

Feb. 8, 1927.

R. H. RANGER

1,616,923

INTERFERENCE REDUCING MEANS FOR RADIO RECEIVING APPARATUS

Filed Dec. 28, 1922

2 Sheets-Sheet 1

Fig. 1

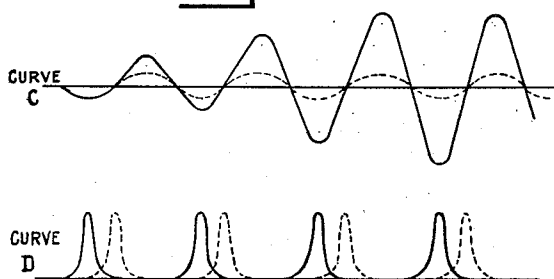


Fig. 2

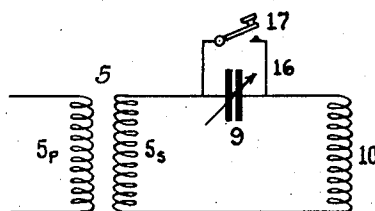


Fig. 4

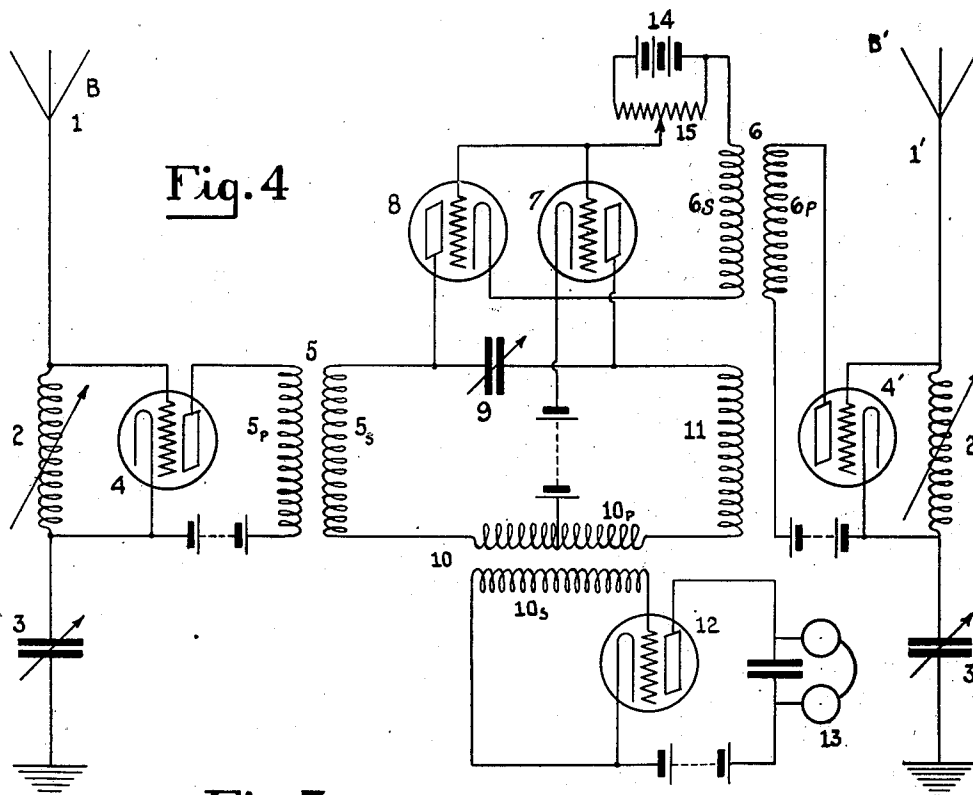
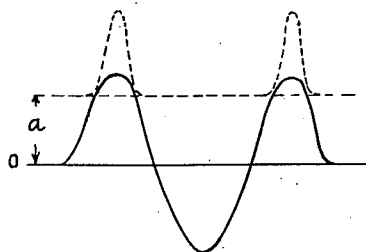


Fig. 3



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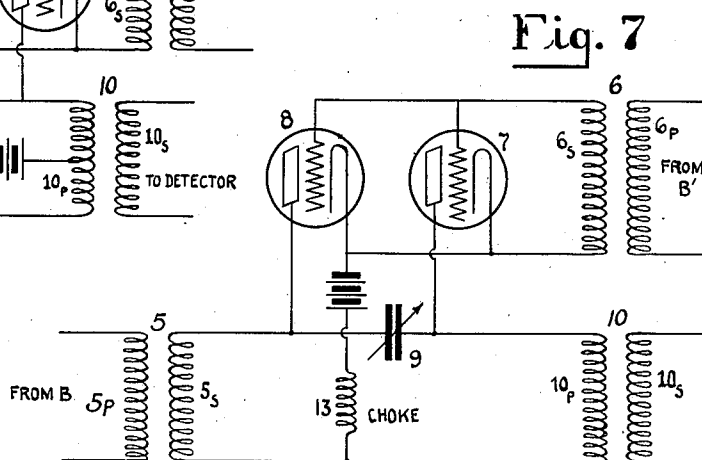
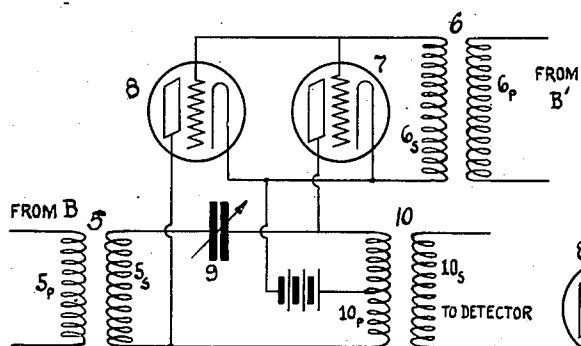
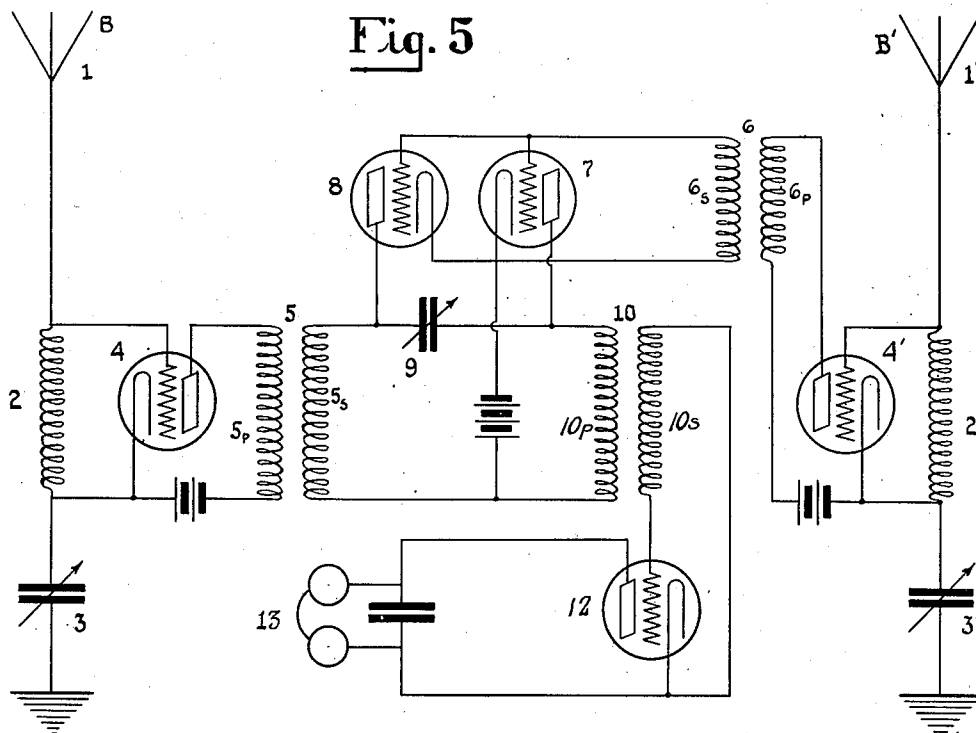
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INTERFERENCE REDUCING MEANS FOR RADIO RECEIVING APPARATUS

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2 Sheets-Sheet 2



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1,616,923

UNITED STATES PATENT OFFICE.

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INTERFERENCE-REDUCING MEANS FOR RADIO RECEIVING APPARATUS.

Application filed December 28, 1922. Serial No. 609,375.

This invention relates to means for improving the reception of signals through interference caused by atmospheric disturbances or so called "static" or by other transmitting stations having approximately the same wave length as the desired station. It is an object of this invention to provide such means which will allow signals from a given station to be selected, distinguishing sharply over signals from other stations and which will at the same time not interfere with the signal desired. It is an object of this invention to provide such means which will be relatively simple and cheap to construct and which shall be reliable and positive in its action. Other objects will be apparent from the specification.

It has been suggested in the past that disturbances might be eliminated in the reception of signals by the use of two receiving antennae, differentiating between received signals as to phase relation; that is to say the signals were received on each antenna and passed on to circuits which were coupled together in such a way that the desired signal was strengthened and the undesired signal was eliminated.

It has also been proposed to apply this scheme to the elimination of static disturbances by providing a plurality of antennae which give currents having a definite phase relation, resulting from static disturbances and currents having a different phase relation resulting from a desired signal. The circuits were then coupled together in such a way that the static effects opposed each other and the signal was strengthened. It has been found in practice that under certain conditions this system gives satisfactory protection from interference, but under other conditions is not entirely satisfactory.

The present invention aims to overcome such interference, as in the former system, by using two receiving antennae having different characteristics with respect to signals, such as different distance from the transmitting station or different directional characteristics, different tuning characteristics, etc. However, instead of providing as in the old system, for a coupling between the two receiving systems in such a manner that the signals combine, I provide that the signals from only one of the receiving systems reach the detector. The signals from the other antenna are used for the purpose

of rendering the indicating means unresponsive under certain conditions and permitting it to respond under other conditions. It will be pointed out how this is done in the specification in conjunction with the drawing, and while I have shown and described certain arrangements adapted to do this, it will be understood that my invention is not limited to the means disclosed but that modifications and changes may be made as will readily be understood by those skilled in the art. The scope of my invention, however, will be pointed out in the appended claims.

Referring to the drawing,

Figure 1 is a set of curves explaining the principle of my invention.

Figure 2 is a diagrammatic showing of certain apparatus by the operation of which my invention may be understood.

Figure 3 is a curve explaining the operation of my invention.

Figures 4, 5, 6, and 7 are various arrangements which may be utilized according to this invention.

It is well understood that an oscillating circuit having a certain natural period may be set into oscillation by impulses transferred to it, either through a circuit inductively coupled thereto or by other means. The full line curve of Figure 1, group C represents the growth of an oscillatory current in a circuit, such as shown in Figure 2, comprising inductances 5 and 10 and variable condenser 9, which circuit may be set into oscillation by the means of coil 5, connected to some suitable source. If the frequency of the oscillations in the primary coil 5, has a value corresponding to the natural frequency of the circuit 5, 9 10 oscillations will be set up according to the full line curve of Fig. 1, group C. These oscillations will be very weak at first but will increase in intensity until a steady condition is reached. However, if by means of key 17 we short circuit condenser 9 periodically for a short time at such point on the cycle as shown by Figure 1 that the condenser voltage is maximum (that is, when the oscillating current is zero) it will be apparent that no energy can be stored in condenser 9 and the circuit will not oscillate in spite of the fact that the impulses transmitted to inductance 5, are in accordance with the natural frequency of the circuit. This is due to the fact that in order to make such a

circuit oscillate it is necessary to provide for a periodical interchange of energy between the inductance and capacity, the energy being represented first by a charge upon the condenser and second by a magnetic field linking the inductance. In the case of a circuit set into oscillations this interchange of energy will continue until the energy is entirely dissipated by losses in the circuit.

It will be evident, therefore, that if key 17 shown in Figure 2 is closed, any energy which may be present in the condenser will be dissipated. Further, if this short circuiting takes place at the beginning of a series of oscillations, for instance, at the extreme left of Fig. 1 very little energy is stored in the condenser by the first oscillation and very little current will flow during the discharge thereof. If this short circuiting is continued periodically, at such point on the cycle that energy is tending to be stored in the condenser, it will be apparent that no appreciable amount of energy can ever be stored in the condenser and consequently the oscillating current can never build up; to all intents and purposes the circuit acts as if entirely detuned. That is to say, no matter how closely the excitation follows the natural period of the circuit, the circuit is never set into steady and pronounced oscillation as shown by full line curve C, but if it oscillates at all, the oscillations will have only a small amplitude, such as shown by dotted curve C.

The result of this is therefore the same as if the circuit is entirely detuned. If, however, this short circuiting takes place at a time when the voltage across the condenser is zero and the energy is stored in the inductances there will be no effect upon the oscillations which will continue to build up until they reach the maximum amplitude. This is clearly shown in Fig. 1 in which the curve of group D shown in full lines represents the conductance of the path around the condenser and the dotted line curve represents the same thing occurring at a slightly different time. The corresponding curves of group C then represent the oscillatory currents under these conditions.

This affords a new means of providing that certain signal currents will be passed through an oscillatory circuit while others will not be. For instance, let it be assumed that instead of operating the key 17 providing the condenser short circuit by hand, it is operated under the control of a signal from one antenna and that the impulses provided by coil 5, are obtained from another antenna. If then the antennae are located with respect to each other in such a way that the signal from one will cause a short circuiting of condenser 9 at a point on the cycle where

the condenser voltage is substantially zero, the signals impressed upon 5, will build up to a maximum amplitude in the oscillating circuit 5, 9 10 and by coupling some suitable detector to this circuit these oscillations can be detected. However, the oscillations impressed upon 5, differing in phase from those which are passed through will obviously not be passed on to the detector for the reason that the condenser will be short circuited at some time when the energy is required to be stored therein in order to continue oscillations, and as explained above the circuit will be in effect detuned to the undesired oscillations. A practical receiving arrangement utilizing this principle is shown in Figure 4.

B and B' respectively designate two receiving stations having different characteristics, as previously described, provided with the usual tuning means, comprising variable inductance 2 and variable capacity 3. Also phase shifting coils or phase rotators, which are well known in the art and form no part in this invention, may be provided either in the input or the output of amplifiers 4 and 4' for a purpose to be explained later.

The signals received upon the antenna of station B are impressed on the control electrodes of a vacuum tube amplifier 4 which has connected in its output circuit the primary 5, of coupling coil 5. In a similar manner signals received upon the antenna of station B' are impressed on a similar amplifier 4', having connected in its output circuit the primary 6, of coupling coil 6. The oscillating circuit utilized in this arrangement consists of the secondary 5, of coupling coil 5, primary 10, of coupling coil 10, inductance 11 and variable condenser 9. A suitable detector 12 is coupled to the oscillating circuit through secondary 10, of coupling coil 10 and any suitable receiving or recording arrangement herein shown as telephone receivers 13 is connected in the output circuit of the detector. Two similar three-electrode tubes 7 and 8 are provided having their plates connected to the opposite plates of condenser 9. The filaments and grids of these tubes are connected as for parallel operation and the secondary 6, of coupling coil 6 is connected across the control circuit of the two said tubes as shown. In addition to this, I provide battery 14 and potentiometer 15 for controlling the grid bias of these tubes in a manner to be explained later. It will be apparent from this arrangement that signals from station B are the only ones which are impressed upon the detector. The signals from station B' are simply used for the purpose of controlling the oscillations of the oscillating circuit. In accordance with this station B will, therefore, be designated hereafter as the actuating station and station B' as the con-

trolling station. The operation of the arrangement is as follows:

If the controlling station is not being used, it is apparent that by tuning and adjusting the actuating station to the signal desired and tuning the oscillating circuit also to the signal, detector 12 will be set into operation in response to the signals which may then be read off by means of telephone receivers 13. This is entirely sufficient for reception where no interference of any sort is experienced, but suppose that interference is being experienced. The controlling station will then be set into operation.

If the antennae of B and B' are so situated with respect to one another and the transmitting station that the desired signals from the indicating station and from the controlling station are 90° different in phase on arrival at the coils 5 and 6, no phase shifting means are necessary. If this is not the case some phase shifting means must be used and arranged so as to give this relation.

The cooperation of the actuating and controlling stations will readily be understood from the foregoing explanation given for the control of the oscillating circuit. Oscillations are set up in oscillating circuit 5, 10 11 9 and condenser 9 is periodically short circuited by one or the other of tubes 7 and 8.

The periodical short circuiting of condenser 9 coming at the instant when the condenser voltage is 0, and maximum current is flowing in the oscillatory circuit, will be without effect on the oscillations taking place in this circuit and these oscillations will be passed on to the detector exactly as if the controlling station were not in use. Oscillations set up by any disturbance, which are out of phase with the desired oscillation will not build up in the circuit because the condenser 9 is short circuited at some point with respect to them when they are tending to store energy in the condenser and consequently will not affect the detector.

Certain precautions must be taken however to provide that the system shall function properly. For instance it is essential that tubes 7 and 8 shall respond only to the desired signal received at the controlling station, and to no other signal. This may be achieved by tuning station B as sharply as possible, either directionally or to wave length, or by a combination of both.

It is further desirable that the short circuiting of condenser 9 shall be for an extremely short time and only when the voltage across condenser 9 due to the desired signal is substantially zero. This result may be obtained by working tubes 7 and 8 as described in my copending application Serial No. 607,476 filed December 18, 1922, by providing a bias on these tubes in such a way that they respond only to the peak of the signals received at station B'. In accord-

ance with the square law the resistance diminishes very greatly when such peak is reached, as shown by Fig. 3 where the dotted line represents the conductance of tubes 7 and 8 and the full line represents the controlling signal. Ordinate *a* represents the voltage necessary to be generated by the controlling signal in order that the conductance of tubes 7 and 8 be altered.

It will be evident that I have provided for short circuiting the condenser 9 for an extremely short time under the control of the signal desired to be received and as explained above only the signals which gives zero voltage of condenser 9 at the time of condenser short circuit will be impressed upon detector. This provides means for blocking out any static disturbances having a phase relation different from the desired signal but not for blocking out static having the same phase. However, this will occur only relatively infrequently, and the result is that signals are rendered much more readable.

Modifications of this arrangement may be made, such as shown in Figs. 5, 6 and 7. In Fig. 5 I omit the inductance coil 11 and connect the plate battery between coils 5, and 10, as shown rather than to the mid point of coil 10. In Fig. 6 the plate battery is shown as connected to the mid point of 10. This arrangement is similar to that shown in Fig. 5. In Fig. 7, however, I connect the plate battery as in Fig. 5 but in this instance I provide a radio frequency choke 18 in the circuit. The object of connecting the plate battery either to the mid point of primary 10, of coupling coil 10 or providing it with a choke is to prevent any condenser discharge current from affecting the detector but this is not essential, and as a matter of fact, the arrangement shown in Fig. 5 is entirely satisfactory for the reason that the condenser discharge current is always very small.

It is obvious that I may apply the principle of this invention by short-circuiting a portion or all of the inductance of the resonant circuit, or a resistance therein. Of course, it will be evident that this short circuit must be made to occur at a time when it will not affect the desired signal, that is to say, when there is no energy stored in the portion to be short circuited. In the case of an inductance this would be when the condenser is at the point of maximum charge. In the case of a resistance, it would be when the oscillatory current is zero.

Having described my invention I declare that what I claim is—

1. In radio signalling apparatus the combination of a plurality of aerials, indicating means connected to one only of said aerials, means connected to another of said aerials for substantially preventing the operation

of said indicating means in response to oscillations received on said first named aerial except when the phase difference between the oscillations received on said aerials has a predetermined value.

2. In radio signalling apparatus the combination of two aerials, indicating means connected to one of said aerials, and means operatively connected to the other of said aerials for preventing the operation of said indicating means in response to signals received upon said first named aerial except when the phase difference between the signals at said preventing means has a predetermined value.

3. In radio signalling apparatus, the combination of two aerials, an oscillating circuit operatively associated with one only of said aerials and deriving energy therefrom and means controlled by the other of said aerials for preventing oscillations in said circuit under predetermined conditions.

4. In radio signalling apparatus, the combination of two aerials, an oscillating circuit operatively associated with one only of said aerials and deriving energy therefrom, and means controlled by the other of said aerials for periodically dissipating energy stored in one of the energy storing elements of said circuit.

5. In radio signaling apparatus the combination of two aerials, an oscillating circuit operatively associated with one thereof, deriving signal oscillations therefrom only, and comprising a capacity shunted by an impedance, and means controlled by said other aerial for varying the value of said impedance.

6. In radio signalling apparatus the combination of two aerials, an oscillating circuit operatively associated with one only of said aerials and deriving energy therefrom, said oscillating circuit containing a capacity shunted by a resistance, and means connected to the other of said aerials for causing the value of said resistance to be controlled by oscillations received on said last named aerial.

7. In radio signalling apparatus, the combination with an aerial, indicating means, and an oscillating circuit interposed between said aerial and said indicating means, of a second aerial having characteristics differing from those of the first aerial and means controlled by oscillations received on said second aerial for substantially preventing oscillations in said oscillating circuit when the phase relation between the oscillations received on said aerial differs from a predetermined value without substantially interfering with oscillations in said circuit when the phase relation between oscillations received on said aerials has such predetermined value.

8. In radio signalling apparatus, the com-

bination of a plurality of aerials, an oscillating circuit operatively associated with one of said aerials, said oscillating circuit containing a capacity, a vacuum tube having its anode connected to one side of said capacity, a second vacuum tube having its anode connected to the other side of said capacity, the cathodes and grids of said tubes being respectively connected together and a coupling coil operatively associated with the other of said aerials connected across the grids and cathodes of said tubes, substantially as described.

9. The method of reducing interference in the reception of radio signals which comprises impressing the received oscillations on an oscillating circuit having a capacity, and periodically discharging said capacity at a definite time with respect to the desired signal oscillations.

10. The method of distinguishing between oscillations of the same frequency but of substantially different phase, which comprises impressing such oscillations on an oscillating circuit having a capacity and tuned to the desired frequency, and periodically short circuiting said capacity only at times when the energy stored therein by the desired oscillation is a minimum.

11. The method of reducing interference in the reception of radio signals which comprises impressing received oscillations on an oscillating circuit tuned to the desired oscillations, and periodically changing the constants of said circuit at a time when the energy stored in the capacity of said circuit by the desired signal is a minimum.

12. The method of receiving radio signals by means of two aerials which comprises impressing the signals from one aerial on an oscillating circuit and periodically altering at least one of the constants of said circuit under control of signals received on the other aerial.

13. The method of receiving radio signals by means of two aerials which comprises impressing the signals from one aerial on an oscillating circuit, and periodically discharging the capacity in said circuit under the control of signals received on the other aerial only at times when the energy stored in said capacity by the desired oscillation is substantially a minimum, whereby only the desired oscillation will build up in said circuit.

14. A method of selecting oscillations having a predetermined frequency and phase relation which consists in impressing the desired oscillations and the residue of undesired oscillations upon an oscillating circuit tuned to the desired oscillation frequency, and periodically discharging an energy storing element of said circuit at such time with respect to the oscillations of desired frequency and phase relation that the energy

stored therein by such undesired oscillations is substantially zero.

15. A method of selecting oscillations having a predetermined frequency and phase relation which consists in impressing such oscillations plus the residue of undesired oscillations upon an oscillating circuit tuned to

the desired oscillation frequency, and periodically dissipating a portion of the energy stored in one of the energy storing elements of said circuit at a time when the energy stored therein by the desired oscillations is substantially zero. 10

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