Aug. 6, 1929. R. H. RANGER 1,723,440

RADIORECEIVER

Filed Feb. 16, 1923 2 Sheets-Sheet 1

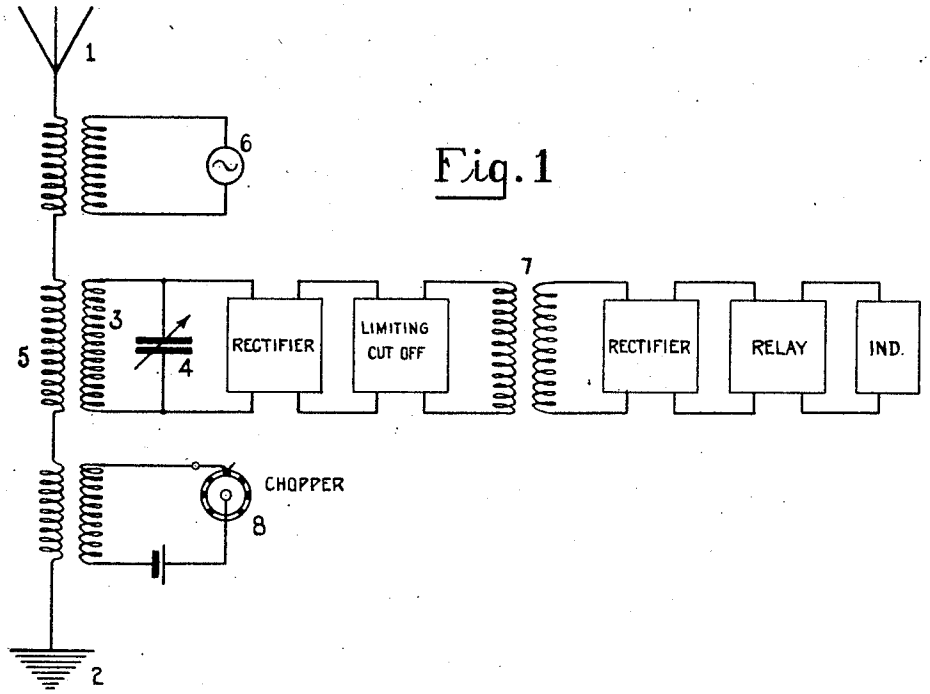


Fig. 1

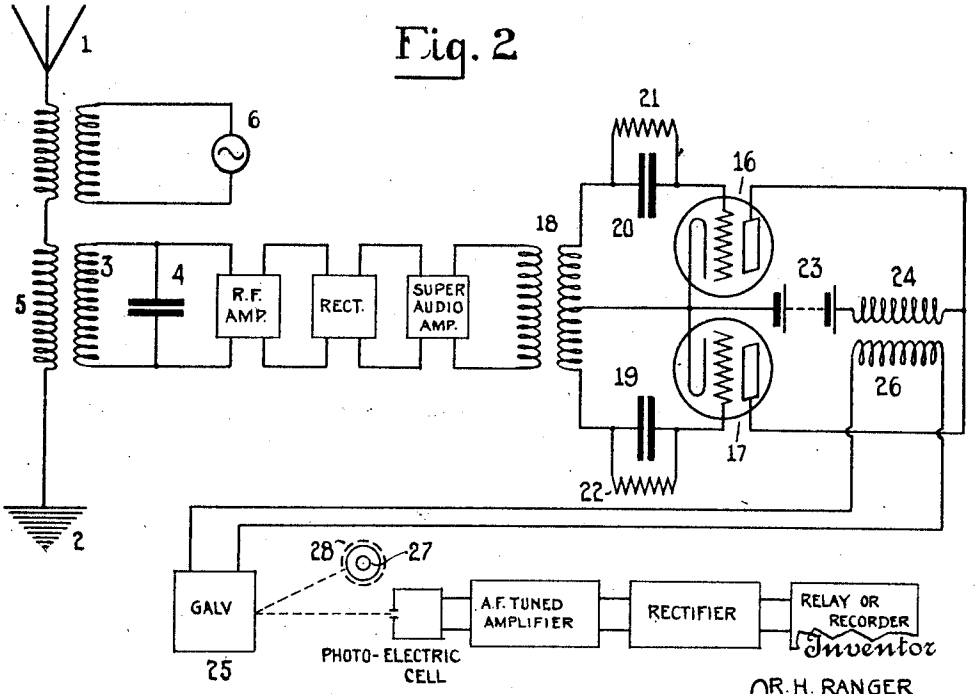


Fig. 2

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Aug. 6, 1929. R. H. RANGER 1,723,440

RADIORECEIVER

Filed Feb. 16, 1923 2 Sheets-Sheet 2

Fig. 3

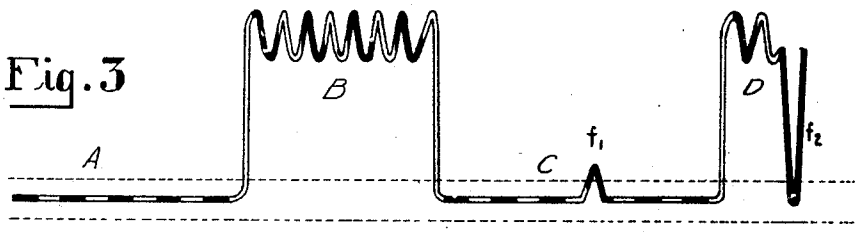


Fig. 4

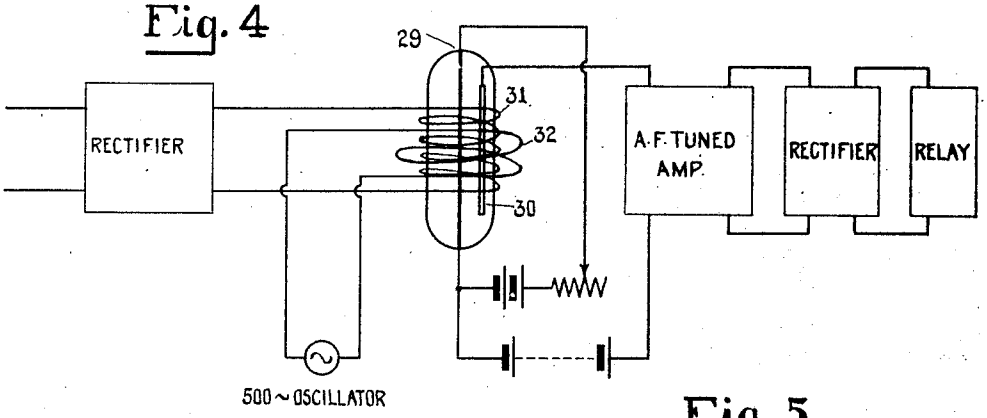


Fig. 5

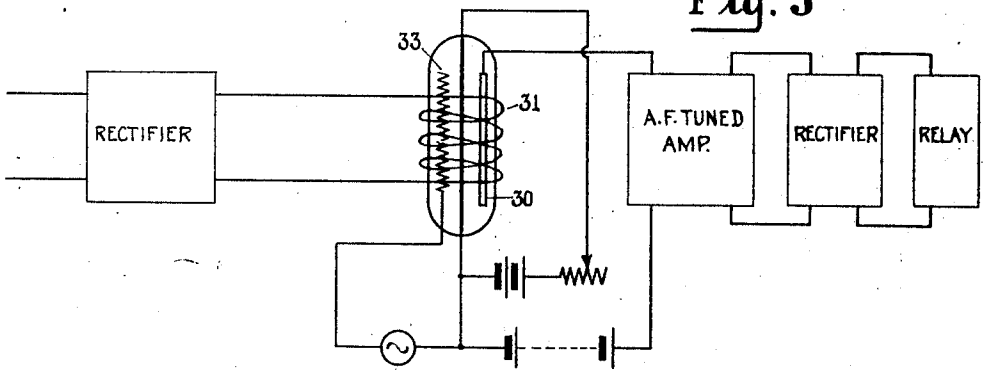
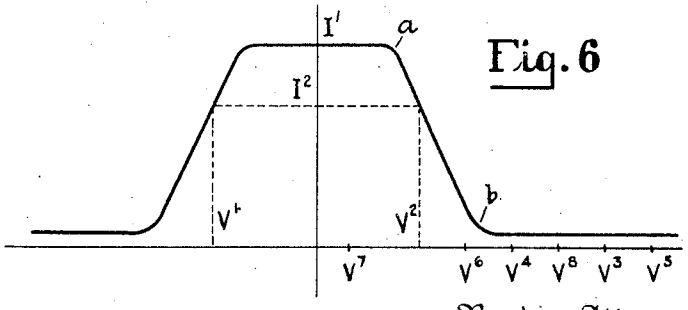


Fig. 6



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Patented Aug. 6, 1929. 1,723,440

UNITED STATES PATENT OFFICE.

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RADIORECEIVER.

Application filed February 16, 1923. Serial No. 619,359.

This invention relates to radio telegraphy and more particularly to a method and means for eliminating or reducing static or natural interference in the reception of radio signals.

Numerous arrangements have been suggested and used for this purpose depending for example on selective tuning or balancing out the static in opposed portions. The efficacy of such arrangements depends upon changing the ratio of signal to static or upon securing systems of similar characteristics so that the resulting static wave forms are alike so as to permit their cancellation by opposition. Considerable difficulty has been encountered in making static eliminators reliable and more or less trouble is encountered in all methods at certain times.

The object of the present invention is to provide an improved system which reduces the difficulty in reading signals when static or natural disturbances occur.

The term "static" used throughout the specification and claims is intended to cover all forms of disturbances such as may be set up by electro-magnetic waves of undesired form striking the receiving antenna and, as a result, troublesome interfering sounds are set up in the receiving apparatus. These sounds have been commonly referred to as static, atmospheric disturbances, strays, or X's, but applicant intends to use the term "static" to include all of the above forms.

The natural disturbances or statics appear to be of a heterogeneous character having considerable energy. The resultant currents in the receiving circuit are of a discontinuous nonuniform character and in general the effect upon a receiving circuit is similar to that which would be produced by heterogeneous shock excitation. The signal waves, however, produce forced oscillations resulting in currents of a continuous and substantially uniform character. The operation of my invention is based on this characteristic difference and to a large extent is independent of the actual amount of the undesired energy.

In the methods now used the indicator, such as the final receiver or recorder directly combines the tone or marking of the signal with the noise or marking of the disturbance. As static is discontinuous the energy is very effective for producing an indication and the known methods permit it to act in a manner by which it often renders the signals unintelligible.

In accordance with the present invention the energy of the signal is utilized to operate a limiting cut off and during this signal period the static energy is not integrated and on account of its discontinuous nature ordinarily cannot alter this condition. During the spacing periods, the static due to its interrupted character actuates the indicator by producing noise in the receiver or a marking period in the recorder and the signal is interpreted from either of the latter. Static on account of its energy will also under some circumstances reach the limiting cut off value but as it is usually of short duration it cannot of itself produce silence in the receiver or a non-marking period and for the same reason during the spacing period it will produce noise or a marking period even if it momentarily operates the limiting cut off.

As static may not always give sufficient noise to enable the signal to be read I find it advantageous to produce a continuous tone in the receiver and to silence this tone by the received signal energy. Static may convert a portion of the tone into noise, but ordinarily will not entirely silence the receiver.

It will be seen that this method of operation reverses the spaces and indicating periods and would be difficult for a Morse operator to read. This may be obviated by any suitable reversal such as reverse Morse signalling or by reversing the relays of the recorder when the latter is used.

In carrying out my invention I utilize an arrangement for cutting off the indicator whenever the received current is greater than a certain limiting valve which is substantially the value of the signal current. I may also utilize an arrangement which also cuts off the indicator when the received current is less than a certain value. The reading signal is only produced when the received energy falls within this band.

The novel features which I believe to be characteristic of my invention are particularly set forth in the appended claims. The invention itself, however, both as to its construction and mode of operation, to-

gether with further objects and advantages thereof, will best be understood by reference to the following description taken in connection with the accompanying drawings in which:

Fig. 1 is a diagrammatic view of apparatus illustrating the principle of my invention,

Fig. 2 shows my invention utilizing a particular form of limiting cut off,

Fig. 3 is a curve showing the path traced by a ray of light from the recording galvanometer mirror,

Figs. 4 and 5 show a modification of my invention utilizing a different type of limiting cut off, and

Fig. 6 is a curve explaining the operation of this form of limiting cut off.

In Fig. 1, which is intended to illustrate the principle of, as well as a system in accordance with the invention, 1 is a receiving antenna grounded at 2 and coupled to a resonant circuit 3, 4 by means of coupling coil 5. For receiving continuous waves a source of alternating current 6 is utilized for modulating the received energy at an audible frequency or for beat reception for example. The received currents, which may if desired be passed through radio or audio frequency amplifiers, are then rectified. The rectified currents are then impressed on a current interrupter or limiting cut off relay which is adjusted so that when current of the magnitude of the normal signal current is impressed thereon the interrupter opens the next circuit. Various arrangements have been utilized for accomplishing this result, several of which will be more specifically referred to in connection with the arrangements hereafter described.

Whenever the current furnished to the limiting cut off is less than the normal received signal currents or less than a certain minimum value, the relay is closed and the currents supplied thereto are impressed on the transformer 7, and are there rectified and used to operate an indicator, such as a recorder or telephone. If no static is received the indicator will respond to the spaces between the dots and dashes. This may be corrected when necessary by a suitable reversal, such as reversing the transmitter or the relay connected to the indicator.

When static is received with the signal currents these added currents cannot, except under extraordinary conditions decrease the signal current below the limiting cut off value and the indication given by the signalling currents during these periods is seldom affected.

During the intervening periods when no signal currents are impressed on the limiting cut off, the static received will not operate the limiting cut off unless it is of the magnitude of the signalling current. When it is of the magnitude of the signalling current and of short duration, the limiting cut off relay will be operated and the indicator may be momentrailly cut off but as the duration is usually very short as compared with a dot or a dash this can ordinarly be distinguished from the effects of signalling currents. As the indications during non-signalling periods will not be sufficiently continuous for easy reading unless there is considerable static, I preferably introduce a continuous audible tone in the system, so that during the intervening periods when signal currents are not received to operate the limiting cut off, a continuous tone more or less interrupted by the static noises will be heard instead of the static noises alone. This made be done for example by means of an audio frequency chopper 8 coupled to the antenna; or in any other suitable manner.

When exceptional static of a duration commensurate to a dot or a dash and of magnitude of the signal current is received during intervening periods between the signals, it will operate the cut off and cause the same effect as a signal, but it will be noted that static is not integrated and cannot, except under extraordinary conditions, affect the non-marking given by the signalling currents.

Fig. 2 shows an arrangement embodying several additional features as well as a particular type of limiting cut off relay which does not integrate the static energy. The arrangement comprises a radio frequency amplifier, preferably a three electrode vacuum tube connected to the resonant circuit. The modulation frequency supplied is preferably a frequency such as will give a 3,000 cycle beat for example, which frequency is doubled by passing the radio frequency through a double or balanced rectifier 16 and 17. The rectified currents of a pulsation frequency of 6,000 are then amplified by means of a suitable audio frequency amplifier and the output is impressed on the impulse balance or balanced rectifier which in itself is a device for reducing the effects of static. This arrangement, which is more particularly described in my copending application Serial No. 581,350 comprises two three-electrode tubes 16 and 17 having the grids connected to opposite ends of the secondary of transformer 18 through grid condensers 19 and 20 shunted by grid leaks 21 and 22. The middle point of the secondary is connected to the cathode of the tubes and the plates are connected together and to the filament through the plate battery 23 and the coil 24. This arrangement serves substantially to balance the initial impulses, but received currents cumulatively decrease the output of

both tubes, so that the large initial impulses of highly damped static are substantially balanced, as well as the small initial impulses of signals. The sustained impulses, however, gradually increase the negative charge on each of the grids so that the resultant plate current decreases when a sustained alternating current is impressed on the grids, but a 6,000 cycle variation occurs in the plate current. This super-audio pulsation of 6,000 is impressed by means of a coupling coil 26 upon a galvanometer 25, which may conveniently be of the type used in the well known oscillograph and be responsive to frequencies as high as 6,000 and thus possess sufficient flexibility to follow the impulses impressed upon it and the deflection may occur at a high frequency or as a single deflection according to the arrangement of the circuit. In addition, it is desirable to impress an audible frequency of 1,000 on the system preferably by means of a light 27 placed to shine on the galvanometer mirror, which light is interrupted by any suitable means, such as a rotating shutter 28, at the desired frequency. The mirror of the galvanometer receives and reflects light on a photo-electric cell when the deflection of the mirror is such that the light is reflected on the aperture of the cell. In this modification the galvanometer and the photo-electric cell constitute the non-integrating limiting cut off relay. The recording galvanometer of this type is particularly described in the patent applications of C. A. Hoxey, Serial Nos. 537,802 filed February 20, 1922 and 544,155 filed March 16, 1922.

The high audible frequency of 6,000 is selected because it is well adapted for operating the limiting cut-off device. The output of the photo-electric cell is then preferably passed to an amplifier tuned to the frequency of light interruption (1,000 cycles). The audio frequency current of 1,000 cycles is then used to operate a relay, recorder or telephone after rectification.

It is seen that the recorder receives a current for the spaces between the signal elements. It may be arranged to give a normal record, i. e. one in which the marks correspond to the signal elements in any suitable manner.

The operation is in general similar to that already described. The 1,000 cycle frequency is impressed on the galvanometer when the signal is coming in as well as when there is no signal. By suitable adjustment the deflection of the galvanometer is zero when no signal is received. The arrangement is such that under those conditions the light, interrupted 1,000 times per second, falls on the photo-electric cell as shown in Fig. 3, where the dotted lines indicates the band in which the photo cell receives light from the galvanometer. When the current carries the mirror so that the light is beyond or does not reach this band, no current is delivered by the photo-electric cell. As the light strikes the band an output current of 1,000 cycles is delivered to succeeding devices. Figure 3 is a curve showing the relationship between deflection of the galvanometer as ordinates and time as abscissae, the black portions indicating the periods when the galvanometer mirror is illuminated by the lamp 27 and the unshaded portions where the illumination is cut off by the revolving screen 28. The uniform undulations at B and D are caused by the 6,000 cycle current induced in 26 from the coil 24. In Fig. 3 the first portion of the diagram shows a space with no signal or static current present. When a dot or a dash is received a rectified current of a frequency of 6,000 cycles is impressed on the galvanometer and the resulting increase in the deflection of galvanometer is such that the light no longer strikes the photo-electric cell, or in other words, the band of rectification is shifted so that no current is delivered by the photo-electric cell. The second portion of Fig. 3 indicates a dash with no static interference present. In the space following the dash the band shifts back to the photo cell, but an impulse of static f_1 is present. This impulse momentarily raises the current to the band where the signal operates, but does not keep the operation in the upper band long enough to break up the current delivered by the photo cell. The musical tone may be somewhat affected but the change will scarcely be noticed in the telephone. In the fourth portion the received current corresponding to the dash carries the band off of the photo cell aperture. While the received energy is on, the static may from time to time break down the band as indicated by the static impulse f_2, but this will only be for short periods which on the average will be different from the 1,000 cycle note and will be eliminated by the tuning to audible frequency. As the energy which gets into this audio tuning device is only that derived from the photo-electric cell there is no possibility of shock excitation, as large impulses have no way of communicating their energy directly into the tuned circuit.

Unusually strong static will, of course, affect the system as shown in Fig. 3 as f_1 and f_2, but in a way which will eliminate the 1,000 cycle band with the received energy on or off. Static therefore can never give a marking period by itself, as shown by B and D on Fig. 3, since it is not of sufficient duration to effect the receiver, other than is shown by Fig. 3.

This arrangement has a further advantage in the fact that the band frequency of 1,000 is independent of the incoming frequency

in every way, so that it, as well as its audio tuning, may be fixed.

The transmitter or the relays will obviously be reversed so that the signal may be read more easily.

Figs. 4 and 5 show arrangements similar to Fig. 2 but using a different type of limiting cut off. The audio frequency output of 3,000 is passed through a double rectifier. A magnetron of the type shown in Hull Patent No. 1,114,697 comprising a heated filament 29 and a plate 30 surrounding the filament is utilized as the limiting cut off. The plate filament circuit is coupled to an amplifier tuned for 6,000 cyles and this frequency after rectification operates a relay, telephone or recorder indicating the currents. The currents from the double rectifier are connected to a control coil 31 wound around the outside of the enclosure and a separate magnetic control coil 32 is connected to a 500 cycle oscillator to produce the band or reading veil. When no energy is being received the 500 cycle oscillator will give two variations of the magnetic field so that a 1,000 cycle variation is produced in the plate circuit and the tone frequency amplifier is tuned to this frequency. When the rectified signals are received on the magnetron control coil 31 this will bias the control and the 500 cycle oscillator will produce a one-sided effect on the magnetron which will depend on the relative intensity of the oscillator and the rectified signal. If the rectification is sufficiently strong, the field created by coil 31 will prevent the flow of any plate-filament current. Neither the signals nor the audio tone will then get beyond the magnetron. Even if the addition of rectified signals is not sufficient to actually cut off the current in the plate circuit, the rectified current will cause the magnetron to operate on one side of the characteristic curve so that the tone will be changed upon the addition of rectified signals from 1,000 to 500 and this tone will be greatly reduced in the subsequent circuits tuned to a frequency of 1,000. Fig. 6 shows the characteristic curve of the magnetron, the ordinates being the plate current and the abscissa the control voltage. When the 500 cycles control is applied the control voltage varies from V^1 to V^2 and the plate current from I^1 to I^2. If the rectified voltage V^3 is sufficiently strong to carry the magnetron substantially above the cut-off point, then the added 500 cycle control varies the voltage from V_4 to V_5 and the plate current is cut off completely. If the rectified signal voltage is V_6 the superimposed 500 cycle voltage causes a variation of control voltage from V_7 to V_8 so that a 500 cycle variation of plate current results which is greatly decreased by the subsequent circuit tuned to 1,000 cycles.

In this system as in the photo cell arrangement described, no effect is produced directly in the second audio tuning by the tone produced by the signal or static as some high audible frequency is selected for modulation. For example, 3,000 cycles which after double rectification becomes 6,000. All that static may do is to raise the control current in the magnetron to such a point that the 1,000 frequency tone produced by the local 500 cycle oscillator is reduced. On account of the high period used, the effect of static will not be very prolonged so that a large part of the static will produce effects of such a short duration as not to affect the 1,000 cycle note to any great extent. Only under very rare conditions can static produce the reading note of 1,000 cycles when the signal is on, as the times when static would oppose the signals for a time interval commensurate with the audio tone of 1,000 cycles would be very seldom.

In the arrangement of Fig. 5 a tube is utilized similar to the magnetron of Fig. 4. In place of the external coil 31 a control grid 33 inside the tube is used for varying the plate current and as the plate current will be varied by means of this grid at the same frequency as that of the applied emf, a 1,000 cycle local oscillator is utilized in place of the 500 cycle oscillator. The rectified audio frequency of 6,000 is applied to the external control coil 31. In this case the magnetic control would be polarized to a point *a* just above the lower cut off limit, so that the addition of any opposed rectified signals will carry it back to *b* and cut off the effect of the audio oscillator on the plate which is connected to the tuned amplifier as for the magnetron. The action of this arrangement for static and signal would be very similar to the magnetron arrangement of Fig. 4.

Having described my invention, what I claim is:

1. The method of receiving radio signals through static, which consists, in receiving radio signals and static, in normally producing observable effects from the receipt of static energy during non-signalling periods and in interrupting the said observable effects upon receipt of desired incoming signal energy and static simultaneously.

2. The method of receiving radio signals through static, which consists, in receiving signals and static, in producing observable effects from static pulses alone in the absence of received signals, in preventing the production of said observable effects due to said static during periods when signals of the desired character are received jointly with said static effects, and in interpreting the desired signals from the absence of said observable effects during periods when both static and signals are being received.

3. A method of receiving radio signals through static, which consists, in normally producing observable effects from static disturbances at periods when signals are interrupted, in interrupting production of said observable effects during periods when signals and static are received simultaneously, and in interpreting the desired signals by the absence of said observable effects as interrupted by the simultaneous reception of signals and static.

4. The method of receiving radio signals through static which comprises causing received static energy to actuate an indicator unresponsive to signal oscillations, and rendering said indicator unaffected by said static during periods when desired signal oscillations are received.

5. The method of receiving radio signals through static, which consists, in normally receiving signals and static, in actuating an indicator by received static during non-signalling periods, in causing desired signals received simultaneously with said static to prevent the actuation of said indicator, and in interpreting desired signals by the absence of any indication during periods when signals are received.

6. The method of receiving radio signals through static which consists in producing at the receiving station a substantially continuous effect normally observable during static periods, and in causing the desired received signals to render said effect substantially unobservable.

7. The method of receiving radio signals through static, which consists, in receiving both signals and static, in producing observable effects by the receipt of said static, in producing a different observable effect at the receiving station during periods when static disturbances are reduced in intensity, and in rendering said effects unobservable during periods when desired signals are received simultaneously with said static disturbances.

8. The method of receiving radio signals through static which consists in simultaneously receiving signals and static, and in causing said received signals of predetermined strength to prevent response in an indicator normally unresponsive to signalling oscillations and normally responsive to static disturbances, whereby the said static will produce an observable effect on said indicator only during intervals when signalling oscillations are interrupted.

9. The method of receiving radio signals through static which consists in simultaneously receiving both static disturbances and transmitted signals, producing a response by said received static in an indicator unresponsive to signalling oscillations but normally responsive to said static, introducing into said indicator a substantially continuous effect observable by means of said indicator during periods when no signalling oscillations or static are received, and in causing said received signalling oscillations to render said indicator normally unresponsive to both said static and said continuously produced effect during periods when signalling oscillations are being received.

10. The method of distinguishing between static and signalling oscillations which consists in producing in a receiver by received static energy fluctuations within a definite range, causing received signalling oscillations to shift said fluctuations to a different position outside of said range, and determining the signal by the interruptions of said fluctuations in said range.

11. In radio receiving systems in combination, a receiving circuit, an indicator associated therewith, and means for causing said indicator to respond to static disturbances received alone, and to be unresponsive to static disturbances when received simultaneously with received signalling oscillations.

12. In a radio receiving system, the combination of a signal receiving circuit for receiving both static disturbances and desired signalling oscillations, an indicating means for indicating both the static disturbances and the desired signalling oscillations, and a limiting cut-off means associated with said receiving circuit for causing a response in said indicator only at periods when the received energy falls within predetermined limits so chosen as to normally include only the energy of the said static disturbances, whereby the said indicator is normally responsive only to static disturbances during periods when there is an absence of signalling oscillations on the receiver and the said indicator is normally unresponsive when both static and desired signalling oscillations are received simultaneously.

13. In a radio receiving system, an antenna circuit, a resonant circuit coupled therewith for receiving signals of a desired character and static disturbances accompanying said desired signals, an indicator associated with said resonant circuit and arranged so as to be normally unresponsive to said signalling oscillations alone, and limiting cut-off means controlled by said resonant circuit for causing said indicator to respond to static disturbances only during periods of interruption and spacing of received signalling oscillations.

14. In radio receiving systems, means for receiving radio waves and static disturbances accompanying the same, limiting cut-off means for causing static disturbances to produce uni-directional pulses of a magnitude normally lying within a predetermined band and for causing signalling oscillations to produce uni-directional pulses of a magnitude normally lying outside of said pre-

determined band, and an indicator actuated by the output energy from said limiting cut-off means and arranged so as to respond only to the uni-directional pulses lying within said predetermined band.

15. In radio receiving systems, the combination of a receiving circuit for receiving desired signalling oscillations and static disturbances accompanying the same, a rectifier for converting static disturbances when received on said receiving circuit in the absence of signals into uni-direction pulses of a magnitude normally lying within a predetermined band and for converting desired signalling oscillations into uni-directional pulses of a magnitude normally outside said predetermined band, an indicator, and galvanometer means actuated by said rectifier for rendering said indicator responsive only to uni-directional pulses lying within the said predetermined band, whereby the receipt of said desired signalling oscillations produce an absence of any recording effect upon said indicator and signals are determined in an inverse order.

16. In radio receiving apparatus, the combination of a receiving circuit, a rectifier associated therewith, a limiting cut-off operated by the output of said rectifier, an indicator controlled by said cut-off, said cut-off being so arranged as to permit said indicator to respond only to current strengths of a value less than that of a predetermined value of currents normally produced by received signalling oscillations and to prevent response of said indicator when the current strengths are equal to or greater than the said predetermined value normally produced by received signalling oscillations.

17. In radio receiving apparatus, the combination of a receiving circuit for receiving desired signalling oscillations and such static disturbances as accompany the same, an indicator associated with said receiving circuit and arranged so as to be normally responsive only to static disturbances and so as to be unresponsive to desired signalling oscillations, means for locally supplying a disturbing effect to which said indicator is responsive, and means for interrupting the production of said disturbing effects upon said indicator when signalling oscillations are being received, said means being adapted to prevent interruptions when static only is being received.

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