

Nov. 18, 1941.

G. GUANELLA

2,262,932

FREQUENCY VARIATION RESPONSE SYSTEM

Filed March 2, 1940

2 Sheets-Sheet 1

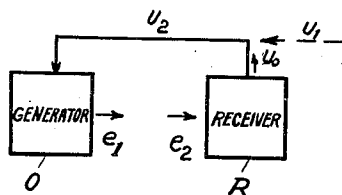


Fig. 1.

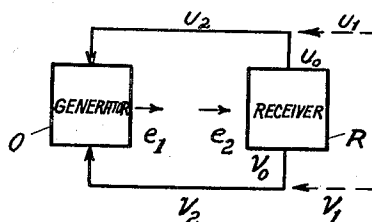


Fig. 2.

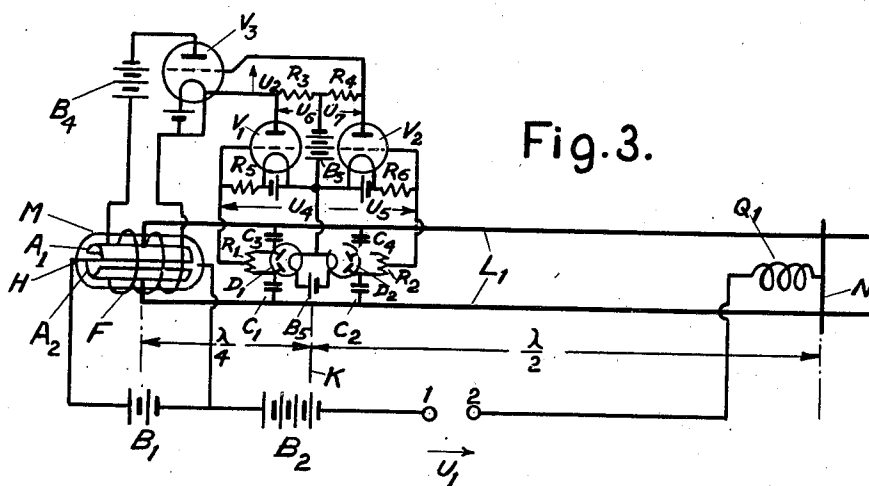


Fig. 3.

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2 Sheets-Sheet 2

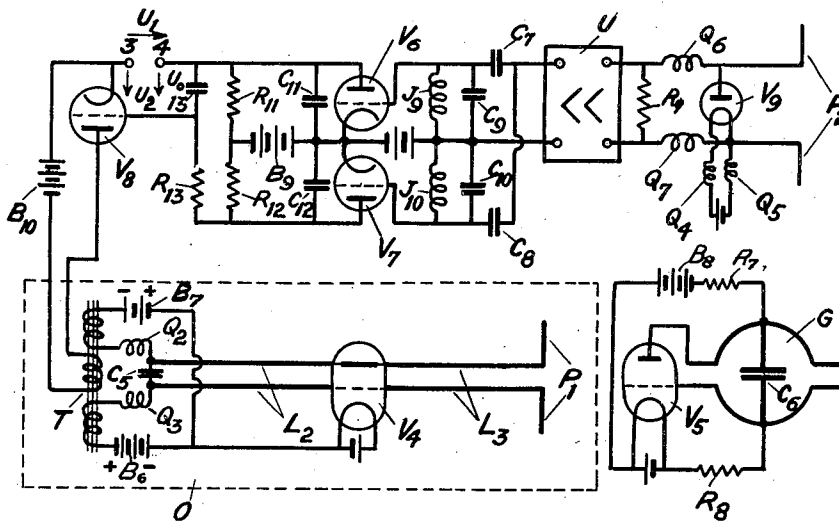


Fig. 4.

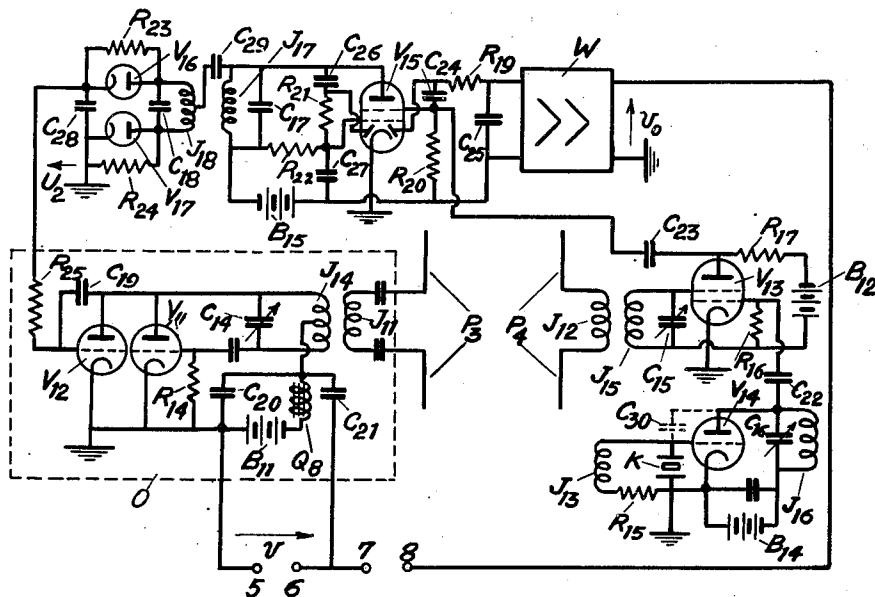


Fig. 5.

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FREQUENCY VARIATION RESPONSE SYSTEM

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Application March 2, 1940, Serial No. 321,833
In Switzerland September 14, 1939

6 Claims. (Cl. 250-17)

The present invention relates to means for and method of generating modulated high frequency oscillations, and has for its main purpose to prevent undesirable frequency fluctuations of the carrier frequency.

As is well known, the frequency of amplitude modulated oscillations produced by a vacuum tube generator may be subject to substantial fluctuations having various origins such as changes of the operating potentials, temperature and a simultaneous frequency or phase modulation of the oscillations in accordance with the variations of a modulating signal wave. Especially in the case of short waves, such frequency fluctuations cannot be avoided or may be suppressed only with great difficulties. Such fluctuations require an increased transmission band width of the apparatus and channels used for the transmission of the signals resulting in a considerable amount of interference and disturbing signals being received together with the useful oscillations. On account of this comparatively wide frequency pass range, the superheterodyne method of reception for such oscillations presents great difficulties in practice.

In my co-pending patent application, Ser. No. 208,366, filed May 17, 1938, there is described a rapidly acting automatic frequency control adapted to eliminate fluctuations of a received carrier wave and making it possible to keep the pass range or band width of the selective means in a receiver substantially within the limits of the frequency band occasioned by the signal modulation. This arrangement, while greatly improving the operation and results of a receiver, does not limit the frequency band or range of the signals generated at the transmitter and passed through a transmitting channel such as a wireless channel by radiation from an antenna or by wired wireless transmission through a co-axial cable or other transmission line.

Accordingly, an object of the present invention is the provision of means for and a method of substantially eliminating carrier frequency fluctuations of a generator for high frequency oscillations having a characteristic (amplitude, frequency, etc.) modulated in accordance with a lower frequency signal wave.

A more specific object is to provide a means and method of suppressing undesirable carrier frequency fluctuations of an amplitude modulated transmitter of the order of and in the rhythm of the frequencies of the modulating signal.

In case of frequency modulated oscillations,

undesirable additional frequency fluctuations may occur also due to various causes such as variations of the operating potentials or frequency distortion caused by non-linear frequency modulation. Such frequency fluctuations will result in unavoidable interference and distortion in the receiver.

Accordingly, a further object of the invention is the provision of means for and a method of substantially suppressing undesirable additional fluctuations of the carrier frequency in a frequency modulated transmitter.

Slow or progressive variations of the carrier frequency of a modulated oscillation can be eliminated in a known manner by the aid of a manual or automatic frequency or tuning control. Undesirable rapid frequency fluctuations equivalent to an additional frequency modulation in the rhythm of a modulating (audio, video) signal wave cannot be eliminated or minimized by the known arrangements due to the large time constant used and inherent in the known controls which are effective only for gradual or progressive rather than a periodic frequency variation.

By the present invention the disturbing periodic frequency fluctuations of a modulated high frequency carrier wave are substantially eliminated by the provision of an auxiliary receiver at the transmitter adapted to generate a regulating potential or current varying proportionately to the instantaneous deviation of the frequency with respect to a predetermined fixed value. This control potential is applied to a frequency controlling element of the oscillation generator through a transmission circuit or network including circuit elements designed to readily pass substantially instantaneously the modulating such as audible frequency components in such a manner as to reduce the relatively rapid periodic fluctuations of the carrier frequency to negligibly small value.

The novel method and further objects of the invention will become more apparent from the following detailed description taken with reference to the accompanying drawings forming part of this specification and wherein:

Figures 1 and 2 are block diagrams illustrating basic arrangements according to the invention, and

Figures 3 to 5 represent circuit diagrams of practical embodiments of the invention.

Referring more particularly to Figure 1, O represents a high frequency generator or oscillator producing a carrier wave modulated according to a signal wave and the frequency of which is nor-

mally subject to relatively rapid fluctuations in the rhythm of the signal wave variations. The portion e_2 of the carrier energy e_1 supplied by the oscillator O is received by the aid of an auxiliary receiver R embodying frequency variation response means adapted to produce a current or potential u_0 which varies in proportion to the instantaneous deviation of the oscillator frequency w from a desired value w_0 . In case of a modulated oscillation, the frequency w_0 corresponds to the desired carrier frequency and the potential u_0 is applied as control potential u_2 to a frequency controlling element of the generator oscillator O. An instantaneous frequency deviation of the generator frequency w from the desired value w_0 will then result in a control potential determined by the following expression:

$$u_2 = u_0 = c_1 (w_0 - w) \quad (1)$$

wherein c_1 is a constant.

On the other hand, each control potential u_0 will result in a proportional change of the generator frequency according to the following expression:

$$w = w_0 + w_z + c_2 u_2 \quad (2)$$

wherein c_2 is another constant and w_z represents the total of the undesirable frequency deviations having various origins such as changing operating conditions, interfering signals or the like. Due to the action of the control potential u_2 a final frequency w of the generator results whose deviation from the desired value is determined as follows in accordance with the Equations 1 and 2:

$$(w - w_0) = \frac{w_z}{1 + C} \quad (3)$$

wherein

$$C = c_1 c_2 \quad (4)$$

As is seen, this frequency deviation is $(1+C)$ times smaller than the deviation w_z without use of the invention due to any cause or origin. Thus, with sufficiently high values of the constants c_1 and c_2 employed in designing the controlling circuit, the undesirable frequency fluctuations may be kept within any desired small limit range from the carrier frequency.

The rapidity of the regulating action is determined by the building up periods of the oscillatory circuits of the generator and the receiver, by the additional transmission time through the entire control circuit as well as the time constants of any filter or smoothing circuits which may be provided. An essential characteristic of the present invention is the fact that these building up periods and time constants are never allowed to exceed the oscillating period of the frequency fluctuations to be suppressed; that is, filter or smoothing circuits are avoided incapable of passing audible or other modulating frequency components. In this manner it is possible to suppress undesirable frequency fluctuations of the generator frequency in the rhythm of the audible or other modulating frequencies by means of a continuous or fast acting automatic frequency control. In practice the time constant of the total control circuit should be at the most of the order of 1000 of a second to fulfill this requirement for both audible and video frequencies to insure compensation of rapid carrier frequency fluctuation at the rate or directly in accordance with the signal frequencies.

The omission or reduction of the smoothing or filtering of the control potential applied from the auxiliary receiver to the transmitter through the

control circuit entails an increased tendency to hunting of the controlling system. This tendency to hunting can be avoided by a proper design of the transit time T_1 and the transition time T_2 of the control circuit, the former comprising the total transmitting time through all the oscillatory and other circuits, amplifiers, etc., of the control system, while the latter comprises the time required for the building up of the control potential upon occurrence of a sudden frequency variation, provided the building up occurs according to a linear function with respect to time. It can be shown that a stable control action is based upon the condition:

$$\frac{T_2}{T_1} > C - 1 \quad (5)$$

that is, the transit time T_1 should have a sufficiently small value. Since this transit time decreases as the band width of the tuned circuit increases, oscillatory circuits with very low damping or band pass filters with too small a pass range should be avoided. Since the method of the invention is of primary use for short wave oscillations for which circuits with an extremely low damping still have a substantial band width, the afore-mentioned requirement can be fulfilled in an easy manner in practice.

The method of the invention is also suited for controlling oscillations having a frequency modulated according to a signal frequency wave u_1 . In this case the desired frequency w_3 is not constant but varies in the rhythm of the modulating wave u_1 as shown by the following expression:

$$w_3 = w_0 + c_3 u_1 \quad (6)$$

wherein w_0 represents the constant average or carrier frequency and c_3 is a constant which may be assumed as follows:

$$c_3 = \frac{C_2}{1 + c_1 c_2} \quad (7)$$

A continuous adjustment of the frequency w to this desired value is obtained if the sum of the potential u_0 produced in the frequency demodulator stage of the auxiliary receiver and the modulating signal potential u_1 to be transmitted is applied to the generator O as frequency control potential u_2 . In Figure 1 this addition of the signals u_0 to the demodulated potential produced in the receiver R is indicated by the dashed arrow, whereby:

$$u_2 = u_0 + u_1 = c_1 (w_0 - w) + u_1 \quad (8)$$

and the generator in place of the uncontrolled frequency $(w_0 + w_z)$ will produce a frequency in view of Equations 2 and 8 as follows:

$$w = w_0 + \frac{w_z + c_2 u_1}{1 + C} \quad (9)$$

This frequency in turn deviates from the desired value w_3 by a negligible amount according to the following expression:

$$(w - w_3) = \frac{w_z}{1 + C} \quad (10)$$

provided the constant C has a sufficiently high value. All variations w_z of the uncontrolled generator frequency including any non-linear frequency modulation are accordingly without appreciable influence upon the frequency w of the oscillations. In case of frequency modulation of the oscillations produced by the generator O it is desirable to maintain the amplitude of the oscillations substantially constant inasmuch as amplitude fluctuations result in corresponding distur-

tion of the output signals of the frequency demodulator stage in most of the known receiving systems.

According to Figure 2 the amplitude A may be maintained at a desired value A_0 by means of a special amplitude control (AVC) potential v_2 . This control potential is produced by rectification of the oscillations in the receiver R and is applied to an amplitude controlling element of the generator O in such a sense as to counteract the deviations of the amplitude from the desired value. The control potential v_2 may be expressed as follows:

$$v_2 = k_1(A_0 - A) \quad (11)$$

wherein k_1 is a constant. The amplitude of the frequency modulated oscillations is then as follows:

$$A = A_0 + A_z + k_2 v_2 \quad (12)$$

wherein k_2 is a further constant and A_z represents the total of the amplitude deviations to be reduced or eliminated. The deviation of the amplitude obtained by this regulation from the constant value is then as follows in view of Equations 11 and 12:

$$(A - A_0) = \frac{A_z}{1 + K} \quad (13)$$

wherein

$$K = k_1 k_2 \quad (14)$$

From the above it is seen that with sufficiently high value of K the amplitude fluctuations A_z which may be caused by varying operating potentials, simultaneous amplitude and frequency modulation, etc., may be reduced to a negligibly small value. In order to suppress the instantaneous amplitude fluctuations occurring in the rhythm of the modulating (audio, video, etc.) signals, filters or smoothing networks in the transmission path of the control potential blocking or suppressing the modulating frequency components are to be avoided. In order to prevent hunting within the control system for the rapid amplitude control, the following stability condition:

$$\frac{T_1}{T_3} > K - 1 \quad (15)$$

should be fulfilled, wherein T_3 represents the total transmitting period for the AVC potential caused by all the elements in the AVC circuit, and T_1 represents the time of building up of the amplitude control potential upon occurrence of a sudden amplitude variation, provided the building up follows a linear function.

If the oscillations produced by the generator O are amplitude modulated in accordance with a signal wave to be transmitted, the instantaneous amplitude deviations from the desired value may be reduced by means of rapid amplitude control described hereinbefore by applying the sum of the signals v_1 to be transmitted and the potential v_0 proportional to the amplitude obtained after rectification in the control receiver as the total amplitude control potential v_2 to the oscillator, whereby the desired amplitude is expressed as follows in case of linear modulation of the transmitter:

$$A_3 = A_0 + k_3 v_1 \quad (16)$$

wherein A_0 represents the constant amplitude of the carrier wave and k_3 is a constant which may be assumed as follows:

$$k_3 = \frac{k_2}{1 + k_1 k_2} \quad (17)$$

If the signals to be transmitted v_1 are applied as indicated in dotted lines in Figure 2, the amplitude control potential will be as follows:

$$v_2 = v_0 + v_1 = k_1(A_0 - A) + v_1 \quad (18)$$

and in turn the uncontrolled amplitude ($A_0 + A_z$) of the oscillations produced by the generator will assume a value as follows in accordance with Equations 12 and 18:

$$A = A_0 + \frac{A_z + k_2 v_1}{1 + K} \quad (19)$$

This amplitude deviates merely by a negligible value from the desired amplitude A_3 as shown in the following:

$$(A - A_3) = \frac{A_z}{1 + K} \quad (20)$$

provided K has a sufficiently high value. All variations A_z of the uncontrolled amplitude as caused by the supply voltage fluctuations, amplitude distortion due to non-linear modulation, etc., in this manner are without appreciable influence upon the actual amplitude A of the controlled oscillations. In other words, this amplitude control constitutes an inverse feedback between the output and input of the transmitter providing all the advantages thereof known in the art.

Several practical embodiments of the invention are shown in Figures 3 to 5 and will now be described in detail.

In the arrangement according to Figure 3, the oscillations to be controlled are produced by the aid of a magnetron M of known design comprising a pair of semi-cylindrical anodes A_1 and A_2 enclosing a cathode or filament H and surrounded by a magnetic coil F adapted to produce a magnetic field substantially in the direction of the filament H . The oscillations generated are impressed upon a Lecher wire or standing wave system L_1 connected to the anodes A_1 and A_2 and provided with a short circuit rod or conductor N for tuning it to the generator frequency in a manner well understood by those skilled in the art. The anode potential supplied by a battery or the like B_2 is impressed upon the center point of the short circuit conductor N through a choke coil Q_1 , while the filament H is suitably heated such as by means of a separate filament battery B_1 . The modulating signal potential u_1 which may be an audio or other signal wave is superimposed upon the anode potential by way of terminals 1, 2 to effect amplitude modulation of the magnetron oscillations. If the frequency of the oscillations is equal to the desired (carrier) frequency ω_0 , a nodal point will occur at a point of the Lecher system as indicated at K . A pair of double diode rectifiers D_1 and D_2 are connected to the opposite wires of the Lecher system through condensers C_1 to C_4 at equally spaced distances from the nodal point K . The filaments of the double diodes are energized by a common battery B_3 , and the anodes of each diode connected through resistors R_1 and R_2 , respectively. As is understood, single diode or any other type of rectifier may be provided for the purpose of the invention. If the oscillator frequency has a desired value (ω_0), the diodes D_1 and D_2 will be excited by equal potentials resulting in like rectified potentials u_4 and u_5 across the diode load resistors R_3 and R_4 which potentials are impressed upon the grids of triode amplifiers V_1 and V_2 . The latter are supplied with a common plate battery B_3 and have

their output load resistors R_3 and R_4 connected in series in opposing polarity. Accordingly, the combined differential output potential u_2 will be zero if the oscillator frequency corresponds to the desired value—amplified output potentials u_6 – u_7 being equal to each other—and will increase in either direction from zero in accordance with and in proportion to an increase or decrease, respectively, of the generator frequency with respect to the desired value. The potential u_2 accordingly varies in proportion to the generator frequency deviations from the desired value both in magnitude and sign and is utilized for controlling the oscillator frequency by energizing the magnet coil F after amplification by means of triode V_3 in addition to the steady energization by a battery B_4 . The polarity adjustment and connections of the system are such that the frequency variations caused by the potential u_2 counteract the initial frequency variation resulting in generation of the potential u_2 . Since the frequency of the magnetron oscillations is dependent upon the strength of the magnetic field the Equation 2 is fulfilled at least approximately; that is, a control potential produced by an instantaneous variation of the magnetron frequency will counteract this variation, thereby reducing any frequency variations to a minimum in accordance with the Expression 3.

Referring to Figure 4, there is shown a system for eliminating or reducing undesirable frequency fluctuations in a frequency modulated transmitter. The generator O in the example shown comprises a breaking field oscillator V_4 of the Barkhausen type to produce micro rays and having a Lecher wire system L_3 terminating in a dipole antenna P_1 connected to one side of its grid and anode electrodes in a manner well known. Positive grid and negative plate operating potentials supplied by batteries B_6 and B_7 are applied through a further Lecher wire system L_2 connected to the opposite ends of the grid and plate of the tube V_4 in series with the choke coils Q_2 and Q_3 , the wire system L_2 being terminated by a blocking condenser C_5 . Each of the plate and grid circuits further includes a secondary winding of the transformer T for applying a modulating potential to be described in detail hereafter. G represents a constant frequency spherical oscillator of known design comprising a pair of metal shells connected through a condenser C_6 and constituting together with a triode V_5 an auxiliary oscillator whose frequency due to the low losses and invariant resonance characteristics is extremely constant. B_8 represents the anode battery, R_7 a voltage drop resistance and R_8 a grid leak resistance for this constant frequency or standard oscillator. The oscillations produced by this oscillator are received simultaneously with the oscillations produced by the generator O by the dipole P_2 of the auxiliary or control receiver. The beats produced due to the difference of the frequencies of both oscillations result in an alternating potential after rectification in the diode rectifier V_6 , and sufficient filtering by a network comprising series choke coils Q_6 and Q_7 and a parallel resistance R_9 . This alternating beat potential at any time corresponds to the difference frequency between the high frequency oscillations superimposed and applied to the diode V_6 . Any variation of the frequency of the oscillations of the generator O thus causes a corresponding variation of the beat frequency which latter is amplified by means of an amplifier U and applied by

way of coupling condensers C_7 and C_8 to a pair of resonant circuits comprising inductance coils J_9 and J_{10} shunted by condensers C_9 and C_{10} , respectively. One of these resonant circuits is tuned slightly above and the other below the average beat frequency w_0 in such a manner that the signal amplitudes in these circuits, and in turn the potentials developed in the output circuits of a pair of vacuum tube rectifiers V_8 and V_7 are equal to each other if the beat frequency is equal to the desired average value w_0 . The triode rectifiers V_8 and V_7 are shunted by condensers C_{11} and C_{12} and provided with output resistors R_{11} and R_{12} connected differentially with a common plate supply source B_9 between the cathodes of the rectifiers and the junction point of the resistors. The differential potential u_0 is derived by means of condenser C_{13} connected in series with a further resistance R_{13} forming a potential divider across the anodes to the rectifiers. Upon deviation of the transmitting frequency from the desired value, the beat frequency in the detuned circuits exciting the rectifiers V_8 and V_7 is varied accordingly whereby the oscillation amplitudes in these circuits become unequal due to the fact that the frequency approaches the resonant frequency of one circuit while simultaneously receding from the resonant frequency of the other circuit. The rectified potentials are then also unequal whereby the differential potential u_0 corresponds to the instantaneous deviations of the transmitting frequency from the desired value both in sign and magnitude. If the terminals 3 and 4 were short circuited this potential would act as control potential u_2 applied after further amplification by means of a triode amplifier V_8 to the primary of the transformer T superimposed upon the steady anode current supplied by battery B_{10} . Since the frequency of the oscillator V_4 is dependent upon the potentials on the grid and plate a corresponding variation of the frequency will ensue in accordance with the variations of the control potential u_0 . In this manner undesirable fluctuations of the oscillator frequency may be eliminated or reduced to a negligible value in substantially the same manner as described hereinbefore. If, as shown in the diagram, the sum of the potential u_0 produced by means of the auxiliary receiver and the modulating potential u_1 applied by way of terminals 1 and 2 is used as controlling potential u_2 , then the instantaneous transmitting frequency deviation will be automatically adjusted at any instant in accordance with the instantaneous value of the modulating signal u_1 as follows from Formula 9. All undesirable frequency fluctuations, which without the special frequency control would have the instantaneous value w_z , are reduced according to Formula 10 to a negligible minimum. As is understood, the time constants of all the circuits in the control receiver should be kept low relative to the oscillation period of the disturbing frequencies to be suppressed. This applies especially to the building up periods for the resonant circuits C_9 – J_9 and C_{10} – J_{10} which should have a minimum damping as pointed out hereinabove.

Referring to Figure 5, there is shown a system comprising an amplitude modulated generator embodying means for maintaining the carrier frequency at a constant value and a special amplitude limiting arrangement for the oscillations used for producing the frequency control potential. The oscillator O comprises a vacuum tube V_{11} having associated therewith a regenerative

system for producing sustained oscillations comprising an oscillatory tank circuit consisting of an induction coil J_{14} shunted by a condenser C_{14} and connected between the grid and plate of the tube. The cathode is connected to a tap of the induction coil J_{14} in series with a space current source B_{11} and a high frequency choke coil Q_8 , both the latter being by-passed by a condenser C_{20} for the high frequency oscillations. R_{14} is a grid leak resistance provided to produce steady operating grid bias in a manner well known. The oscillations are impressed upon a dipole antenna P_3 by way of a secondary winding J_{11} in inductive coupling relation to the inductance J_{14} . The low frequency or modulating signals v are applied by way of terminals 5, 6 and coupling condenser C_{21} to be superimposed upon a steady anode potential supplied by the battery B_{11} . A further vacuum tube V_{11} acting as a control tube is shunted across the oscillator tube V_{12} having its plate and grid connected through a condenser C_{19} whose impedance for high frequency current is high compared with the impedance of the resistance R_{25} . In this manner, the anode cathode path of the tube 12 constitutes an effective capacity which may be varied by controlling the amplification in accordance with an average grid potential applied through the resistance 25. By this electronic capacity the tuning of the generator may be varied within predetermined limits.

The oscillations received by the antenna P_4 of the auxiliary or control receiver are applied through the primary J_{12} of a tuned input transformer having a secondary G_{15} shunted by a tuning condenser C_{15} to one of the grids of a mixing tube V_{13} . The other grid of tube V_{13} is excited in accordance with a standard oscillation produced by a separate oscillator tube V_{14} by way of coupling condenser C_{22} and grid leak resistance R_{16} . The grid circuit of the auxiliary oscillator comprises an inductance coil J_{13} , a biasing resistance R_{15} and a piezo-crystal or other stabilizing device K , while the anode or plate circuit includes a parallel resonant circuit consisting of an inductance coil J_{18} shunted by variable condenser C_{16} . B_{14} represents the anode current source by-passed by a condenser for high frequency currents in a manner well known. The feedback between the plate and grid circuits for maintaining sustained oscillations in the example shown is by way of the internal grid-anode capacity C_{30} as indicated by dotted lines in the drawing. It is understood that any other stabilized oscillator may be used for the purpose of this invention.

There is thus produced in the output of the modulating or mixer tube V_{13} which includes a load resistance R_{17} and a space current supply source B_{12} a component having a frequency equal to the difference between the frequency of the generator O and the standard crystal oscillator. This difference frequency accordingly varies in proportion to the frequency fluctuations of the received oscillations and is applied to a control grid of a composite duo-diode multi-grid amplifying tube V_{15} by way of coupling condenser C_{23} and grid leak resistance R_{20} . The amplified intermediate frequency oscillation is impressed from the plate of tube V_{15} upon one of the diode anodes of the tube through coupling condenser C_{26} , whereby a further condenser C_{27} is charged through a resistance R_{21} to a potential proportional to the intermediate frequency amplitude. The condenser C_{27} is continuously discharged through a resistance R_{22} in such a manner that

the potential at this condenser is enabled to follow the relatively rapid signal amplitude fluctuations. This (AVC) potential is applied to another grid of the tube V_{15} adapted to control the signal amplification in such a manner as to counteract the amplitude fluctuations of the signal variations in the anode circuit. Thus, the amplitude fluctuations or modulation of the oscillations applied to the intermediate frequency resonant circuit $C_{17}-J_{17}$ are substantially suppressed. Any other known limiting device or system may however be provided to obtain the same object as is understood. B_{15} represents the anode current supply source for the tube V_{15} . $J_{18}-C_{18}$ is a secondary tuned circuit arranged in inductive coupling relation with the circuit $J_{17}-C_{17}$ and having its electrical center (center tap of inductance 18) connected to the high potential side of the circuit $J_{17}-C_{17}$ through coupling condenser C_{29} . In this manner the sum and difference of the primary and secondary potentials of the resonant circuits are set up at the opposite sides of the tuned secondary circuit which sum and difference potentials are rectified by the aid of a pair of diode rectifiers V_{16} and V_{17} shunted by load resistors R_{23} and R_{24} having their anodes connected to the opposite sides of the resonant circuit and having their cathodes connected through a condenser C_{28} in such a manner that a rectified differential potential characteristic of the instantaneous deviations of the carrier frequency produced by the oscillator O from a desired value both in magnitude and sign is applied to the grid of the variable reactance tube V_{12} to control the tuning of the oscillator frequency so as to counteract an initial frequency deviation. According to a feature of the invention, the regulating circuit for the frequency control should have a sufficiently low time constant to prevent suppression of fluctuating frequency components within the range of the modulating frequencies. In particular, the building up period for the band-pass filter $C_{17}-J_{17}-C_{18}-J_{18}$ should be sufficiently high or the pass range of the filter should be large with respect to the low frequency components of the transmitter frequency fluctuations. A reaction upon the rapid frequency control due to the amplitude modulation is substantially avoided by the suppression of the amplitude variations by the tube V_{15} .

In order to control the low frequency modulation, the intermediate frequency oscillations are further applied by way of a condenser C_{24} to a further diode anode of the tube V_{15} . The thus obtained low frequency potential v_0 after sufficient filtering by means of series resistance R_{19} and condenser C_{25} and after amplification by means of an amplifier W is superimposed upon the initial modulating potential v_1 supplied by way of terminals 7, 8 and the sum $v_2 = v_0 + v_1$ impressed as modulation potential upon the oscillator O . In this manner the high frequency amplitude A coincides at all times with great accuracy with the desired value A_3 due to the rapid amplitude control as follows from formula 20; that is, in other words, all non-linear amplitude distortions or other disturbances A_2 are reduced to a negligible minimum by a negative feed-back or modulation control of this type.

It will be evident from the foregoing that the invention is not limited to the specific circuit arrangements and details as well as steps described and disclosed herein for illustration, but that the underlying idea and principles of the invention are susceptible of numerous variations and modi-

fications coming within the broader scope and spirit of the invention as defined in the appended claims. The specification and drawings are accordingly to be regarded in an illustrative rather than a limiting sense.

I claim:

1. The combination with a transmitting system comprising an oscillator for generating a short wave carrier frequency, said carrier being subject to undesirable fluctuations in frequency, a standing wave tuning system excited by said oscillator and adapted to produce a standing potential wave having a nodal point shifting to either direction from a normal position in proportion to deviations of the oscillator frequency above and below, respectively, a desired frequency, means to derive potentials from points opposite to and equi-distant from said nodal point, means for rectifying the derived potentials and for differentially combining the rectified potentials, a frequency control element for said oscillator, and further means for impressing the differential potentials upon said control element to counteract the frequency deviations of said oscillator.

2. The combination with a transmitting system comprising an oscillator for generating a short wave carrier frequency modulated in amplitude according to a signal frequency wave, said carrier being subject to undesirable fluctuations in frequency at the rate of said signal frequency, a standing wave tuning system excited by said oscillator and adapted to produce a standing potential wave having a nodal point shifting to either direction from a normal position in proportion to deviations of the oscillator frequency above and below, respectively, a desired frequency, means for deriving potentials from points opposite to and equi-distant from said nodal point, means for rectifying the derived potentials and for differentially combining the rectified potentials, a frequency control element for said oscillator, and further means for impressing the differential potential upon said control element to counteract the deviations of the carrier frequency to substantially instantaneously compensate said carrier fluctuations.

3. In a transmitting system comprising an oscillator, a standing wave system excited by said oscillator, said standing wave system adapted to produce a standing potential wave having a nodal point shifting to either direction from a normal position in proportion to deviations of the oscillator frequency above and below, respectively, a predetermined frequency, means for deriving a pair of potentials from points at oppo-

site sides of and substantially equally spaced from said nodal point, means for rectifying the derived potentials and for differentially combining the rectified potentials to produce a control potential varying in sign and magnitude in proportion to frequency deviations of said oscillator from said predetermined frequency, control means responsive to electric potential for varying the frequency of said oscillator, and means for impressing said control potential upon said control means to counteract the frequency deviations of said oscillator.

4. A frequency variation response system comprising a standing wave system excited by radio frequency signals of varying frequency, said standing wave system adapted to produce a standing potential wave having a nodal point shifting to either direction from a normal position in proportion to deviations of the signal frequency above and below, respectively, a predetermined frequency, means for deriving a pair of potentials from points at opposite sides of and substantially equally spaced from said nodal point, means for rectifying the derived potentials, and further means for differentially combining the rectified potentials.

5. A frequency variation response system comprising a standing wave system excited by high frequency signals of varying frequency, said standing wave system adapted to produce a standing potential wave having a nodal point shifting to either direction from a normal position in proportion to deviations of the signal frequency above and below, respectively, a predetermined frequency, means for deriving a pair of potentials from points located at opposite sides of and substantially equally distant from said nodal point, means for rectifying the derived potentials, and further means for differentially combining the rectified potentials.

6. A frequency variation response system comprising a two wire system excited at one end by radio frequency signals of varying frequency and provided with reflecting means at the opposite end to produce standing waves, a pair of rectifiers with means for impressing thereon signal voltages derived from two pairs of tapping points of said system, said pairs of tapping points being located at opposite sides of and substantially equally distant from a potential nodal point of said system when the exciting frequency has a predetermined value, and means for differentially combining the rectified potentials.

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