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AMPLIFIER CIRCUITS WITH CONTROLLED GAIN

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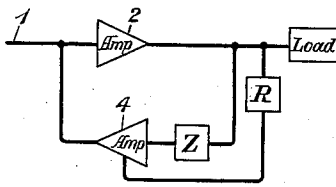


Fig. 1

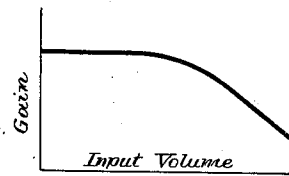


Fig. 2a

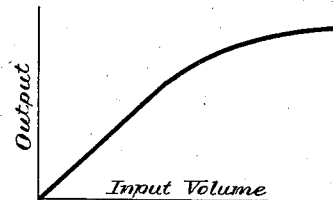


Fig. 2b

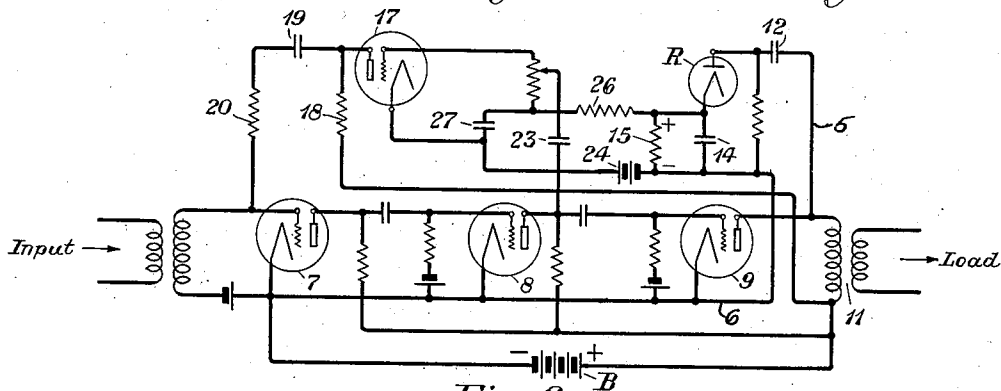


Fig. 2

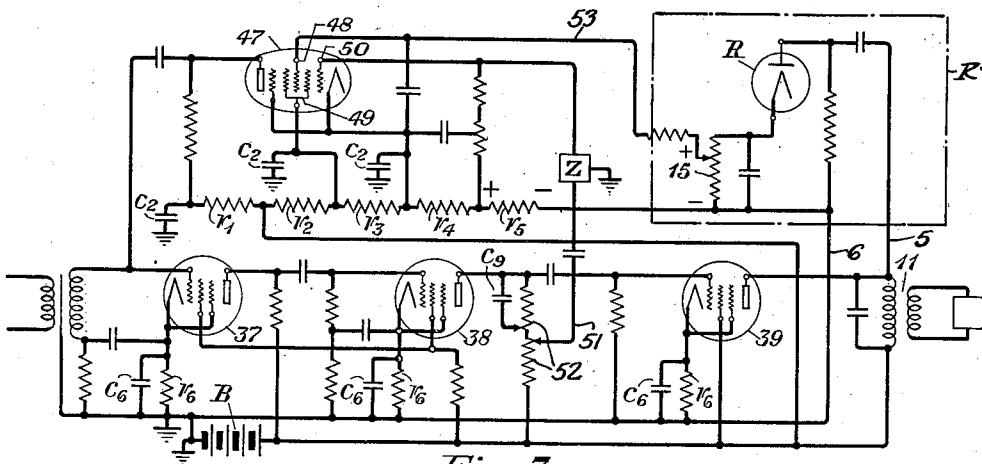


Fig. 3

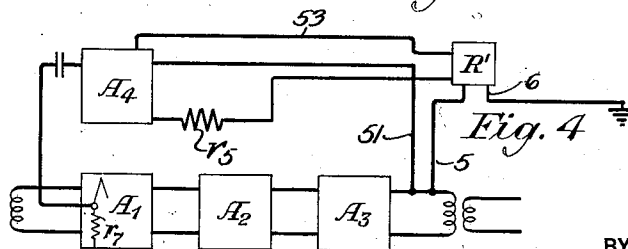


Fig. 4

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AMPLIFIER CIRCUITS WITH CONTROLLED GAIN

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3 Claims. (Cl. 179—171)

This invention relates to amplifier circuits and more particularly to circuits for voice frequency or speech signals. Its object is to devise a circuit for limiting the signal power delivered by an amplifier circuit to a value within a restricted range of power, and within the power capacity of the associated parts of the circuit, this being attained by means of a negative feedback action in the amplifier circuit. A further object is to devise an amplifier circuit with a feedback the gain of which is automatically variable. Still further, an object of the invention is to devise such a circuit in which the negative feedback connection is normally inoperative, but which becomes operative when the output power of the circuit reaches a certain value and becomes rapidly more effective as the output power exceeds that value.

In many circuits involving wide range of power of incident speech and an amplification suitable for the weaker powers to be amplified, it frequently occurs that one part of the circuit or another, such as a loud-speaker, will at times be substantially overloaded, which leads to undesirable effects. This may readily occur, for example, in conference circuits where a speaker may frequently change the volume of his speech or may change his position with respect to the receptor into which he speaks. It is important to reduce the effects of these wide variations and in particular to avoid excessive overloading of the elements of the amplifier circuit and associated circuits. To this end, I make use of a negative feedback action from one point in the circuit to a preceding point and at the same time make the feedback action a variable one. More specifically, as noted above, I provide a circuit in which the feedback action is inoperative for a signal output level below a specified value but which becomes rapidly more effective as the level passes beyond that specified value. Not only does this reduce the overloading but gives to the circuit those desirable properties of increased stability characteristic of negative feedback circuits and does so especially at a time when such added stability is most needed.

The invention will be better understood by reference to the following specification and accompanying drawing in which:

Fig. 1 is a schematic circuit diagram showing the principles of my invention;

Fig. 2 shows in further detail an amplifier circuit adapted for voice frequency signals, the circuit involving relatively simple tubes;

Figs. 2a and 2b illustrate the gain and the

input-output characteristic of the amplifier circuit;

Fig. 3 is a circuit showing the use of more complex tubes with characteristics peculiarly suitable for carrying out the objects of my invention; and

Fig. 4 is a modification of the circuit of Fig. 3.

Referring more particularly to Fig. 1, there is shown a transmission circuit 1 in the path of which there is an amplifier 2 consisting of one tube or several tubes in tandem. From the output of the amplifier tube to its input is a feedback circuit comprising the impedance Z and an amplifier 4. Such a negative feedback circuit has the characteristic of lending increased stability, linearity and reliability of action of the amplifier represented by 2. The negative feedback has also the characteristic of reducing the gain which the amplifier 2 would otherwise yield. When the input power is low, it is desirable that the amplifier 2 shall be operating with normal gain and to this end I provide that the amount of negative feedback shall be low or even reduced to zero. When the input power becomes large, it may be such as to supply excessive power to the load with undesirable effects and to prevent this, I provide that the negative feedback action shall increase in amount. I accomplish this by taking some of the output power at a suitable point in the circuit through a rectifier R, the magnitude of whose output will increase as the power increases. This output is then used to operate on the amplifier 4 to change its gain in a manner to increase the amount of feedback action.

Referring more specifically to Fig. 2, there is shown a series of three amplifiers 7, 8 and 9 in tandem. These are shown as three-electrode amplifier tubes with a resistance coupling. In the output of the last tube there is shown a transformer 11 and across the primary of that transformer there is connected through conductors 5 and 6 a rectifier circuit R' including a rectifier R which may be of any suitable form but preferably of the hot cathode highly evacuated type. By means of the condenser 12 in conductor 5 all direct current power from the main amplifier circuit is blocked off from the rectifier and it becomes subject then to the voltage variations across the primary of the transformer 11. As a result of the rectification by this tube, the condenser 14 is given a charge until a more or less steady voltage is built up across the resistance 15, the magnitude of this voltage varying with the volume level of the speech message delivered to the transformer 11.

The impedance of the rectifier R is preferably low so that an increase in volume at transformer 11 is quickly registered by a change in the charge of condenser 14, but a decrease in volume is registered slowly because of the relatively high time constant of the circuits 14 and 15.

An amplifier tube 17 is connected with its filament to the negative of the power supply B and with its plate connected through the load resistance 18 to the positive of that supply. The control grid of this tube is connected to some point in the amplifier circuit, here shown as the plate of the second tube. The voltage variations of the plate of tube 17, are then brought to the grid of the first tube 7 through the capacitance 19 and protective resistance 20. Thus there is provided a feedback from the output of the second tube to the input of the first and it will be observed that the poling is such that the feedback becomes a negative feedback, feeding back power of the same frequency and signal form as the signal input of tube 7. A condenser 23 is introduced in the grid circuit of 17 to block off direct current voltage from the main amplifier circuit.

In order to render the amount of feedback action variable, a bias is also provided to the grid of tube 17, this biasing voltage coming from the potential drop across the resistance 15 which in turn, as heretofore explained, varies in accordance with the volume of the speech signal at 11. A biasing voltage 24, preferably a fixed voltage as from a battery, is also provided and may be given such value that the tube 17 is rendered inoperative unless and until the potential drop across the resistance 15 exceeds a certain specified value. A resistance 26 and condenser 27 provide a filter for any signal voltage variations present across condenser 14. The power supply B is here shown as a battery but it is to be understood that it may consist of any well-known type of alternating current power pack.

The operation of the circuit may now be described briefly as follows: If the input power is relatively low, the potential drop across 15 is very low and there is little or no feedback action through the tube 17. The gain of the amplifier circuit under these conditions remains substantially constant and is fairly high, as indicated by the curve of Fig. 2a. Also the power delivered is proportional to the input to tube 7, as indicated by the curve of Fig. 2b. If the power delivered to the transformer 11 exceeds a certain value, there will then be an increased drop of potential across the resistance 15 sufficient to bring the tube 17 into operative condition and feedback action then becomes effective. As the power increases the gain of the tube 17 increases and the feedback action becomes more effective, reducing the gain as indicated by Fig. 2a.

While the circuit of Fig. 2 has been described in terms of the well-known three-electrode tubes, I find it desirable to use tubes of a more complex nature, bringing in certain desired characteristics. Such a circuit is shown in Fig. 3 which is similar to that of Fig. 2 except for the fact that the tubes 7, 8 and 9 are replaced by well-known pentode tubes 37, 38 and 39. Also, the feedback tube 17 is replaced by the tube 37 which may be of a variety of forms, but one which I find particularly useful is that commonly known as the type 6L7 tube. This tube is characterized by a gain control grid 48 which is shielded by the grid 49. The gain of this tube may be readily controlled by the potential of the grid 48 and has the desirable property that change in the

potential of 48 does not introduce the distortions characteristic with the arrangement using the tube 17 in Fig. 2. Through a conductor 51, the control grid 50 of the tube 47 is connected, as formerly, to some point in the amplifier circuit, here shown as a point on a resistance 52 in the output of tube 38. The gain of the tube is determined by the potential of the grid 48 connected through a conductor 53 to the resistance 15. As the potential of the grid 48 rises to more positive values with increase of power at the transformer 11, the gain of the tube 47 is increased and the effectiveness of the feedback connection to the input of tube 37 is correspondingly increased, but the voltage variation supplied through this feedback to the tube 37 is a more faithful reproduction of the incoming speech message than when the tube 17 is used.

It will be noted that in the circuit of Fig. 3 power is supplied to the tube 47 by means of a potential divider made up of the resistances r_1 , r_2 , r_3 , r_4 and r_5 , the values of the resistances in this divider being such as to supply the desired potential to the various elements of the tube. Capacitance shunts c_2 to ground are provided at various points in a manner well understood in the art. Self-biasing resistances r_6 with shunt capacitances c_6 to ground are also provided for the tubes 37, 38 and 39 in a manner well known in the art. In addition, a capacitance c_3 is shown connected across a portion of the load resistance 52 of the tube 38, this being a small capacitance and of such value and shunted around such a portion of the resistance 52 as to serve as a phase-correcting network, bringing the phase of the feedback potential variations on the grid of tube 37 to its proper value for stable negative feedback action.

It will be noted that the grid 48 is maintained normally at a negative potential by means of the voltage drop through the resistance r_5 , this being preferably of such a magnitude as to render the tube 47 inoperative. This bias, however, is neutralized to a greater or lesser extent by the potential drop across the resistance 15 and when this exceeds a certain value the negative feedback action becomes effective, the extent to which it is effective depending upon the signal level across the primary of the transformer 11 and thus on the potential drop across the resistance 15.

While the circuits of Figs. 2 and 3 have been shown with a feedback circuit consisting essentially of an amplifier with variable gain, it is to be understood that this feedback circuit may be more complex by the inclusion of an impedance device of any desired characteristic to render the action of the feedback dependent in any desired manner on the frequencies of the signal being transmitted. This is shown in Fig. 3 by the impedance Z connected as a shunt to ground from the feedback connection and it is to be understood that such impedances may take on a large variety of forms and may be connected in a large variety of ways.

Also, in Figs. 2 and 3 the connection to the control grid of the feedback tube has been from the output circuit of the second tube. This particular arrangement is not necessary for the connection to that control grid may be made from other stages in the amplifier circuit. Thus, in Fig. 4 the connection 51 to the control grid 50 is taken from the output of the third stage. This involves a reversal of phase of the signal impressed on the control grid of the feedback ampli-

fier A₄. In order that the desired negative feedback action shall be retained, the output of A₄ is applied in proper magnitude and phase across a resistance r_7 in the cathode circuit of A₁.

5 What is claimed is:

1. A power limiting system comprising a source of audio frequency message waves of varying volume, a load circuit, an amplifier for amplifying said waves and delivering audio frequency message waves to said load circuit, a negative feedback circuit for feeding back from the output to the input of said amplifier audio frequency message waves, an electric space discharge device in said feedback circuit, a discharge control grid in said device, a rectifier connected to said load circuit, said rectifier developing a potential difference which varies in accordance with the volume of the audio frequency message output of the amplifier delivered to said load circuit, means biasing said grid so far negative that said device is rendered substantially inoperative and feeds back substantially nothing unless and until said potential difference exceeds a specified value corresponding to a value of the message output volume in said load circuit at which overloading is approached in elements of the system comprised in the amplifier and the load circuit, whereby throughout the normal input volume range of the message waves delivered to said amplifier from said source said amplifier operates with substantially normal gain, and means responsive to said potential difference for so varying the bias on said grid that as said message output volume increases beyond said overloading value the feedback action becomes rapidly effective and thereby prevents supply of excessive power to the load circuit and gives increased amplifier stability when such added stability is most needed because of said increase of said message volume beyond said overloading value.

2. A power limiting system comprising a source of audio frequency message waves of varying volume, a load circuit, an amplifier for amplifying said waves and delivering audio frequency message waves to said load circuit, a negative feedback circuit for feeding back from the output to the input of said amplifier audio frequency

message waves, an electric space discharge device in said feedback circuit, a discharge control grid in said device, a rectifier in series with an impedance including a resistance and a condenser in parallel connection, means for applying from said load circuit across said rectifier and impedance in series audio frequency message waves having a volume range substantially equal to the full volume range of the audio frequency message waves received by said load circuit, said rectifier developing across said impedance a unidirectional voltage which varies in accordance with the volume of the audio frequency message output of the amplifier, means biasing said grid so far negative that said device is rendered substantially inoperative and feeds back substantially nothing whenever said voltage is below a prescribed value corresponding to an overload value of the message volume output of the amplifier, and means responsive to said voltage for so varying the bias on said grid that as the message volume output of the amplifier increases beyond said overload value the feedback action becomes rapidly more effective and thereby prevents supply of excessive power to the load circuit.

3. A wave translating system comprising a source of audio frequency message waves of varying volume, a load circuit, an amplifier for amplifying said waves and delivering audio frequency message waves to said load circuit, a feedback circuit for feeding back in said amplifier gain-reducing audio frequency message waves, a rectifier connected to said amplifier, means effective whenever the audio frequency message volume at the amplifier output is below overloading value for the amplifier and load circuit to prevent said feedback circuit from substantially reducing the amplifier gain, and means responsive to rectified current from said rectifier for so varying the transmission efficiency of said feedback circuit that as said message volume output increases beyond said overloading value the negative feedback action becomes rapidly more effective and thereby prevents supply of excessive power to the load circuit.

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