Oct. 13, 1936. P. C. GARDINER 2,057,613

DIVERSITY FACTOR RECEIVING SYSTEM

Filed July 28, 1932 2 Sheets-Sheet 1

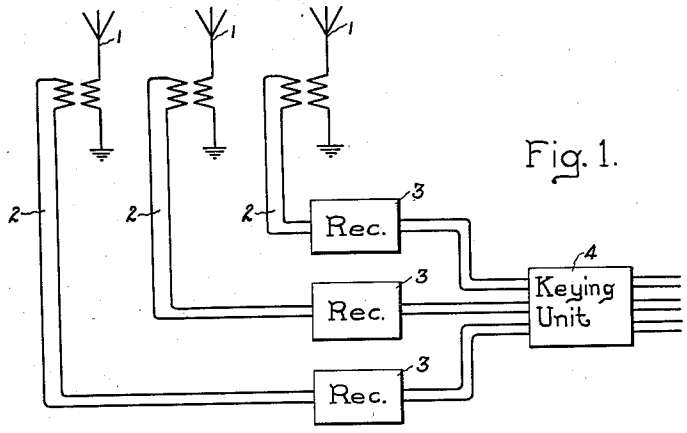

Fig. 1.

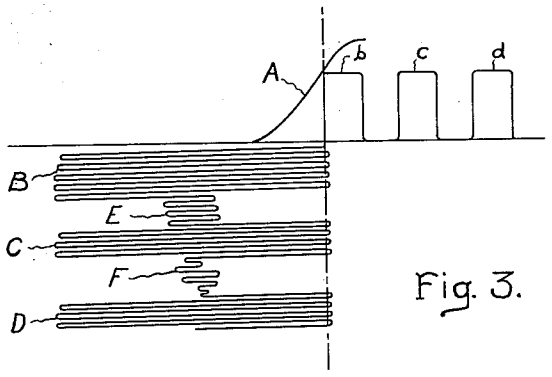

Fig. 3.

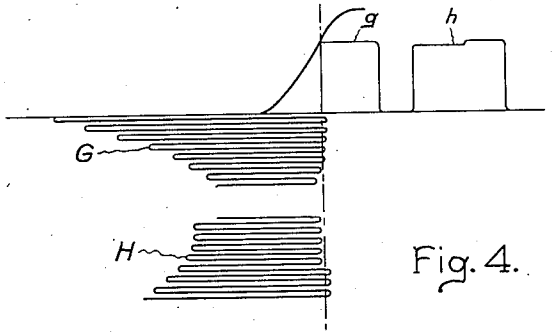

Fig. 4.

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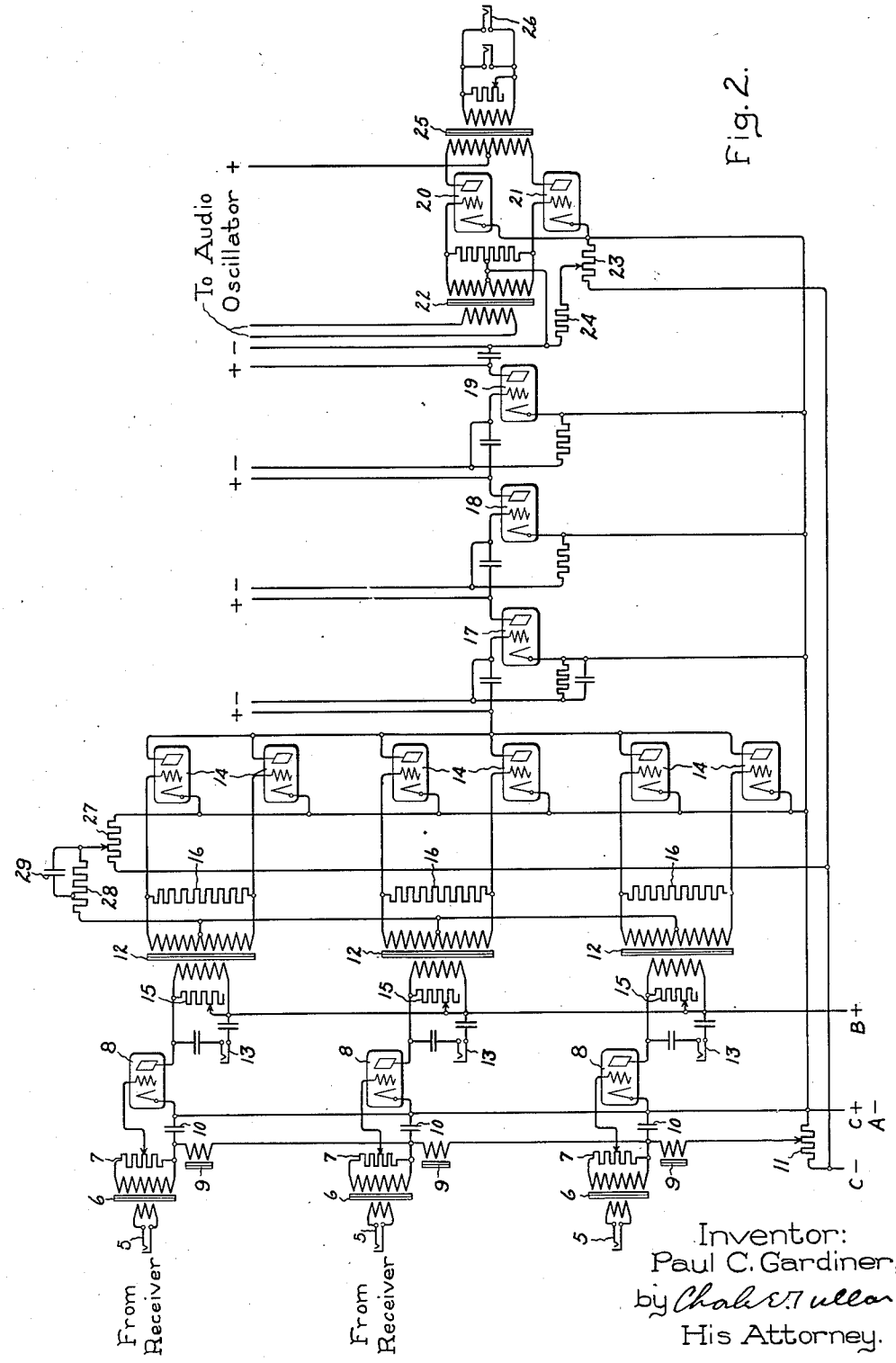
Filed July 28, 1932 2 Sheets-Sheet 2

Fig. 2.



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UNITED STATES PATENT OFFICE

2,057,613

DIVERSITY FACTOR RECEIVING SYSTEM

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15 Claims. (Cl. 250—8)

My invention relates to radio receiving systems and more particularly to diversity factor receiving systems of the type employed for the reception of high speed telegraphic and facsimile radio transmissions.

It has for one of its objects to provide a diversity factor receiving system having an improved mixing unit to reduce the effect of fading.

It is generally customary to transmit facsimile impulses by means of interrupted continuous waves. In the reception of such transmissions it often occurs that between the impulses of the signal wave an "echo" effect causes the receiver to mark during the normal spacing interval. This echo effect causes the letters and portions of the spaces to be filled in, which results in an illegible reproduction.

Another object of my invention is to provide means in the mixing unit which substantially eliminates the "echo" effect and the disadvantages resulting therefrom.

The novel features which I believe to be characteristic of my invention are set forth with particularity in the appended claims. My invention itself however both as to its organization and method of operation, together with further objects and advantages thereof, may best be understood by reference to the following description taken in connection with the accompanying drawings in which Fig. 1 diagrammatically shows a facsimile reception system wherein my invention has been embodied; Fig. 2 shows the mixing unit embodying my invention; Fig. 3 and Fig. 4 graphically illustrate the operation of my invention.

Referring to Fig. 1 of the drawings, I have illustrated therein a plurality of spaced antennae 1 each coupled by a suitable transmission line 2 to one of a plurality of radio receivers 3. The radio receivers 3 may be of any suitable circuit construction so that either an intermediate frequency or an audio frequency will be produced in the output circuit of the receiver. The low frequency outputs of the receivers 3 are fed into a mixing and keying unit 4 wherein the signal energy of the receivers is used to control the transmission of an alternating current to the translating devices for reproduction of the transmitted high speed telegraph and facsimile signals.

Fig. 2 of the drawings schematically shows the circuit elements which comprise the mixing and keying unit 4. In Fig. 2 I have shown a jack 5 connected to the primary winding of a transformer 6 to receive the alternating current output of one of the receivers 3. The secondary winding of the transformer 6 is provided with a potentiometer 7 so that any desired portion of the voltage developed in the secondary winding may be impressed upon the grid or control element of the electron discharge amplifier 8. A choke coil 9 and a by-pass capacitor 10 prevent the alternating currents from entering the negative grid biasing source of potential and from entering the other alternating current channels. The negative potential impressed upon the control element of the electron discharge device 8 may be adjusted to any desired value by means of the potentiometer 11 which is connected across a source of biasing potential. The output of the electron discharge amplifier 8 is connected to the primary winding of the push-pull input transformer 12, which is arranged to permit monitoring of the signal channel by connecting a pair of headphones, or other monitoring device, to the jack 13.

The secondary winding of the transformer 12 is connected to a pair of electron discharge devices 14 which are arranged to operate as full wave rectifiers of the alternating current signals. Resistors 15 and 16 are connected respectively across the primary and secondary windings of the transformer 12 to compensate for the normal lagging action of the transformer which would tend to destroy the sharp sides of the signal impulses passing through the channel. This compensates for the phenomenon commonly known as "transients" which causes "shadows" in the background of the letters of the facsimile. The direct current outputs of all of the pairs of rectifiers 14 are combined in a common output circuit and amplified by the electron discharge devices 17, 18 and 19 which are arranged to form a direct current amplifier.

The amplified direct current signals are then fed into a keying unit comprising a pair of electron discharge devices 20 and 21 arranged in push-pull. A source of audio frequency supplies current to the input transformer 22 of the discharge devices 20, 21. The electron discharge devices 20 and 21 are normally biased negatively to a point below anode current cut-off by means of a potential obtained from across the resistor 24 and the potentiometer 23 which is arranged across a suitable source of biasing potential. This biasing arrangement prevents the audio frequency from being repeated to the output of the discharge devices 20, 21 until the negative bias is reduced by the rectified signal passing through the direct current amplifier.

The anode circuit of the electron discharge device 19 may be traced from the anode to the source of potential indicated by plus and minus and through the resistor 24, and part of the resistor 23 to the cathode. Each of the signal impulses passing through the discharge device 19 reduces the anode current in this device and likewise the negative potential across the resistor 24 which, in turn, reduces the total negative potential applied to the control elements of the discharge devices 20, 21, thus permitting them to transmit the audio frequency current for the duration of the signal impulse to output transformer 25. The secondary winding of the output transformer is provided with jacks 26 which may be connected to transmission lines, facsimile recorders or other translating devices.

It is to be understood however that the output of the direct current amplifier may be connected directly to direct current recording apparatus whenever it is desired to reproduce the high speed telegraph or facsimile signals at the radio receiving station.

The control elements of the rectifying electron discharge devices 14 are negatively biased by a common source of potential connected to all of the cathodes. A potentiometer 27 arranged across this source of potential provides a convenient means for adjusting the amount of bias potential impressed upon the control elements. The movable point of the potentiometer 27 is connected through a resistor 28 to the midpoints of the secondary windings of the push-pull input transformers 12. The resistor 28 is tapped so that a capacitor 29 may be connected across the greater portion of the resistor.

When the alternating current signals supplied by the receiver are of sufficient amplitude to draw grid current in the electron discharge devices 14, a voltage is developed across the resistor 28 which increases the negative bias on the grid element. As the voltage across the resistor 28 is developed, the capacitor 29 is charged to this potential. After the alternating current signal has ceased, the capacitor 29 retains a substantial portion of the potential to which it has been charged, and this maintains an additional bias upon the grid element for a predetermined period of time after the signal.

The operation of the push-pull rectifier circuit of the electron discharge devices 14 may best be understood by reference to Fig. 3 in which to present a clear understanding the various representations are exaggerated. The curve A represents the grid bias-anode current characteristic of an electron discharge device 14. At the left and below the axis of the characteristic curve, the oscillations B, C. and D represent alternating current facsimile signal impulses impressed upon the grid elements of the electron discharge devices 14. At the right and above the axis of the characteristic curve the combined output of the electron discharge devices 14 due to the impressed signal impulses B, C and D is represented as *b*, *c*, and *d*. The oscillation E which is shown between B and C may be due to an echo, another signal transmitter, or improper operation of the facsimile transmitter. The oscillation F which is shown between C and D represents an occurrence of static. Because of the negative bias maintained upon the grid elements, these oscillations E and F do not produce any effect in the output of the electron discharge rectifiers 14.

The negative bias impressed upon the control grids of the rectifiers 14 is adjusted by means of the potentiometer 27 to at least anode-current cut-off. When a signal impulse such as is shown at B is impressed upon the grids of the rectifiers 14, the grids draw current as the grids become positive, and the grid current flowing through the biasing resistor 28 increases the negative bias. This negative bias reaches its maximum value after a few oscillations of the signal impulse as will be apparent from the extent to which the successive oscillations of the impulse B swing to the left as represented in Fig. 3. This negative bias prevents the grids from swinging positive to any appreciable extent so that the output as shown at *b* is substantially constant. Each of the signal periods B, C and D is rectified by the push-pull devices 14 to provide substantially constant direct current impulses *b*, *c* and *d* which may be amplified by the direct current amplifier.

When a signal impulse, such as the impulse B, ceases, the capacitor 29 which has been charged to the biasing value developed by the resistor 28 continues to bias the rectifiers 14 for a predetermined time. This biasing charge on the capacitor 29 slowly leaks off so that in time the negative bias on the rectifiers 14 returns to the minimum value determined by the potentiometer 27. This decrease in the biasing effect of the capacitor 29 is apparent from the slope of the median of the extraneous oscillations represented at E. When a succeeding signal impulse such as C is received the bias potential across the resistor 28 is again built up to a high negative value which again charges the capacitor 29.

The relative positions of the axes of the oscillations shown at E and F and the point at which the curve A intersects the horizontal axis clearly illustrates how the additional negative bias supplied by the capacitor 29 prevents extraneous and static oscillations from affecting the output of the rectifiers 14 between signal impulses. Because of this additional negative bias, these oscillations are unable to overcome the negative bias sufficiently to impress any potential upon the grids which will have a value above the anode-current cut-off point. The output remains unaffected so that interfering signals have no effect upon the facsimile reproduction.

The negative bias potential supplied by the resistor 28 and the capacitor 29 is common to the control grids of all of the rectifiers 14. The receiver supplying the strongest signal determines the value of the biasing potential developed across the resistor 28 and thus the receiver having the strongest signal automatically is the one which provides the signal impulses produced in the common output circuit. This reduces the effect of fading as the common biasing arrangement is responsive to the strongest signal, and a weak signal is prevented from affecting the common output. It will be apparent that when one receiver is supplying oscillations having the amplitude shown at B, that a receiver merely supplying oscillations having the amplitude shown at E will be unable to cause operation of its pair of rectifiers 14.

The effect of fading is further eliminated by an action illustrated in Fig. 4. This figure shows the action of the rectifiers when fading has affected all of the receivers. In practice fading occurs over a plurality of signal impulses which gradually diminish, but for the purpose of simplified illustration, this is shown in exaggerated form as occurring appreciably during a single

signal impulse such as G. At the beginning of the signal impulse the oscillations are indicated as of sufficient amplitude to produce an additional negative bias potential across the resistor 28. As the signal decreases, the additional bias also decreases until at the end of the signal impulse G, the only biasing potential present is that supplied by the potentiometer 27 which is connected across a negative source of potential. Although the amplitude of the signal impulse G decreases, the signal output *g* of the rectifiers 14 remains substantially the same. Thus it is apparent that a reasonably weak signal provides substantially the same signal output as a strong signal.

Due to the use of the diversity reception system, the signal amplitude rarely decreases below this value. The signal impulse H however illustrates the action of the rectifiers 14 when the amplitude of the signal impulse decreases below the normal minimum value. The signal impulse H at its initial value produces an output signal substantially as great as a normal signal, as is apparent at the output *h*. The latter portion of the signal impulse H is shown to be sufficient to draw grid current and hence the signal output at *h* is at maximum value. It will be apparent that the signal output *h* when amplified by the direct current amplifier 17, 18, 19 will be sufficient to produce an even keying action of the amplifiers 20, 21 and the marking action of the facsimile recorder will not disclose any signal variation.

If the telegraphic speed is low or if the receiver 3 produces an intermediate frequency output, or a high audio frequency signal, the push-pull rectifiers 14 may be replaced by single electron discharge rectifiers. The push-pull rectifiers as shown operate with equal efficiency regardless of the signal output of the radio receivers, but where the receivers produce a low audio frequency signal the push-pull rectifiers provide smoother direct current signal impulses.

My invention has the advantage of providing means for reducing the effect of fading and substantially eliminating echo effects.

While I have shown and described my invention in connection with certain specific embodiments it will of course be understood that I do not wish to be limited thereto, since it is apparent that the principles herein disclosed are susceptible of numerous other applications and modifications may be made in the circuit arrangements and in the instrumentalities employed without departing from the spirit and scope of my invention as set forth in the appended claims.

What I claim as new and desire to secure by Letters Patent of the United States is:

1. A facsimile receiving system for reducing the effect of fading including a plurality of antennae each coupled to one of a plurality of receivers, said receivers being arranged to supply audio frequency currents, a plurality of electron discharge devices for individually rectifying the audio frequency currents of each of said receivers, means common to said rectifying discharge devices for causing the rectification of the audio frequency currents of the receiver supplying currents having the greatest amplitude, and for rendering the remaining receivers inoperative, a common means for amplifying said rectified audio frequency currents, and a translating circuit operating in accordance with the rectified audio frequency current impulses.

2. In a telegraphic receiving system, the combination of a plurality of electron discharge devices each having a cathode, an anode and a control element, input circuits for said electron discharge devices arranged in push-pull, means for supplying audio frequency currents to said input circuits, a common output circuit for combining the outputs of said electron discharge devices, means for negatively biasing said control elements to substantially anode current cut-off, and means in series with said biasing means and common to all of said electron discharge devices for automatically increasing the negative bias on said control elements in accordance with the strength of said audio frequency currents.

3. In a system for reducing the effects of fading, the combination of a plurality of radio receivers for supplying alternating current signals, a plurality of electron discharge devices, means for supplying said alternating current signals to said discharge devices, negative biasing means for said discharge devices whereby said discharge devices operate to rectify said alternating current signals, and means common to all of said electron discharge devices for applying an additional negative bias to said discharge devices in accordance with the amplitude of said alternating current signals whereby said devices operate substantially to rectify only the signal currents from the receiver supplying currents having the greatest amplitude.

4. In a keying unit for high speed telegraphic receiving systems, the combination of a plurality of electron discharge devices, input circuits for each of said electron discharge devices, a source of alternating current signals for each of said input circuits, biasing means connected to said input circuits for negatively biasing said discharge devices to anode current cut-off whereby said discharge devices operate to rectify said alternating current signals, and means in series with said biasing means for automatically increasing said negative bias on said discharge devices in accordance with the strength of said alternating current signals and for maintaining an increased bias on said discharge devices during the periods between said telegraphic impulses, whereby during said periods said discharge device is unresponsive to undesired electromotive forces supplied to said input circuits of less than predetermined amplitude.

5. In a signal receiving system, the combination of a plurality of electron discharge devices each having an anode, a cathode and a control element, input circuits for said electron discharge devices, a plurality of means for supplying alternating current signal impulses to said input circuits, a common output circuit for said electron discharge devices, means for negatively biasing said control elements to substantially anode current cut-off, biasing means common to all of said electron discharge devices in series with said first biasing means for automatically increasing the negative bias on said control elements in accordance with the strength of said alternating current signals, and means for maintaining an increased bias on said control elements for a predetermined period after the secession of said alternating current signal impulses.

6. A system for reducing echo effects and fading including a plurality of diversity reception receivers for reducing the frequency of received high frequency signals, a plurality of electron

discharge devices arranged to receive said signals individually, negative biasing means for causing said discharge devices to rectify said signals, means common to said discharge devices for applying an additional negative bias to said devices in accordance with the amplitude of said signals whereby said devices operate substantially to rectify the signals of the receiver supplying signals of the greatest amplitude, and means for maintaining an increased negative bias on said discharge devices for a predetermined period after the secession of said signals to prevent rectification of echo signals.

7. In a system for reducing the effects of fading, the combination of a plurality of radio receivers for supplying alternating current signals of varying intensity, a plurality of electron discharge devices, means for supplying said alternating current signals to said discharge devices, negative biasing means for said discharge devices whereby said discharge devices operate to rectify said alternating current signals and produce direct current impulses, and means common to all of said electron discharge devices for applying an additional negative bias to said discharge devices in accordance with the intensity of the alternating current signals and sufficiently to cause said discharge devices to produce direct current impulses having substantially constant amplitudes.

8. In a telegraphic receiving system, the combination of a plurality of electron discharge devices each having a cathode, an anode and a control element, input circuits for said electron discharge devices, means for supplying audio frequency currents of varying intensity to said input circuits, means for negatively biasing said control elements to substantially anode current cut-off whereby said electron discharge devices operate to produce direct current impulses, and biasing means in series with said first mentioned biasing means and common to all of said control elements for automatically increasing the negative bias in accordance with the intensity of said audio frequency currents and sufficiently to cause said discharge devices to produce direct current impulses having substantially constant amplitudes.

9. In a signal receiving system, the combination of a plurality of electron discharge devices each having a grid and an anode, individual input circuits for said discharge devices, a common output circuit for said discharge devices, a common source of potential connected to said grids for negatively biasing all of said discharge devices to anode current cut-off, and a grid-bias resistor connected in series with said source of potential for increasing the negative bias potential on all of said grids upon receipt of strong signals by any of said discharge devices whereby all of said discharge devices are rendered insensitive to weak signals.

10. In a signaling system, the combination of an electron discharge device having a control element and an anode, means for supplying alternating current signal impulses of varying intensity to said discharge device, means for negatively biasing said control element to substantially anode current cut-off, and means including a resistor in series with said biasing means, said last means being responsive to grid current flowing in said discharge device for increasing the negative bias sufficiently in accordance with the intensity of said alternating current signals to cause said discharge device to produce anode current impulses having substantially constant amplitude for varying amplitudes of said alternating current signal impulses.

11. In a signaling system, the combination of a plurality of electron discharge devices each having an individual input circuit, a grid, and an anode, an output circuit common to all of said discharge devices, a source of potential common to said grids for negatively biasing said discharge devices, a grid-bias resistor connected in series with said source of potential for increasing the negative bias of said grids upon receipt of strong signals by any of said discharge devices whereby all of said discharge devices are rendered insensitive to weaker signals, and a capacitor connected in parallel with said resistor for maintaining an increased negative bias on said grids for a predetermined period after the secession of said strong signals.

12. The method of controlling the sensitivity of receivers for alternating current impulses separated by periods when said alternating current is interrupted and undesired currents are present, which includes utilizing said impulses to render the receiver sufficiently insensitive during the periods between impulses to prevent reception of said undesired currents.

13. In a receiver of alternating current impulses, said impulses each comprising a train of waves, said trains being separated by periods when said alternating current is interrupted, the combination of means to vary the sensitivity of said receiver in response to the intensity of said impulses to an extent sufficient to maintain the output from said receiver substantially constant during reception of signal impulses of widely varying intensity, and means to maintain said sensitivity between impulses substantially the same as determined by the last preceding impulse.

14. In a receiver of alternating current impulses, said impulses being separated by periods when said alternating current is interrupted, each of said impulses comprising a train of waves, the combination of means automatically to control the sensitivity of said receiver in response to the intensity of received impulses, and means to render the response of said last means sufficiently rapid to increases in intensity of received signals to cause faithful reproduction of the initial impulse of any series of impulses and sufficiently slow to decreases in intensity of received signals to render said receiver insensitive between impulses in any series.

15. The combination, in a receiver of alternating current telegraphic impulses affected by fading, of means automatically to control the sensitivity of said receiver in response to the intensity of said received telegraphic impulses thereby to maintain the currents in the output circuit of said receiver substantially constant during variations in intensity of the received alternating current impulses produced by fading and means to render the response of said last means sufficiently rapid to increases in intensity of received signals for faithful reproduction of said impulses and slow to decreases in intensity of received signals, the rate of response of said means to decreases in intensity of received impulses relative to the rate of fading by which said impulses are affected being such that the effect of fading upon the output current from said receiver is substantially reduced.

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