May 9, 1933. G. W. PICKARD 1,907,572

STATIC NEUTRALIZER FOR RADIORECEIVERS

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Fig. 1.

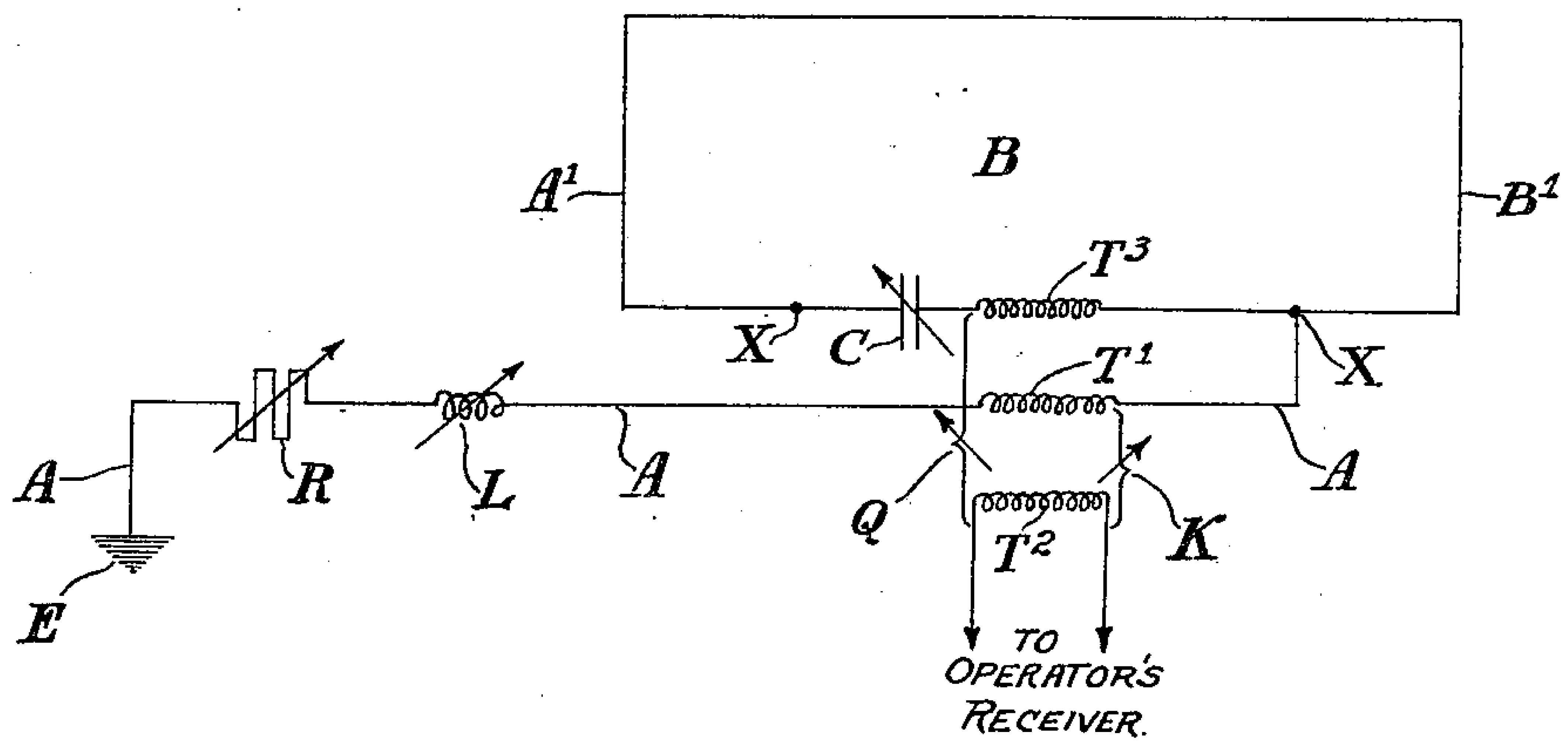
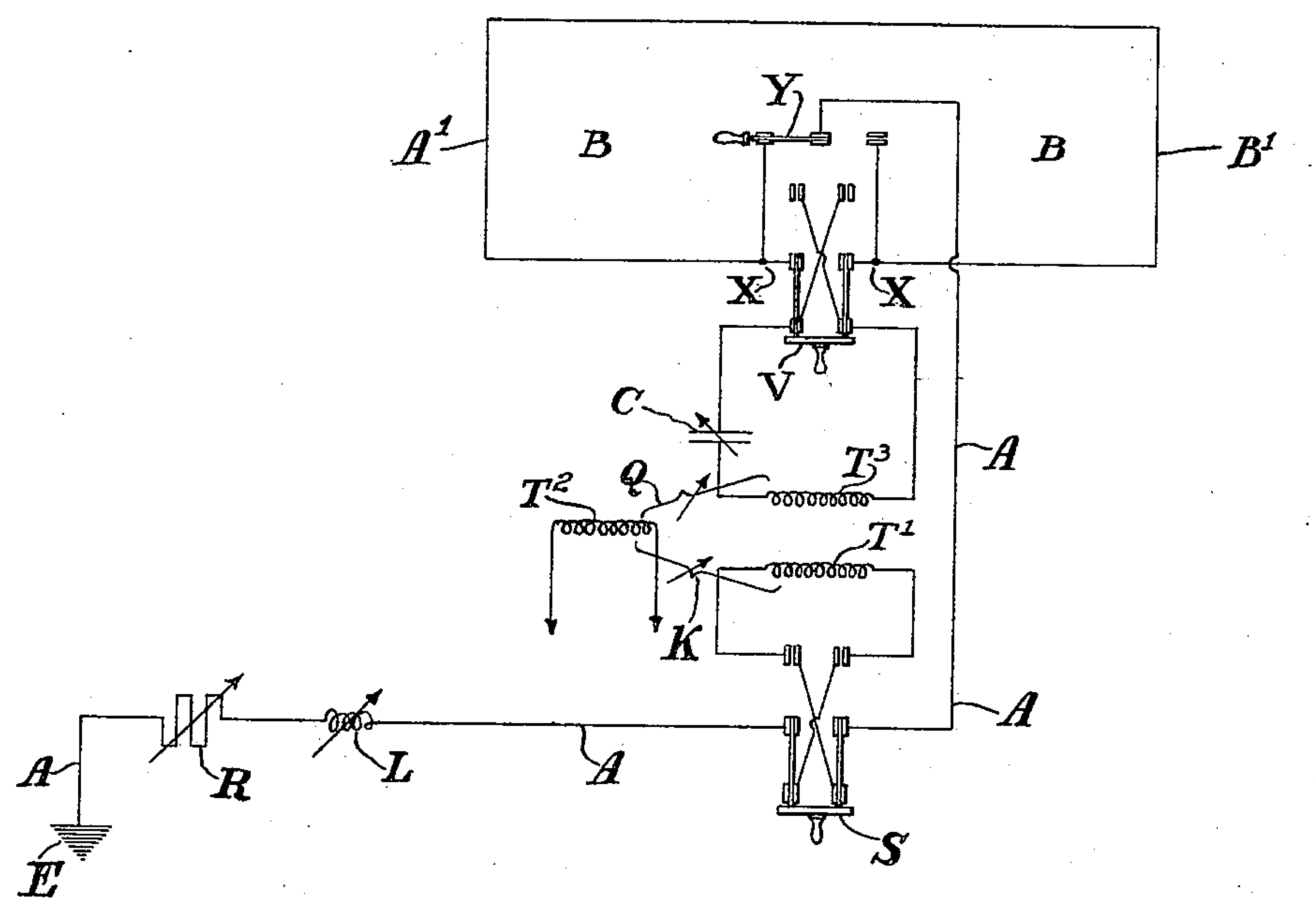


Fig. 2.



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UNITED STATES PATENT OFFICE

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STATIC NEUTRALIZER FOR RADIORECEIVERS

Continuation of application Serial No. 256,978, filed October 5, 1918. This application filed May 6, 1920. Serial No. 379,405.

This application is a continuation of an application, Serial Number 256,978, filed by me October 5, 1918 and a continuation in part of an application Serial No. 368,903 filed by me March 26, 1920.

This invention relates to receiving apparatus and method employed in radio communication, and its object is to prevent static from interfering, at the receiving apparatus, with the useful energy received from a distant transmitter (static being the common name for atmospheric electrical disturbances).

In practice, the embodiment of this invention which is shown in the drawing and hereinafter described has resulted thus far in the improvement of the ratio of signal intensity to static intensity twenty-four times, which is equivalent to an elimination of ninety-six per cent of the intensity of static received at the receiving station.

The object of the invention is to oppose and neutralize the static energies received by the aerials and at the same time secure sufficient signal energy to be useful.

This object is preferably attained by employing a plurality of collectors or aerials properly positioned or having different directional properties in any desired plane and suitably coupled to combine the energies received. The intensity of the signal and static received by a directional system varies, of course, with the position the aerials occupy with respect to the wave fronts. Such a system should preferably be located to receive the greatest amount of signal consistent with total elimination of static, and any adjustments, other than the above, necessary to eliminate the static, is done by means of the coupling between the aerials, or by means of the other adjustments hereinafter more fully described, or both.

Of the drawing,

Fig. 1 is a simple diagram of the embodiment which up to date has proved best, as to both efficiency and simplicity; and

Fig. 2 is another diagram of the same embodiment showing the operator's switches which may be employed in practice.

A is an aerial or antenna or collecting circuit of any type ordinarily used, including a primary coupling-coil T′; the secondary coupling-coil being at T^2, and connected to the receiving or indicating apparatus and circuits, such as a detector and telephone receiver or the like, as commonly used in the radio art in various ways. Of course, all the coupling-coils, as well as the tuning condenser C, are most conveniently located in the vicinity of the operator's receiver, and not up in the air as might be inferred from the diagram.

In addition to antenna A, one (or more) additional collecting circuits is employed, such as B, which is a directional form of collector, i. e., operates best when disposed with respect to the direction of the transmitted signal waves. Although circuit B may assume various forms of directional circuits, yet it preferably consists of (and in such cases is disposed so as to act as) a magnetic loop, as described in my Patent No. 876,996.

Circuits A and B are connected together at point X, so that the wires A′ B′, which constitute the magnetic loop B, also act as an upper part of antenna A.

It is very desirable, at least, that the difference between the amounts of static energy tending to be induced upon secondary T^2 by the two circuits respectively be less than the algebraic sum of useful signal energy tending to be so induced by the two circuits, respectively.

The static disturbances arrive at the receiving station from various directions in altitude and azimuth, which, of course, affect the aerials. Possibly a larger proportion of the static comes from a horizontal direction. According to my observat ons on the North Atlantic Coast, the less bothersome forms of static appear to come indeterminately from all points in the hemisphere above with a certain preponderance towards the zenith; the more bothersome forms of static, however, are localized and occur at intervals, so that, by suitable adjustments of the apparatus, hereinafter described, its effect may be greatly diminished.

Directional aerials or combinations of directional aerial and open antenna herebefore known do not to any useful extent eliminate the less bothersome form of static, because it is impossible, by reason of the multiplicity of disturbances in all directions at substantially every interval of time, to properly direct or adjust the aerials. On the other hand, the localized discharges may be eliminated by either proper adjustment of the position of the apparatus or by manipulation of the couplings and other adjustments. It is, therefore possible to eliminate, by means of the combined open antenna and magnetic loop, a large percentage of the more bothersome form of static, but this is not enough for practical operation.

The object of the present invention is, therefore, to improve upon present constructions and to provide adjustments and methods of eliminating enough static so that the ratio between static and signal will be such as to render the signal audible under the most severe conditions.

Of collecting circuits A and B, the magnetic loop B is such a directional or signal-receiving circuit as above indicated, and in the practice of this invention it is preferably located with its plane normal to the vertical plane of the magnetic circles or lines in the advancing wave front, i. e., the plane of the loop is vertical to the earth and in line with (pointed at) the distant transmitter, all as described in my said Patent No. 876,996. Thus loop B is a directional circuit, and disposed to function as such and therefore to receive the signal waves very efficiently.

The circuit A, as here illustrated, is substantially non-directional in a horizontal plane, but it is to be understood that other types of aerials arranged in different positions may be substituted therefor.

The collectors A and B receive from the waves both signal and static energies, as hereinafter fully described, where the static energies are neutralized and sufficient signal energy retained to be useful.

Collector B includes the primary coupling-coil T^3, which, through primary coupling-coil T' in collector A, supplies energy to the secondary coupling-coil T^2.

In accordance with this invention, the greater part of the static energy received at the receiving station is prevented from reaching the circuit of secondary coil T^2; or, at least, such a large proportion of the static is eliminated from the receiving system that too little exists in the secondary circuit to prevent the operator from intelligibly reading the signals. This result is obtained in the following manner.

Equalization of static energies

Notwithstanding that collectors A and B, if properly constructed and positioned, may receive substantially similar amounts of static energy, they never receive the same amounts save by accident, and in order to eliminate the greatest proportion of the energy due to static, the electromotive forces due to static which are induced, across secondary coil T^2, by primaries T' and T^3 in collectors A and B respectively, are made equal by coupling adjustment. Such equalization is permitted to be done by the operator, by providing variable couplings between coils T' and T^2, and between coils T^3 and T^2, respectively, such couplings being indicated at K and Q, respectively, by conventional symbol, and comprising any of the known constructions permitting variability of coupling-adjustment by the operator. By adjusting the couplings Q and K relatively to each other, the coupling between the coils T^3 and T' may be varied.

Neutralization of static energies

The electromotive forces due to the energy of static, which result from the above equalization, are then set in opposition to each other, with the result of neutralizing or nearly neutralizing one another, so that the resultant electromotive force due to static in the circuit of secondary T^2 is substantially zero, or at least very much reduced as compared with either of the received static electromotive forces in collectors A and B prior to neutralization. This setting in opposition is effectuated by so connecting one of the primaries, T' or T^3, in its own collecting circuit, that the electromotive forces due to static set up across secondary coil T^2 are in opposite directions. The means for doing this in a practical manner is described more particularly later on in connection with Fig. 2.

Preponderance of signal-energy

Since the system of aerials herein disclosed and illustrated in Figs. 1 and 2 has unilateral directional properties, as is well known, the amount of adjustment necessary to equalize and oppose the static energies received by the collectors A and B will vary in accordance with the direction from which the static comes, or the relation between the wave fronts set up by the static discharge and the aerials. The prime purpose of the invention is to oppose and equalize the static received by the aerials to eliminate the greatest possible amount. In some cases this will necessitate the sacrifice of a comparatively large amount of signal energy received by two aerials, especially if the static discharge is in the direction of the transmitting station. In such cases, the setting in opposition of the static energies received by the collectors A and B is accompanied by a setting in opposition to each other of the signal energies received by the collectors A and B. Inasmuch as the static discharge rarely, if ever, comes from a point in line with the transmitter and receiving station, by reason of the unilateral directive properties of the system, sufficient signal energy will remain after eliminating static to be useful.

This preponderating or remaining electromotive force of signal energy received by collectors A and B is sufficient to operate the indicating apparatus so that the signals are intelligible to the operator. In fact, even if the static be not completely eliminated or excluded from the secondary circuit by the action of neutralization, yet the ratio of signal intensity to static intensity in the secondary circuit is so greatly increased by the use of this invention that always signals can be read under such bad conditions of static in the atmosphere as otherwise would prevent intelligibility of even strong signal responses. Thus, for example, take the actual instance of a use by me of the embodiment of Fig. 1 (data of which chances to be now at hand), wherein, at a given instant, collectors A and B were receiving energy as follows, in terms of units of signals which would be barely audible in the absence of static:

Collector A
Signal 600 Static 4000

Collector B
Signal 2000 Static 5000

Thereupon the static energies from the collectors are made more nearly equal in their effect upon the secondary by the coupling adjustments. This coupling adjustment might have been done in either or both of two ways, i. e., either (*a*) by tightening the coupling K between the coils T′ and T^2, resulting in increasing the amount of static energy and signal energy transferred from the collector A to the secondary T^2; or (*b*) by loosening the coupling Q between the coils T^3 and T^2, resulting in decreasing the amount of signal and static energy transferred from the collector B to the secondary T^2. In the given case, the latter method was chosen, fortuitously, with the following change in energy, in units of audibility, which collector B tended to transfer to the secondary T^2:

Signal 1600 Static 4000

Thus the static was apparently equalized in collectors A and B, the secondary (T^2) receiving six hundred audible signal units from collector A, as noted in the first above schedule. (All the above figures represent actual measurements.) The result thereupon, of setting in opposition the two totals of electromotive forces from A and B, would produce, according to theory, zero static energy in the secondary (T^2), and would produce useful signal energy in the secondary (T^2) of sixteen hundred minus six hundred, or one thousand times audibility. In fact, however, actual measurements showed the result in the secondary circuit (of T^2) to be as follows:

Signal 600 Static 100

Comparing this result with that in the case of using collector B alone (receiving signal 2000, static 5000 as above), it is seen that the use of this invention gave an improvement of the ratio of intensity of signal to intensity of static, in the secondary circuit, from four-tenths of a unit to six units, i. e., an improvement of fifteen times.

The above difference between the theoretical result and the actual result is believed to be due, (*a*) to unavoidable losses of signal energy in any embodiment of the invention, and (*b*) to the intentional omission to use or employ refinements of operator's adjustments and re-adjustments for equalization and neutralization which if used would produce a result which would be an improvement but not worth the time necessarily consumed. A valuable feature of the invention is the magnitude of improvements obtained by simple adjustments quickly made. As a practical matter, all that is necessary to be accomplished, for example, is the elimination of a sufficient portion of the static to prevent a static response which shall be, say, any more intense than the signal response; and that is accomplished readily by this invention by an ample margin without adjustments consuming much time, as indicated by the above example showing a result in the secondary circuit of useful energy six times as great as static energy; while without the employment of the invention, the intensity of static response would have been, from circuit A, nearly seven times as great as the signal response, and from circuit B the intensity of static response would have been nearly three times as great as the signal response.

Before equalizing and neutralizing the static, the operator is to tune collector B to the transmitted signal-waves until his telephones indicate the greatest intensity of signal response. This he may do by adjustment of condenser C or of inductance T^3, or both. This tuning may be done, however, at any stage of the operations if desired, as for example in a case where the static is at first too bad to enable the operator to distinguish the signal with sufficient clearness to permit accurate tuning.

Also, before making the coupling-adjustment for equalizing the static, primary coils T′ and T^3 are assumed to be so connected to each other with respect to secondary coil T^2 as to permit neutralization of the equalized static (see infra, as to the switches of Fig. 2 employed in practice).

Also, before making any of the operator's adjustments for executing the invention, each of the primary coils T′ and T^3 is assumed to be mediumly loosely coupled to secondary coil T^2 as a condition precedent to the coupling-adjustment for equalization.

The collector A is also provided with an inductance coil L, constructed to be adjustable and variable for the purpose of tuning, which can be done at any time that the operator deems convenient and advantageous.

It has been found that complex wave formations, or coupling waves, are set up in systems such as here disclosed, in which a plurality of aerials are coupled to each other, as by way of a secondary circuit. These complex wave formations are especially noticeable where the collectors are excited by aperiodic or single pulse waves, such as static. These formations are not as noticeable in connection with the signal waves, as the latter are but feebly damped and they persist for a long enough time to permit an opportunity to set up a wave train in which there are no complex wave formations.

These complex wave formations are of such a nature that a large percentage of their energies transferred to the secondary cannot be eliminated by coupling adjustment. I have devised means for overcoming and preventing these complex wave formations or coupling waves.

This means, in the form here illustrated, comprises a resistance R, shown as a non-inductive resistance. As here illustrated, this resistance is inserted in the collector A, although it may be inserted in the aerial B, or in both. It has been found that when such resistance is placed in the system, in either aerial or both, or in the open antenna aerial, as here illustrated, effective means is provided for preventing the complex wave formations above described.

In placing such resistance R as here shown,—that is, in the open antenna circuit,—it has been possible to make the energies received by the two aerials more nearly equal, as without the resistance the open antenna would receive a larger amount of energy. The resistance R is adjustable and can be adjusted by the operator until as noted by the ear at the receiving telephone there is a marked decrease in static response. The necessary amount of resistance, of course, depends upon the other characteristics and constants of the system and upon the received wave length. The specific resistance that I used in an actual construction is described more fully hereinafter.

Irrespective of the nature of the electrical operations that are taking place in this system, which I believe to be due to the complex wave formations above described, I find that the insertion of a resistance, such as R, in either aerial or both, where such coupled aerials are employed, produces surprising results in eliminating static.

After the adjustment of the resistance R, or after adjustment of any of the other parts of the apparatus, particularly the couplings, it may be again necessary to adjust the coil L and the condenser C to re-tune the circuits and further decrease the static.

The amount of resistance R necessary in a given system depends, of course, upon the extent of adjustment, or upon the tightness or looseness of the couplings between the aerials and the secondary circuit. Therefore, if these couplings are tightened or loosened at any time, it will be necessary to readjust the resistance R. This can be done by the operator, who will soon learn from experience what additional adjustment of R will be needed. The coupling adjustment above described may consist of either tightening or loosening either coupling K or Q to increase or decrease the amount of static and signal energy transferred to the secondary circuit from collectors A and B. The operator recognizes the best adjustment by the lowest intensity of static response in his telephone.

The above series of operations, including tuning of collector B, adjustment of R and L, and adjustment of couplings K or Q, or both, may be repeated several times, if and when desired, in order to effect the best result or to make sure that the best results are being obtained. The best result is, of course, the signals which are most readily intelligible to the particular operator who is making the adjustments. Sometimes circumstances may exist where it is desirable to take the time to make such re-adjustments; and an example of such potentiality of the invention in this respect is afforded by a comparison of the two cases mentioned above, in one of which the ratio of signal to static was increased twenty-four times and in the other only fifteen times.

Fig. 2 is a more detailed diagram of the same embodiment as Fig. 1, showing the operator's switches employed in practice. The parts in Fig. 2 which are the same as in Fig. 1 are lettered the same.

The parts in Fig. 2 which are not shown in Fig. 1 are the operator's switches Y, V and S.

Switch Y is used to locate the point X, Figs. 1 and 2, either to the right (see Fig. 1) of coil T^3 or to the left of condenser C: I have found that under any given set of circumstances one or the other location of point X permits markedly better results (i. e, less static response) than the other. Switch Y is a single-pole double-throw switch, as is shown. It may be worked at any stage of the operations, but the preferred stage is described later on.

Switch V is a reversing switch, by which primary coil T^3, and in the present showing condenser C, are reversed in their connection in their circuit B, and coil T^3 is reversed with relation to secondary coil T^2 and primary coil T'. Switch V is a double-pole, double-throw switch, and its connections are clearly shown.

The switch V is important inasmuch as by throwing this switch to one position or the other the amount of static received is enormously increased or enormously decreased, according to the direction from which it is coming. At any rate, the switch V should be so arranged as to set the static energies received by the aerials in opposition in the secondary.

Switch S has been supplied to reverse the primary coils T′ and T^3 with respect to each other and with respect to the secondary coil T^2 for this same purpose,—that is, to cause opposition of static. It will be noticed that this switch is located in a different position in the system and broadly performs the same function as the switch V. Yet it may be useful in order to secure refinements of adjustment by reason of the fact that in such a grouping of coils as T′, T^2 and T^3 there are present not only magnetic or inductive couplings but electrostatic couplings as well, and, hence, the reversal of coil T′ with respect to T^3 may have a different effect upon the secondary T^2 than the reversal of coil T^3 with respect to T′.

The operator may then adjust these switches to obtain the best results as determined by trial and observance of telephone response during static conditions. The proper arrangement of coils for neutralization should exist before the operator begins to adjust R or L or the couplings K or Q, or both, or refinements of adjustment, or for the purposes of equalization of the static. If switch V or S, or both, be used, the operator, after determining by the response in the telephones the correct position of switch V, next determines by similar trial the correct position of switch S, and then he begins the adjustments of L, R, Q and K.

Switch S is also a double-pole, double-throw switch, and its connections are clearly shown.

It is clear that the switches of Fig. 2 and their connections may be rearranged or combined in various ways to effect the same results as herein described.

Summing up with reference to Fig. 2, the steps by which the invention is executed are as follows, and generally in the following order:

1. In installing directional circuit B in respect of a given transmitter, it is moved to point more directly toward the distant transmitter, while being kept vertical, until the loudest signal-response is heard in the telephones, which will indicate that it is in line with the transmission.

2. Collector B is tuned to the length of the transmitted signal waves, as by adjusting condenser C or inductance T^3, or both. At this stage the switch S must be open, as each aerial is preferably tuned separately. The collector A is then tuned by any suitable means, such as the inductance L, the switch S in this instance being closed and the switch V open. Both switches V and S are then closed. Generally, better results may be obtained if this step is repeated after some or each of the subsequent steps of adjustment, because the latter (as the coupling adjustments) are liable to affect the wave-length of circuit B. Such subsequent tuning adjustments of circuit B, however, generally do not require as much time as the first tuning.

3. Adjusting couplings K and Q to a condition of medium loose coupling, in order that, later on, they may be tightened or further loosened respectively.

4. Operation of switch S to each of its two closed positions, alternately, in order to determine, by the much weaker intensity of static response in the telephones in one position of the switch, that in that position primary coils T′ and T^3 are in proper position relatively to each other and with respect to secondary coil T^2, so that the amounts of static received by A and B, respectively, are in opposition and, to a preliminary degree, neutralized in respect of their effect on secondary T^2.

5. Tightening or loosening of coupling K, or loosening or tightening coupling Q, or both or all, in order to make more nearly equal the induced effect on secondary T^2 of the amounts of static energy received in A and B as the result of adjusting R and L.

6 and 7. The resistance R and inductance L, or either of them, are then adjusted until the best response is obtained in the telephone. The purpose of the adjustment of R has already been described above, and the adjustment of R and L, or either of them, also tends to make the amounts of static in the collectors A and B more nearly equal in intensity and frequency.

8. Location of point X by switch Y. Switch Y is closed in each of its two positions alternately, to enable the operator to determine, by the telephone response at each position, which location of point X gives the weaker response to static, that being the position in which the switch is left.

9. Reversing the connections of T^3 and C, inclusive. Switch V is for this purpose operated either before or after switch Y, and either of them may be operated at any stage, but preferably directly after the tuning of collector B, in case the static conditions are not so bad as to prevent a showing of different intensity of static responses for the respective positions of each switch.

When switch S has been operated (as in step 4 above) to obtain the condition of neutralization, then whenever thereafter switch V is reversed from the position it occupied at the neutralization position of switch S, switch S must be reversed simultaneously with switch V, in order to preserve the condition of neutralization. The reversal of switch V alone, by its reversal of the loop with respect to condenser C and primary coil T^3, would not only destroy the condition for opposition and neutralization which was obtained by the proper setting of switch S, but such destruction in turn would mask the effect of the preferred relation of the loop B to condenser C and coil T^3 to be obtained by the proper setting of switch V. Hence the operator cannot determine, by the telephone response, the correct setting for switch V without simultaneously reversing both switches V and S. By such simultaneous reversal is meant a reversal of both said switches at or about the same time for the purpose of enabling the operator to judge best as to the telephone response for the two positions of switch V.

10. Another operation of switch Y to determine the better location of point X under the conditions resulting from the above steps will show sometimes that this switch now ought to be reversed from its previous better position.

It is clear, not only that the above series of steps may be repeated, to obtain, by finer adjustments of C, L, R, K, and Q, etc., results still better in degree, but that most of the individual steps may be repeated at any time relative to all or any one of the other steps. Thus, as one example, directly after above step 5, instead of operating switch Y, both switches V and S might be reversed, etc., etc. Emphasis is to be placed on the fact that after the condition of neutralization is obtained by the proper setting of switch S, it is necessary, in order to preserve that condition, that whenever switch V is reversed, switch S also must be reversed.

The above method of manipulating the specific system herein shown and described may, of course, be modified according to circumstances.

The prime purpose or object to be achieved is the equalization and neutralization of the static, at the same time retaining sufficient signal to be useful. Other means than that here illustrated may be employed to oppose the static energies and their relative amounts, such as, for instance, the proper positioning of the aerials, especially the loop, with reference to the wave front produced by the static discharge.

In order to obtain this neutralization and opposition, it is necessary that the oscillations of the static energies received by the collectors A and B must have substantially the same amplitude, frequency and decrement or damping. In other words, neutralization only takes place when the energies are at every instant during the wave trains produced by static equal and opposite. This condition is secured by the present invention.

The details of the apparatus comprising the particular embodiment shown in the drawing are as follows:

Collector B was rectangular, being two hundred feet long by twenty feet high, the lower side of the rectangle being ten feet above the ground. The loop consisted of four turns of number sixteen copper wire, these turns being spaced one foot apart.

Condenser C was a variable air-condenser and had an operating range from zero to three one-thousandths (0.003) microfarad.

Primary coil T^3 had an inductance of twenty-two (22) millihenries.

Primary coil T' had a like inductance of twenty-two (22) millihenries.

Inductance coil L in collector A had a range of inductance from zero to ninety (90) millihenries, and was variable by small steps of about one millihenry each.

Resistance R in collector A was a non-inductive resistance consisting of a carbon sector, with sliding contact, and had a range from zero to seventy-five hundred (7500) ohms.

Secondary coil T^2 had an inductance of seventy-one (71) millihenries.

The above dimensions have been found suitable for undamped-wave signals having a wave-length of from ten thousand to fifteen thousand meters, such as used at present in trans-Atlantic communication. For use on wave-lengths longer or shorter than those stated, larger or smaller values of inductance and capacity should be used, and those may be determined approximately by the well-known formulæ for resonant circuits.

Inasmuch as it is the fact that the practical use of this invention in the trans-Atlantic service of the Government has demonstrated that it accomplishes for the first time results which have been aimed at for nearly twenty years, it seems unnecessary to explain in detail the advantages or value of the invention.

I claim broadly:

1. In a unilateral direction receiving system the method of selectively receiving signals from one station and substantially shutting out all other electrical energies of receivable frequency comprising the steps of, absorbing energy radiated by said station, the nature of which absorbed energy is characteristic of the direction of said transmitting station, absorbing energy radiated by said transmitting station, the nature of which absorbed energy is non-characteristic of the direction of said transmitting station, producing currents characteristic of each absorbed energy, adjusting the amplitude of one of said currents to equal the amplitude of the other of said currents, affecting the phase of said currents so that the phase of currents resulting from other than signal energy it is desired to receive are substantially opposite

in phase, and combining said currents whereby the currents resulting from energies other than the signal energy are substantially eliminated and only signal energy remains.

2. The hereindescribed method of reducing static effects on a unilateral receiving system comprising a plurality of absorption members, which consists in absorbing signal and static energies in said members, equalizing and opposing the static energies in the said members to neutralize said energies, damping oscillations in one of said members, and detecting the signal energy absorbed.

3. In a unilateral directional receiving system the method of selectively receiving signals from one station and substantially shutting out electrical energy of receivable frequencies from all other stations comprising the steps of, absorbing energy radiated from said station, producing current characteristic of the direction of said station from the absorbing point, absorbing a second portion of energy from the energy radiated by said station, producing current, the nature of which is non-characteristic of the direction of said radiating station from said absorbing point, damping out oscillations in said energies produced by absorbed energy other than the signal energy, superimposing said energies in like amounts to produce resultant energy, and producing indications with the resultant energy.

4. The hereindescribed method of reducing static effects on a receiving system at a receiving station comprising a plurality of collectors having different directional properties, which consists in receiving both static waves and a maximum of plane polarized signal waves on each of such collectors, adding, by differential adjustment according to the direction from which static comes, the static energies received in substantially equal and opposite amounts to be neutralized and adding the signal energies of radio frequency received in substantially unequal and opposite amounts, leaving a preponderating amount of radio frequency signal energy due to the optimum operation of the more directional aerial for useful operation of a detector.

5. The herein-described method of reducing static effects on the receiving system at a radio station which consists of subjecting said system to the influence of signal and static waves collected by a plurality of collectors, preventing the formation of coupling waves in said system, adding the static energies received in substantially equal and opposite amounts to be neutralized, and adding the signal energies received leaving a preponderating amount of signal energy for useful operation.

6. The method of selectively receiving signals from a desired transmitter and for substantially eliminating electrical energy radiated from all other points including the steps of, absorbing energy radiated by said transmitter in two portions, producing oscillating currents by the energy of one of said portions which are characteristic of the direction of said transmitting source from said point of absorption, producing current oscillations from said other portion of energy which are non-characteristic of the direction of said transmitter from said absorption point, adjusting the currents produced from several portions in phase so that the currents resulting from energy other than signal energy substantially oppose, regulating the amplitude of one of the produced currents to substantially the same amplitude as the other of the produced currents, combining said produced energies, damping out oscillations in the combined currents which result from energy other than signal energy from said transmitter, and producing indications with the resultant energy.

7. The herein-described method of reducing static effects on the receiving system at a radio station which consists of receiving static and signal waves directionally and non-directionally with reference to any desired plane and at substantially the same point relatively to the wave length, preventing coupling waves by damping, adding the static energies received in substantially equal and opposite amounts to be neutralized, and adding the signal energies received leaving a preponderating amount of signal energy for useful operation.

8. Means for selectively receiving signals from a transmitter station and for substantially excluding electrical energy originating at other points on the compass comprising, a movable frame aerial in the form of a closed conductor, a lumped inductance in series with said conductor, means for tuning said frame aerial to the signal frequency, a vertical aerial comprising a linear conductor connected to ground at one terminal, means for increasing the capacity of said linear aerial including switching means for connecting said linear aerial to said frame aerial at either side of said lumped inductance, an inductance in said linear conductor variably coupled to the inductance in said frame aerial, a damping resistance in said linear conductor for damping out oscillations of a certain type which may appear therein, and means for coupling both of said aerials to a receiver.

9. An arrangement as claimed in claim 8 in which said vertical aerial is tuned by means of a variable inductance in said linear conductor.

10. The method of selectively receiving energy from a desired source and excluding energy from other sources which includes the steps of, absorbing energy radiated from said source, the characteristic of which ab-

sorbed energy is representative of the direction of said source, absorbing energy from said source, the characteristic of which absorbed energy is non-representative of the direction of said source, regulating the amplitude of one of said energies so that the amplitude of both of said energies is equal, damping out and compensating out-of-phase energies in said absorbed energy, combining said energies, and utilizing said combined energies to produce a resultant.

11. Apparatus for receiving radio communications from a given distant transmitter through interference originating out of direction therewith, which comprises two aerials of substantially different directional properties; means for setting in opposition to one another the currents due to the effects upon the respective aerials, of interference originating from sources out of direction with the given transmitter; both aerials being disposed to receive as much energy as possible from the given transmitter; means for usefully receiving the preponderance of energy from the given transmitter; and means for varying the damping of said aerial system.

12. In an apparatus of the character described, a plurality of aerials coupled together and means associated with said aerials to prevent wave excitation in said aerials from producing complex oscillations in the system.

13. In an apparatus of the character described, a plurality of aerials having different directional properties and coupled together and means associated with said aerials to prevent wave excitation in said aerials from producing complex oscillations in the system.

14. In apparatus of the character described. a plurality of aerials comprising coupling means between them for equalizing and opposing static energies received thereby and a resistance associated with said aerials and of an order of magnitude to promote the neutralization of said static energies.

15. A unilateral receiving system comprising a closed loop and open aerial, a reversible and adjustable coupling between them for neutralizing the static energies received thereby and a resistance associated with said aerials and of an order of magnitude to promote said neutralization.

16. The method of receiving on two aerials of substantialy different directional properties, radio communication from a given distant transmitter through interference originating out of direction therewith, which consists in setting in opposition to one another, while damping the aerial system, the currents due to the effects on the respective aerials, of interference from directions out of direction with the given transmitter, while receiving as much energy as possible from the given transmitter by each aerial; and usefully receiving the preponderance of energy from the given transmitter.

17. Apparatus for receiving radio communications from a given distant transmitter through interference originating out of direction therewith, which comprises co-operating aerials of the closed and open types respectively, the closed circuit aerial being vertical, and tuned to the wave length of the transmitter; means for setting in opposition to one another the currents due to the effects upon the respective aerials, of interference originating out of direction with the transmitter; the loop being pointed as nearly as permissible toward the transmitter; and means for usefully receiving the preponderance of signal energy due to the reception from the given transmitter.

18. A unilateral receiving system comprising a plurality of aerials having different directional properties in any given plane and all arranged to receive signal waves of radio frequency from any given transmitter and all adapted to receive static impulses, adjustable and reversible couplings between said aerials for equalizing and opposing the static energies received for neutralizing them and for adding the radio frequency signal energies leaving a preponderating amount of signal energy for useful operation, a resistance associated with said aerials and of an order of magnitude such as to promote the neutralization of static and a detector for said added signal impulses.

19. Apparatus for receiving radio communications from a given distant transmitter through interference originating out of direction therewith, which comprises co-operating aerials of the closed and open types respectively; means for setting in opposition to one another, the currents due to the effects upon the respective aerials, of interference originating from sources out of direction with the transmitter; the closed circuit aerial being vertical, pointed as nearly as permissible toward the transmitter and tuned to the wave length thereof; means for usefully receiving the preponderance of energy from the given transmitter; and means for varying the damping of said aerial system.

20. Apparatus for receiving radio communications from a given distant transmitter through interference originating out of direction therewith, which comprises a vertical closed circuit aerial; a substantially non-directional aerial; means for tuning each of said aerials to the given transmitter; a variable inductance coupling between said two aerials; a switch for reversing the connection of at least one of the coupling coils in its aerial; the closed circuit aerial being arranged to receive as much energy as permissible from the given transmitter; and a local

circuit having a variable inductive coupling with each of the coupling coils of said two aerials.

21. Apparatus for receiving radio communications from a given distance transmitter through interference originating out of direction therewith, which comprises co-operating directional and non-directional collectors and a local circuit common to both; inductive couplings between the local circuit and each collector; means for tuning each collector to the desired communication; means for varying the coupling of each collector to said common circuit; a switch for reversing the connections of at least one of the collector-coupling coils in its collector; and a variable resistance in at least one of the collectors.

22. The method of receiving on two aerials of substantially different directional properties and coupled to a common secondary circuit, radio communications from a given distant transmitter through interference originating out of direction therewith, which consists in tuning each collector to the given transmitter; varying the coupling of at least one of said collectors to said local circuit; causing the electromotive forces in the two collectors due to static to act in opposition to one another; and varying the damping of at least one of said collectors.

23. In an apparatus of the character described, a plurality of aerials comprising a magnetic loop and open antenna, means comprising adjustable couplings for combining the energies received by said aerials, means for tuning said aerials, and means for preventing complex wave excitation in said aerials, from producing complex oscillations in the system.

24. In an apparatus of the character described, a plurality of aerials coupled together, means for preventing wave excitation in said aerials from producing complex oscillations in the system, and means for opposing the static energies received by said aerials to eliminate static and leave a prepondering amount of signal energy for useful operation.

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