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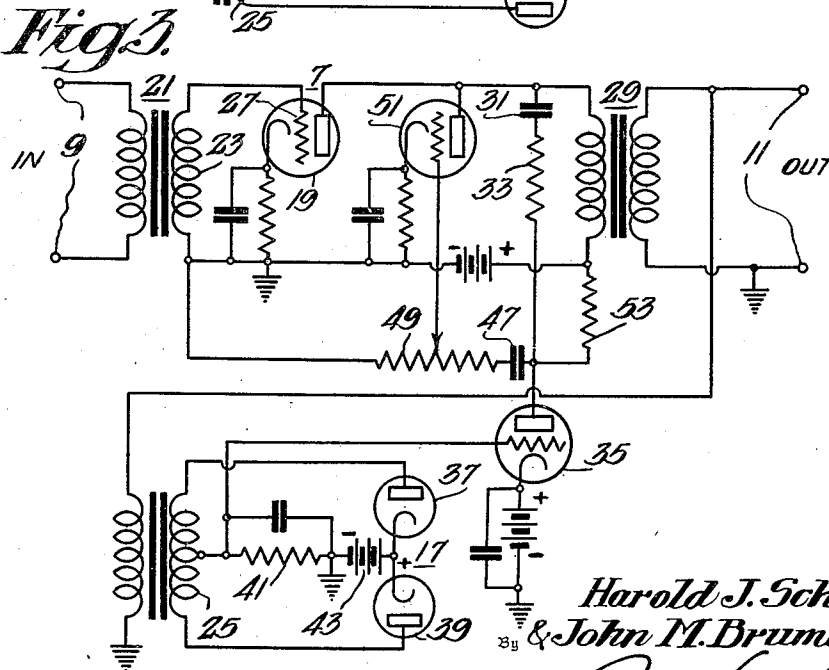
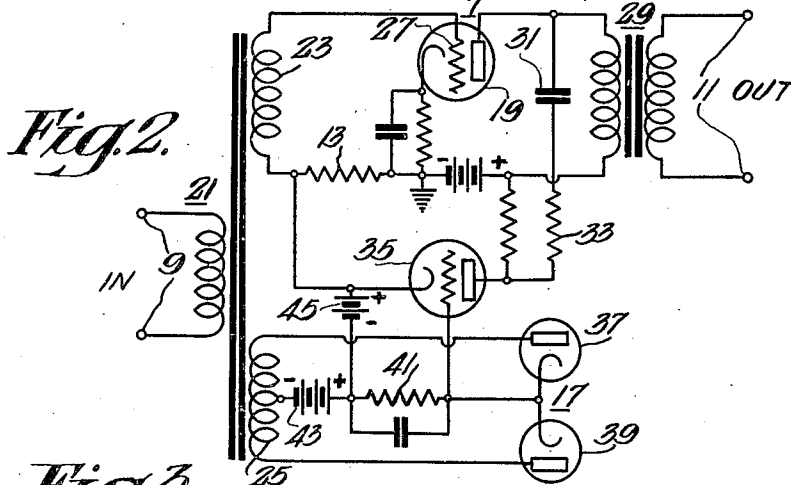
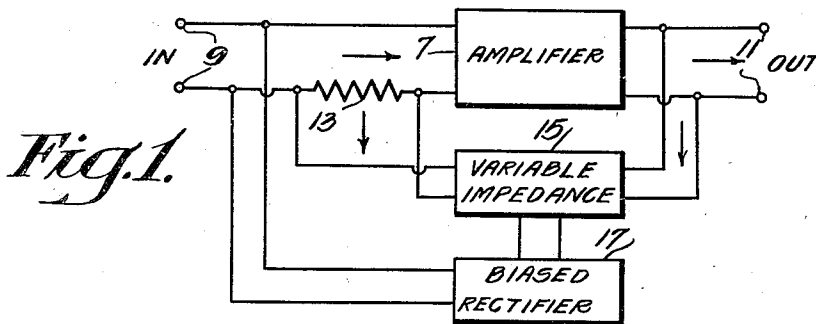
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2,343,207

WAVE TRANSLATION DEVICE.

Filed Feb. 7, 1940

2 Sheets-Sheet 1



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2 Sheets-Sheet 2

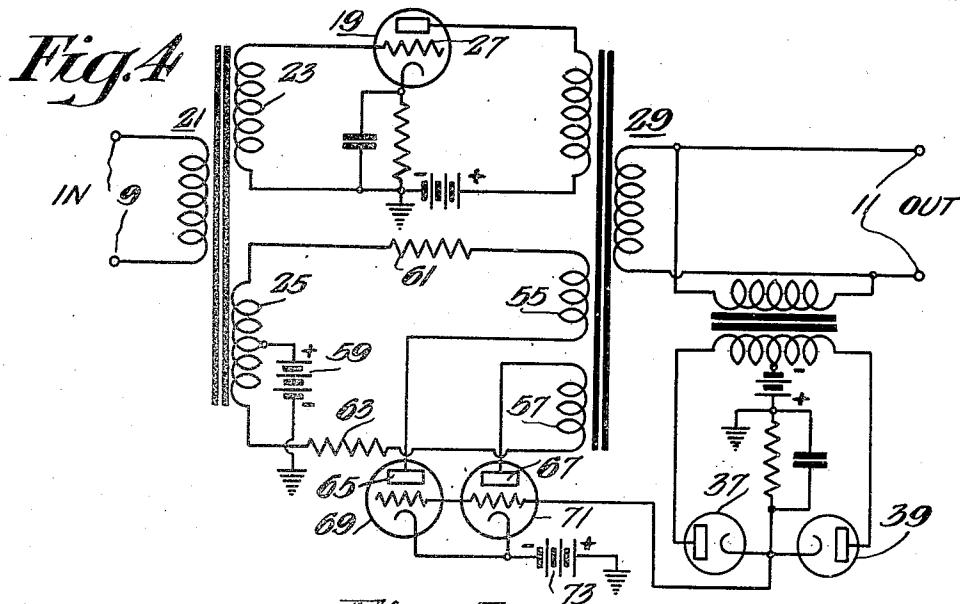
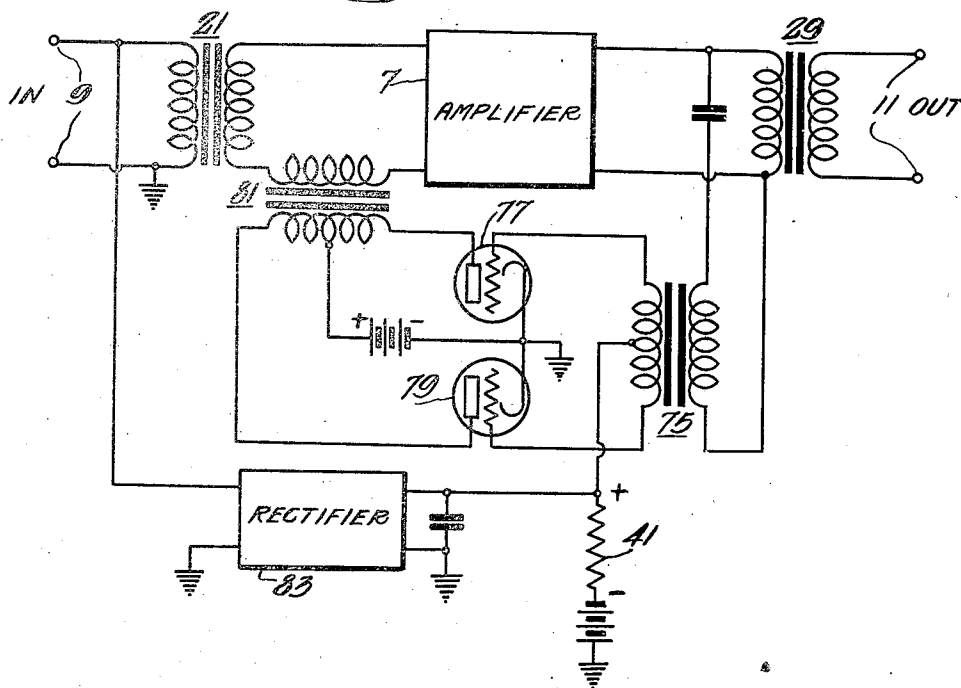


Fig. 5



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WAVE TRANSLATION DEVICE

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7 Claims. (Cl. 179-171)

This invention relates to signal wave transmission and amplification, and more particularly to improved circuits for automatically contracting the volume range or limiting the peak amplitude of signal waves.

The use of a fixed amount of degenerative feedback to improve the operation of amplifiers is well known. For example, systems for utilizing degenerative feedback to reduce or stabilize the gain of thermionic amplifiers and to reduce distortion therein are described in United States Patent 2,102,671, which issued to H. S. Black on December 21, 1937.

Volume contractors and expanders which modify the amplitude of a signal wave in accordance with some non-linear function are likewise well known. Such systems conventionally utilize a direct bias voltage to vary the gain of an amplifier. As a result, transient voltages are induced in the system by reason of this change of bias, thus introducing distortion into the system. It is the principal object of this invention to provide a system for contracting or limiting the amplitude of a signal wave which has the advantages of degenerative feedback and which is free from transient impulses and distortion.

The present invention differs from the known prior art in this essential, that the amount or degree of degenerative feedback is varied as a function of the average signal amplitude, thus utilizing the principle of degeneration to reduce the transients and distortion produced by the control operation itself. The invention may be utilized to produce an overall contraction of the signal amplitude or to limit to some predetermined level the maximum signal amplitude. The former system is usually employed to effect transmission within a comparatively small range of signal amplitude, in conjunction with an expander which restores the original dynamic range of the signal. The latter system may be used to prevent over modulation in a transmitter by reducing excessive modulated voltage peaks.

This invention will be better understood from the following description when considered in connection with the accompanying drawings, and its scope is indicated by the appended claims. Similar reference numerals refer to similar elements throughout the several drawings.

Referring to the drawings,

Figure 1 is a simplified diagram illustrating the principle of this invention;

Figure 2 is a circuit diagram of a limiting circuit;

Figure 3 is a circuit diagram of an alternative embodiment of the system illustrated in Fig. 2;

Figure 4 is a circuit diagram of a preferred embodiment of this invention; and

Figure 5 is a circuit diagram of a modification of the arrangement illustrated in Fig. 4.

A simplified form of this invention is illustrated

ed in Fig. 1 to which reference is now made. An amplifier 7 is provided with input terminals 9 and output terminals 11. A resistor 13 is connected between one of the input terminals 9 and the amplifier 7. A variable impedance device 15 is connected between the output terminals 11 of the amplifier 7 and resistor 13. A rectifier 17 is energized by a voltage derived from the input terminals 9 although the rectifier may be energized by a voltage derived from the output terminals 11, as will subsequently appear. Connections are made between the rectifier 17 and the variable impedance device 15 so that the impedance of the latter is varied in accordance with the amplitude of voltage produced by the former.

The operation of the device illustrated in Fig. 1 will now be described. A degenerative voltage is obtained from the output terminals 11 of the amplifier 7 and is impressed across resistor 13 by means of connections which include a variable impedance 15. Consequently, the degree or percent of degeneration is determined by the variable impedance device 15. It is to be understood that the voltage impressed across resistor 13 by the variable impedance device is in phase opposition to the input voltage which is applied to the input terminals 9. It is also to be understood that the amplifier 7 may include one or more stages of amplification, as is well known. The variable impedance device 15 is controlled by the voltage developed in the rectifier 17, and consequently the degree or percent degeneration is a function of the signal amplitude which is applied to the rectifier, which may be operated as a "biased rectifier." By the term "biased rectifier" is herein meant a rectifier which is provided with a fixed bias voltage which prevents rectification until the applied signal amplitude exceeds the bias. Consequently, the degree of feedback remains constant until such time as the applied signal voltage exceeds the predetermined bias. When operated without such a fixed bias, the rectified control voltage is proportional to the average signal amplitude, and uniform volume contraction will be effected over the entire operating range.

An actual circuit corresponding to the illustrative diagram of Fig. 1 is illustrated in Fig. 2 to which reference is now made. For convenience, amplifier 7 has been illustrated as a single stage amplifier comprising a triode tube 19. Input terminals 9 are coupled to the amplifier input circuit by means of a transformer 21 having two secondary windings 23 and 25. Resistor 13 is connected in series with one terminal of the secondary winding 23 between ground and the grid 27 of the amplifier tube 19. The output circuit of this tube is connected to the output terminals 11, for example, by means of a transformer 29.

A degenerative feedback voltage from the

output circuit is impressed across resistor 13 by means of a path which includes a blocking capacitor 31, a resistor 33 and the anode-cathode path of a thermionic tube 35. Grid voltage for thermionic tube 35 is derived from a rectifier which includes, for example, a pair of diode tubes 37 and 39 whose anodes are connected to the outer terminals of the secondary winding 25, and whose cathode electrodes are connected through a diode load resistor 41 and a biasing battery 43 to the center tap of the secondary winding 25. A second biasing battery 45 is connected between cathode and the junction of resistor 41 and battery 43.

In operating the device illustrated in Fig. 2, the amplitude of the bias voltage produced by battery 45 is adjusted to that value which causes the variable impedance tube 35 to impress the desired normal degenerative voltage on the amplifier input circuit. It will be observed that resistor 33 and the anode-cathode impedance of tube 35 constitute a voltage divider. Consequently, the degree of feedback may readily be determined by varying the impedance of the tube. A variable bias is likewise impressed on the grid of the tube 35 when a voltage appears across the anode load resistor 41. Such a voltage is developed in the illustrated circuit when the amplitude of the input voltage reaches that value which is sufficient to overcome the negative bias, due to battery 43, on the anode electrodes of the rectifier tubes 37 and 39. The polarity of the variable bias is chosen so that an increase in signal amplitude causes the grid of thermionic tube 35 to become more positive, thus decreasing its impedance, and permitting a larger feedback voltage to be impressed upon the amplifier input. By removing battery 43, the system will function as an automatic volume control to reduce the dynamic range of the output voltage with respect to that of the input voltage.

Fig. 3 represents an alternative system in which the variable impedance tube is connected in shunt with a fixed voltage divider which provides the normal feedback voltage. In addition, an alternative method of impressing the feedback voltage on the amplifier input circuit is illustrated, and finally, the control voltage is obtained from the amplifier output.

As before, the input voltage is applied to the amplifier 19 through a transformer 21, and its output is connected to the output terminals 11 through a transformer 29. A degenerative voltage is developed across a voltage divider which includes, in series, blocking capacitor 31, resistor 33, a second blocking capacitor 47 and a second resistor 49, connected between the anode of amplifier 19 and ground. It is to be understood, however, that the feedback voltage may, if desired, be obtained from the secondary circuit of the output transformer 29. In the embodiment illustrated in Fig. 2, the feedback voltage was superimposed on the grid of the amplifier tube. In the present instance, a separate tube 51 has been provided. The cathode and anode electrodes of the control tube 51 are connected in parallel with the corresponding electrodes of the first amplifier tube 19. The grid electrode, however, is connected to a suitable tap on resistor 49. An alternating degenerative voltage is, therefore, applied to the control tube 51 which has the same effect as a similar voltage superimposed on the grid of the amplifier tube 19. The degree of feedback is controlled by means of a thermionic tube 35 whose anode-cathode path

is connected in parallel with a portion of the voltage divider. Specifically, the anode of the control tube 35 is connected to the junction of resistor 33 and blocking capacitor 47. A suitable positive anode potential for the control tube is supplied by means of a resistor 53. It will be appreciated that the alternating feedback potential on the grid of the auxiliary tube 51 will be determined by the impedance of the control tube 35, which is in turn controlled by a direct voltage derived from a rectifier 17, as before. In this instance, however, the variable bias potential developed across the diode resistor 41 has such a polarity that the bias on the control tube 35 becomes more negative when the signal amplitude increases, thus permitting the maximum feedback voltage to be applied to the amplifier.

It will be noted that the rectifier in Fig. 3 is connected to the amplifier output. This connection is desirable when it is not necessary to cause the curve representing the input versus output voltage characteristic of the amplifier to be horizontal beyond the point at which control is initiated. That is, the feedback can change only when the output voltage changes. Consequently when connected in this manner the control will not be able to hold the output voltage at a predetermined maximum, but there will always be a slight increase in the amplitude of the output voltage when the amplitude of the input voltage is increased. However, when the control voltage is derived from the amplifier input circuit, it is possible to over-compensate the amplifier so that its output actually decreases when the amplitude of the input voltage is increased. The selection of the type of operation desired is largely a matter of choice.

In utilizing circuits of the type described above, we have found that a certain amount of distortion is inherently introduced into the system by reason of the change of anode current in the control tube as its grid bias is varied in response to a change in amplitude of the applied voltage.

A system for overcoming this disadvantage is illustrated in Fig. 4 to which reference is now made. Input terminals 9 are connected to an input transformer 21 having two secondary windings 23 and 25, as before. The first secondary winding 23 is connected to the input of a thermionic tube 19 which is intended to represent one or more stages of amplification. The output circuit is taken from the secondary of an output transformer, as before. Feedback is provided by means of connections between secondary winding 25 of the input transformer 21 and a pair of similar windings 55 and 57 which are coupled to the output transformer 29. A center tap of the secondary winding 25 is grounded through a battery 59. The outer terminals of secondary 25 are connected respectively to the outer terminals of windings 55 and 57 through a pair of resistors 61 and 63. The inner terminals of the two windings 55 and 57 are connected respectively to the anode electrodes 65 and 67 of a pair of control triodes 69 and 71. The cathode electrodes of the latter tubes are connected to ground through a bias battery 73. The grid electrodes of the same tubes are connected to the cathodes of rectifier tubes 37 and 39 which are energized by a voltage derived from the output transformer 29.

It is to be noted that in the arrangement illustrated in Fig. 4, the amplitude of the degenerative feedback voltage is determined by the plate impedances of control tubes 69 and 71, which are

in turn controlled in like manner by a voltage which is proportional to the output signal amplitude. A change in the output signal amplitude changes the plate current of the two control tubes 69 and 71 in like manner. The resultant current impulses, which are the cause of distortion in the circuits described heretofore, now flow in opposite directions through windings 55 and 57 and likewise in opposite directions through the two halves of the secondary 25, and are consequently cancelled out. As a result, the control tubes may be made to respond rapidly to changes in the average amplitude of the signal output without introducing transient voltages into the circuit.

A limiting amplifier must be made to respond rapidly to changes in the signal amplitude if distortion is not to be produced in the signal wave front when its amplitude changes suddenly. It has been found that in the systems illustrated in Figs. 1 to 3 the transient introduced into the system when the control voltage was applied reacted on the amplifier through the feedback network in a direction which tended to oppose the change. This fact made it impossible to obtain a quick response to changes in signal amplitude. By the arrangement now proposed, however, these undesirable transients have been removed, thus permitting the control voltage to vary the degree of feedback almost instantly.

Fig. 5 is a modification of the arrangement illustrated in Fig. 4. The essential difference between the two arrangements lies in the method of applying the normal feedback voltage. In the present instance, the feedback voltage is taken from the output circuit by means of a transformer 75 and is applied to a pair of triode amplifier tubes 77 and 79 which are connected in push-pull, and coupled to the amplifier input circuit by means of a transformer 81. As before, a direct control voltage is produced across the diode load resistor 41 by means of a rectifier which has been indicated by a rectangle 83. The rectified voltage is polarized so that the grids of the amplifier tubes 77 and 79 become more positive when the amplitude of the signal input is increased. The operation of this embodiment is essentially the same as that of the arrangement described in connection with Fig. 4. The advantage of the present system lies in the utilization of the control tubes as amplifiers to improve the sensitivity of the control.

We claim as our invention:

1. In combination with a wave translating device having input and output circuits, a pair of thermionic amplifier tubes connected in push-pull and coupled from said output circuit to said input circuit for producing a degenerative feedback voltage in said device, means for simultaneously varying the amplification of said tubes to control the amplitude of said feedback voltage in accordance with the average amplitude of said waves whereby said changes in the amplification of said tubes do not apply distorting impulses to said device.

2. In combination with a wave translating device having input and output circuits, a pair of thermionic amplifier tubes connected in push-pull relation between said output and input circuits for applying to said device a degenerative feedback voltage, a rectifier connected to said device for producing a direct voltage whose amplitude is proportional to the average amplitude of said waves, and means for varying the bias of said tubes in accordance with said direct voltage.

3. In combination with a wave translating device having input and output circuits, a pair of thermionic amplifier tubes connected in push-pull relation between said output and input circuits for applying to said device a degenerative feedback voltage, a biased rectifier connected to said input circuit for producing a direct voltage whose amplitude is proportional to the average amplitude of waves exceeding a predetermined fixed amplitude, and means for varying the bias of said tubes in accordance with said direct voltage.

4. In combination with a wave translating device having input and output circuits, a pair of thermionic tubes, means including the anode-cathode path of said tubes for applying to the input of said device a degenerative feedback voltage corresponding to a predetermined proportion of the output of said device, means for deriving a bias voltage proportional to the average amplitude of waves in said device, and means for applying said bias to said tubes to vary the amplitude of said feedback voltage, said tubes being so connected that the change in anode-cathode current due to said variation of bias is balanced out and does not affect said device.

5. In a wave translating device having input and output circuits the combination of a feedback circuit for applying a feedback voltage to said input circuit including thermionic variable impedance means, means for varying said impedance means in accordance with the average amplitude of the waves flowing through said translating device, and balanced coupling means connecting said variable impedance means to said input and output circuits in such manner as to prevent currents generated by said impedance variation from producing resultant currents in said translating device.

6. In a wave translating device having input and output circuits, the combination of a feedback circuit including a pair of variable impedance electron discharge devices connected in balanced circuits coupling said output circuit to said input circuit for applying degenerative wave voltages to said input circuit, and means including a rectifier for varying the impedances of said variable impedance devices in accordance with the average amplitude of the waves flowing through said translating device, whereby currents generated in said coupling circuit by reason of changes in said impedances are balanced out and do not appear in said translation device.

7. The method of controlling the amplification of an alternating voltage input by an amplifier, comprising the steps of deriving a feedback voltage from the alternating voltage output of said amplifier, deriving a unidirectional voltage proportional to the average amplitude of one of said voltages, combining said feedback voltage with said unidirectional voltage so as to provide two resultants, each comprising one alternating component similar to said feedback voltage but variable in magnitude with respect thereto in accordance with the magnitude of said unidirectional voltage and another component similar to said unidirectional voltage, combining said resultants so as to provide addition of the alternating components of said resultants and cancellation of the variations of said unidirectional components, and combining said combined resultants with said input voltage in such polarity as to oppose said input voltage.

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