

Sept. 9, 1941.

L. E. RYALL

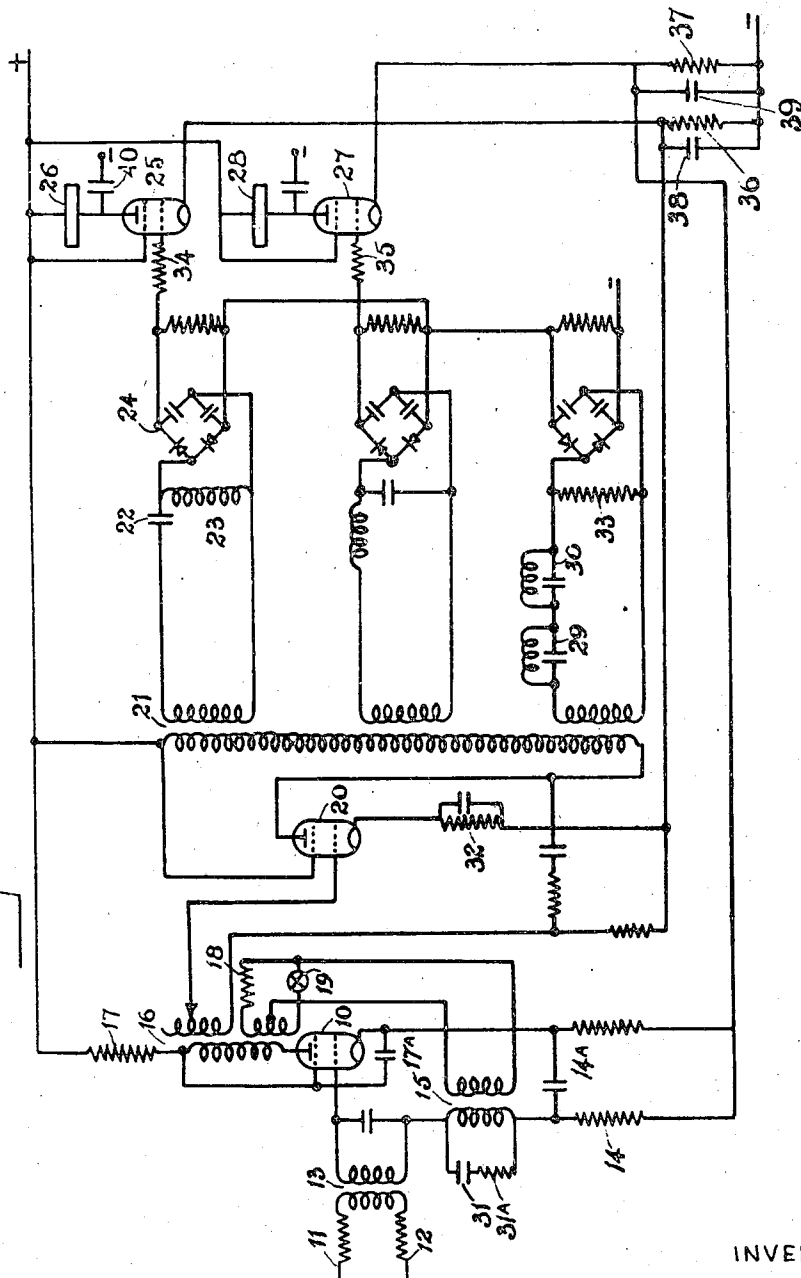
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VARIABLE AMPLIFYING DEVICE

Filed Jan. 27, 1940

2 Sheets-Sheet 1

Fig. 1



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2 Sheets-Sheet 2

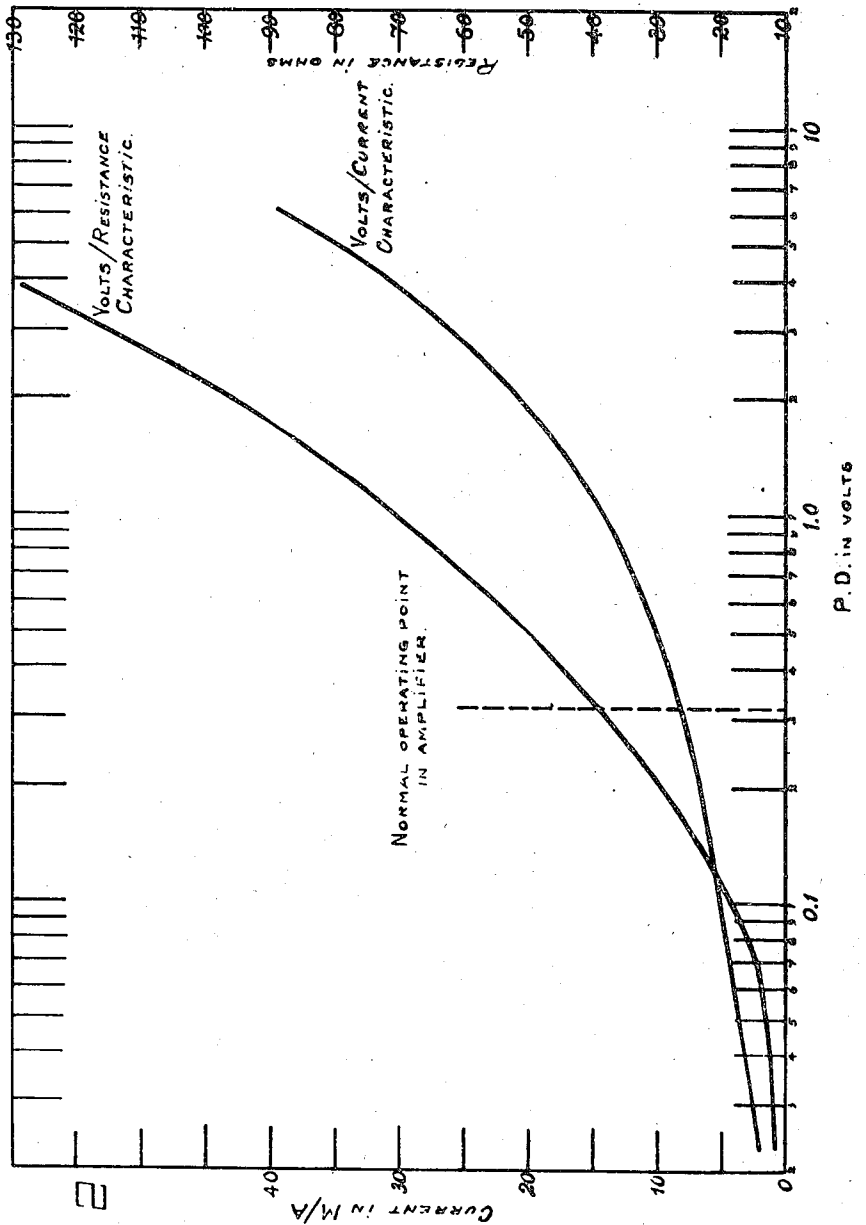


Fig. 2

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VARIABLE AMPLIFYING DEVICE

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11 Claims. (Cl. 179-84)

The present invention concerns improvements in or relating to amplifying circuits and has for its object the provision of a circuit which is suitable for use as an amplifier in which the gain is controlled in accordance with the signal input thereto and has the further object of providing a circuit which is of particular advantage in connection with the reception of alternating current signals.

According to one feature of the present invention current is fed back from the output to the input circuit of an amplifying device so as to cause the device to be normally in a state of oscillation, said feedback path including a non-linear impedance device by which the amount of feedback is varied with the strength of the signals received in such a manner that the amplification of weak signals is greater than the amplification of strong signals. According to a further feature of the invention the gain or amplification factor of an amplifying device is caused to vary with the strength of the signals received by providing a feedback path between the output and the input to bring the device into a state of oscillation, which includes an impedance device variably controlled by the output to modify the amount of feedback so that the amplification of the stronger signals is less than the amplification of the weaker signals.

In receiving alternating current signals of a predetermined frequency from a circuit over which currents of other frequencies are allowed to pass it has been usual to provide a limiting device so that the actual receiving equipment tends to receive current of constant amplitude or approximately constant amplitude. Such devices in practice are found to have the disadvantage that they introduce harmonics of the fundamental frequency of the signal which is disadvantageous, particularly in the case where currents of other frequencies than the signalling frequency are used as these harmonics have to be rendered more effective as they would otherwise tend to weaken the sensitivity of the device for receiving the signals of predetermined frequency and according to a further feature of the invention such limitation is brought about by an impedance device having a time factor such as a resistance in vacuum or in an inert gas which causes the amplitudes of the weaker and stronger signals to more nearly approach each other without causing the generation of harmonic frequencies before reaching the tuning arrangement by which

currents of the predetermined frequency are alone enabled to control the signal responding device, the time factor being so chosen that the device will not respond to variations corresponding to the harmonic component of the signal but only to changes which take place over a period greater than one cycle of the predetermined frequency. That is to say, the device does not respond to the instantaneous values of the currents received but rather to the mean or R. M. S. value of such currents.

The preferred form of device for meeting the above conditions conveniently takes the form of a filament wire in a vacuum or gas-filled envelope whose resistance varies in accordance with the current flowing through it having regard to the fact that due to the heat inertia it will not respond to very rapid changes of current. Preferably the adjustment of the feedback path of the thermionic valve amplifier device is arranged so that the valve device is in the condition of oscillation and the effect of a received signal is to cause the system to stop oscillating. As is well known in this condition the amplification factor of the valve is a maximum and the greater the amplitude of the received signal the greater will be the departure from the point of oscillation and consequently the less will be the amplification of the system.

One arrangement for carrying the invention into effect will be described by way of example with reference to the accompanying drawings which illustrate the application of the device to the reception of signalling currents of two different predetermined frequencies. It will be understood however that the invention can be readily applied to the reception of a single predetermined frequency and also for other purposes in which the output of a valve with respect to the input requires to be automatically and variably controlled.

Fig. 1 is a schematic diagram of the invention.

Fig. 2 is a graph explaining the operation of Fig. 1.

In Figure 1 of the accompanying drawings the oscillatory amplifier is represented by a single valve 10 which may be of the screen grid or pentode type, although other forms of valves are suitable, or combinations of more than one valve may be employed. The input for valve 10 is fed in over the terminals 11, 12 which may be connected to a telephone line or cable or to a wireless receiver or the like. The current passes via the transformer 13 to the grid cathode circuit

which includes a high impedance 14 and decoupling condenser 14A. The input circuit also includes the secondary winding of a transformer 15, the primary of which is connected to the output circuit as will be described later. The primary of the input transformer 13 is connected to the line through two resistors of such a value that the tapping loss is of such a value that for a voice frequency range from 200 to 3000 cycles per second, the tapping loss is kept within very low limits. If the transformer 15 is disconnected the amplification of the valve 10 is reasonably uniform over the voice frequency range. The output circuit of the valve 10 includes the primary winding of a transformer 16 and a decoupling resistance 17 and condenser 17A. The lower secondary winding of the transformer 16 has a central tapping and is arranged to form two arms of a bridge arrangement, the other two arms of which consist of a fixed resistance 18 and a non-linear resistance 19, the primary of the transformer 15 being connected to the midpoint of the transformer winding and to the junction point of the resistances 18 and 19. The upper secondary winding of the transformer 16 is connected to the grid and cathode of a valve 20 the output of which includes the primary winding of a transformer 21 having three secondaries. The uppermost secondary serves to supply a tuning device for one of the predetermined frequencies, say 750 cycles and comprises a series condenser 22 and a shunt inductance 23, across the inductance being a rectifier bridge 24, from which currents are fed to the input circuit of the valve 25 having a responding relay 26 (preferably quick acting) or its equivalent in the anode circuit. The circuit connected to the middle secondary winding is similar except that the rectifier bridge is connected across the condenser and it is tuned to a different frequency, for instance 600 cycles per second and controls via a valve 27 a relay 28. The circuit connected to the lower winding constitutes a guard circuit which is adapted to reject currents of frequencies to which the two above-mentioned devices respond by means of the rejector circuits 29 and 30 and its sole purpose is to provide a potential in the grid circuit in opposition to the potentials generated in the grid circuits of the valves 25 and 27 so as to render these valves non-responsive or less responsive. The latter arrangement acts as a guard circuit and need only operate on frequencies away from the signal frequencies, for instance above 1000 cycles per second and below 500 cycles per second. Such a guard circuit has not been possible hitherto because the harmonic and inter-modulation products introduced by the limiting devices generally used have prevented an effective guard circuit operating over a frequency range covering the second and third harmonic frequencies of the signalling currents, especially for receivers which had to accept compound frequency signals. The new guard circuit has proved so effective in practice that when used in conjunction with compound signals wide band signal acceptor circuits can be used and the tuned circuits need only have low Q values. An effective band width of 300 cycles per second can be provided for impulsing so that almost rectilinear impulse signals are obtained. If the rectified guard voltage has a longer build-up time and a longer decay time than the rectified signal voltage the wave front (and end) of the signal impulse is not affected by the guard voltage as the front (and end) have formed before the effect

of the guard voltage comes into play. Hence a larger guard voltage could be used without affecting the impulse characteristics. The equivalent band width used in impulsing is derived from the rectified signal only which is larger than when the guard voltage is taken into account. Such a receiver may be designed so that no adjustments need be made when installed and the impulsing distortion is very small even when supply voltages and valves vary over wide limits.

The signal from the line or other source is passed via a high impedance input circuit to the oscillating amplifier 10 where the output power is controlled so as to be substantially constant; for instance with an input variation of 25 db. the output may be constant to within + or - 1 db. The actual value of the output is solely determined by the wire resistor 19 which varies with signal strength in conjunction with the resistor 18 which does not vary. The constant output is fed to a buffer amplifier stage 20 provided with negative feedback to make the voltage independent of load, valve and supply variations.

The valves 25 and 27 are normally biased so that the anode current is almost zero and the rectified signal voltages applied to their grid circuits cause the anode currents to increase and operate relays 26 and 28 which are conveniently of high speed type.

The signal fed back through the anode circuit to the grid circuit of valve 10 it will be noted is taken from the diagonally opposite corners of a bridge circuit and the automatic volume control device of the invention operates by changing the feedback from positive to negative as the input level increases. The non-reactive resistor 18 has approximately twice the impedance of the resistor 19 with no current flowing. The resistor 19 conveniently consists of a metal filament lamp and has a voltage current characteristic and a voltage resistance characteristic of the kind shown in Fig. 2. The bridge is therefore unbalanced so that a considerable positive feedback effect is normally obtained which is arranged to be sufficient to produce oscillation. The oscillation currents heats the lamp filament 19 so that its resistance increases and reduces the feedback. This continues so that oscillation is only just maintained. Under this condition the resistance of resistor 19 is only very slightly less than resistor 18 and a very small change of the current in 19 is then sufficient to reduce the positive feedback to zero or even to change it to negative feedback whenever the resistance of 19 exceeds that of 18. The frequency response characteristic of the circuit when not in oscillation should be nearly uniform over the range of frequencies over which it is desired to operate the amplifier. The oscillation frequency occurs at the frequency of maximum amplification and this is arranged to be just outside the operating frequency bands of the signals to be received. When an input of signal or normal speech frequencies is received via the transformer 13 the signal is initially amplified considerably, since a system in oscillation has an infinite amplification at the oscillating frequency and a very high amplification at other frequencies. The increased output causes the temperature of the lamp to rise and consequently the resistance of 19 to increase. This causes the quiescent oscillation to stop and reduces the positive feedback with the result that the amplification of the system will fall until equilibrium is established. The output from the

amplifier now corresponds in frequency to the input into transformer 13 and the RMS amplitude is very slightly above that of the quiescent oscillation since the lamp resistance 19 is only changed to a very small degree. Any further increase of input to transformer 13 causes only a very slight increase in output which is sufficient to affect the feedback so that the amplification is reduced by an amount almost corresponding to the increase in signal input level.

Advantages of this arrangement are that the controlled output level can be determined almost entirely by simple resistance values of 18 and 19 and their resistance temperature coefficients. These values can be determined very simply and do not change with time so that external influences cannot affect the operation appreciably. Variations of valve amplification due to changes in the amplifying valve and the anode and heater supplies only change the level at which the input signal takes control to cause the natural oscillations to cease. By using a pure metal such as copper for the resistance 18 having the same resistance coefficient as 19 (approximately .004 ohm per degree centigrade for tungsten) the output level becomes practically independent of temperature variations.

A further advantage of the invention is that owing to positive feedback the circuit provided a large maximum amplification.

A further advantage is that the quiescent oscillation maintains the temperature of the lamp 19 at the operating value so that very little extra heat has to be introduced when a signal is received in order to produce the desired volume control. Hence the speed of operation is high while a further advantage is that negligible harmonic distortion is introduced. The RMS output is maintained constant instead of as with other automatic volume control circuits which operate on peak voltages and in which the level of each component of the two-frequency signal may be reduced as much as 6 decibels as compared with the level of a simple signal assuming that the signals are each of the same amplitude. By operating on RMS voltages the reduction in amplitude is much less.

The valve 10 may take the form of any valve with a good mutual conductance, for instance an electron multiplier could be used. The larger the amplification of the valve however the smaller is the amount of feedback required to maintain oscillation and hence the more nearly the resistance of 19 can approach the resistance of 18 so that very small changes of the resistance of 19 can effect a large degree of feedback control. The output of the valve is limited by the decoupling resistor 17 in the anode circuit so that when operating with, for instance, 150 volt anode supply, the maximum power obtainable is only just sufficient to cause the lamp 19 to glow a dull red. The lamp cannot therefore be burnt out by excessive input voltages. The resistance lamp 19 can also be of standard design, for instance, a lamp having a nominal rating of 6 volts 40 milliamps has been found to be very satisfactory. The lamp normally operates with a resistance of about 40 ohms when the voltage across it is .33 volt, so that its power consumption is less than 3 mw. as compared with its lamp rating of 240 mw. Thus the lamp acts solely as a resistance wire operating in a vacuum and has an indefinitely long and constant life. The equal windings feeding the bridge of the lower secondary winding of the transformer 16 are twin-

wound for balance. The resistor 18 should be of such dimensions that the signal current causes no appreciable rise in temperature and may conveniently be 40 ohms, non-inductively wound with copper wire so that its temperature coefficient is equal to that of the tungsten wire used in the lamp. If the resistor 18 is inductive, oscillation may occur at a very high frequency. The arrangement is such that both frequencies of signals to be received are amplified to the same degree when a compound signal is received so that equal proportions of the two signals should be present in the final amplitude-controlled signal.

Speech signals of frequencies above and below the predetermined signal frequencies which are to provide a guarding function to prevent the signal receivers operating by speech receive the same amplification at the predetermined frequencies so that an effective guard voltage is derived from the speech. The feedback transformer 15 also has a reasonably uniform response characteristic but its maximum response is obtained at the frequency at which the quiescent oscillation occurs, for instance 340 cycles per second. The oscillation frequency is controlled by the capacitor 31 and resistor 31A and must be outside the range of frequencies that operate the receiver.

In order to obtain flat response characteristics for the transformers 13 and 15 in conjunction with high step-up ratios, "Mumetal" cores are used.

Preferably the quiescent oscillation is designed to be below rather than above the signalling frequencies as a low frequency tone of between 300 to 400 cycles per second is less audible than a corresponding level of a signal of 1000 to 1500 cycles per second. A small amount of quiescent oscillation is normally fed back to the line due to the capacity to earth associated with the secondary winding of the transformer 13. The level of this oscillation is however very small so as to be substantially negligible. The intermediate amplifier stage represented by valve 20 is provided to enable adequate power to be applied to the frequency selecting circuits without affecting the frequency response characteristic of the oscillating amplifier circuit. Negative feedback is incorporated by coupling the anode to the grid bias end of the transformer winding associated with the grid of this valve. Approximately sufficient feedback is obtained to make the output voltage from the valve independent of the valve characteristics and of the load impedance. A large value of the cathode bias resistor 32 is used to reduce the anode current drain. The impulsing characteristics of the receiver are not critically dependent on the signal level and the effect of the changing output on voice immunity is very slight since the guard circuit voltage changes in the same ratio as that applied to the signal operating circuits.

The higher frequency signal to be rectified is derived from the inductance component of the series tuned circuit 22, 23 which is connected across one winding of the output transformer 21. By deriving the signal from across the inductance instead of across the capacitor, a response below the signalling frequency falls off rapidly so that the lower frequency signal cannot operate the higher frequency signal relay while at the same time a large upper side band is obtained which is required for good impulsing. In the case of the lower frequency signal, the signal to

be rectified is derived from across the capacitor component of the series tuned circuit so that the response above the lower frequency falls off rapidly. The guard circuit which consists of parallel tuned circuits to reject both the signalling frequencies, is connected in series with a resistance 33 across which the output voltage is obtained. The impedances of the two parallel tuned circuits are approximately equal at their respective resonance frequencies. It is realised that a guard circuit operating from a larger input voltage would be more effective in providing speech immunity but it may reduce the available side band for impulsing if suitable precautions are not taken such as making the guard circuit with longer build up time and longer decay time as described above. Since the transmitted side bands contain both very low and very high frequency components it is undesirable that the guard circuit should be too sensitive even at frequencies distant from the impulsing frequency. The quiescent oscillation which is present immediately prior to the impulsing signal being received provides a negative grid bias voltage which however has practically no effect on the impulse ratio. The time constants of the rectifier circuits are made very short so that speech immediately preceding a signal does not cause the guard circuit to block the receiver and prevent the operation by the signal to any appreciable extent. The rectifiers are operated with large input signals so that they operate under the most efficient conditions.

The charging time of the voltage-doubler capacitors depends on the values of the capacitor capacitance and the forward impedance of the rectifier which is a function of the voltage across its terminals. If only a small rectified voltage were required to operate the receiver relay the voltage across the rectifier would be an appreciable amount of the total voltage available. The forward impedance of the rectifier would then materially affect the rectified voltage wave-form. Actually the use of rectifiers having five times the forward impedance of the normal rectifiers for the same potential difference across the rectifier changes the impulse ratio by less than 1%. The time constant of the discharge circuit apart from being very short is practically unaffected by the backward impedance of the rectifiers.

The guard circuit voltage is applied in opposition to both the signal voltages and the total voltages are applied to the control grids of the signalling valves through high resistances 34, 35. These resistors limit the grid current which can be obtained when a large rectified voltage from either of the signalling frequencies is obtained. Otherwise the capacitors in the guard circuit rectifier system would be charged by the grid current derived from the larger signal and an excess negative bias voltage obtained which may prevent operation of the relay associated with the smaller rectified signal when a compound signal is being received.

The effective voltage applied to the control grids of the two signalling valves is the difference between rectified voltage obtained from the respective tuned circuits and that obtained from the guard circuit. When simple or single frequency voltages are considered the resultant positive grid voltage extends over a wide frequency range, particularly in the case of the higher frequency signal although a signal at an intermediate frequency between the two signalling frequencies cannot produce a sufficient grid volt-

age to operate both the signal relays. The response characteristic of the guard circuit plays an important part in achieving this result. Without the guard circuit it would not be possible to obtain a wide effective frequency band using low Q tuned circuits without operating both relays by means of a single intermediate frequency signal. The higher frequency signal response characteristic conveniently extends from 600 to 900 cycles per second so that a wide side band is available. This side band is attenuated at the remote side-band frequencies and a side-band attenuation equalising circuit is introduced in the signalling valve circuit so that full use of the side-band is obtained to produce nearly rectangular signals. The wide frequency side band is possible mainly because voice immunity is achieved by using a compound signal. Such a signal produces a larger guard voltage than with the single frequency acting alone due to the larger contribution to the guard signal of the lower signalling frequency component. The power in each of the signals however is only half that of a single signal and the rectified voltage derived from the signalling tuned circuits is correspondingly less. A resistor 36 of 1600 ohms in the cathode lead of the higher frequency signalling valve 25 provides considerable negative feedback so that variations in the valve characteristics have a negligible effect on the performance. With the lower frequency signalling valve 27 a 2000 ohms bias resistance 37, which functions similarly to 36, is used since the anode current from a valve 10 which is used to provide the additional grid bias potential is less than that derived from the valve 20 which serves a similar function for the valve 25. To compensate for the high side-band attenuation of the higher frequency in an approximate manner a two microfarad capacitor 38 is connected across the resistor 36. The effect of the capacitor is to make the impulse more rectilinear and the distortion is consequently reduced. Similar remarks apply to the capacitor 39 across the resistor 37.

By using a very sensitive high speed relay for the relays 26 and 28 it is possible to arrange that signals of one quarter the amplitude normally received are sufficient to operate the receiver and thereby very large factors of safety can be introduced. Capacitor 40 by-passes the double-frequency signal component in the anode circuit of the higher frequency signalling valve 25. This capacitor increases the time in which the relay is operated, but only very slightly and this in conjunction with the additional time obtained due to the time constant of the condenser-resistor combination in the signal rectifier circuit compensates for the shortening of the direct output current signal due to the transit time of the relay armature. The variation in impulse ratio using different relays is very small. The arrangement of relay and by-pass capacitors for the lower frequency valve is similar to those used for the higher frequency valve. By the arrangement a very high degree of voice immunity is obtained. The two relays cannot both be operated simultaneously by a single pure tone and it has been found almost impossible by the use of speech to produce the two tones required without producing sufficient signals in the guard frequency range to prevent operation of one or both of the relays. After much practice a certain voice intoning a quiet note of the required character has succeeded in operating the re-

ceiver. When no delay times whatsoever have been introduced one or both of the relays in these circumstances is in a chattering condition and it is believed that operation can only be obtained on transient signals, that is signals of which the frequency spectrum is continuously changing. By introducing 100 milliseconds delay before operation of the receiver effective operation becomes impossible by voice sounds in a telephone transmitter.

As a modification to the arrangement above described the valve 10 may be arranged to oscillate over a portion or portions of the frequency range and to be in a non-oscillating condition over another portion or portions of the range. For example when applied as a current limiting device for voice frequency signals such as are at present employed over telephone lines for signalling, dialling and other operations, the output transformer 16 may be replaced by two transformers having their primary windings in series. The secondary winding of one transformer is arranged as described above to give the necessary feedback. The other transformer has connected in series across the secondary winding thereof two parallel tuned circuits of frequencies equal to the frequencies employed for signalling and a third untuned impedance. The impedance of this last transformer is a maximum at the two frequencies in question so that at those frequencies but small proportion of the output voltage appears across the primary winding of that transformer from which the feedback voltage is derived. The signal currents are derived from the voltages across the two tuned circuits and a guard circuit may be operated from the aperiodic impedance. In place of the two transformers one having four secondary windings may be employed using series-tuned instead of parallel-tuned resonance circuits. The slope of the applied voltage impedance characteristic of the impedance device 19 exhibits varying slopes over varying portions of the characteristic and it is advantageous to pass polarising current through the impedance to adjust the operating point on the characteristic to the position of maximum slope. Where the thermionic valve is operated in an oscillating condition the oscillating current itself may be adjusted to give the optimum operation.

I claim:

1. An amplifying circuit for receiving alternating current signals, comprising an amplifying device having an input and an output circuit, a path from said output circuit to said input circuit including an impedance device variably controlled by current in the output circuit, and a device tuned to a frequency outside the range of frequencies to be received, the arrangement of said impedance device and said tuned circuit being such that when no signals are being received the amplifying device oscillates at a frequency determined by said tuned device and that when signals are being received the current fed back over said path causes the oscillation to cease and the amplification of the stronger signals to be reduced as compared with the amplification of the weaker signals.

2. An amplifying circuit for receiving alternating current signals, comprising an amplifying device having an input and an output circuit, a path from said output to said input circuit including a non-linear impedance device whose resistance varies with the strength of signals in said output circuit, and a device tuned to a fre-

quency outside the range of frequencies to be received, the arrangement of said non-linear impedance device and said tuned device being such that when no signals are being received the amplifying device oscillates at a frequency determined by said tuned device and that when signals are being received the current fed back over said path causes the oscillations to cease and the amplification of the stronger signals to be reduced as compared with the amplification of the weaker signals.

3. A receiving circuit for alternating current signals of a predetermined frequency comprising an input circuit, a signal responding device, a tuning arrangement between said input circuit and said signal responding device by which currents of predetermined frequency are alone enabled to reach said signal responding device, a variable impedance device located between said input circuit and said tuning arrangement and having a time factor which causes the amplitudes of the weaker and stronger signals to more nearly approach each other without causing the appreciable generation of harmonic frequencies.

4. A receiving circuit for alternating current signals of a predetermined frequency which may be mixed with currents of other frequencies, comprising an input circuit, a signal responding device responsive only to signals of predetermined frequency, a device responsive to other frequencies arranged to reduce the sensitivity of said signal responding device, and a device for reducing the variation of amplitude of all currents received over said input terminals which operates relatively slowly compared with the signal frequency and so produces negligible signal distortion and harmonic frequencies so that the sensitive reducing device is not affected substantially by the operation of said amplitude variation reducing device.

5. An amplifying circuit for receiving alternating currents of predetermined frequency, comprising an amplifying device having an input and an output circuit and a path from said output circuit to said input circuit, said path including an impedance device whose impedance changes in accordance with the R. M. S. value of current flowing through it, whereby a substantially constant output is obtained with substantially no harmonics of the signalling frequency, and a device tuned to a frequency outside the range of frequency to be received, the arrangement of said impedance device and said tuned circuit being such that when no signals are being received the amplifying device oscillates at a frequency determined by said tuned circuit and that when signals are being received a current fed back over said path causes the strength of weak and strong signals in the input circuit to approximate to the same strength in the output circuit.

6. An amplifying circuit for receiving alternating current signals, comprising an amplifying device having an input and an output circuit, a path from said output to said input circuit including a non-linear impedance device whose resistance varies with the strength of signals in said output circuit, and a device tuned to a frequency outside the range of frequencies to be received, the arrangement of said non-linear impedance device and said tuned device being such that when no signals are being received the amplifying device oscillates at a frequency determined by said tuned device and that when signals are being received the current fed back

over said path causes the oscillations to cease and the output to be substantially constant irrespective of the strength of signals received.

7. A receiving circuit for alternating current signals of a predetermined frequency, comprising an input circuit, a signal responding device, a tuning arrangement between said input circuit and said signal responding device by which currents of predetermined frequency are alone enabled to reach said signal responding device, and an amplifier having a feed back circuit to bring it to a state of oscillation and including a variable impedance device having a time factor which causes the amplitudes of the weaker and stronger signals to more nearly approach each other without causing the appreciable generation of harmonic frequencies located between said input circuit and said tuning arrangement.

8. A receiving circuit for alternating current signals of a predetermined frequency which may be mixed with currents of other frequencies, comprising an input circuit, a signal responding device responsive only to signals of predetermined frequency, a device responsive to other frequencies arranged to reduce the sensitivity of said signal responding device, and an amplifier normally in a state of oscillation and including in its feed back circuit a device for reducing the variation of amplitude of all currents received over said input terminals which responds to high frequency harmonic less quickly than to the predetermined frequency and thereby ensures that the sensitivity reducing device is substantially not affected by harmonics of signalling frequency derived from said amplitude variation reducing device.

9. An amplifying circuit for receiving alternating current signals, comprising an amplifying device having an input and an output circuit, a path from said output circuit to said input circuit including an impedance device in the form of bridge circuit variably controlled by current in the output circuit, and a device tuned to a frequency outside the range of frequencies to be received, the arrangement of said impedance device and said tuned circuit being such that when no signals are being received the amplifying device

oscillates at a frequency determined by said tuned device and that when signals are being received the current fed back over said path causes the oscillations to cease and the amplification of the stronger signals to be reduced as compared with the amplification of the weaker signals.

10. An amplifying circuit for receiving alternating current signals, comprising an amplifying device having an input and an output circuit, a path from said output to said input circuit including a bridge circuit having a non-linear impedance device in one limb whose resistance varies with the strength of signals in said output circuit applied to opposite terminals of said bridge, and a device tuned to a frequency outside the range of frequencies to be received and connected to the other terminals of said bridge, the arrangement of said non-linear impedance device and said tuned device being such that when no signals are being received the amplifying device oscillates at a frequency determined by said tuned device and that when signals are being received the current fed back over said path causes the oscillations to cease and the amplification of the stronger signals to be reduced as compared with the amplification of the weaker signals.

11. An amplifying circuit for receiving alternating current signals, comprising an amplifying device having an input and an output circuit, a path from said output circuit to said input circuit, including an impedance device comprising a resistance wire in a vacuum or gas-filled envelope variably controlled by current in the output circuit, and a device tuned to a frequency outside the range of frequencies to be received, the arrangement of said impedance device and said tuned circuit being such that when no signals are being received the amplifying device oscillates at a frequency determined by said tuned device and that when signals are being received the current fed back over said path causes the amplification of the stronger signals to be reduced as compared with the amplification of the weaker signals.

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