J. L. HOGAN, Jr.

RADIOSIGNALING.

APPLICATION FILED NOV. 27, 1916.

1,350,100. Patented Aug. 17, 1920.

3 SHEETS—SHEET 1.

FIG.1.

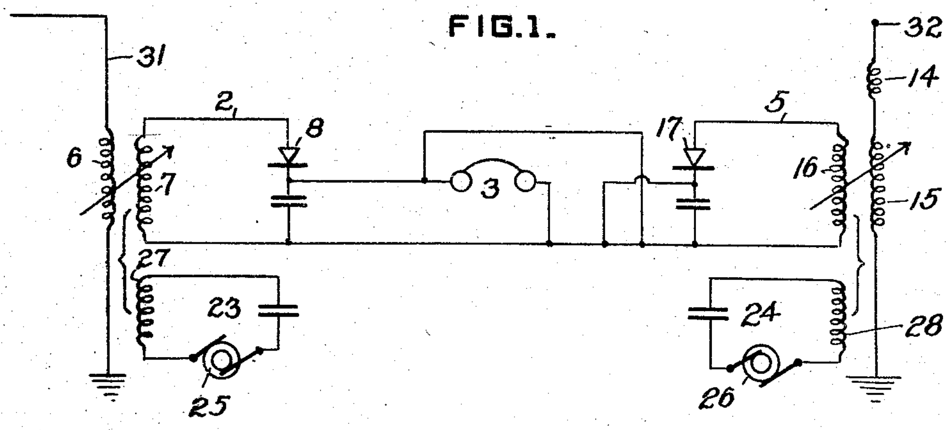


FIG.3.

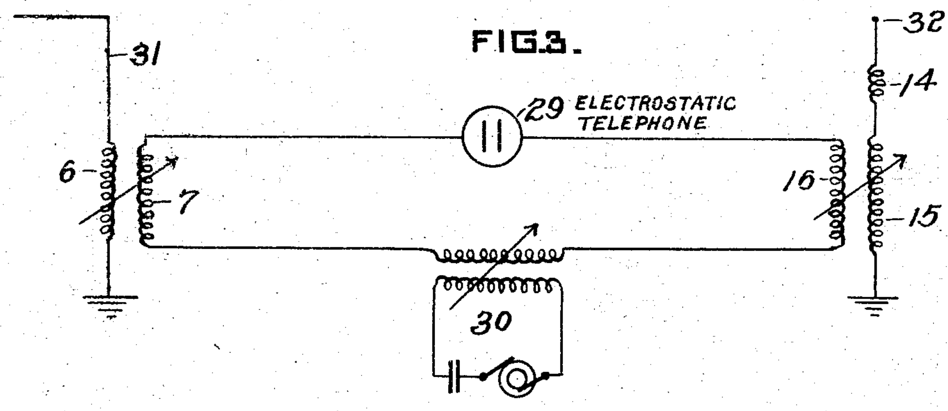


FIG.2.

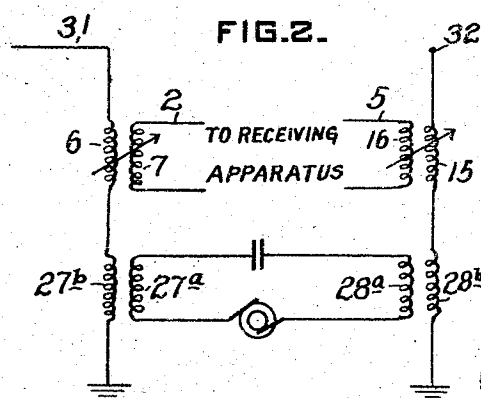
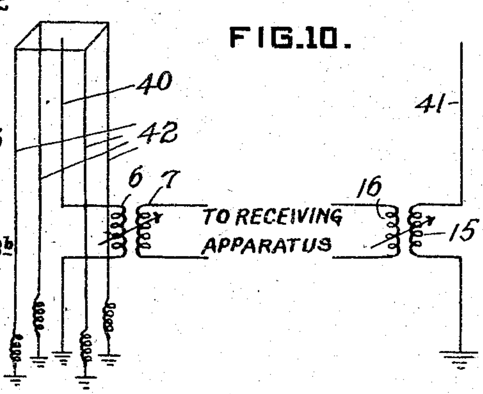


FIG.10.



WITNESSES

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3 SHEETS—SHEET 2.

FIG. 4

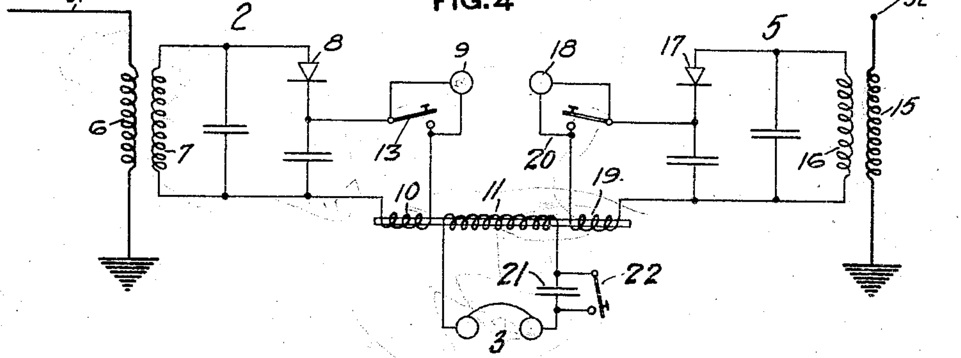


FIG. 5

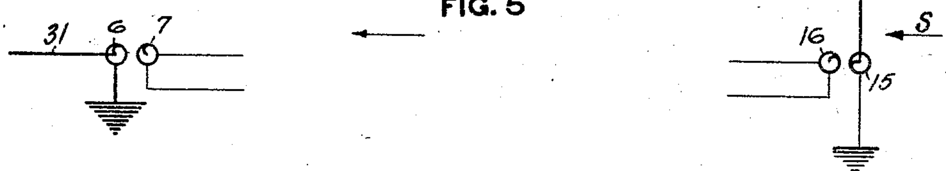


FIG. 6

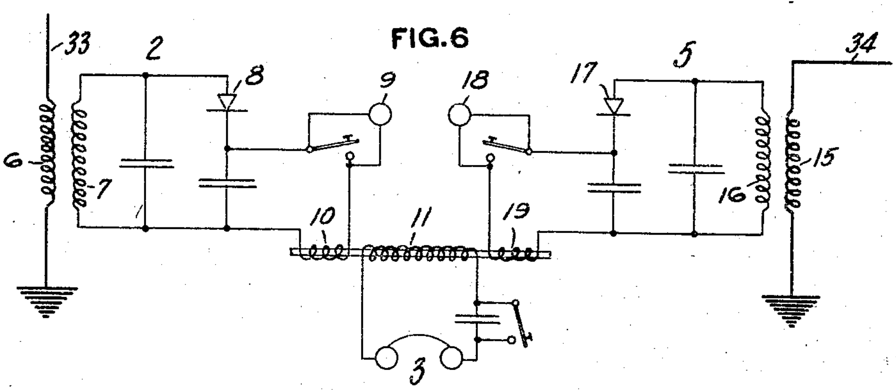
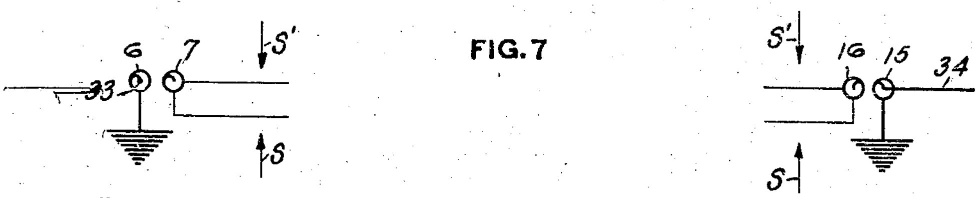


FIG. 7



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3 SHEETS—SHEET 3.

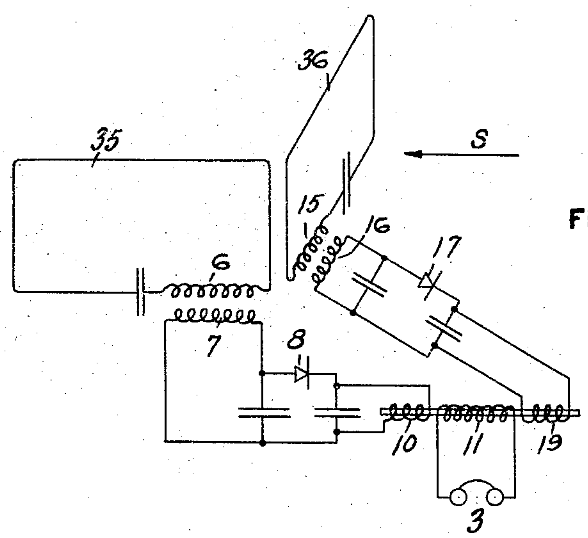
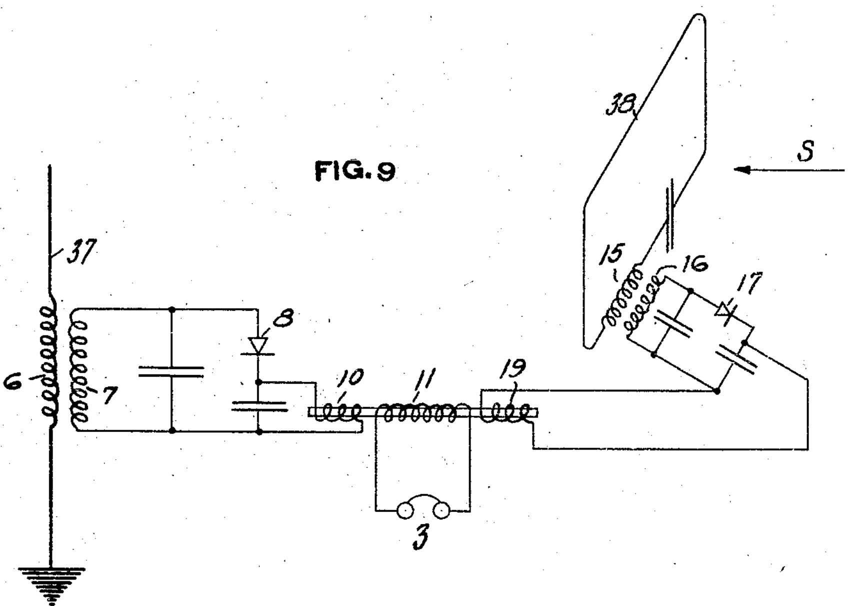


FIG. 8

FIG. 9



WITNESSES

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UNITED STATES PATENT OFFICE.

JOHN L. HOGAN, JR., OF BROOKLYN, NEW YORK, ASSIGNOR, BY MESNE ASSIGNMENTS, TO INTERNATIONAL RADIO TELEGRAPH COMPANY, A CORPORATION OF DELAWARE.

RADIOSIGNALING.

1,350,100. Specification of Letters Patent. Patented Aug. 17, 1920.

Application filed November 27, 1916. Serial No. 133,656.

To all whom it may concern:

Be it known that I, JOHN L. HOGAN, Jr., a citizen of the United States, residing at Brooklyn, in the county of Kings and State of New York, have invented certain new and useful Improvements in Radiosignaling, of which the following is a full, clear, and exact description.

The invention relates to a method of and apparatus for receiving radio signals, particularly to a method and apparatus for increasing the operating efficiency of wireless signaling systems by increasing the distance over which signals may be transmitted under given conditions without being detrimentally affected by atmospheric disturbances or other disturbing effects in the receiver.

The general object of the invention is to provide a system which will reduce or eliminate the usual interfering effects produced by the arrival of atmospheric disturbances at a radio receiving system station.

Interference from atmospheric disturbances is one of the principal factors limiting the distance of reliable radio transmission and the elimination or reduction of these harmful effects has been one of the most difficult problems of radio signaling.

Atmospheric disturbances may be classified into two main groups, namely, " charging static " and " strays." The first of these includes effects produced by any type of contact charging of the aerial or wave absorbing conductors, as, for example, the voltages impressed on the aerial or conductors by the contact of snow flakes, dust, moisture, etc. This " charging static " does not, generally speaking, cause any great difficulty in commercial radio practice since its simplest effects are manifested only when a condenser is used in series with the antenna-to-ground circuit. Such effects may be avoided by constructing this condenser of such form that it will withstand high potentials, or by providing a shunt path of high resistance or inductance or by entirely eliminating the series condenser.

The " charging static " is silent when an ordinary receiver is used with an antenna grounded through an inductance or when the potentials developed upon a series condenser are prevented from producing abrupt discharges in the circuit.

Interference from "strays" or other harmful effects are generally considered to arise from the action of traveling electromagnetic waves which strike the receiving antenna. The traveling wave is generally highly damped and produces free oscillations in the entire receiver, which oscillations have natural frequencies and natural dampings corresponding to the various modes of resonant vibration possible in the receiver. These stray disturbances greatly interfere with receiving since their amplitude is often great and their similarity to the desired incoming signal effects makes their separation from the signals exceedingly difficult. The " strays " ordinarily produce clicks in the receiving telephone but they may be so numerous and so nearly uniform in amplitude as to cause a hiss or similar sound when the simple detector receivers are used.

A third disturbing effect is noted when a heterodyne receiver is used, that is, a receiver which includes a local source of oscillating energy at the receiving station which is combined with the incoming signal energy to produce an audible signal having a musical or beat tone. This disturbing effect is a soft hiss, sometimes of considerable amplitude, whose basic pitch depends upon the difference between the free period of oscillation of the receiving system and the period of oscillation of the local heterodyne exciter or local source of oscillating energy. One cause of this type of disturbance is probably the interaction between the forces of the local heterodyne exciter and those set up by weak, natural antenna oscillations produced practically continuously and with random phase relation by small charges contacting with the aerial wires. Another cause may be the interaction between the forces of the local oscillator and those set up by antenna oscillations caused by the practically continuous arrival in random phase relation of weak traveling electromagnetic waves or " strays."

This third disturbing effect is, generally speaking, not particularly troublesome in commercial radio transmission, since the amplitude of the hiss is almost never so great that commercially strong signals can not be read through it. It is, however, advantageous to reduce or eliminate this interfering effect so that the utmost sensitiveness of the receiving apparatus may be obtained.

The largest part of the disturbances in both simple and heterodyne receivers result from traveling electromagnetic waves or "strays." There are several ways of differentiating the harmful effects or "strays" from the desired effects of electromagnetic signal waves, particularly when the signal waves are of the persistent or sustained type generated in accordance with the disclosure of Fessenden Patent No. 706,737, Reissue No. 12,168. The most effective modes of reducing these disturbing effects which have so far been produced, involve the use of musical heterodyne signals generated by the interaction of two sustained radio frequency energies, or of detectors, amplifiers, or indicators having a response-limiting characteristic. These, as well as other auxiliary methods, such as group tuning the telephone circuit broadly to a low audio frequency and forcing high pitched musical signals into it, or other suggestions outlined by me on page 258 of the *Proceedings of the Institute of Radio Engineers*, for September, 1915, may be used in connection with the present invention.

A number of methods of reducing or eliminating disturbing effects, atmospheric effects, or static have been proposed, but none of these have been effective and useful in practice and most of them have been experimentally demonstrated to be of no value. These useless methods include the use of the screened or insulated, high resistance and leaky antennæ as well as of excessively loose couplings in receiving circuits for eliminating atmospheric disturbances and merely reducing the intensity of the signals. Also sharply group tuned indicators have been used but have been found to be unsatisfactory. Further, the utilization of simple radio frequency differential systems with a single antenna has not remedied the difficulty. The reason that these methods have proven unsatisfactory when used alone is, generally speaking, that they are based upon misconception of the nature and actions of the portion of atmospheric effects which produce the greatest disturbances.

The present invention, broadly speaking, involves the use of two antennæ or absorbing systems of such form, location or disposition that they are both substantially equally affected by the undesired atmospheric or other disturbances but differently affected by the incoming signal impulses, said absorbing systems being differentially associated with circuits wherein the effects produced by the undesired disturbances in the two absorbing systems neutralize each other but without materially reducing the intensity of the desired signals; and which circuits may, or may not, have associated with them a local source of alternating voltage to operate upon the heterodyne principle disclosed in Fessenden Patents Nos. 1,050,441 and 1,050,728 and the Lee and Hogan Patent No. 1,141,717.

The accompanying drawings illustrate several embodiments of apparatus for carrying out the invention. In these drawings Figure 1 shows two absorbing systems of the character specified comprising two directive antennæ associated with a receiving and indicating system operating upon the heterodyne principle and in which a local source of alternating voltage is associated with each absorbing system; Fig. 2 is a partial view of a similar system having a single local source of alternating voltage associated with both absorbing systems; Fig. 3 illustrates an apparatus also operating on the heterodyne principle but using an electrostatic telephone as an indicator; Fig. 4 shows similar absorbing systems associated with a receiver and indicating system not operating on the heterodyne principle; Fig. 5 is a partial plan view of the apparatus shown in each of Figs. 1, 2, 3 and 4; Fig. 6 illustrates a modification in which a directive antenna is combined with a non-directive antenna; Fig. 7 is a partial plan view of the apparatus shown in Fig. 6; Fig. 8 illustrates still another modification having two magnetic loop absorbing circuits placed at right angles; Fig. 9 illustrates still another modification in which a simple antenna is combined with a magnetic loop; and Fig. 10 illustrates still another modification showing two simple antennæ, one of which is screened so that it is affected differently than is the other antenna by the incoming signal impulses.

The drawings are purely diagrammatic and are not intended to represent in detail the relative proportions and dispositions of the various structures, but serve to make clear the principle involved in the invention.

The drawings show several arrangements of absorbing systems which are substantially equally affected by atmospheric disturbances but differently affected by the incoming signal impulses. Figs. 1 to 5 illustrate the use of two directive antennæ or aerials 31 and 32 of inverted L form, which are well known to be directive and which receive best from stations which lie in line with them. Fig. 5 is a plan view showing the relative location or disposition of the two antennæ of Figs. 1, 2, 3 and 4, the direction of the arriving signals being indicated by the arrows S. These signals will produce maximum effects upon the antenna 31 which lies in the direction of propagation of the electromagnetic waves, and a minimum effect upon the antenna 32 which is at a right angle to the direction of propagation of the electromagnetic waves. Consequently even with very little or no detuning of the aerial 32 and its associated circuits, said antenna will not be strongly affected by the signal waves. Experience however has shown that severe atmospheric disturbances produce identical effects upon two such aerials regardless of the direction in which they extend. The two receiving systems are thus substantially equally affected by the atmospheric disturbances, but differently affected by the signal impulses, one thereof being strongly affected by the signal impulses and the other only weakly affected thereby.

These two antennæ are associated with circuits in which the disturbing effects are opposed and therefore neutralized, thus allowing the signal impulses to be received substantially without diminution of strength. Referring first to Fig. 4, the antenna 31 has associated therewith an oscillating circuit 2 arranged to affect a receiving instrument 3, and the antenna 32 has associated therewith an oscillating circuit 5 also arranged to affect the receiving instrument 3, but being differentially connected thereto with respect to the connections of the circuit associated with the antenna 31.

The antenna 31 has connected therein a coil 6 by means of which it is tuned to substantial syntony with the frequency of the desired incoming signals. The signal energy together with such disturbing effects as are picked up by the antenna 31 are transferred to the secondary 7 in the oscillating circuit 2 and its associated detector 8, and produce signals in the ear piece 9. The currents affecting this telephone ear piece also pass through the primary coil 10 of the three-coil telephone transformer, the secondary 11 of which is connected to the receiving instrument 3. The telephone ear piece 9 may be shunted out of the circuit by the switch 13 so that after the apparatus is properly adjusted the signals may be received through the secondary 11 of the three-coil transformer and the telephone 3 associated therewith.

The antenna 32 has connected therein a primary coil 15 inductively connected to the secondary coil 16 in the oscillating circuit 5. This antenna may be tuned to some frequency other than that of the desired signal, if desired, but this is not essential. Since this antenna is at an angle to the antenna 31, it is not strongly affected by the signal energy, but the disturbing effects are picked up and transferred to the oscillating circuit 5 and its associated detector 17 and produce signals in the ear piece 18. The currents through the telephone receiver 18 also pass through the primary coil 19 of the three-coil telephone transformer. The telephone 18 may be shunted out of circuit by means of a switch 20 so that the energy in the oscillating circuit 5 affects only the three-coil transformer and the telephone 3 associated therewith.

The circuit of the secondary 11 of the three-coil transformer, which includes the telephone 3, may also include a condenser 21 for the purpose of group tuning, and a switch 22 may be provided for shunting the condenser out of circuit when desired.

The apparatus is adjusted for receiving signals in the following manner:—

The system including the antenna 31, the oscillating circuit 2 and the telephone 9 is first employed to receive signals, and observation of the effect of various tuning adjustments is made by the use of the telephone 9. The system including the antenna 32 and oscillating circuit 5 is then adjusted so that there are produced in the telephone 18 disturbing effects practically identical with those in the telephone 9, but the form, location or disposition of the antenna 32 is sufficiently different from that of antenna 31 so that the arriving signal waves produce different effects in the two absorbing systems. With the disturbing effects in the telephone 9 and 18 substantially identical the switches 13 and 20 are closed to shunt out the telephones 9 and 18, and the system is then operated to receive the signals by use of the telephone 3.

The coupling between the transformer coils 10 and 11 is adjusted relative to the coupling between the coils 19 and 11, so that the disturbing effects present in both coils 10 and 19 neutralize each other on the secondary 11. The desired signals, however, are freely indicated in the transformer coil 11 and the telephone circuit associated therewith, because the signals produce different effects in the coils 10 and 19. The signals that are thus received in the telephone 3 are free from the effects of atmospheric disturbances because, as already pointed out, these disturbances neutralize each other and produce no effect in the telephone circuit.

It is to be understood, however, that adjustment of the circuits to obtain neutralization of static effects may be made in part by varying other elements of the circuit, such, for example, as the coupling between the coils 6 and 7, or between the coils 15 and 16, or by the sensitiveness of the detectors 8 and 17.

Figs. 1, 2 and 3 illustrate directional antennæ of the same kind shown in Fig. 4, but having connected to the associated circuits a source or sources of local oscillations to cause the receiver to operate upon the heterodyne principle.

Fig. 1 illustrates an arrangement in which the two antennæ are associated with their respective oscillating circuits 2 and 5 which include the detectors 8 and 17, the rectified signal energy from which is opposed in the telephone 3,—and in which the two antennæ 31 and 32 have associated therewith separate sources of high frequency oscillating energy or heterodyne exciters 23 and 24. These sources of local energy are provided with suitable generators of high frequency alternating voltage, which are shown as high frequency alternators 25 and 26, but which obviously may be any other well known generator of alternating voltage of suitable frequency. The circuits of these two generators may be directly associated with their respective antennæ and are shown as associated therewith by means of primary coils 27 and 28 with the secondaries 7 and 16 associated with the two antennæ.

In the operation of this system, the antenna 31 and its associated circuit 2 are tuned exactly or approximately to the period of the incoming signals, and the local oscillating source 23 is tuned to a frequency slightly different from that of the incoming signals so that electrical beats will be produced in accordance with the well known heterodyne principle. These signal beats are rectified by the detector 8 and operate the telephone 3.

Damped currents set up by atmospheric disturbances or "strays" and having the natural frequency and damping of the resonant system 2 produce decadent beats of short duration by interaction with the oscillating energy of the local source 23 and consequently give a hissy indication through the detector 8 in the telephone 3. The form, location or disposition of the antenna 32 relative to the antenna 31 is, however, such that little or no signal energy is applied to the detector 17, so that little, if any, of the effects produced by the signals from the antenna 31 and in the telephone 3 are neutralized by currents in the receiving system including the antenna 32 and its associated circuits.

The form of the local source of oscillating energy 24 is adjusted so that the disturbing effects from "stray" excitation upon the antenna 32 and its associated circuits produce the same sound in the telephone 3 as do similar "stray" excitations which strike the system including antenna 31 and its associated circuit, the two systems being assumed to be connected separately or successively.

The circuits from the two receiving systems are connected oppositely to the telephone 3, and consequently the effects of atmospheric disturbances or "strays" are neutralized, while the signals produce their full indication in the telephone.

Fig. 2 shows a single source of local oscillations associated with both antennæ systems. As here shown the local source of energy is a suitable radio frequency alternator 25^a, but which obviously can be replaced by any of the other well known sources of high frequency alternations well known in the art. The circuit 23^a of this local source may be associated with the two antennæ in any suitable way, and is shown as associated therewith through the primary coils 27^a and 28^a indirectly connected with the secondary coils 27^b and 28^b in the two antennæ circuits.

It is obvious that the two local sources of oscillating energy shown in Fig. 1 may be employed with circuits such as illustrated in Fig. 4, and that the single source of local oscillations shown in Fig. 2 may be employed with circuits such as illustrated in either Fig. 1 or Fig. 4.

The indicating means illustrated in Figs. 1 and 2 includes the well known crystal detector (which transforms the radio frequency currents into audio frequency or impulse currents) and the polarized magnetic telephone, but any equivalent responsive apparatus, such as the local barretter, the audion, or the static telephone may be used for the purpose of the present invention. For example, Fig. 3 shows the secondary 7 and 16 which are associated with the antennæ 31 and 32 respectively, connected in series across an electrostatic telephone 29, this apparatus being well known as a combined detector and indicator of radio frequency current and being described in early patents to Fessenden and Stone. A local source 30 of radio energy is associated with the system for receiving upon the heterodyne beat principle.

In the arrangements shown in Figs. 1, 4, 6, 8 and 9, the incoming signal impulses are transformed by the detectors 8 and 17 into rectified energy which is opposed in the telephone 3 and consequently the differentiation of signals from strays is dependent upon a difference of amplitude of the currents which are produced by the signal waves absorbed by the two antennæ respectively. The arrangement shown in Fig. 3 however contains no audio frequency circuit and involves only radio frequencies, and the differentiation of signals from strays is dependent not only upon the difference in amplitude in the signal waves absorbed by the two antennæ but also upon a difference in phase between the currents set up in the two antennæ by the incoming signal waves.

In Fig. 6 a modification is shown in which a simple symmetrical antenna 33 is used in combination with a directive antenna 34. The antenna 33 may be of any suitable substantially symmetrical shape, such as a vertical harp, umbrella, or flat topped antenna, connected to ground through a primary coil 6 which is coupled to a secondary 7 associated with a resonant circuit 2. The directive antenna is preferably of the inverted L type and includes a primary coil 15 coupled to a secondary coil 16 associated with the resonant circuit 5. A plan view of the system of Fig. 6 is shown in Fig. 7, the direction from which the signals are received being indicated by the arrows S or S′. Signals received from either of these directions will produce substantially no effect upon the antenna 34 but a maximum effect upon the antenna 33. The effects of harmful atmospheric disturbances, however, will be substantially equal upon the two antennæ. By means of the circuits and apparatus shown these are opposed to each other and neutralized so as to produce no interfering sounds in the telephone 3. The intensity of the signal is consequently not destroyed, but the atmospheric disturbance effects are largely reduced or eliminated.

Another form of apparatus, in which magnetic loop aerials are employed, is shown in Fig. 8. Two magnetic loops 35 and 36 are employed, and are located with their planes at right angles to each other. The loop 35 includes a primary 6 coupled to a secondary 7 and the loop 36 includes a primary coil 15 connected to a secondary 16. The secondaries are connected to suitable resonant circuits, detectors and telephones in the manner illustrated for the apparatus shown in Fig. 1.

Signals received from the direction indicated by the arrow S will affect the loop 35 strongly, but will produce substantially no current in the loop 36. Harmful "stray" effects, however, will produce practically the same disturbances in both loops and consequently by associating the secondaries 7 and 16 with suitable indicating systems and circuits such as already described, so as to neutralize the effects of the atmospheric disturbances, the signals may be received to the substantial exclusion of the atmospheric effects.

A further modification is illustrated in Fig. 9, in which a simple symmetrical antenna 37 is employed in combination with a magnetic loop 38. The loop has its plane at right angles to the direction of propagation of the desired signal waves which are received from the direction indicated by the arrow S. Consequently the loop is unaffected by the signal waves while the antenna 37 is excited by them. Both the loop and the antenna are excited by "stray" disturbing effects which, however, are neutralized in the circuits connected to the secondaries 7 and 16, these circuits being the same in principle as those illustrated in connection with the apparatus of Fig. 1.

It is to be understood that the arrangements and combinations of antennæ shown in Figs. 1 to 9 inclusive may be used even though the direction of the incoming signals is not exactly such as to prevent said signals setting up some current in the absorbing systems which are located or arranged for the purpose of not being affected by the signals. In such cases, the differentiation may be made by detuning the one absorbing system. It will also be understood that the aerials indicated by the vertical wires in Figs. 6, 7 and 9 need not be entirely symmetrical as to their absorbing powers, but differentiation between the signals and the "stray" effects in the antennæ may be made by any combination of detuning or directive adjustments. In fact the invention may be practised by preventing or reducing the absorption of signals in one antenna, without preventing the absorption of "strays," by any other suitable selective means, such as screening. Such an arrangement is shown in Fig. 10 which illustrates two simple antennæ 40 and 41 associated with suitable receiving apparatus which may be of any of the forms shown in the other views, and in which one of these antennæ, such as the antenna 40 is screened by the grounded vertical wires 42, which, as is well known, absorb a portion of the horizontally propagated signal waves, whereby said antenna 40 is less affected by the incoming signal impulses than is the antenna 41, but both of said antennæ are equally affected by atmospheric disturbances. The screen wires may be grounded through resistance coils, as shown, to prevent oscillation therein.

The various elements which have been shown in the several embodiments of the invention may be recombined in many groupings other than those illustrated, or they may be materially varied in structural adjustment and detailed operation without affecting the utility of the system for the reduction of undesired atmospheric effects at the receiving stations. The neutralization of the effects of atmospheric disturbances may take place in any circuit or instrument throughout the complete receiving system and between the energies in radio frequency, audio frequency, or other form.

Where the phrase "incoming signals" is used, such term is intended to refer to the desired signals or those coming from a communicating or transmitting station and not to such undesired or interfering signals as may be received under certain conditions. The phrase "absorbing system" is intended to signify any type of circuit adapted to abstract a portion of the energy of passing electromagnetic waves and includes numerous variations of antennæ, magnetic loops, etc. The use of the word "indicator," "responsive apparatus" or the like is not intended to imply that indicators, so-called detectors or responsive systems in general must consist of separate units. The operation is basically identical whether or not one apparatus performs the several functions. The terms "atmospheric disturbances," "atmospheric interference," and "disturbing effects" as herein used have the broad meaning of so-called natural or similar disturbances which have been called in the art "static," "parasitic waves," "X's," and the like. While the invention is directed more particularly to the suppression of effects to that division of atmospheric interferences which is termed "strays," it is not confined to the reduction of atmospheric disturbances from this source alone.

It is to be understood that the structure of apparatus shown is for purposes of illustration only and that other structures which come within the spirit and scope of the appended claims may be devised or arranged.

What is claimed is:—

1. In a radio signal receiving system, the combination of two wave absorbing systems arranged substantially at right angles to each other, whereby the ratio of static strength to signal strength is different in one absorbing system from that in the other, a receiving circuit connected to said two absorbing systems arranged to substantially neutralize the effects of static in said circuit, and an indicator responsive to the signal waves.

2. In a radio signal receiving system, the combination of two closed-circuit absorbing systems arranged substantially at right angles to each other, whereby the ratio of static strength to signal strength is different in one absorbing system from that in the other, a receiving circuit connected to said two absorbing systems arranged to substantially neutralize the effects of static in said circuit, and an indicator responsive to the signal waves.

3. In a radio signal receiving system, the combination of two wave absorbing systems having the same natural period, one of which is arranged to absorb little or no energy from waves arriving from a certain direction and the other arranged to absorb a relatively greater amount of energy from the waves arriving from that direction, whereby the ratio of static strength to signal strength is different in one absorbing system from that in the other, a receiving circuit connected to said two absorbing systems arranged to substantially neutralize the effects of static in said circuit, and an indicator responsive to the signal waves.

In testimony whereof I affix my signature in the presence of two subscribing witnesses.

JOHN L. HOGAN, Jr.

Witnesses:
GLENN H. LERESCHE,
A. E. JOHNSON.