

Oct. 29, 1929.

E. Y. ROBINSON

1,733,824

HIGH FREQUENCY SIGNALING SYSTEM

Filed Aug. 20, 1923

3 Sheets-Sheet 1

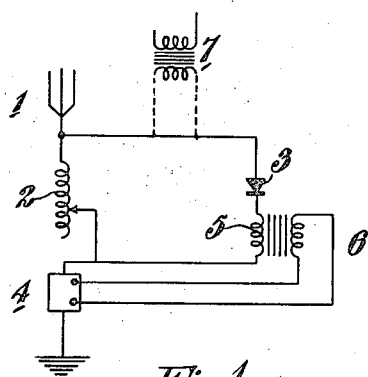


Fig. 1.

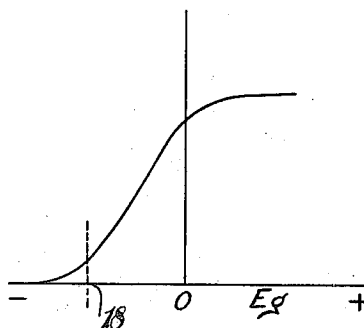


Fig. 2.

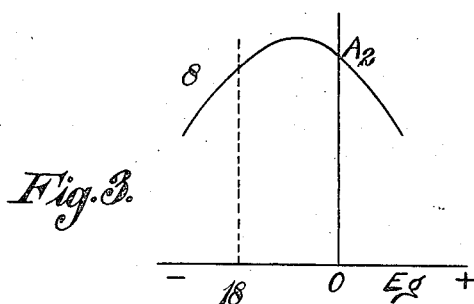


Fig. 3.

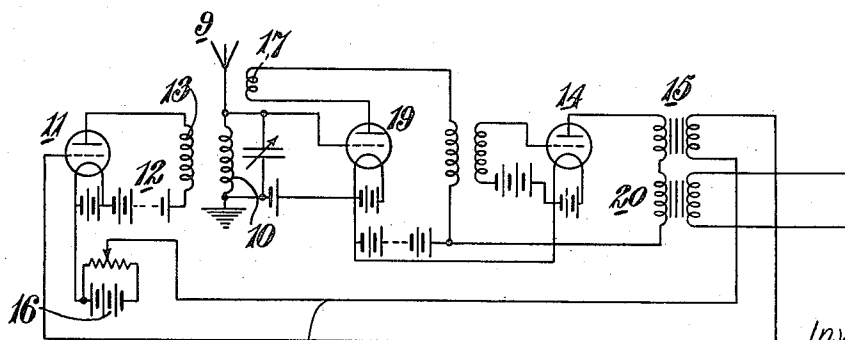


Fig. 4.

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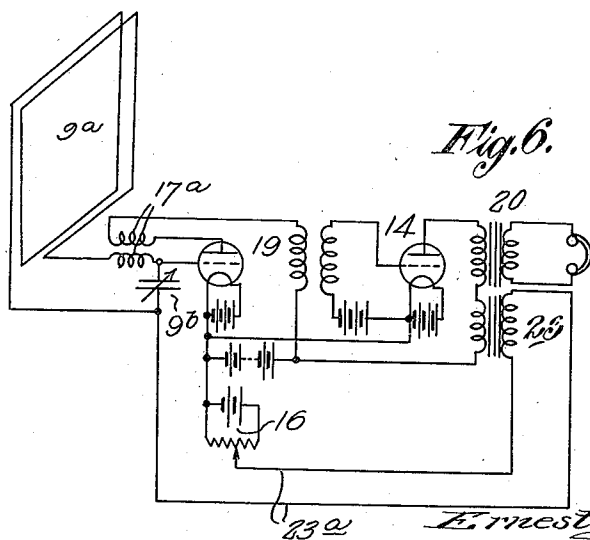
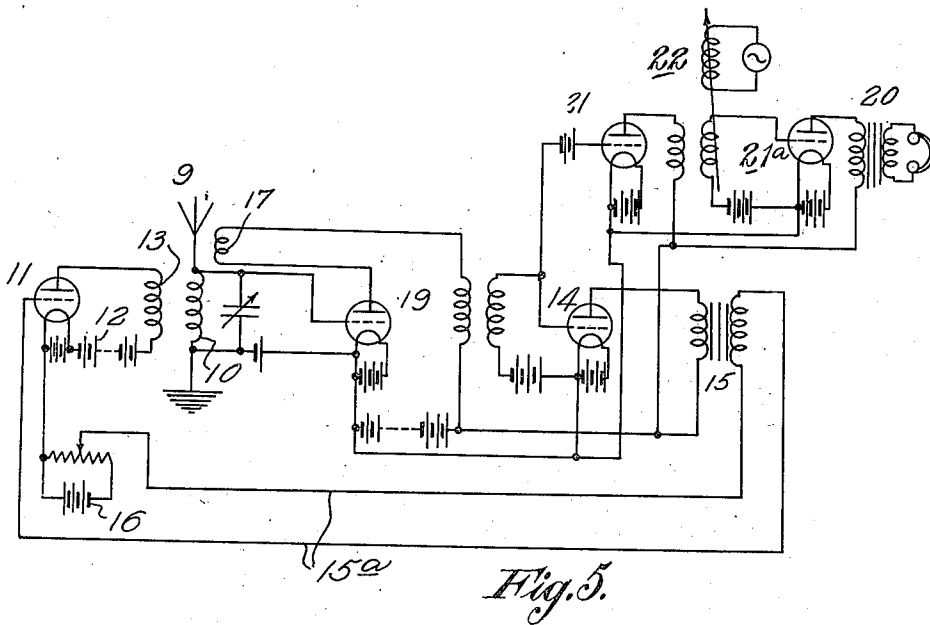
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3 Sheets-Sheet 2



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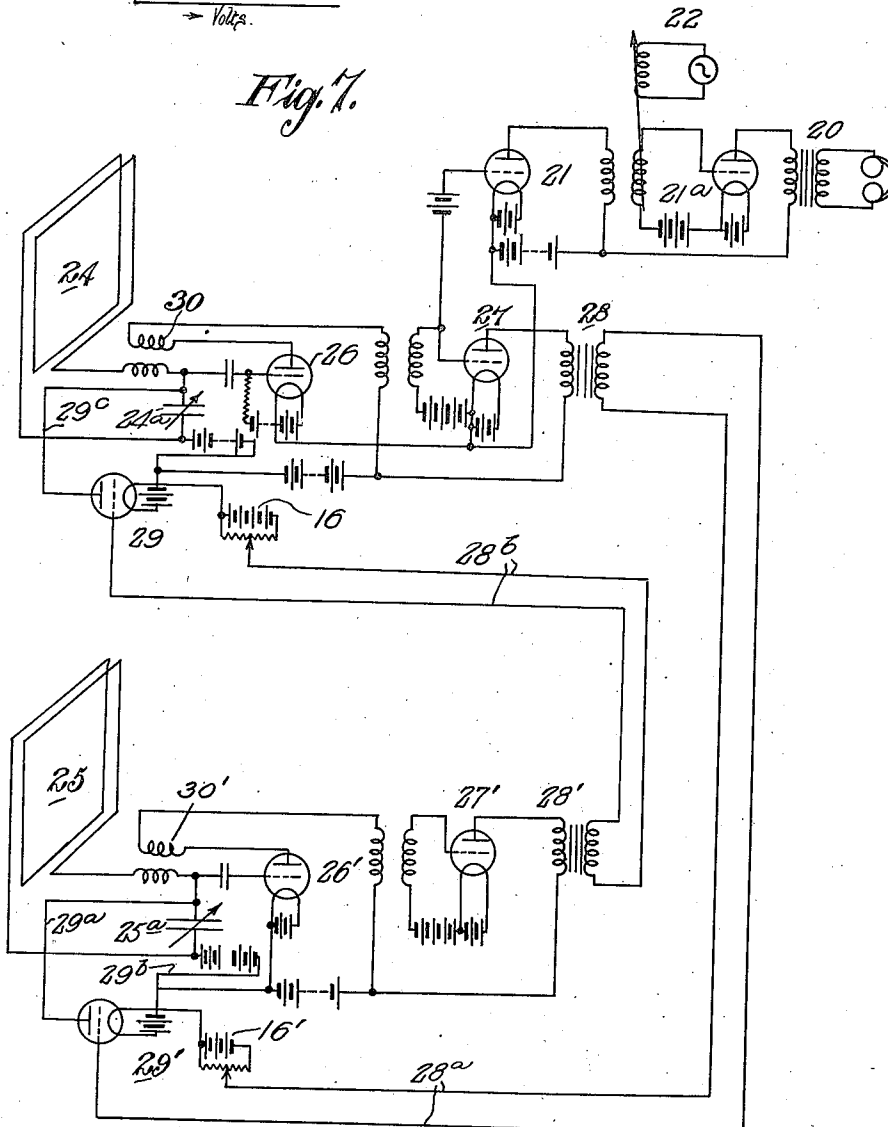
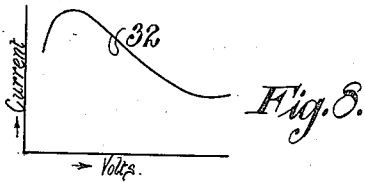
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HIGH FREQUENCY SIGNALING SYSTEM

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3 Sheets-Sheet 3



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UNITED STATES PATENT OFFICE

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HIGH-FREQUENCY SIGNALING SYSTEM

Application filed August 20, 1923, Serial No. 658,408, and in Great Britain August 22, 1922.

This invention relates to improvements in changes of decrement. Moreover, it may be arranged that at some times when the signal is increasing in strength the decrement of the circuit or circuits is made negative so that a relatively large amount of power is locally supplied in order effectively to compensate for the energy capacity of the antenna and oscillatory circuits connected thereto. Preferably it is arranged that the change of decrement of the antenna is proportional to the rate of change of signal strength; it is of course of such a sign that the above effects occur.

In high frequency signaling systems, such as wireless telegraphy and telephony, it is well known that reducing the resistance of the antenna or oscillatory circuits connected thereto as by connecting a "negative resistance" device, for example regenerative three-electrode valves thereto, results in an increase of signal strength and increased selectivity. Apart from the question of the stability of the circuits however there is a limit to the degree of signal strength which may be obtained in this manner owing to the time lag which occurs in building up and dissipating the oscillations which are induced in the antenna or antenna circuits. Thus, in the case of spark telegraphy, no gain in signal strength occurs if the resistance of the antenna is reduced to such a low degree that the oscillations from one spark train merge into the next; in the case of continuous wave telegraphy if the resistance of the antenna is reduced to too low a value one signal will not be clear of the receiving apparatus before the next arrives; in the case of telephony it is necessary in order to produce distortionless reception that none of the oscillatory circuits in the receiving apparatus should have a lower decrement than the highest decrement in the received waves. Moreover, in high speed telegraphy even when the decrement of the receiving circuit is relatively high the speed of sending is limited by the said circuits because even if the decrement is high enough to ensure rapid dying away of the signal oscillations the growth of the oscillations is limited by the energy capacity of the antenna and circuits connected thereto.

In accordance with this invention it is arranged that the decrement of the antenna or the oscillatory circuits employed or both is decreased when the signal is increasing in strength and is increased when the signal is decreasing in strength and preferably remains substantially constant when the signal strength is zero or is constant. Furthermore, in the preferred method it is arranged that the incoming signal itself effects these

As a result of this invention it is possible to employ receiving circuits having much lower decrements than has hitherto been possible and thus the receiver may be made highly sensitive and selective without producing such effects as distortion or the merging of one signal into the next. Another result of this invention is that when it is employed with a plurality of receiving circuits atmospherics are reduced as will be herein-after described.

To enable the invention to be clearly understood it will now be described with reference to the accompanying drawings in which Fig. 1 is an elementary circuit diagram illustrating the method of reception according to the invention; Figs. 2 and 3 are characteristic curves of a three-electrode valve; Figs. 4, 5 and 6 are electrical diagrams of three forms of reception circuits in accordance with the invention; Fig. 7 is an electrical diagram of a reception circuit in accordance with the invention for receiving signals transmitted on two wave lengths, and Fig. 8 is a characteristic curve of a typical negative resistance device.

In Fig. 1 of the drawings, 1 represents an antenna connected to a loading coil 2, across which is connected a circuit containing a detector 3. Included in the antenna circuit is a device 4 the resistance of which may be controlled and which preferably also serves to introduce sufficiently negative resistance in the antenna circuit to reduce the constant component of the antenna resistance to a low value. The rectified currents pass through the primary winding 5 of a trans-

former the secondary winding 6 of which is connected to the device 4. The transformer is of such construction that the electromotive force induced across the secondary winding 6 thereof is proportional to the rate of change of amplitude of the antenna oscillations and this secondary electromotive force is caused to control the value of the resistance of the device 4. The signal may be caused to operate telephones or relays (not shown) through the medium, for example, of a transformer 7 connected in the detector circuit as indicated by dotted lines.

The decrement of the circuits may be varied by varying the output of a negative resistance device and examples of this method will be hereinafter described but in the preferred method it is arranged that a vacuum electric device, for example a three-electrode valve is coupled to the circuit so that it introduces resistance into the circuit and the resistance is varied by means of the vacuum electric device while the resistance of the whole circuit is reduced to a low value by means of a negative resistance device, for example a regenerative three-electrode valve. Alternatively these two effects may be produced by means of one reactively coupled valve and the variable resistance produced by means of the grid current flowing therein.

Referring to Figs. 2 and 3 which illustrate respectively the anode current-grid voltage characteristic of a three-electrode valve and the differential conductance of the valve, it will be seen that when the grid voltage E_g is such that the representative point is on the lower curved portion of the anode characteristic the differential conductance A^2 of the valve is represented by the rising portion 8 of the curve shown in Fig. 3. If the curved portion of the anode characteristic follows a square law then the corresponding portion of the differential conductance curve follows a straight line law. Therefore in the preferred method a valve is coupled to the antenna and is employed as a variable resistance the resistance of the valve being varied by varying the grid potential thereof, whilst the resistance of the circuit is reduced to a low value by means of a negative resistance device such for example as a "dynatron" or a reactively coupled three-electrode valve.

Fig. 4 illustrates this method. The antenna is shown at 9 and the antenna loading coil at 10. The variable resistance valve is shown at 11; it has an anode battery at 12 and is coupled to the antenna by means of an inductance 13. The received oscillations are amplified if necessary by a valve 19 and are detected by the valve 14. The rectified current passes through the primary of the transformer 15 which preferably comprises a small number of turns well spaced so that the shunted capacity is small, the transformer being so designed that the electromotive force

induced across the secondary thereof is proportional to the rate of change of current flowing through the primary. That is to say, the transformer windings are preferably arranged so that the distributed capacity across each winding and from one winding to another is made small. This may be effected by building the windings in sections well spaced from each other and from the iron core preferably so that the major portion of the dielectric is air and the sections of the two windings interlink with each other. Furthermore, it is preferable in order that the distributed capacity shall be low that the transformation ratio is unity and that a relatively large air gap is provided in the iron circuit. It is further desirable that the average input reaction of this transformer is considerably less than the differential anode resistance of the valve in order that the current flowing therein is proportional to the mean value of the electromotive force applied to the grid of the said valve. The primary of the transformer should be shunted by a small condenser (not shown) in order to pass the high frequency component of the rectified current. The capacity of this condenser should be so low that the oscillatory circuit so formed is not in resonance to any of the high frequency components present in the rectified current. The secondary of the transformer 15 is coupled by the conductors 15^a to the grid of the valve 11. A suitable grid biasing battery 16 is employed and the mean grid potential is adjusted so that the representative point is on the curved portion of the characteristic. Preferably this grid biasing electromotive force is negative so that the load on the transformer is negligible. The resistance of the antenna circuit is reduced to a low value by means of the back coupling provided by the coil 17. When the signal strength is zero or constant, the electromotive force induced in the transformer 15 is zero and the grid potential of valve 11 is due to that of the grid biasing battery. Suppose it is represented by the point 18 on the curves of Figs. 2 and 3. During an increase of signal strength the grid potential of the valve 11 becomes more negative and the representative point 18 moves down the curve so that the resultant resistance of the antenna is decreased and it may even become negative, that is, the oscillations may be generated locally. As a result the growth of oscillations is facilitated. When the signal decreases in strength the representative point 18 travels up the curve and the existing oscillations are quickly reduced to their proper value.

In order that the circuit should operate without "back-lash" as is requisite if the antenna resistance becomes at any time negative, the mean grid potential of the valve 19 should be such that the representative point is on the straight portion of the characteristic or

where there is no straight portion, the point of inflexion. It should however be noted that if the mean grid potential of this valve is positive so that a grid current flows, the grid voltages will not necessarily be at the point of inflexion but may be displaced therefrom. The amount of displacement will depend upon the curvature of the grid current characteristic of the valve. The signals may be applied to telephones, recorders or the like by means for example of the transformer 20.

In Fig. 5 which illustrates connections which may be employed when it is desired to receive the incoming signal by the heterodyne method, the decrement of the antenna is varied in the manner described with reference to Fig. 4, the same elements being designated by the same reference characters in these two figures, whilst the incoming oscillations are led off through an amplifier 21 to a separate detector 21^a and are detected by the heterodyne method by inducing oscillations of suitable frequency in the grid circuit of this detector by means of the local generator 22 which may consist for example of a valve oscillation generator.

In Fig. 6 which illustrates a method wherein the decrement of the aerial may be varied by means of the grid current flowing in the first valve 19 connected therewith, the grid bias produced by the grid biasing battery 16 is such that the mean grid potential is positive and the means grid potential is varied in proportion to the rate of change of the incoming signal so that owing to the curvature of the grid current characteristic the decrement of the aerial, which in this example is shown as a frame aerial 9^a, is varied in accordance with the rate of change of the incoming signal. The transformer producing the electromotive force necessary to produce these changes of decrement is indicated at 23 and is coupled to the grid circuit through the conductors 23^a one of which is connected to one terminal of the aerial 9^a which has a tuning conductor 9^b connected across its terminals, the other terminal of said aerial being connected to the grid of the valve 19, so that the fluctuations in the electromotive force produced by the transformer 23 will be impressed on the grid of the valve 19. In order that the circuit should operate without "back-lash" in case oscillations are either intentionally or accidentally produced in the aerial, it is necessary that the characteristic of the valve should have a long straight portion so that the negative resistance effect introduced by means of the back coupling from the valves through the back coupling coils 17^a is constant although the mean grid potential may change within wide limits in order to produce the necessary changes of grid current. 14 represents the detector valve and 20 a transformer which

may be connected to a telephone or the like, as in Figs. 4 and 5.

In the examples illustrated the output current of the receiving device has been passed through the primary of a transformer and the decrement controlling electromotive force induced across the secondary circuit thereof. Alternatively the output current may be passed through a choke coil and the electromotive force controlling the decrement produced in a circuit capacitatively coupled to the said choke coil.

When transmission is effected on more than one wave length, for example when a spacing wave is employed, then a plurality of receiving devices each resonant to one of the wave lengths employed may be used, the output circuits of the said receiving circuits being interconnected to the devices producing variable decrement so that the variations of signal current in one receiving device control the decrement of circuit or circuits of another receiving device.

Fig. 7 illustrates an application of this modification of the invention to the reception of continuous wave telegraphy wherein a spacing wave is transmitted. Two antennae are employed for the reception of the signal. The antenna 24 is tuned to the signal wave and the antenna 25 to the spacing wave by the tuning condensers 24^a and 25^a respectively connected across their terminals. The oscillations induced in the antenna 24 are amplified by means of the high frequency amplifier 26 and may be detected by the heterodyne method as in Fig. 5, and the oscillations are also detected in a detector 27. The output circuit of this detector 27 consists of the transformer 28 which is so designed that the voltage induced across its secondary circuit is proportional to the rate of change of current in the primary. The secondary of the transformer 28 is connected by the conductors 28^a to the grid of a valve 29^a which is placed across the aerial 25 by the conductors 29^a and 29^b so that it produces a variable decrement therein, said decrement being varied by the change of signal strength and the change of decrement is preferably made proportional to the rate of change of signal current in the receiving circuit tuned to the signal wave and comprising the aerial 24 the amplifier 26 and the detector 27. The aerial 25 which is resonant to the spacing waves is connected to a receiver similar to that described with reference to the aerial 24 the elements 16', 26', 27', 28' and 29' of the receiver connected to the aerial 25 corresponding respectively with the elements 16, 26, 27, 28 and 29 of the receiver connected to the aerial 24 and the output circuit of the said receiver connected to the aerial 25 is interconnected by the transformer 28' and conductors 28^b to the valve 29 which is placed across the aerial 24 by the conductors 29^c

and 29^a so as to control the decrement of the aerial 24. The constant portion of the decrement of the antenna is reduced to a low value by connecting thereto a suitable negative resistance device. In the example shown the decrement of the antenna 24 is reduced by means of the back coupling 30 from the first amplifier valve 26 and the decrement of the antenna 25 is reduced by a similar back coupling 30' from the first amplifier valve 26'.

It will be seen that with this modification the decrease of signal current in one circuit decreases the decrement of the other and vice versa and oscillations are more readily brought up to their correct value for although by the modifications hereinbefore described the rate of decrease of oscillations may be made infinite the rate of increase of oscillations depends finally on the energy capacity of the oscillatory circuits. In the present modification (Fig. 7) oscillations which are locally produced in one receiving circuit at the inception of the signal may be made very strong since they are dependent on the rate of damping out of the oscillations in the complementary receiver. This method of reception will incidentally decrease or eliminate the reception of atmospherics since for the decrement of the circuits to be increased or decreased as may be required it is necessary that an increase of signal strength in one receiver occurs concurrently with a decrease in the other and vice versa. When an atmospheric or stray is received the rise and fall of amplitude of oscillations in both receivers will occur concurrently. This will prevent the rise of stray signals and quickly damp them out when they are produced.

When telephony is transmitted by varying the frequency of the transmitted waves and reception effected by operating on the slope of the resonance curves of the receiver then two receiving devices as in Fig. 7 may be employed the wave length and constant decrement of the receivers being adjusted so that a decrease in signal strength in one receiver occurs concurrently with an increase of signal strength in the other.

Although the invention has been described with reference to the reception of wireless telegraphy and telephony it is obvious that it may be applied to any system of high frequency signaling such for example as "wired wireless".

In the examples given herein the decrement of the antenna is varied by connecting a variable resistance to the antenna either by putting a variable resistance across the antenna or by connecting it thereto by means of an inductive or capacitative coupling. However, the decrement of the antenna may be varied by varying the output of the negative resistance device connected thereto. Figure 8 illustrates a characteristic of a typical nega-

tive resistance device. In accordance with this invention in order that the aerial may have a variable decrement, the said decrement is to be varied according to the rate of change and amplitude of oscillations. The mean voltage applied across the device would be on the curved portion of the characteristic; for example, the mean voltage across the device might be represented by the point 32 on the characteristic curve of Fig. 8. Then if the mean voltage is increased the negative resistance of the device is increased and the decrement of the aerial is decreased. If the voltage on the device is decreased then the reverse operation takes place. Therefore the electromotive force controlling the decrement would be applied to vary the mean potential across the electrodes of said negative resistance device. In a three-electrode valve which is reactively coupled to the input circuit and which is employed as a negative resistance device the output from the said device may be varied in several ways. For instance, the electromotive force controlling the decrement may be caused to vary the mean grid potential of the device; the grid potential when no signal is being received being adjusted so that the representative point is on the curved portion of the valve characteristic. Or the electromotive force controlling the decrement may be so applied as to vary the mean anode potential of the device the normal operating parts of the valve being suitably adjusted. However, when these methods are used considerable back lash effect occurs and hence it is necessary that the antenna should not be set either accidentally or intentionally into oscillation. Further a variable resistance consisting of a three-electrode valve may be placed in the anode circuit of the valve producing the negative resistance effect and the grid potential of this resistance valve varied by means of the electromotive force controlling the decrement so that the resistance of the valve varies in proportion to the rate of change of amplitude of the incoming oscillations and hence the output from the reactively coupled valve is correspondingly varied.

What I claim is:—

1. The method of reception in high frequency signaling systems, which comprises receiving the signals in a circuit, detecting the received signals, causing the signals after detection to effect a decrease in the decrement of said circuit while the detected signals are increasing in strength, and causing the signals after detection to effect an increase in the decrement of said circuit while the detected signals are decreasing in strength.

2. The method of reception in high frequency signaling systems, which comprises receiving the signals in an antenna, detecting the received signals in a circuit connected with

said antenna, causing the signals after detection to effect a decrease in the decrement of said antenna while the detected signals are increasing in strength, and causing the signals after detection to effect an increase in the decrement of said antenna while the detected signals are decreasing in strength.

3. The method of reception in high frequency signaling systems, which comprises receiving the signals in a circuit, detecting the received signals, causing the signals after detection to effect a decrease in the decrement of said circuit while the detected signals are increasing in strength, causing the signals after detection to effect an increase in the decrement of said circuit while the detected signals are decreasing in strength, and controlling the changes in the decrement of said circuit by variations in the strength of the signals after detection.

4. The method of reception in high frequency signaling systems, which comprises receiving the signals in a circuit, detecting the received signals, causing the signals after detection to effect a decrease in the decrement of said circuit while the detected signals are increasing in strength, causing the signals after detection to effect an increase in the decrement of said circuit while the detected signals are decreasing in strength, and controlling the changes in the decrement of said circuit by the signals after detection substantially proportionally to the rate of change of amplitude of the received oscillations.

5. The method of reception in high frequency signaling systems, which comprises receiving the signals in an antenna, detecting the received signals in a circuit connected with said antenna, causing the signals after detection to effect a decrease in the decrement of said antenna while the detected signals are increasing in strength, causing the signals after detection to effect an increase in the decrement of said antenna while the detected signals are decreasing in strength, and controlling the changes in the decrement of the antenna by the signals after detection substantially proportionally to the rate of change of amplitude of the received oscillations.

6. A receiving system for high frequency signals, comprising a receiving circuit, means for detecting the received signals, and means controlled by the signals after detection for decreasing the decrement of said circuit while the detected signals increase in strength and for increasing the decrement thereof while the detected signals decrease in strength.

7. A receiving system for high frequency signals, comprising a receiving antenna, a circuit connected with said antenna including means for detecting the received signals, and means responsive to variations in the strength of the signals after detection for decreasing the decrement of the antenna while the detected signals increase in strength and

for increasing the decrement thereof while the detected signals decrease in strength.

8. A receiving system for high frequency signals, comprising a receiving circuit, means for detecting the received signals, and means whereby the variations in the strength of the signals after detection are caused to effect decreases and increases in the decrement of said circuit substantially proportionally to the rate of increase and decrease respectively in the amplitude of the incoming oscillations.

9. A receiving system for high frequency signals, comprising a receiving circuit, means for rectifying the incoming oscillations, an inductive winding so related to the system that rectified high frequency oscillations pass through it, a variable resistance device connected with said receiving circuit, and means for controlling said variable resistance device in accordance with the voltage variations produced by the rectified oscillations across said inductive winding so that the decrement of said receiving circuit decreases and increases with the rate of increase and decrease respectively of the received oscillations.

10. A receiving system for high frequency signals, comprising a receiving circuit, means for rectifying the incoming oscillations, an inductive winding so related to the system that rectified high frequency oscillations pass through it, a variable resistance device connected with said receiving circuit, a second winding operatively connected with said variable resistance device and magnetically coupled with said inductive winding so that said variable resistance device is thereby controlled to decrease and increase the decrement of said circuit proportionally to the rate of increase and decrease respectively in the amplitude of the received oscillations.

11. A receiving system for high frequency signals, comprising a receiving circuit, means for detecting the received oscillations, a three electrode valve connected with said circuit for controlling the decrement thereof, and means operatively connected with said control electrode of said valve and responsive to variations in the strength of the oscillations after detection for effecting decreases and increases in the decrement of the circuit proportional to the rate of increase and decrease respectively in the amplitude of the received oscillations.

12. A receiving system for high frequency signals, comprising a receiving circuit, a negative resistance device for reducing the decrement of said circuit to a low value, means for detecting the received oscillations, and means responsive to variations in the strength of the oscillations after detection for controlling the output of said negative resistance device so as to effect decreases and increases in the decrement of said circuit substantially proportionally to the rate of in-

crease and decrease respectively in the amplitude of the received oscillations.

13. The method of reception of high frequency signals transmitted on a plurality of wave lengths which comprises receiving the signals in a plurality of circuits which are tuned respectively to the wave lengths employed, detecting the received signals, and causing the received signals after detection to effect a variation in the decrement of one of said circuits when the strength of the detected signals in another of said circuits varies.

In testimony whereof I have hereunto subscribed my name this eighth day of August, 1923.

ERNEST YEOMAN ROBINSON.

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