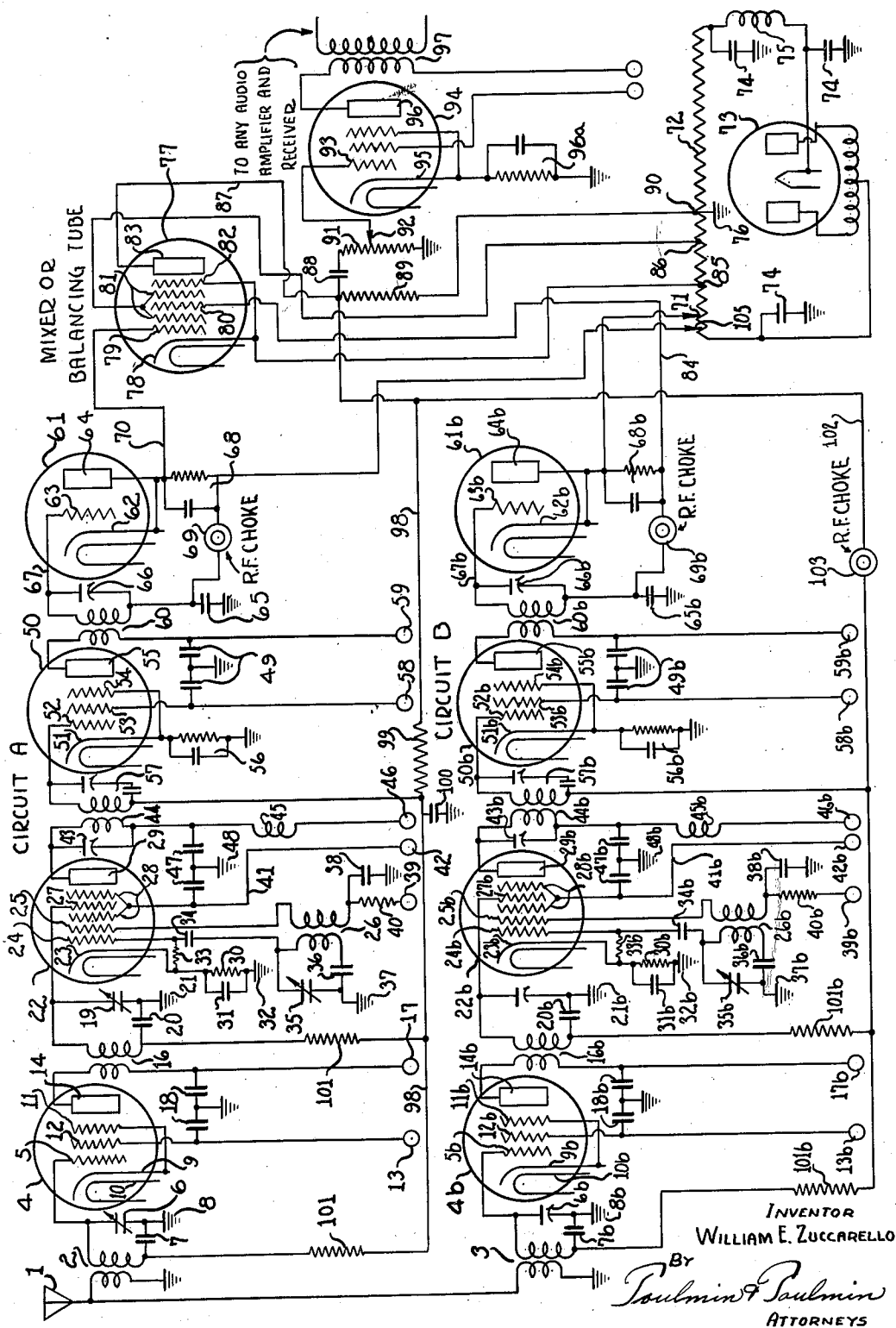


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# ANTISTATIC RECEIVING SYSTEM

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## ANTISTATIC RECEIVING SYSTEM

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The present invention relates to radio systems designed to prevent interference from extraneous electrical disturbances, such as static from natural or artificial sources.

5 In the past, many attempts have been made to eliminate static interference from radio receiving systems, but in general these attempts have culminated in failure due, in a large part, to the fact that the exact character of static impulses has not been sufficiently taken into account, nor  
10 has the deleterious effect of these impulses on the modulated carrier been given sufficient consideration. In order that the present improvement over existing systems will be thoroughly understood, it is desirable to set forth certain fundamental assumptions, the correctness of which  
15 has been fully ascertained by elaborate experiments.

The first of these assumptions is that there is  
20 no static that is audible which decreases the carrier, i. e., a static impulse cannot cause audible decrease of the carrier. Static is not tunable within practical limits, because it is highly damped. The static shock-excites the tank coils  
25 of the coupled circuits, causing continuous waves to be set up therein regardless of the frequency to which the coil is tuned. Individual discharges, such as lightning, last 1/50,000 of a second; therefore, to increase the carrier wave of a given  
30 strength for an audible period, the impulse would have to heterodyne against the carrier, beginning as an inaudible heterodyne note, preceeding to an audible note with a simultaneous decrease in power to an inaudible note again, all within  
35 1/50,000 of a second period. The first powerful static impulse causes the currents in the tank coil to oscillate in direct proportion to the strength of the static which may be many times greater than the carrier, causing an audible current to  
40 build up of a duration and amplitude sufficient to actuate a speaker diaphragm which vibrates usually long after the initial build-up has ceased. Any swing of the tank coil current that is less than the carrier current is immediately brought  
45 back to carrier strength by the next carrier oscillation.

Static impulses which are in phase with the carrier do not decrease the voltage, whereas static impulses which are out of phase tend to reduce  
50 the carrier for one cycle, after which the next cycle carrier brings the tank coil current back to the original power. In other words, in order to receive static, the latter must be highly damped or it would be tunable. To be highly damped, the static must be of short duration and if it is  
55 not highly damped, the static causes little or no interference.

The second proven assumption is that, within a given practicable wave band, coupling coils have  
60 nearly the same angle of decrement which is evi-

denced by the same static noise at either end of the band. Decrement depends upon resistance, coupling and radiation, more than upon capacity, in the commercial tank or coupling coils; the first three are practically the same regardless of capacity. Shorter frequency tuning radiates  
5 more than longer frequencies, but not enough to make any great change in the angle of decrement. Therefore, for a given practical band of frequencies, the decrement is practically the same and  
10 only the amplitude need be considered in balancing.

The third assumption, on which the present invention is based, is that only direct current  
15 can successfully be balanced by grid action or otherwise, and the frequency of the source of interference does not necessarily control the audible note. Only the angle of decrement of the static source and the amplification of the receiver determine the static note or noise.  
20

The final principle on which the present invention is based is that radio telephony is accomplished commercially by increasing and decreasing the carrier strength (above and below a mean), but static energy is always an increase  
25 from zero to maximum and back to zero, never above and below a fixed mean strength. Therefore, to balance such conditions, only a direct current can be successfully used. Any circuits purporting to use transformers (audio) or condensers, which tend to create or convert to alternating current are impracticable. Any circuits which purport to use push-pull transformers or any like arrangement of balancing will not balance, due to the above conditions and the action of the lines of force in the transformer. Any circuit which uses the automatic volume control (A. V. C.) feed back of the ordinary type to the grids of the radio frequency coils merely reduces the strength of the signal carrier during a static impulse. If this impulse is sufficiently rapid, as in the case of atmospheric disturbances, the automatic volume control circuit may cut off the carrier entirely. Hence, there are no means of eliminating the static that fills in the carrier modulations. Any circuit to filter static can only do so on the frequency of the filter limits. Any prior circuit that limits the maximum increase over carrier strength distorts the signal, as no method is used to take out carrier impulses when the carrier is modulated.  
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Furthermore, any method that purports the balance by the use of two separate receiving channels and does not shape the received power static to the same characteristics as that static which is impressed on the signal cannot balance out static on any signal, but can only limit the power of the static. The stronger the static, the less the balance and the greater the noise, as the power of the static without the carrier will cut  
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into the signal strength, causing as much noise on strong signals or more than static itself on the signal. On weak signals, the oscillograph shows the ear as being deceived and, upon amplification, noise would again be heard under these conditions, because no attempt is made to cancel the static that is being received during the modulation of the carrier to zero or near zero.

Accordingly, the primary object of the present invention is to simplify the circuits and apparatus employed in eliminating static from any source whatsoever.

A more particular object is to provide a radio system which will receive the static impulses of an audible character together with a modulated carrier, but thereafter precludes the static from reaching the telephone receiver.

A still further object is to cause the audible static impulses to cancel one another within the system. These objects and the manner in which they are attained rely for their effectiveness on the four fundamentals which have been discussed at length hereinbefore. In brief, I make use of parallel receiving circuits, one of which is adapted to respond to a combined modulated carrier and audible static impulses, the other being adapted to respond to only audible static impulses and balancing the static impulses against one another in a mixer or balancing tube whereby the static impulses are cancelled.

Other objects and features will be apparent as the specification is perused in connection with the accompanying drawing. This drawing shows a typical electrical system with the tubes diagrammatically illustrated for carrying my invention into effect.

Referring to the drawing, numeral 1 designates an antenna to ground system. Coupled to this antenna through the transformers 2, 3, there are a pair of parallelly connected radio receiving circuits which are designated circuit A and circuit B, respectively. As will be explained hereinafter, each of these circuits constitutes a single stage of radio frequency amplification, a heterodyne-oscillator stage, one or more stages of intermediate frequency amplification, and finally a detector stage. These circuits are identical in construction and arrangement, for reasons which will be stated hereinafter, the only difference being in the nature of the feed-back circuit or automatic volume control connection made to the various stages. Consequently, a description of only one circuit is necessary, since the other is a duplicate except for the details mentioned.

The radio frequency stage is preferably constituted of a pentode 4, in which the control grid 5 is connected to the tank coil 2 through a variable condenser 6 and a small fixed condenser 7. One terminal of these condensers is grounded at 8. The cathode 9 which is indirectly heated by the filament 10 is connected directly to the suppressor grid 11. The screen grid 12 is connected to a source of positive voltage indicated by the terminal 13 which preferably is connected to a tap on a resistor shunted about a double wave rectifier which will be described hereinafter. The anode 14 is connected through the primary winding of a coil 16 to another terminal 17 of positive potential which is likewise connected to a full wave rectifier.

The condensers leading to the grid 12 and the anode 14 are shunted by a pair of fixed condensers 18 to ground so as to prevent radio frequency currents from passing through the terminals 13, 17 into the rectifier. The secondary

winding of the transformer 16 is shunted across a variable condenser 19 and a small fixed condenser 20 to ground at 21 to constitute a tuned circuit for the input of the oscillator-demodulating device 22. This device is constituted of a combined triode and tetrode of the ordinary construction. The triode is made up of the cathode 23, control grid 24 and the grid-like anode 25, all of which cooperate to produce oscillations through the feed-back connection 26, which oscillations are impressed or combined with the impulses applied to the control grid 27 of the frequency mixing portion of the tube. The control grid 27 is preferably enclosed within a screen grid 28 for well-known purposes and cooperates with the cathode 23 and the anode 29 to amplify and mix the received electrical impulses with the oscillations produced in the triode portion of the tube, the cathode 23 being preferably of the indirectly heated type as indicated. The immediately associated circuits by which these results are obtained will now be described.

The cathode 23 is connected through the usual grid leak resistor 30 and the condenser 31 to ground at 32 so as to provide the proper bias to the grids of the heterodyne oscillator. The grid 24 is additionally biased by means of a grid leak resistor 33 and a condenser 34. The condenser 34 is connected through the primary of the feed-back coupling 26 through a variable condenser 35 and a fixed condenser 36 to ground at 37. The grid-like anode 25 of the oscillator is connected through the secondary of the coupling 26 to ground through a condenser 38. A connection from this circuit is also made to a terminal of positive potential indicated at 39 through a resistor 40. The screen grid 28 is connected through condenser 41 to a terminal 42 of positive potential. The anode 29 is connected through a tuned circuit consisting of a variable condenser 43 and a transformer primary 44 to a radio frequency choke 45 and thence to a terminal 46 of positive potential. Radio frequency currents are prevented from reaching the terminals 42 and 46 by means of radio frequency bypass condensers 47 which are connected to ground at 48.

The circuit which has been described up to this point constitutes one stage for radio frequency and a combined oscillator-demodulating stage 22, the frequency of which can be adjusted by the variable condenser 35 to beat with the incoming frequency impulses applied to the grid 27 and to pass on through the transformer 44 the difference frequency which is considerably lower than the radio frequency and is thereafter amplified by the intermediate frequency amplifiers to be described presently. The first two stages of the receiving system are of standard type so that no information need be given as to the size and adjustments of the various condensers, resistors, coils, etc., other than to point out that the input circuits of these stages are both tuned to the received carrier, and the coupling circuit 43, 44 is tuned to the difference frequency obtained by the heterodyning action of the tube 22.

The intermediate frequency amplification stage is exemplified by the pentode tube 50. This tube contains an indirectly heated cathode 51, a control grid 52, a screen grid 53, a suppressor grid 54 and an anode 55. The biasing potential for some of these grids is obtained by a resistor-condenser network 56 to ground. The suppressor grid is connected directly back to the cathode. The control grid 52 is connected through a con-

denser-transformer coupling circuit indicated generally at 57 to the output circuit of the tube 22. The screen grid 53 is connected to a source of positive potential 58. The anode is energized by current obtained from the terminal 59 through the primary of the coupling coil 60. Radio frequency currents are by-passed around the sources of direct current potential by means of condensers 49 connected to ground.

As stated hereinbefore, the purpose of the tube 50 is to amplify the difference frequencies obtained from the heterodyne tube 22 and to pass these currents on to the detector 61. This detector may take any suitable form, but, as illustrated, operates on the diode-detection principle. The diode has an indirectly heated cathode 62, a grid-like element 63 which serves the function of the rectifier anode and an element 64. The secondary of the coupling coil 60 is grounded through a fixed condenser 65 and is provided with a variable condenser 66 for tuning purposes. The tuned circuit 60, 66 is made responsive to the intermediate frequency impulses and, by means of a connection 67, impresses these impulses on the element 63. The electrode 64, which is illustrated as an anode, but which simply constitutes the cathode of the rectifier, is connected directly to the thermionic cathode 62. The element 64 is connected through a condenser-resistor network 68 and a radio frequency choke 69 to the upper plate of the condenser 65. The electrode 64 is connected through this network to a tap 105 on the negative side of the resistor 72. This resistor is connected across the output circuit of a typical full-wave rectifier 73 which need not be described in detail. Condensers 74 are provided for grounding the radio frequency currents which might find their way into the rectifying circuit. Radio frequency choke coil 75 is provided for a similar purpose. As will be noted, an intermediate point on the resistor 72 of the rectifying circuit is grounded at 76 so that all potentials taken off from points to the left of ground represent the negative potentials, and those to the right represent positive potentials.

The purpose of the tube 61 is to rectify the incoming waves and, in particular, to eliminate the carrier so that the potential drop across the network 68 is devoid of carrier, but contains all of the other components including the signal which has been passed through the coupling circuits of the amplifying and heterodyning stages. A connection 70 is taken from a point between the electrode 64 and the resistor of the network 68 to the control grid of a mixer or balancing tube, which will be described presently.

As stated hereinbefore, the circuit B is similar to circuit A, except for a few details which will be referred to specifically. It is, therefore, unnecessary to duplicate the description of these circuits and, for convenience in referring to the various elements of the two circuits, the elements of circuit B have been given the same reference character as the corresponding element of circuit A, except that a small *b* has been inserted after the reference character.

The mixer or balancing tube 77 includes an indirectly heated cathode 78, a control grid 79, another control grid 80 which is shielded from the control grid 79 by a screen grid 81, a suppressor grid 82 and an anode 83. The output currents from the detector 61 of circuit A are conducted to the grid 79 of the mixer or balancing tube 77. On the other hand, the output cur-

rents of the detector 61*b* of the circuit B are taken by the conductor 84 to the control grid 80 of the tube 77. It will be noted that the conductor 70 is connected to a point on the upper side of the resistor-condenser network 68, whereas the conductor 84 is connected to the lower side of resistor-condenser network 68*b*. Consequently, the output currents of the detectors 61 and 61*b* are impressed on their grids in opposition to one another in the tube 77. The cathode 78 and the suppressor grid 82 of the tube 77 are charged negatively with respect to ground due to the position of the terminal 85 on the resistor 72. The screen grid 81 of the tube 77 is likewise charged negatively at the terminal 86. The anode 83 is connected through a conductor 87, a fixed condenser 88 and a fixed resistor 89 to the ground terminal 90 on the resistor 72. The purpose of the resistor 89 and this ground connection will be described hereinafter.

From a point between the condenser 88 and the plate 83, a connection is made to a resistor 91, from which a variable tap 92 is taken to the control grid 93 of an audio frequency amplifier 94. This amplifier includes an indirectly heated cathode 95 connected through a grid biasing network 96*a* to ground. The usual screen grid and suppressor grids are provided, also an anode 96 which is connected through an audio frequency coupling 97 to any audio amplifier and receiver arrangement which have been merely indicated on the drawing, since their construction is well known.

As stated hereinbefore, the present invention depends for its effectiveness in removing or cancelling static upon the feature of balancing out that part of the static impulses which have been found to be most deleterious by way of objectionable noise in the telephone receiver. Experiments have shown that that part of the static impulse, which is of greater intensity than the carrier or which in any other manner overrides the carrier, is the part which is most objectionable. For that reason, I propose to so adjust the circuits A and B that one of the circuits, for example circuit A, will be tuned to receive the combined signal-modulated carrier and static impulses; whereas the other circuit, for example circuit B, will be so adjusted as to receive only the static impulses which override the carrier. The difference in adjustment of the circuits which are otherwise identical, except for the detector stage, is brought about by energy feed-back circuits of different character. Thus, in circuit A, the energy feed-back circuit, which is indicated at 98, is taken from a tap between the resistor 89 and the condenser 88 through a resistor 99 and a capacity to ground circuit 100 to each of the first three stages of circuit A.

Fixed resistors 101 are connected between the input tuned circuits of the tubes 4 and 22 to the conductor 98 so as to prevent inter-tube oscillation. A direct connection is made between the input circuit of the tube 50 and the conductor 98 to a point between the resistor 99 and condenser 100. On the other hand, the feed-back connection 102 in circuit B is passed through a radio frequency choke 103 to the various stages. It will be noted that each of these feed-back connections originates from the same point in the anode circuit of the balancing tube 77, so that the same components flow through these circuits, except such that are prevented or otherwise attenuated by the resistor 99-condenser 100 net-

work in circuit A, and the radio frequency choke 103 in circuit B.

These attenuating elements affect the feed-back energy in a different manner so that the feed-back current or voltage impressed on the various stages of the two parallel circuits is of a different biasing character and magnitude. It is apparent that the nature and adjustment of these elements can be controlled in such a way that the difference in the character of the feed-back current or voltage will discriminate between the circuits A and B as to their respective amplifying properties. Using the elements, as illustrated, I have found that it is feasible to reduce the amplifying property of circuit B, for example, to such an extent that it will respond to antenna energy only above a predetermined amount, at the same time leaving circuit A with its full or other desired amplification. This circuit A will be permitted freely to respond to modulated carrier and static, whereas circuit B will be biased to such an extent that it will respond only to static above a predetermined intensity level, for example, above carrier strength.

Consequently, the grid 79 of the balancing tube receives from circuit A, combined signal and static impulses (the carrier has already been eliminated in the detector 61) and the grid 80 receives only static impulses greater than carrier intensity from circuit B. The effect of static on grid 80 is opposite to the effect of the static component on grid 79, because as one grid is driven negative, the other is driven positive with respect to the cathode. This is due to the fact that the conductor 70 is connected to the opposite side of the network 68 from the side to which conductor 84 is connected to its network 68b. Thus, a cancellation or balancing out effect of static impulses of greater intensity than the carrier takes place in the tube 77. In order to prevent inter-electrode capacity errors, the grids 79 and 80 are shielded from one another by the screen grids 81.

The grid 79 of the tube 77 is preferably biased by means of the tap 105 so that the tube will cut off when there is no signal. It will be noted that the plate 83 is connected to ground through the resistor 91 so that, when no signal current is passing through the tube, the plate is maintained at zero potential. On the other hand, when signal currents are flowing, the plate is maintained at negative potential due to the drop in the resistor. Thus, the tube 77 is maintained in a highly sensitive condition between signals.

The current which is fed to the input circuit of the audio frequency amplifier 94, through the tap 92, is devoid of static, at least of that static which is of greater intensity than the carrier and which normally is most objectionable in the telephone receiver. The static which is of less intensity than the carrier is not so harmful from the auditory standpoint, since it does not mask out the signals or speech to any great extent and readily permits discrimination at the receiver.

By providing two parallel circuits, stages of which are substantially identical, assures that the same electrical actions are performed by the tubes and their various coupling circuits including the tank coils on the static in both circuits. Consequently, the balancing tube receives two static impulses of exactly the same wave shape, which can completely cancel one another. It will be noted that the cancellation of the static impulses is performed solely by the use of direct currents in the balancing tube and, therefore, en-

tails the only practical way in dealing with static as is fully discussed under the fourth assumption set forth at the beginning of the specification.

In order that the grids 79 and 80 will have the same effect, but in the opposite sense, on the electron stream in the balancing tube, notwithstanding their difference in position with respect to the cathode, the bias on these respective grids is maintained at different values and controlled by the tap 71 which is connected through the resistor of the network 68b to the grid 80.

Modifications of the system which has been shown and described will readily occur to those skilled in the art. For example, the detectors 61 and 61b may be combined in one envelope and any number of high and intermediate radio frequency stages employed, indeed, other well-known forms of receiving circuits could be used to advantage, provided these circuits lend themselves to automatic volume control feed-back which will selectively control the amplifying properties of the two circuits, and in that manner cause one of the circuits to respond to the deleterious impulses which are eventually cancelled out in the balancing tube.

Consequently, it will be understood that I desire to comprehend within my invention such modifications as come within the scope of the claims and the invention.

Having thus fully described my invention, what I claim as new and desire to secure by Letters Patent is:

1. A static eliminating system comprising two receiving radio circuits, one of said circuits comprising means for receiving combined signal-modulated carrier and static impulses, the other circuit comprising means for receiving static impulses only of greater strength than the carrier, means for differentially balancing the output currents of one circuit against the output currents of the other circuit, whereby the static impulses of greater strength than the carrier are removed, and means for amplifying the differential currents.

2. A static eliminating system comprising two receiving radio circuits, means for tuning one of said circuits to respond to the combined signal-modulated carrier and static impulses, means for adjusting the other circuit to respond only to the static components of greater strength than the carrier, means for separating the signals from the carrier but leaving in the static impulses, a balancing tube for combining the output currents of the circuits in a differential manner, whereby the static impulses of greater strength than the carrier are removed from the signal, and means for receiving the output currents of the balancing tube.

3. A static eliminating system comprising two parallel heterodyne radio receiving circuits, each including a detector, a balancing tube for differentially combining the output currents of said circuits, means including automatic volume control circuits connected between the output circuit of said balancing tube and said receiving circuits for causing one of the receiving circuits to respond to combined signal-modulated carrier and static impulses and to cause the other of said receiving circuits to respond to static impulses which override the carrier, whereby the output circuit of said balancing tube contains no static of greater intensity than the carrier, and means for translating the output current of the balancing tube into sound undulations.

4. A static eliminating system comprising two

parallel heterodyne radio receiving circuits, each including a detector, a tube for balancing predetermined components of the output current of one of said circuits against similar components of the output current of the other of said circuits, means for feeding back energy from said tube to one of the receiving circuits, said energy being of a biasing character to permit its receiving circuit to respond to the combined signal-modulated carrier and static impulses, means for feeding back energy from said tube to the other of said receiving circuits, said energy being of a biasing character to permit its receiving circuit to respond only to static impulses which override the carrier, whereby the audible static impulses are balanced out in said tube, leaving only the signal component, and means for translating the signal component into audible undulations.

5. A static eliminating system comprising two parallel radio receiving circuits, each including a plurality of tube elements of similar number and character, means for adjusting one of said circuits to receive combined signal-modulated carrier and static impulses, means in said one circuit for eliminating the carrier, means for adjusting the other of said circuits to receive only the static impulses which override the carrier, means for balancing the audible static currents in one circuit against the audible static currents in the other circuit, whereby the deleterious static impulses are removed from the signal, and means for translating the signal impulses into sound undulations.

6. A static eliminating system comprising two parallel radio receiving circuits, each including a plurality of tube elements of similar number and character, means including a feed-back connection for adjusting one of said circuits to receive combined signal-modulated carrier and static impulses, means in said one circuit for eliminating the carrier, means including a feed-back connection for adjusting the other of said circuits to receive the static impulses which override the carrier, means for balancing the audible static currents in one circuit against the audible static currents in the other circuit, whereby the deleterious static impulses are removed from the signal, and means for translating the signal impulses into sound undulations.

7. A static eliminating system comprising two parallel radio receiving circuits, each including a plurality of tube elements of similar number and character, one of said circuits comprising means for receiving the combined signal-modulated carrier and static impulses and the other of said circuits comprising means for receiving only static impulses which override the carrier, a detector tube in each of said circuits, means for balancing the output static currents from one detector against the output static currents from the other detector, said balancing means comprising a balancing tube having an anode and a plurality of grids, said output static currents being applied in a differential manner to said grids, whereby signal currents appear in the anode circuit of the balancing tube, and means for translating the signal currents into sound undulations.

8. A static eliminating system comprising two parallel radio receiving circuits, each including a plurality of tube elements of similar number and character, one of said circuits comprising means for receiving the combined signal-modulated carrier and static impulses, and the other

of said circuits comprising means for receiving only static impulses which override the carrier, a detector tube in each of said circuits, means for balancing the output static currents from one detector against the output static currents from the other detector, said balancing means comprising a balancing tube having an anode and a plurality of grids, said static currents being applied in a differential manner to said grids, whereby signal currents appear in the anode circuit of the balancing tube, one of said grids being biased to cut off the anode current in said balancing tube when no signal passes through the detector tube of that circuit which responds to the combined signal-modulated carrier and static impulses, and means for translating the signal currents into sound undulations.

9. A static eliminating system comprising two parallel radio receiving circuits, each including a plurality of tube elements of similar number and characteristics, one of said circuits comprising means for receiving the combined signal-modulated carrier and static impulses and the other of said circuits comprising means for receiving only static impulses which override the carrier, a detector tube in each of said circuits, means for balancing the static tube currents from one detector tube against the static output currents from the other detector tube, said balancing means comprising a balancing tube having an anode and a plurality of grids, said static output currents being applied in a differential manner to said grids whereby signal currents appear in the anode circuit of the balancing tube, one of said grids being biased to cut off the anode current in said balancing tube when no signal passes through the detector tube of that circuit which responds to the combined signal-modulated carrier and static impulses, the anode of the balancing tube being maintained at zero potential when no signal is passing through the detector tube of that circuit which responds to the combined signal-modulated carrier and static impulses but automatically being biased negatively when signal impulses are passing through the detector tube of that circuit which responds to the combined signal-modulated carrier and static impulses, an energy feed-back connection from said anode to each of said receiving circuits to adjust one of said circuits to respond to the combined signal-modulated carrier impulses and to adjust the other of said circuits to respond only to static impulses which override the carrier, whereby the impulses applied to one of the grids of the balancing tube are constituted of signals mixed with static and the impulses applied to the other grid of the balancing tube are constituted solely of static so that the differential effect of these grids is to balance out static above a predetermined intensity, leaving only the signal currents and static below said predetermined intensity, and means for translating the signal currents into sound undulations.

10. In a static eliminating system, the method of receiving a combined signal-modulated carrier and a static wave, comprising removing the carrier by detection, simultaneously receiving static impulses of only greater intensity than said carrier, then balancing the static component of the received impulses against the static impulses to remove the static of greater intensity than the carrier and leave the signal with static of less than carrier intensity, and finally translating the signal into sound undulations.

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