line.

4. The combination in a radio receiving system of a receiving antenna, a plurality of receiving sets, an artificial transmission line associated with said antenna and means for impressing upon each of said receiving sets a current derived from said artificial line of the proper intensity and phase relation to neutralize the effect of undesired currents in said receiving sets.

5. The combination in a radio receiving system of a receiving antenna, a plurality of receiving sets, an artificial transmission line associated with said antenna, means for impressing upon each of said receiving sets a current derived from said artificial line, and means for separately adjusting the phase and intensity of the currents impressed from the artificial line upon each of said receiving sets.

6. The combination in a radio receiving system of an aperiodic receiving antenna, a plurality of receiving sets, means for impressing desired signaling currents of a plurality of different frequencies received upon said antenna upon said receiving sets, an artificial transmission line associated with said antenna and means for impressing upon each of said receiving sets a current derived from said artificial line.

7. The combination in a radio receiving system of an aperiodic receiving antenna, a plurality of receiving sets, a plurality of circuits which are resonant to a plurality of different desired frequencies, an artificial transmission line associated with said antenna, and means for impressing upon each of said resonant circuits a current derived from said artificial line.

8. The combination in a radio receiving system of an aperiodic receiving antenna, a plurality of receiving sets, a plurality of circuits which are resonant to a plurality of different desired frequencies, an artificial transmission line associated with said antenna, and means for impressing upon each of said resonant circuits a current derived from said artificial line of the proper intensity and phase relation to neutralize the effect of undesired currents in said resonant circuits.

9. The combination in a radio receiving system of an aperiodic receiving antenna, a plurality of receiving sets, a plurality of circuits which are resonant to a plurality of different desired frequencies, an artificial transmission line associated with said antenna, means for impressing upon each of said resonant circuits a current derived from said artificial line, and means for separately adjusting the phase and intensity of the currents impressed from the artificial line upon each of said resonant circuits.

10. The combination in a radio receiving system of an aperiodic receiving antenna, a plurality of receiving sets, a plurality of circuits which are resonant to a plurality of different desired frequencies, means for impressing desired signaling currents of a plurality of different frequencies received upon

said antenna upon said resonant circuits, an artificial transmission line associated with said antenna, and means for impressing upon each of said resonant circuits a current derived from said artificial line.

11. The combination in a radio receiving system of an aperiodic receiving antenna, a plurality of receiving sets, a plurality of circuits which are resonant to a plurality of different desired frequencies, means for impressing desired signaling currents of a plurality of different frequencies received upon said antenna upon said resonant circuits, an artificial transmission line associated with said antenna, and means for impressing upon each of said resonant circuits a current derived from said artificial line of the proper intensity and phase relation to neutralize the effect of undesired currents in said resonant circuit.

12. The combination in a radio receiving system of an aperiodic receiving antenna, a plurality of receiving sets, a plurality of circuits which are resonant to a plurality of different frequencies, means for impressing desired signaling currents of a plurality of different frequencies received upon said antenna upon said resonant circuits, an artificial transmission line associated with said antenna, means for impressing upon each of said resonant circuits a current derived from said artificial line, and means for separately adjusting the phase and intensity of the currents impressed from the artificial line upon each of said resonant circuits.

13. The combination in a radio receiving system of a receiving antenna, a plurality of receiving sets, a plurality of electron discharge amplifiers having input and output circuits, an artificial line associated with said antenna, means for impressing upon each of said input circuits a current derived from said artificial line, and means for impressing upon each of said receiving sets a current derived from the output circuit of one of said amplifiers.

14. The combination in a radio receiving system of a receiving antenna, a plurality of receiving sets, a plurality of electron discharge amplifiers having input and output circuits, an artificial line associated with said antenna, means for impressing upon each of said input circuits current derived from said artificial line, means for impressing upon each of said receiving sets a current derived from the output circuit of one of said amplifiers of the proper intensity and phase relation to neutralize the effect of undesired currents in each of said receiving sets.

15. The combination in a radio receiving system of a receiving antenna, a plurality of receiving sets, a plurality of electron discharge amplifiers having input and output circuits, an artificial line associated with said antenna, means for impressing upon each of said input circuits a current derived from said artificial line, means for impressing upon each of said receiving sets a current derived from the output circuit of one of said amplifiers, and means for separately adjusting the phase and intensity of the currents impressed from the artificial line upon each of said input circuits.

16. The combination in a radio receiving system of a receiving antenna, a plurality of receiving sets, a plurality of electron discharge amplifiers having input and output circuits, means for impressing upon each of said input circuits desired signaling currents received upon said antenna, an artificial line associated with said antenna, means for impressing upon each of said input circuits a current derived from said artificial line and means for impressing upon each of said receiving sets a current derived from the output circuit of one of said amplifiers.

17. The combination in a radio receiving system of a receiving antenna, a plurality of receiving sets, a plurality of electron discharge amplifiers having input and output circuits, means for impressing upon each of said input circuits desired signaling currents received upon said antenna, an artificial line associated with said antenna, means for impressing upon each of said input circuits a current derived from said artificial line, means for impressing upon each of said receiving sets a current derived from the output circuit of one of said amplifiers of the proper intensity and phase relation to neutralize the effect of undesired currents in each of said receiving sets.

18. The combination in a radio receiving system of a receiving antenna, a plurality of receiving sets, a plurality of electron discharge amplifiers having input and output circuits, means for impressing upon each of said input circuits desired signaling currents received upon said antenna, an artificial line associated with said antenna, means for impressing upon each of said input circuits a current derived from said artificial line, means for impressing upon each of said receiving sets a current derived from the output circuit of one of said amplifiers, and means for separately adjusting the phase and intensity of the currents impressed from the artificial line upon each of said input circuits.

19. The combination in a radio receiving system, of a receiving antenna, a plurality of receiving sets, a plurality of electron discharge amplifiers having input and output circuits, means for impressing upon each of said input circuits desired signaling currents received upon said antenna, an artificial line associated with said antenna, separate means for impressing upon each of said input circuits a current derived from

said artificial line, and means for impressing upon each of said receiving sets a current derived from the output circuit of one of said amplifiers.

20. The combination in a radio receiving system of a receiving antena, a plurality of receiving sets, a plurality of electron discharge amplifiers having input and output circuits, separate means for impressing upon each of said input circuits desired signaling currents received upon said antenna, an artificial line associated with said antenna, means for impressing upon each of said input circuits a current derived from said artificial line, means for impressing upon each of said receiving sets a current derived fro the output circuit of one of said amplifiers; of the proper intensity and phase relation to neutralize the effect of undesired currents in each of said receiving sets.

21. The combination in a radio receiving system of a receiving antenna, a plurality of receiving sets, a plurality of electron discharge amplifiers having input and output circuits, separate means for impressing upon each of said input circuits desired signaling currents received upon said antenna, an artificial line associated with said antenna, means for impressing upon each of said input circuits a current derived from said artificial line, means for impressing upon each of said receiving sets a current derived from the output circuit of one of said amplifiers, and means for separately adjusting the phase and intensity of the currents impressed from the artificial line upon each of said input circuits.

22. The combination in a radio receiving system of a receiving antenna, a plurality of receiving sets, a plurality of electron discharge amplifiers having input and output circuits, an artificial line associated with said antenna, means for impressing upon each of said input circuits a current derived from said artificial line, and means for impressing upon each of said receiving sets a current derived from the output circuit of one of said amplifiers, said input circuits being aperiodic and each of said output circuits having a resonant circuit associated therewith.

23. The combination in a radio receiving system of a receiving antenna, a plurality of receiving sets, a plurality of electron discharge amplifiers having input and output circuits, means for impressing upon each of said input circuits desired signaling currents received upon said antenna, an artificial line associated with said antenna, means for impressing upon each of said input circuits a current derived from said artificial line and means for impressing upon each of said receiving sets a current derived from the output circuit of one of said amplifiers, said input circuits being aperiodic and each of said output circuits having a resonant circuit associated therewith.

24. The combination in a radio receiving system of a receiving antenna, a plurality of receiving sets, a plurality of electron discharge amplifiers having input and output circuits, separate means for impressing upon each of said input circuits desired signaling currents received upon said antenna, an artificial line associated with said antenna, means for impressing upon each of said input circuits a current derived from said artificial line, means for impressing upon each of said receiving sets a current derived from the output circuit of one of said amplifiers, and means for separately adjusting the phase and intensity of the currents impressed from the artificial line upon each of said input circuits, said input circuits being aperiodic and each of said output circuits having a resonant circuit associated therewith.

25. The combination in a radio receiving system of a receiving antenna, a plurality of receiving sets, a plurality of electron discharge amplifiers having input and output circuits, means for impressing upon each of said input circuits desired signaling currents received upon said antenna, means for impressing upon each of said receiving sets a current derived from the output circuit of one of said amplifiers, and separate means for impressing upon each of said input circuits a current derived from said antenna of suitable phase and intensity to neutralize in the receiving sets the effect of undesired currents therein.

26. The combination in a radio receiving system of a receiving antenna, a plurality of receiving sets, a plurality of electron discharge amplifiers having input and output circuits, means for impressing upon each of said input circuits two separate currents derived from said antennna, means for separately adjusting the phase and intensity of one of said currents, and means for impressing upon each of said receiving sets a current derived from the output circuit of one of said amplifiers.

27. The combination in a radio receiving system of an aperiodic receiving antenna, a plurality of receiving sets, a plurality of electron discharge amplifiers having aparaiodic input circuits and output circuits, means for impressing upon each of said input circuits two separate currents derived from said antenna, means for separately adjusting the phase and intensity of one of said currents impressed upon each of said input circuits, and means for impressing upon each of said receiving sets the current derived from the output circuit of one of said amplifiers.

28. The combination in a radio receiving system of a receiving antenna, a plurality

receiving sets, a plurality of electron dis-
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29. The combination in a radio receiving
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said receiving sets a current derived from
e output circuit of one of said amplifiers.

30. The combination in a radio receiving system of an aperiodic horizontal receiving antenna, a plurality of receiving sets, a plurality of electron discharge amplifiers having aperiodic input circuits and output circuits, means for impressing upon each of said input circuit currents derived from two different points in said antenna, means for separately adjusting the phase and intensity of one of the currents impressed upon each of said input circuits, a circuit associated with each of said receiving sets which is resonant to signals to be received upon the set with which it is associated, and means for impressing upon each of said resonant circuits a current derived from the output circuit of one of said amplifiers.

In witness whereof, we have hereunto set our hands this 26th day of April 1921.

EDWARD W. KELLOGG.
CHESTER W. RICE.