To all whom it may concern:

Be it known that I, Alcott B. Moulton, a citizen of the United States, and a resident of room 1856, 233 Broadway, New York, N. Y., have invented new and useful Improvements in Radio Receiving Systems, of which the following is a specification accompanied by drawings.

This invention relates to radio receiving systems and particularly to improvements in an antenna system of the type described in Beverage U. S. Patent No. 1,881,089. In the patent referred to an antenna is shown and described consisting of a long horizontal collector extending in the general direction of transmission and having a length of at least a half wave and preferably of the order of magnitude of the wave length to be received. When the velocity on the antenna is properly adjusted the strength of the desired signal will be greatest at the end which is farthest from the transmitter, and by providing a surge impedance in a ground connection at the end nearest the transmitter, the wave which is built up from the opposite direction will be damped out in the ground connection and reflection back to the receiver at the distant end will be prevented. In this way a unidirectional receiving system is secured which has been found to eliminate interfering signals and atmospheric disturbances to a very large extent.

In the patent of Edward W. Kellogg, No. 1,487,339, dated March 18, 1924, and in Patent No. 1,434,985 to H. H. Beverage dated November 7, 1922, a second horizontal collecting wire has been used for the purpose of providing an arrangement whereby the damping resistance may be located at the same end of the antenna as the receiver and the two wire antenna thus formed is used as a line for conducting the desired currents back to the end nearest the transmitter. The arrangement therein described utilizes a transformer at the end farthest from the transmitter. In the application of E. W. Kellogg, Serial No. 558,866, the transformer is eliminated by utilizing open circuit reflection and short circuit reflection for producing currents in the circuit formed by the two antenna wires.

The present invention in certain of its aspects embodies some of the features disclosed in the patents and application previously mentioned.

One of the improvements contemplated by the invention is a simplification of the damping arrangement and also an arrangement in which the damping resistance and the receiver may, when desired, be located at the end of the antenna farthest from the transmitter.

Another improvement in the circuit arrangement which will be described is in the utilization of the transmission line formed by a two wire antenna as a circuit for conveying the interfering currents over the line to the damping circuit instead of conveying the signal current over the line to the receiver. In this manner the signal is not subjected to transmission line losses.

The antenna circuit arrangement shown may be utilized in conjunction with various arrangements for reception of a number of signals as in the multiplex operation described and claimed in patents to H. H. Beverage No. 1,487,308, dated March 18, 1924; Patent No. 1,434,984, dated November 7, 1922; Patent No. 1,434,985, dated November 7, 1922, and in connection with the arrangement shown in the patent of E. W. Kellogg and C. W. Rice No. 1,435,009, dated November 7, 1922. Various arrangements, such as described in the patents and application mentioned as well as others, for eliminating or balancing residual interfering effects may also be utilized with the arrangements which are described herein.

The novel features which I believe to be characteristic of my invention are set forth with particularity 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 drawings in which I have illustrated two arrangements whereby the invention may be carried into effect.

In the drawing, Fig. 1 is a diagrammatic representation of a circuit arrangement utilizing the new method of damping together with circuit arrangements for multiplex operation and elimination of residual undesired effects.

Fig. 2 is a diagrammatic view of the modification which also illustrates a different
method of balancing residual undesired effects, particularly vertical antenna components.

Fig. 3 is a diagrammatic view of a further modification.

Referring to Fig. 1 of the drawings, 1 and 2 are the two long horizontal antenna wires extending in the general direction of the transmitting station and having a length which is approximately equal to the wave length to be received. One of the conductors, for example 2, is grounded at the end 3 which is nearest to the transmitting station. At the other end the two conductors are connected together by means of a reactance such as a coil 4 which preferably has its turns in close relation to each other so that one end of the coil is sufficiently close to the other to provide a close coupling relation between the turns of the coil. The midpoint 5 of the coil is grounded at 6 through a coil 7 to which the receiving apparatus is coupled. The antenna wires 1 and 2 are connected together at the receiver end by a damping resistance 10 which is preferably adjustable and located at the end farthest from the transmitting station, that is, at the same place as the receiving apparatus.

Any suitable receiving apparatus may be coupled to coil 7. In the drawing a receiver is shown consisting of two receiving systems 11 and 12, the grid of the first tube of the former being connected to the coil 13 which is coupled to coil 7 and the receiver 12 being similarly coupled to the coil 7 by means of coil 14. Each of the receiving systems is shown by way of example in the drawing as consisting of an amplifier and a detector tube, although obviously any suitable amplifying and detecting arrangements may be used.

An arrangement is also shown for balancing residual interfering effects. This consists of a vacuum tube 15 having its grid circuit coupled to the coil 4 by means of coil 16, and its plate circuit coupled to an artificial line 17 by means of a transformer 18. One end of the artificial line is grounded at 19. The grounded end 19 of the artificial line is connected through resistances 20 and 21 to a separately adjustable contact members 22 and 23 which cooperate with the artificial line. One end of the coil 14 is connected to the resistance 20 by means of adjustable contact 24 and one end of the coil 13 is similarly connected to the resistance 21 by means of the adjustable contact 25.

The arrangement as described is adapted to most efficiently receive signals coming in the direction indicated by the arrow to the substantial exclusion of signals from the opposite direction. The invention is not limited to any particular theory of operation of the long antenna, and as a theory has already been given in the patent previously mentioned, in this application it will not be necessary to consider the theory except to refer to the fact that the strength of the signal progressively increases along the antenna. The desired signal builds up in such a manner that substantially equal currents due to the desired signal are produced in wires 1 and 2 at the end farthest from the transmitter. The current then flows from the wires 1 and 2 in opposite directions through the halves of the coil 4 to the ground connection. The inductance introduced by the two halves of the coil to the desired signal currents will be relatively low, since the signal currents are equal and in phase on wires 1 and 2, and, therefore, upon passing through the two halves of the coil 4 in opposite directions, the fields due to the two currents neutralize, and the effective reactance in series with the receiver coil 7, therefore, depends only on the leakage reactance between the two halves of the inductance coil. The damping resistance 10 has no effect on the desired signal currents since it is connected between equipotential points as far as the desired signals are concerned. It will thus be seen that the desired currents will only affect the coils 13 and 14 which are associated with the receiving systems 11 and 12.

By means of the relay circuit 15, 16, 18 a certain amount of energy originating from a direction opposite to that of the desired signals will be drawn from the antenna system and placed on the artificial line. The undesired effects in the receivers 11 and 12 may then be balanced by means of the adjustable contacts 22 and 23 and the adjustable resistances 20 and 21, which permit the selection of an electromotive force from the artificial line of the proper phase and magnitude for neutralizing the interfering effects in each of the receivers.

Interfering effects coming from a direction opposite that of the signal will build up on the line in the same manner as the signals are built up and the electromotive forces will be a maximum at the end nearest the desired transmitter. Due to the utilization of open circuit reflection at the point 20 and short circuit reflection at the grounding 19, the reflected current on one wire will be 180° out of phase with the reflected current on the other wire so that a potential difference exists between the two wires which tends to produce a circulating current. The coil 4 will have a high impedance to a flow of these circulating currents because the current flows through the entire coil in the same direction. The damping resistance 10 however, will be low in comparison with the reactance of the coil 4.

The value of the resistance 10 for maximum damping may be theoretically determined from the following considerations: If an antenna D meters long is connected as
shown in Figure 1, with one wire grounded and the other open at the end farthest from the receiver, the action at the far end is equivalent to a transformer of ratio N which transfers energy from the antenna to a transmission line of length D. If the antenna is not damped and the transformer is a perfect impedance fit, the former will oscillate or resonate like an antenna of approximately of length 2D. The antenna could be dampened by a resistance R between end 26 and ground 3 equal to the surge impedance of the antenna, which is approximately equal to \( \sqrt{L/C} \) where L and C are the inductance and capacity per unit length of the two wires 1 and 2, with respect to earth; but if the antenna is to be dampened at the receiver end a different value of resistance is required because the impedance of the antenna to circulatory current depends upon the capacity and inductance per unit length between the conductors as well as the inductance and capacity per unit length with respect to earth. In order to produce equivalent damping with the circuit of Figure 1, where the damping resistance is placed between conductors 1 and 2 at the receiver end, it is necessary to use a value of resistance 10 represented approximately by the expression \( R_c = N^2 R \), where R is the resistance which would be required if damping was used between end 26 and ground 3, and N is the ratio of the equivalent transformer at 3 and depends on the impedance of the antenna to circulatory currents. It has been found that in order to provide an impedance fit N should be substantially \( \sqrt{2} \), so that under ideal conditions the damping resistance across the conductors would be twice the damping resistance of a direct ground. With coil 4 suitably damped to give low leakage reactance, its impedance with respect to the out of phase or circulating reflected currents on conductors 1 and 2 is high compared to the damping resistance 10 over a wide range of wave lengths, giving good damping over a range such as 3 to 1. For very great range in wave length, the impedance of coil 4 may be sufficiently low at the long wave lengths, to become comparable with the resistance R, thereby making the damping circuit 4, 10 inductive. In general, the damping circuit should give the effect of practically pure resistance. The inductive reactance of coil 4 may be neutralized for a particular wave length by a suitable condenser 10' in parallel with it as shown in Fig. 2 or by placing an inductance and variable capacity 9 in series with the resistance 10, as shown in the modification of Figure 3. The latter connection may be used for balancing residuals by selective reflection, as described in the patent of E. W. Kellogg, No 1,487,339 dated March 18, 1924, mentioned heretofore.

In Fig. 2 the ends of the wires 1 and 2 nearest to the transmitting station are connected together by means of a coil 37 the middle point of which is grounded at 29 through the coil 28 forming the primary of a transformer in inductive relation to the coil 27, forming the secondary. The interfering currents which build up toward the end nearest to the transmitting station pass through the two halves of the coil in opposite directions producing a low impedance, and then flow together in the same direction through the coil 28 to ground 29. The currents flowing through 28, by transformer action, produce a circulating current in the loop circuit consisting of the antenna wires 1, 2 and coil 27. The circulating currents are damped by the damping resistance 10 in the same manner as in Fig. 1, because of the fact that the coil 5 has a high impedance to circulating currents. The signal currents pass to ground through the coil 7 in the same manner as already described, in connection with Fig. 1.

Residual interfering effects, those due to electrostatic or vertical antenna effects, may be cancelled by utilizing a separate antenna 30 which is connected to ground 6 through condenser 31, adjustable resistance 32 and a coil 33, which is coupled to the receiver coil 34. The separate antenna collects interfering effects and these are applied to the receiver to neutralize the vertical antenna effect by a suitable adjustment of the amplitude and phase by means of the condenser 31, resistance 32 and coil 33. Obviously the multiplex and balancing arrangements of Fig. 1 may be used with the arrangement of Fig. 2 and vice versa.

The arrangement described is particularly suitable for localities where it is impossible to run the antenna in a direction away from the signal. The arrangement still maintains the damping circuit and the receivers at the same location so that each of these may be conveniently adjusted. The desired signal is not reflected back into the antenna wires and transmitted back to the opposite end, and in this manner transmission line losses on the signal are eliminated. The transmission line losses merely act on the strength of the undesired signal.

Having described my invention what I claim is:

1. A radio receiving system comprising in combination a long horizontal antenna consisting of two parallel conductors and a damping resistance connected across adjoining ends.

2. A radio receiving system comprising in combination a long horizontal antenna
consisting of two parallel conductors, a damping resistance connected across adjoining ends and means associated with the other adjoining ends for converting like currents at said ends to circulating currents in the conductors.

3. A radio receiving system comprising in combination a long horizontal antenna consisting of two parallel conductors extending in substantially the direction of signal approach, and a damping resistance connected across the adjoining ends of said conductors located farthest from the transmitter.

4. A radio receiving system comprising in combination a long horizontal antenna consisting of two parallel conductors and a damping circuit comprising reactance and a damping resistance connected in parallel across a pair of adjoining ends.

5. A radio receiving system comprising in combination a long horizontal antenna consisting of two parallel conductors and a damping circuit comprising an inductance and a damping resistance connected in parallel across a pair of adjoining ends.

6. A radio receiving system comprising in combination a long horizontal antenna consisting of two parallel conductors and a damping circuit comprising an inductance and a damping resistance connected in parallel across a pair of adjoining ends, said inductance having an impedance substantially greater than said resistance.

7. A radio receiving system comprising in combination a long horizontal antenna consisting of two parallel conductors and a damping circuit comprising a damping resistance and a reactance connected across the same adjoining ends, said reactance being grounded at an intermediate point.

8. A radio receiving system comprising in combination a long horizontal antenna consisting of two parallel conductors and a damping circuit comprising a damping resistance and an inductance connected across the same adjoining ends, said inductance being grounded at an intermediate point.

9. A radio receiving system comprising in combination a long horizontal antenna consisting of two parallel conductors, a damping circuit comprising a damping resistance and a reactance connected across the same adjoining ends, a ground connection to an intermediate point of said reactance and a receiving coil in the ground connection.

10. A radio receiving system comprising in combination a long horizontal antenna consisting of two parallel conductors, a damping circuit connected across a pair of adjoining ends comprising an inductance and a resistance in parallel across said ends, and means for substantially neutralizing the inductive effect of said inductance whereby the damping circuit has substantially the effect of pure resistance.

11. A radio receiving system comprising in combination a long horizontal antenna consisting of two parallel conductors, a damping circuit connected across a pair of adjoining ends comprising an inductance and a resistance in parallel across said ends, and a condenser in series with said resistance.

12. A radio receiving system comprising in combination a long horizontal antenna consisting of two parallel conductors, a damping circuit connected across a pair of adjoining ends comprising an inductance and a resistance in parallel across said ends and a capacity and inductance in series with said resistance.

13. A radio receiving system comprising in combination a long horizontal antenna consisting of two parallel conductors, a damping circuit connected across a pair of adjoining ends, and a ground connection for the other end of one of the conductors.

14. A radio receiving system comprising in combination a long horizontal antenna consisting of two parallel conductors, a damping circuit connected across a pair of adjoining ends comprising a reactance and a reactance connected across said ends, a ground connection to an intermediate point of said reactance, a receiving coil in the ground connection and means associated with said receiving coil for balancing residual interfering effects.

15. A radio receiving system comprising in combination a long horizontal antenna consisting of two parallel conductors, a damping circuit connected across a pair of adjoining ends comprising a reactance and a reactance connected across said ends, a ground connection to an intermediate point of said reactance, a receiving coil in the ground connection and a second antenna for balancing vertical antenna effects.

16. A radio receiving system comprising in combination a long horizontal antenna consisting of two parallel conductors extending in substantially the direction of signal approach and a damping resistance connected across adjoining ends of said conductors located farthest from the transmitter.

17. A radio receiving system comprising in combination a long horizontal antenna consisting of two parallel conductors extending in substantially the direction of signal approach, a damping resistance connected across adjoining ends and means associated with the other adjoining ends of said conductors located farthest from the transmitter for converting like currents at said ends to circulating currents in the conductors.

18. A radio receiving system comprising in combination a long horizontal antenna consisting of two parallel conductors, a damping circuit connected across a pair of adjoining ends comprising an inductance and a resistance in parallel across said ends, and means for substantially neutralizing the inductive effect of said inductance whereby the damping circuit has substantially the effect of pure resistance.
consisting of two parallel conductors extending in substantially the direction of signal approach and a damping circuit comprising reactance and a damping resistance connected in parallel across a pair of adjoining ends of said conductors located farthest from the transmitter.

19. A radio receiving system comprising in combination a long horizontal antenna consisting of two parallel conductors extending in substantially the direction of signal approach and a damping circuit comprising an inductance and a damping resistance connected in parallel across a pair of adjoining ends of said conductors located farthest from the transmitter.

20. A radio receiving system comprising in combination a long horizontal antenna consisting of two parallel conductors extending in substantially the direction of signal approach and a damping circuit comprising an inductance and a damping resistance connected in parallel across a pair of adjoining ends of said conductors located farthest from the transmitter, said inductance having an impedance substantially greater than said resistance.

21. A radio receiving system comprising in combination a long horizontal antenna consisting of two parallel conductors extending in substantially the direction of signal approach and a damping circuit comprising a damping resistance and a reactance connected across the same adjoining ends of said conductors located farthest from the transmitter, said reactance being grounded at an intermediate point.

22. A radio receiving system comprising in combination a long horizontal antenna consisting of two parallel conductors extending in substantially the direction of signal approach and a damping circuit comprising a damping resistance and an inductance connected across the same adjoining ends of said conductors located farthest from the transmitter, said inductance being grounded at an intermediate point.

23. A radio receiving system comprising in combination a long horizontal antenna consisting of two parallel conductors extending in substantially the direction of signal approach, a damping circuit comprising a damping resistance and a reactance connected across the same adjoining ends of said conductors located farthest from the transmitter, a ground connection to an intermediate point of said reactance and a receiving coil in the ground connection.

24. A radio receiving system comprising in combination a long horizontal antenna consisting of two parallel conductors extending in substantially the direction of signal approach, a damping circuit connected across a pair of adjoining ends of said conductors located farthest from the transmitter, comprising an inductance and a resistance in parallel across said ends, and means for substantially neutralizing the inductive effect of said inductance whereby the damping circuit has substantially the effect of pure resistance.

25. A radio receiving system comprising in combination a long horizontal antenna consisting of two parallel conductors extending in substantially the direction of signal approach, a damping circuit connected across a pair of adjoining ends of said conductors located farthest from the transmitter comprising an inductance and a resistance in parallel across said ends, and a condenser in series with said resistance.

26. A radio receiving system comprising in combination a long horizontal antenna consisting of two parallel conductors extending in substantially the direction of signal approach, a damping circuit connected across a pair of adjoining ends of said conductors located farthest from the transmitter comprising an inductance and a resistance in parallel across said ends and a capacity and inductance in series with said resistance.

27. A radio receiving system comprising in combination a long horizontal antenna consisting of two parallel conductors extending in substantially the direction of signal approach, a damping circuit connected across a pair of adjoining ends of said conductors located farthest from the transmitter and a ground connection for the other end of one of the conductors.

28. A radio receiving system comprising in combination a long horizontal antenna consisting of two parallel conductors extending in substantially the direction of signal approach, a damping circuit connected across a pair of adjoining ends of said conductors located farthest from the transmitter comprising a resistance and a reactance connected across said ends, a ground connection to an intermediate point of said reactance, a receiving coil in the ground connection and means associated with said receiving coil for balancing residual interfering effects.

29. A radio receiving system comprising in combination a long horizontal antenna consisting of two parallel conductors extending in substantially the direction of signal approach, a damping circuit connected across a pair of adjoining ends of said conductors located farthest from the transmitter comprising a resistance and a reactance connected across said ends, a ground connection to an intermediate point of said reactance, a receiving coil in the ground connection and a second antenna for balancing vertical antenna effects.

ALBERT B. MOULTON.