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Fig. 1.

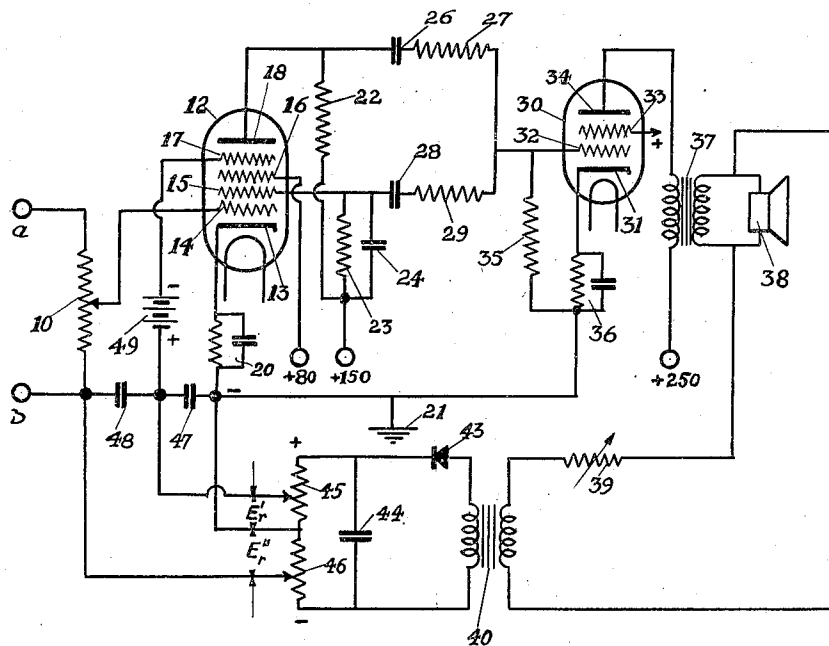
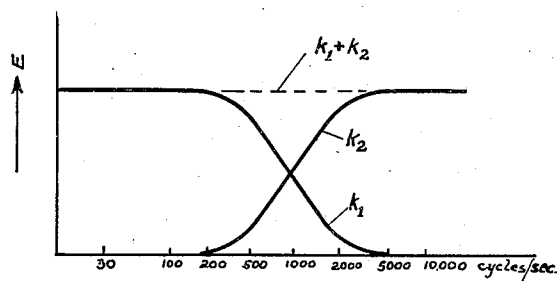


Fig. 2.



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AMPLIFIER

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11 Claims. (Cl. 179-171)

The present invention is concerned with arrangements for amplification control in a single electron valve amplifying stage serving for simultaneously amplifying several frequencies or groups of frequencies and an object of the invention is to subject one part or group of frequencies to amplification control while maintaining the amplification of another part or group of frequencies substantially constant.

A further object of the invention is to provide a system for and method of band width or fidelity control in an amplifier for composite signal energy comprising a band of component frequencies which is both simple in design and efficient and stable in operation.

Another object is to control one group of frequencies in a single amplifying stage independently of and without affecting the amplification of another group of frequencies passed through and translated by the same stage together with the first frequency group.

The above and further objects of the invention will become more apparent from the following detailed description taken with reference to the accompanying drawing forming part of this specification and wherein,

Figure 1 is a circuit diagram of a tone control circuit embodied in an audio amplifier constructed in accordance with the principles of the invention,

Figure 2 represents a graph explanatory of the operation of the circuit according to Figure 1.

Among various practical applications, a control stage according to the invention offers the possibility to suppress the higher frequency range corresponding to the background noise or needle scratch frequencies in sound record reproduction by the aid of a control potential varying in proportion to the output volume or sound intensity in such a manner as to decrease the background or needle scratch noise in proportion as it becomes more objectionable; that is, during the periods of low sound intensity. Noise control circuits or filters of this type have been known in the art per se. A simple and efficient circuit of this type is disclosed in applicant's prior application, Ser. No. 250,315 filed January 11, 1939. This application, like the present invention, utilizes an amplifying valve comprising a pair of output circuits controlled by a so-called current distribution grid. The present invention, is differentiated structurally from the prior arrangements in various essential features as well as by new effects and results as will become obvious.

invention involves basically the use of an amplifying valve comprising at least the following electrodes arranged in succession as enumerated: a cathode, an input control grid to which are applied the signals to be amplified or translated and which may have a straight or exponential (variable μ) operating characteristic, a positively biased grid also referred to as an anode or output grid serving to supply amplified output signal potential, a further positively biased (screen) grid maintained at zero alternating potential with respect to ground or cathode, a second control or current distribution grid having impressed thereon a negative control potential for band width volume range, etc., control, and a positively biased plate or anode serving to supply amplified signal output current or potential similar to said anode grid. When using the inventive system for fidelity or band width (noise) control coupling networks are inserted in the output circuits of the anode grid and the anode, respectively, said coupling networks being designed to have different selectivity characteristics. Thus, in a system for background noise control in an audio amplifier for recorded sound signals, a filter circuit is connected to the anode grid adapted to suppress the high audible frequencies corresponding to the needle scratch or noise frequencies in such a manner that in the signal band transmitted from the anode grid to a subsequent amplification stage or to a translating device the higher frequencies from about 2000 to 3500 cycles upward are substantially weakened or eliminated. The same result can be obtained by a frequency selective rejector or blocking circuit arranged in the coupling path between the anode grid and the subsequent part of the system. Contrary to the anode grid, the anode circuit includes a frequency selective or filter network allowing free passage to all the frequencies which are weakened or suppressed in the circuit of the anode grid while suppressing all the frequencies which are freely passed from the anode grid to the subsequent circuit portion. Both the anode circuit and the circuit of the anode grid may be connected by way of suitable decoupling elements such as high ohmic resistances or choke coils directly to the control grid of a subsequent amplifier or both circuits may be coupled to separate amplifiers or translating devices having their outputs combined in a suitable manner.

If, in an arrangement of the aforescribed type, a control potential is impressed upon the current distribution grid, the current to the anode grid remains practically unaffected due to

With the aforementioned objects in view, the

the shielding effect of the screen grid placed between this grid and the anode, whereas the anode current is subjected to efficient control. With a sufficiently negative bias potential applied to the current distribution grid, which in the case of the standard hexode tubes is at about -10 or -15 volts, a complete blocking of the anode current may be effected, obtaining in this manner a minimum over all band width for the amplifier. If the negative bias is decreased, the anode path will be opened in proportion resulting in a corresponding widening of the frequency acceptance band or effective pass range of the amplifier.

The location of the anode grid next to the input grid and its shielding from the current distribution grid by a special screen grid has the advantage that the control is limited to the output current supplied by the anode, or in other words, the amplification of the current or potential supplied by the anode grid is substantially constant, thus enabling a simplified design and connection of the filter or selective circuit elements in the anode circuit.

A further advantage of an arrangement of the above type embodying a shielding or screen grid between the anode grid and the current distribution control grid is the fact that a substantially higher degree of amplification may be obtained by the control stage. Practical tests have shown that in the absence of a screen grid maintained at alternating cathode or ground potential, distortion of the anode current will occur whenever the current to the anode grid exceeds a determined value. This is obviously due to an accumulation of electrons in the space between the anode grid and the adjacent current distribution control grid preventing a further increase of the anode current by further increase of the control potential on the input grid. In the prior circuits it was necessary for this reason to use a much lower impedance in the anode grid and anode circuits as would have been desirable in the interest of attaining high amplification. In the new circuit according to the invention, the danger of distortion due to electron accumulation is substantially minimized by the provision of a screen grid between the anode grid and the current distribution control grid enabling the use of considerably higher output or coupling resistances and consequent increased amplification.

Referring to Figure 1 illustrating a system for tone control or background noise control, the input signals derived from a phonograph pick-up device or the like are impressed by way of an adjustable input potentiometer 10 upon the grid-cathode path of an amplifier valve 12 used as a single control stage according to the invention. The valve 12 in the example shown comprises a cathode 13 connected to ground or a metallic chassis followed in succession by input grid 14, positively biased output or anode grid 15, screen grid 16, current distribution control grid 17 and a plate or anode 18. Item 20 represents a biasing network comprising a resistance shunted by a condenser inserted in the cathode lead to provide proper operating potential for the input grid 14 in accordance with standard practice. The anode grid 15, screen grid 16, and plate 18 are connected to sources of positive potential such as a potentiometer in a manner well known to those skilled in the art. Thus the screen grid potential may be 30 volts and the potential on the positive grid or plate 150 volts as indicated, these values being merely illustrative and by way of

example. A high ohmic coupling resistance 23 of about .1 to .2 megohm which may be replaced by a suitable inductance coil is inserted in the lead from the high potential source to the positive grid 15 to produce signal potential variations at the grid 15. The resistance 23 is shunted by a condenser 24 designed to effectively by-pass the higher audio (scratch noise) frequencies. The amplified potential variations are transmitted to the input grid 32 of a subsequent amplifier 30 by way of blocking condenser 28 and a decoupling resistance 29. Similarly a coupling impedance such as high ohmic resistance 22 is inserted in the anode circuit to produce anode potential variations at signal (audio) frequency which latter are also impressed upon the grid 32 of the amplifier 30 by way of blocking condenser 26 and decoupling impedance 27. The latter as well as the impedance 29 may have values of about .5 megohm. The condensers 26 and 28 serve to isolate the grid circuit of the amplifier 30 from the high potential on the grid 15 and anode 18. The alternating current impedance of the condenser 28 should be sufficiently small for the frequencies to be transmitted. The coupling circuit 23, 24 advantageously has a frequency characteristic as shown at k_1 in Figure 2 representing signal amplitude or potential E as a function of the frequency passed to the amplifier 30. As is seen, the higher frequencies are gradually attenuated by the network 23, 24 beginning at about 200 cycles to about 5000 cycles. Coupling condenser 26 is designed in conjunction with resistance 27 and the grid leak resistance 35 for the amplifier 30 in such a manner as to present a high impedance for the low frequencies resulting in a transmission characteristic as shown at k_2 in Figure 2 being substantially inversely related to the characteristic k_1 . The grid leak resistance 35 may have a value of several megohms. Item 36 represents a network comprising a resistance shunted by capacity in the cathode lead of valve 30 to provide proper grid operating bias. Valve 30 further comprises cathode 31, screen grid 33 and plate 34. The amplified output currents are applied in the example shown directly to a translating device such as loud speaker 38 by way of output transformer 37. A portion of the output energy is applied from the secondary of this transformer to the input of another transformer 40 in series with an adjustable resistance 39. A rectifier 43 in series with a pair of load resistances or potential dividers 45 and 46 is connected to the secondary of the transformer 40, a smoothing condenser 44 being placed across the resistances 45 and 46 in series. There is developed in this manner across the resistances 45 and 46 a potential varying in proportion to the sound volume or average output current intensity, a portion of which E_r' developed by the resistance or potential divider 45 is impressed upon the grid 17 in series with a fixed negative biasing source 49. 47 is a condenser to produce additional smoothing of the control potential.

The operation of the circuit is as follows: With normal or medium signal strength a certain negative bias is applied to the grid 17 as determined by the fixed biasing source 49 opposed by a positive potential E_r' produced by potential divider 45. As the signal strength increases more positive potential E_r' will oppose the negative bias 49 resulting in a decrease of negative bias on the grid 17. As a result thereof more current will flow to the plate 18 causing increased strength of the high frequency or noise com-

ponents. On the other hand, as the signal strength decreases, less positive bias E_r' will oppose the bias provided by the source 49, resulting in a total negative bias increase on the grid 17 and proportionate blocking of current to the anode 18. As a result thereof the higher or noise frequencies in the output will be attenuated.

The voltage divider 46 may serve to provide a further control potential E_r'' applied to the input grid 14 after additional filtering by condenser 48 to effect amplification control for the signals being translated. If the variable tap on the potential divider 46 is in the upper limit position corresponding to ground or cathode, the circuit will operate in the manner described above; that is, with pure selectivity or noise control. If, however, an additional negative bias E_r'' is applied to the grid 14, a certain compression of the volume or intensity range is obtained, provided the grid 14 is designed with a regulating (variable μ) characteristic. In this manner, a slight volume expansion caused by selectivity control or due to physiological characteristics of the human ear may be compensated. On the other hand, by controlling the grid 14 in the opposite direction, that is in the same sense as the current distribution grid 17, the invention may serve to provide both band width control and volume expansion in a single stage.

In place of the control potential varying according to the average sound intensity it is possible in the case of a broadcast or other high frequency receiver to utilize an AVC potential varying in proportion to the average high frequency or intermediate frequency amplitude of these signals.

It will be understood that the valve 12 as shown may contain further electrodes in addition to those shown and described. Thus, a suppressor grid connected to the cathode may be arranged adjacent to the anode or a further screen grid may be provided between the grids 14 and 15. Furthermore, it may be desirable to add a screen placed between the grids 16 and 17 or between the grid 17 and the anode without departing from the spirit of the invention.

The fidelity or band width control as described in connection with Figure 1 may be applied to high frequency or intermediate frequency amplifiers in which case resonant selective networks are connected to the anode grid 15 and to the plate 18 designed in such a manner as to have different selectivity characteristics such as parallel tuned resonant circuits, one of which has a narrow band width, while the other has a wide band width such as by shunting it by a resistance in the manner shown in my co-pending application Ser. No. 314,410, filed January 18, 1940. The advantage of the present system over the co-pending application is the fact that the amplification by the anode grid is substantially independent of the control by the current distribution grid. This fact should be taken into consideration in regard to the high frequency band width control by the proper design of the frequency characteristic of the anode circuit, it being desirable to cause the anode circuit to predominantly pass the side bands corresponding to the low audio frequencies. This effect may be obtained by arranging in the anode circuit two sharply resonant circuits tuned to the side band limit frequencies.

If with a certain type of tube the effect of the screen grid 16 should not be as complete as desirable to prevent reaction from the current dis-

tribution control upon the positive grid 15, this slight reaction may be compensated by an additional amplification control applied to the input grid 14 or to a separate grid placed between the grid 15 and the cathode 13. Preferably, the grid 13 is used and for this purpose should be designed with a regulating (variable μ) characteristic.

A countercontrol produced in this manner manifests itself in an additive sense with regard to the amplification control in the anode circuit and for this reason the control at the current distribution grid may be less intensive. The potential for the counteracting potential may be produced in a manner similar as shown in Figure 1 by means of an arrangement for generating a control potential or separate circuit may be used for this purpose.

In arrangements for band width or noise control for audio signals such as shown in Figure 1, the output currents derived from the anode composed substantially of high frequencies (curve k_2 according to Figure 2) may be applied directly or through a suitable amplifier to a loud speaker designed especially for high note reproduction.

As will be understood from the foregoing, a control stage may be designed according to the principle of the invention for amplifying more than two frequency groups or ranges and controlling one or more of the frequency groups substantially independently of each other. For this purpose the anode 18 is constructed in the form of a grid and followed by further electrode systems in a manner well understood from the above.

It will be evident from the foregoing that the invention is not limited to the specific details and arrangements of parts shown and disclosed herein for illustration, but that the underlying novel thought and principle of the invention are susceptible of numerous modifications and variations coming within the broad scope and spirit of the invention as defined by the appended claims. The specifications and drawing are accordingly to be regarded in an illustrative rather than a limiting sense.

I claim:

1. In an electric amplifier for signals comprising a band of component frequencies, an amplifying valve comprising at least a cathode followed in succession by an input grid, a positively biased anode grid, a further control grid and an anode, means for applying signal potential to said input grid, coupling means having different selective characteristics connected to said anode grid and to said anode to develop output potentials for different partial ranges of said band, means for combinedly translating the developed potentials, further means for applying a variable bias potential to said further control grid to vary the current flow to said anode, and means for substantially preventing reaction from said further control grid upon said anode grid.

2. In an amplifier as claimed in claim 1, said last means being constituted by a screen grid at alternating cathode potential located between said anode grid and said further control grid.

3. In an electric amplifier for signals comprising a band of component frequencies having high and low frequency ranges, an amplifying valve comprising at least a cathode followed in succession by an input grid, a positively biased anode grid, a screen grid at alternating cathode potential, a further control grid and an anode, means for applying signal potential to said input grid,

band-pass coupling means having a frequency pass range corresponding to said low frequency range connected to said anode, further band-pass coupling means having a frequency pass range corresponding to said high frequency range connected to said anode grid, means for combinedly translating the potentials developed by said coupling means, and further means for impressing a variable bias potential upon said further control grid.

4. In an electric amplifier for audio frequency signals, an amplifying valve comprising at least a cathode followed in succession by an input grid, a positively biased anode grid, a screen grid at alternating cathode potential, a further control grid and an anode, means for applying audio signal potential to said input grid, selective coupling means connected to said anode effective in producing amplified potential for the higher audio frequency range, further coupling means connected to said anode grid effective in producing amplified potential for the lower audio frequency range, means for combinedly translating the potentials developed by said coupling means, and further means for applying a variable bias potential to said further control grid to vary the current flow to said anode.

5. In an amplifier as claimed in claim 4, a common output circuit connected to said anode grid and anode, said bias potential being derived from an averaged portion of the signal energy being amplified to effect automatic band width control in dependence upon signal strength.

6. In an audio frequency amplifier, an amplifying valve comprising a cathode followed in succession by an input grid, a positively biased anode grid, a screen grid at alternating cathode potential, a further control grid and an anode, means for applying signal potential to said input grid, coupling means connected to said anode effective in developing potential for the higher audio frequency range, further coupling means connected to said output grid effective in producing amplified potential for the lower audio frequency range, a common output circuit connected to said anode and to said anode grid, means for averaging a portion of the output energy to derive a control potential varying in proportion to the intensity of the signals being amplified, and means for impressing said potential upon said further control grid.

7. In an amplifier as claimed in claim 6, means for applying a portion of said bias potential to

said input grid to effect automatic amplification control in dependence upon signal strength.

8. In an amplifier for electric signals comprising a plurality of component frequencies, an amplifying valve comprising at least a cathode followed in succession by an input grid, a first grid shaped anode, a screen grid at alternating cathode potential, a further control grid and a second anode, selective coupling means connected to each of said anodes having different frequency response characteristics to develop output potentials at said anodes comprising different frequency groups of said band, and means for applying a varying bias potential to said further grid to control the relative strength of said output potentials.

9. In an amplifier as claimed in claim 8, a common output circuit connected to said anodes, said biasing potential being produced by averaging a portion of the output energy to effect variable effective band width control of said amplifier in proportion to signal strength variations.

10. In an electric amplifier for signals comprising an extended band of component frequencies, an amplifying valve comprising a cathode followed in succession by an input control grid, a first grid-like anode, a further control grid and a second anode, means for impressing signal potential upon said input grid, load impedance means having different frequency characteristics connected to said anodes to develop output energies for different partial frequency ranges of the signal frequency band being translated, means for combining and translating said output energies, and means for applying variable bias potential to said further control grid.

11. In an electric amplifier for signals comprising an extended band of component frequencies, an amplifying valve comprising a cathode followed in succession by an input control grid, a first grid-like anode, a screen grid, a further control grid and a second anode, means for impressing signal potential upon said input grid, load impedance means having different frequency characteristics connected to said anodes to develop output energies for different partial frequency ranges of the signal frequency band being amplified, means for combining and translating said output energies, and means for applying a variable bias potential to said further control grid.

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