

A. M. CURTIS,
RADIO RECEIVING SYSTEM.
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1,376,679.

Patented May 3, 1921.
2 SHEETS—SHEET 1.

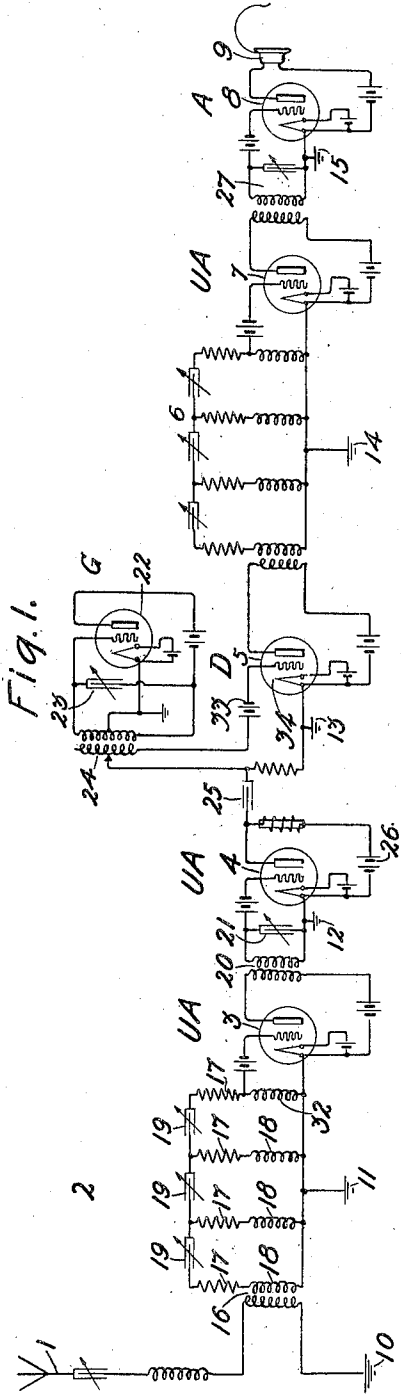


Fig. 3.

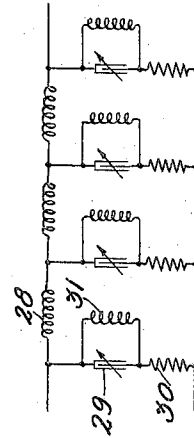
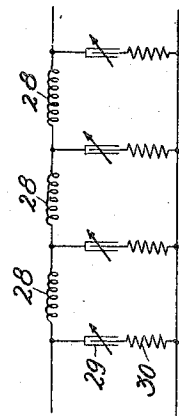


Fig. 2.



INVENTOR:
Austen M. Curtis.

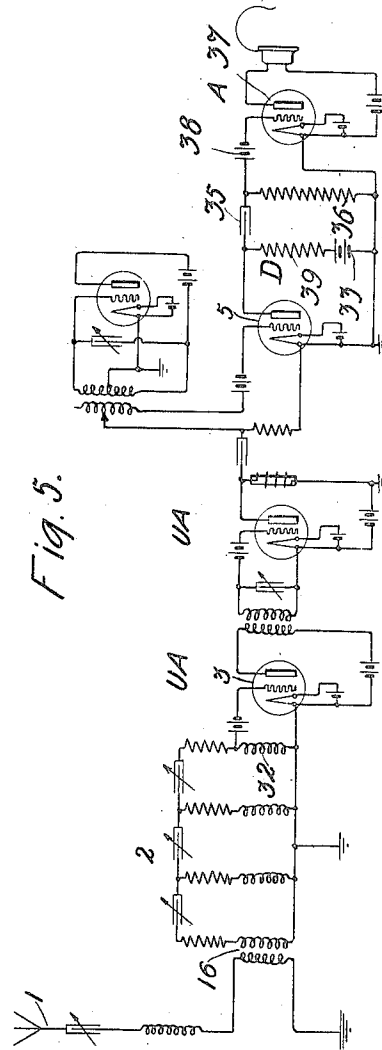
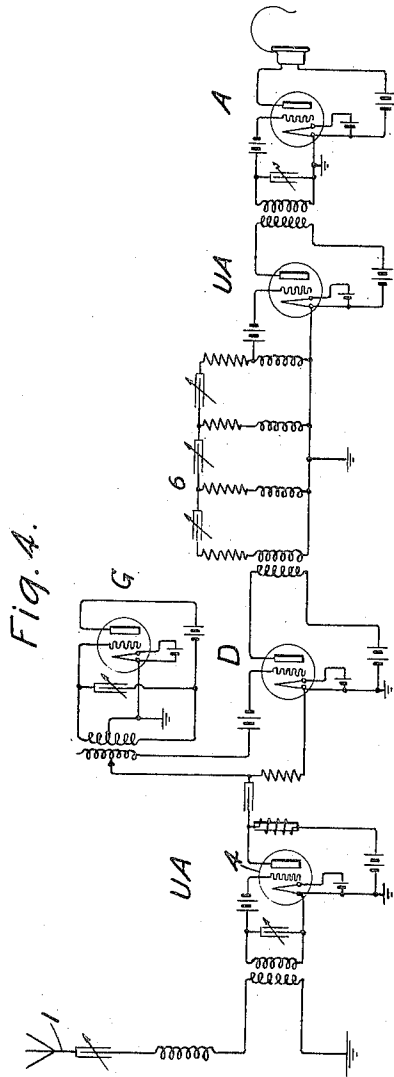
by

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2 SHEETS—SHEET 2.



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by

J. K. Roberts Att'y.

UNITED STATES PATENT OFFICE.

AUSTEN M. CURTIS, OF BROOKLYN, NEW YORK, ASSIGNOR TO WESTERN ELECTRIC COMPANY, INCORPORATED, OF NEW YORK, N. Y., A CORPORATION OF NEW YORK.

RADIO-RECEIVING SYSTEM.

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Specification of Letters Patent.

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To all whom it may concern:

Be it known that I, AUSTEN M. CURTIS, 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 Radio-Receiving Systems, of which the following is a full, clear, concise, and exact description.

This invention relates to radio receiving systems, and particularly to the reduction of static interference at such stations.

An object of the invention is to convert the energy of the static into a form different from the form of the signaling energy, or to convert the static into a plurality of different forms of energy, only one of which corresponds to the signaling energy, the latter having a definite character to which the signaling receiving circuit is selective, so that the effect of the static is reduced in proportion to the conversion of the same into the form or forms to which the signaling receiving circuit is not responsive.

This is accomplished by using between the antenna and the signaling receiving device an intermediate network capable of oscillating at more than one frequency. An irregular electric wave, such as static, on striking the network will have a portion of its energy diverted to the production of the natural oscillations of the network. The more nearly the static approaches a pure impulse, the more nearly will it be completely changed into these natural oscillations. If the frequency of the continuous signaling wave is made to coincide with one of the natural frequencies of the network and a circuit sharply resonant to this frequency is non-reactively, *i. e.*, unidirectionally or loosely coupled to the network, the continuous wave and also oscillations of the natural frequency of the network which are caused by the impression of the static upon it, will be produced in the resonant circuit; but the natural frequencies of the network other than the one which is made to coincide with the continuous wave, will be almost completely suppressed. The continuous signaling wave will be reduced in amplitude by losses in the network and in the coupling. The static will be subject to losses which are similar although different in magnitude, plus a loss caused by the fact that part of its energy has been used in the

production of natural oscillations which are not appreciably transmitted to the resonant circuit.

This method of reducing static is applicable to either the high or the audio frequency circuit of the receiver if we are dealing with telegraphy by continuous waves, but only to the high frequency circuit in the case of telephony. It is also possible to take the mixture of static and signals obtained from the combination of network and resonant circuit and put it into another similar circuit, in order to obtain a further reduction. But this is seldom of assistance, as the static obtained from the first circuit has already been changed into very weakly damped oscillations of the same frequency as the continuous wave, and ordinarily such reduction is too small to justify the increase in operating difficulties.

For further details of the invention reference may be made to the drawings, in which Figure 1 shows a receiving system in which a sectional network is used in both the high and low frequency circuits; Figs. 2 and 3 show different forms of network that may be used; Fig. 4 illustrates a system in which the network is applied only to the low frequency circuit, and in Fig. 5 a system is shown in which the network is employed only in the high frequency circuit.

Referring to Fig. 1, receiving antenna 1 supplies its energy to the following elements, which are connected in tandem: network 2, audions 3 and 4, detector 5, network 6, audions 7 and 8, and receiver 9. The antenna 1 is grounded at 10; network 2 is grounded at 11; audion 4 at 12; audion 5 at 13; network 6 at 14; audion 8 at 15. The audions 3, 4 and 7 are amplifiers and they transmit unidirectionally, preventing reaction between the elements energized by their output circuits and the elements connected to their input circuits. These unidirectional amplifiers are designated in the drawing by "UA." Antenna 1 is coupled to the network 2 by means of the transformer 16.

Network 2, while shown as having three sections, may be made up of some other number of sections such as two or four. The resistances 17 usually have a small value. It has been found that the resistance of the inductances 18 is generally sufficient.

The natural frequencies of this network may be adjusted by means of the variable condensers 19. If the inductance in each one of the three sections of the network 2, has a value of 4.7 millihenry, and if the capacity in each of these sections has the value .005 microfarad, then this network will not transmit any frequencies which are below 16,500 cycles and its three periods of natural oscillations will be 17,900, 23,400 and 43,200 cycles. Natural oscillations of other frequencies may be obtained if desired by assigning the electrical constants of each section other values which may be computed from well known formulae.

Natural oscillations of the predetermined definite frequencies will be set up in the network 2 whenever a static impulse is supplied to it by the antenna 1. These natural oscillations are amplified and unidirectionally transmitted by the audion 3 which has its input terminals connected across coil 32 in the last section of network 2. The audion 3 has the primary coil of the transformer 20 in its output circuit. Shunted across the secondary coil of the transformer 20 is a variable condenser 21 by means of which the input circuit of audion 4 is sharply tuned to the signaling frequency.

The signaling frequency may be the same as one of the natural oscillations of network 2 or it may be different therefrom. If the frequency of the continuous wave is different from that of the natural frequencies of the network the decrease of its amplitude which the network causes will be greater, but if the damping of the network is properly adjusted it is possible to find certain frequencies at which the static is discriminated against more than in the case where the frequency to be transmitted coincides with one of the natural frequencies of the network. To carry this into effect one should keep the circuit 20—21 tuned to a frequency intermediate the frequencies of natural oscillation of network 2. Also the values of the resistances 17 and the capacities 19 should be varied until the best results are obtained. The network 6 and circuit 27 in the low frequency circuit may be similarly adjusted.

The input circuit of audion 4 is preferably loosely coupled to the output circuit of audion 3. Since the latter audion is a unidirectional device, the high frequency selective circuit 20—21, provided in the input side of audion 4, is non-reactively coupled to the network 2. This non-reactive coupling may also be approximately effected by omitting audion 3 and by very loosely coupling the secondary of transformer 20 to coil 32. The oscillations selected by the circuit 20—21 are transferred to the detector 5 (also D), which may be of the audion type as shown. Preferably the battery 33 assigns a high negative

voltage to the grid 34 of detector 5. This prevents any voltage likely to be encountered in practice from making the grid 34 positive, which would cause current to flow in the input circuit of detector 5, thereby putting a load on the circuit. If the detector 5 should in this manner put a load on the circuit the sharpness of its tuning would be decreased. The only current which flows in the input circuit of detector 5, *i. e.*, through the secondary of transformer 24, is the current which charges the grid of tube 5. The transformer 24 is therefore practically open-circuited. This gives the advantage that changing the value of the voltage supplied by generator 22, by varying the number of turns in the secondary of transformer 24, does not change the load on the generator 22 so that its frequency remains constant while its voltage is being varied. Another advantage is that changing the tuning of the circuit 20—21 does not affect either the intensity or frequency of the voltage supplied by generator 22, since circuit 20—21 is separated from the circuit of transformer 24 by a unidirectionally transmitting amplifier 4.

For the heterodyne reception of signals, the generator 22 (also G) supplies a frequency which is slightly different from the signaling frequency to which the circuit 20—21 is tuned. The generator 22 may be an oscillating audion, as shown, and its frequency may be adjusted by varying the value of the capacity 23. The voltage of this generator may be adjusted by varying the number of turns in the secondary coil of transformer 24. The generator 22 is coupled to the input circuit of the detector 5 by means of the transformer 24. Between the output circuit of audion 4 and the input circuit of audion 5, condenser 25 is provided to prevent short-circuiting of the battery 26, which is in the output circuit of audion 4, through the ground connections 12 and 13. The audion 4 is unidirectionally conducting so that the generator 22 is non-reactively coupled to the circuit 20—21.

The network 2 provides a discrimination between the signals and the static. If a further discrimination is to be made, the low frequency network 6 may be used, for telegraph signals, on the low frequency side of the detector 5. Network 6 is similar to the network 2, but the values of its electrical elements would have to be different and may be computed from well-known formulae. The network 6 supplies oscillations to the unidirectionally conducting amplifier 7, which is loosely coupled to the circuit 27. This low frequency selective circuit is sharply tuned to the beat or difference frequency of the received continuous signal oscillations and locally supplied oscillations. The detected low frequency beat currents

selected by the circuit 27 are amplified by the audion 8 and transferred to the receiver 9.

The networks 2 and 6 may be made up in various ways, and some of the forms which this network may assume, are shown in Figs. 2 and 3. In Fig. 2 the inductances 28 are connected in series with the line and the capacities 29 and resistances 30 are connected in shunt to the line. Fig. 3 is the same as Fig. 2 except that the capacities 29 are shunted by inductances 31.

A useful reduction in the static may be effected by the use of the network only in the low frequency circuit. Such a circuit is suitable only for telegraphy, because speech currents are seriously distorted by the network and resonant circuit. Such a system is shown in Fig. 4, which is substantially the same as that of Fig. 1 except that the network 2 and audion 3 of Fig. 1 have been omitted.

A further modification is shown in Fig. 5, which is the same as Fig. 1 except that the network 6 and audion 7 have been omitted. In this case the battery 33 and high resistance 39 in the output circuit of detector 5 are connected through condenser 35 in shunt to the high resistance 36 in the input circuit of amplifier 37. The condenser 35 prevents the battery 33 from putting a potential on the amplifier 37, while the resistance 36 provides a path for the small charging current supplied by battery 38 to the amplifier 37.

The operation of the system shown in Fig. 1, is as follows: The mixture of static and signals received by the antenna is fed into the high frequency network 2 through the inductive coupling 16. The continuous signaling wave is transmitted to the audion 3 and it produces an amplified continuous wave in the output circuit of this amplifier. The static produces in the network 2 a number of natural oscillations of different frequencies and amplitudes, and also some forced oscillations which produce certain damped voltages in the last coil 32 of the network and corresponding currents in the output circuit of audion 3. The combined output of signals and static is also supplied to the resonant circuit 20—21, which receives efficiently and amplifies the signals to which it is resonant. This tuned circuit is little affected by any of the damped oscillations unless these are of the same frequency as the signals. The output of audion 4, which is in the high frequency selective circuit, then contains continuous signal waves of its own frequency, damped waves of its own frequency, which are set up by the static in the network, and relatively weakened damped waves of forced frequencies due to the static and natural oscillations having frequencies different from the frequency to which the circuit 20—21 is tuned. These

currents are then combined with the locally generated continuous wave and detected to produce audible frequency currents corresponding to the static and the signals, and similar processes of conversion of the static damped waves of definite frequencies and separation of these from the continuous waves is made use of in the low frequency system.

The operation of the system shown in Figs. 4 and 5 will be readily understood from the preceding description of Fig. 1.

The nature of "static" and hence the manner in which it will be transmitted by systems such as shown, is so complex that it is not possible to predetermine by calculation the behavior of these systems. The explanation of the operation as given above is qualitatively correct as has been verified by tests which have been made of the system and also by oscillograms which have been taken of its operation. Tests made of systems, such as shown above, have indicated that it was possible to reduce the ratio of the amplitude of the static effects to the amplitude of the signal to as little as one-fiftieth of its value in the antenna circuit, and, in some cases, this reduction was to one-ninetieth. When the initial ratio of static interference to signals is not excessively high, this system reduces it to such an extent as to greatly increase the ease with which signals may be understood.

Although the invention has been described solely in connection with radio signaling, it is to be understood that it is applicable as well to teledynamic transmission either by radio or conductive transmission systems, and in certain aspects for transmission purposes generally as well as for signaling.

What is claimed is:

1. The method of discriminating between sustained and damped oscillations which comprises converting said damped oscillations to oscillations of a plurality of frequencies other than that of said sustained oscillations, filtering out the energy of oscillations of frequencies other than that of said sustained oscillations combining therewith locally generated oscillations of another and different frequency and filtering from the combined oscillations a frequency component produced by the combination of said sustained oscillations and said locally generated oscillations.

2. The method of receiving signals which comprises impressing the received energy directly upon a network resonant to a plurality of frequencies other than that of the signaling frequency and not resonant to said signaling frequency combining the energy transmitted by said network with sustained oscillations of a frequency different than those of the signals which it is desired to receive and selecting from the resultant

energy oscillations of the difference frequency of said sustained oscillations and said signal oscillations.

3. The method of receiving signals which
5 comprises converting substantially all of the static impulse energy received to oscillations of a plurality of frequencies other than that of the signal oscillations, filtering out substantially all energy except that of the signal
10 oscillation frequency combining with said signal oscillations, oscillations of a different frequency and again filtering the resultant energy to select a signal component.

4. The method of receiving signals which
15 comprises converting substantially all of the static energy received into oscillations having a plurality of frequencies other than that of the desired signal oscillations, filtering out substantially all energy except that
20 of said signal oscillation frequency combining the energy of said signal oscillation frequency with that of separately generated oscillations and causing said resultant energy to produce a signal indication.

5. The method of receiving signals which
25 comprises converting substantially all of the static energy received into oscillations of a plurality of frequencies other than that of the signal oscillations, filtering out substantially all energy except that of said signal
30 oscillation frequency, subsequently detecting said energy and filtering said detected energy to select a component resulting from the signal oscillations.

6. The method of receiving signals which
35 comprises converting substantially all of the static energy received into oscillations of a frequency other than that of given signal oscillations, filtering out substantially all the
40 resulting energy except that of the signal oscillation frequency, detecting said signal oscillations, converting substantially all remaining static energy to oscillations of a frequency other than that of said detected
45 signals, and filtering out all energy of frequency other than that of said detected signals.

7. In combination, means for receiving
50 signal oscillations, means for converting substantially all of the energy of static received therewith, to oscillations of a plurality of frequencies other than that of said signal oscillations, means for combining with said
55 received oscillations, oscillations of a different frequency and means for suppressing from the resultant energy substantially all components except combination frequency components produced by said signal oscillations and said different frequency oscillations.
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8. In combination, means for receiving
65 signal oscillations, means for converting substantially all of the static received therewith into oscillations of a plurality of frequencies other than said signaling frequency,

means for detecting the resulting energy and means for selecting from the detected energy the component resulting from the detection of said signal oscillations.

9. Means for receiving signal oscillations
70 of a given frequency and for discriminating against other energy comprising a network adapted to convert transients and impulsive disturbances into oscillations of other than the signal oscillation frequency, a local
75 source of oscillations, means for combining the energy of said local oscillations with the energy transmitted by said network and means for preventing transmission of said
80 locally produced oscillations to said network.

10. In combination, means for receiving
signal oscillations, means for converting substantially all of the static received therewith
into oscillations of other than said signaling
85 frequency, asymmetric means for impressing the resulting energy upon a circuit strongly responsive to the signal oscillation frequency, and local means for impressing upon
said circuit sustained oscillations of a frequency different from that of said signal
90 oscillations, said asymmetric conductor being interposed between said local means and said converting means.

11. A signal receiving system comprising
95 means for converting static energy to oscillations of other than a given signaling frequency, means for selecting therefrom oscillations of signal frequency, means for combining with said signal frequency oscillations, oscillations of a different frequency,
100 and means comprising a multisection network for selecting from said combined oscillations a component resulting from said signal frequency oscillations.

12. A signal receiving system comprising
105 means for converting static energy to oscillations of other than a given signaling frequency, means for selecting therefrom oscillations of said signal frequency, means for combining with said signal frequency oscillations, oscillations of another frequency, so
110 as to produce beat frequency oscillations, signal indicating means responsive to said beat frequency oscillations, and a filtering circuit including damping resistance elements
115 connected to said combining means for selecting said beat frequency oscillations to the exclusion of undesired energy and for transmitting said selected oscillations to said
120 signal indicating means.

13. A radio receiving system comprising
an antenna, a detector, signal receiving
means, means between said antenna and said
detector for reducing static, and other means,
125 between said detector and said signal receiving means, for further reducing static.

14. In combination, a receiving conductor,
a network resonant to oscillations of a plurality of frequencies other than a given signaling frequency but not resonant to said
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signal frequency, connected to said conductor, a local source of oscillations of a frequency other than said signaling frequency and signal indicating means connected to
5 said network and responsive only to the conjoint action of said signaling frequency oscillations and said locally produced oscillations.

15. A radio receiving system comprising
10 an antenna, a sectional network, not resonant to a given signaling frequency, adapted to be energized by said antenna, a selective circuit responsive to said signaling frequency nonreactively connected to said network,
15 and means for combining locally generated oscillations with the energy trans-

mitted from said antenna to said selective network.

16. A radio receiving system comprising an antenna, an oscillatory network adapted
20 to be energized thereby and not resonant to a given signaling frequency, a receiving circuit responsive to said signaling frequency, a thermionic relay nonreactively connecting said network to said circuit, and means
25 for combining locally generated oscillations with the energy transmitted from said antenna to said receiving circuit.

In witness whereof I hereunto subscribe my name this 4th day of October, A. D. 1917. 30

AUSTEN M. CURTIS.