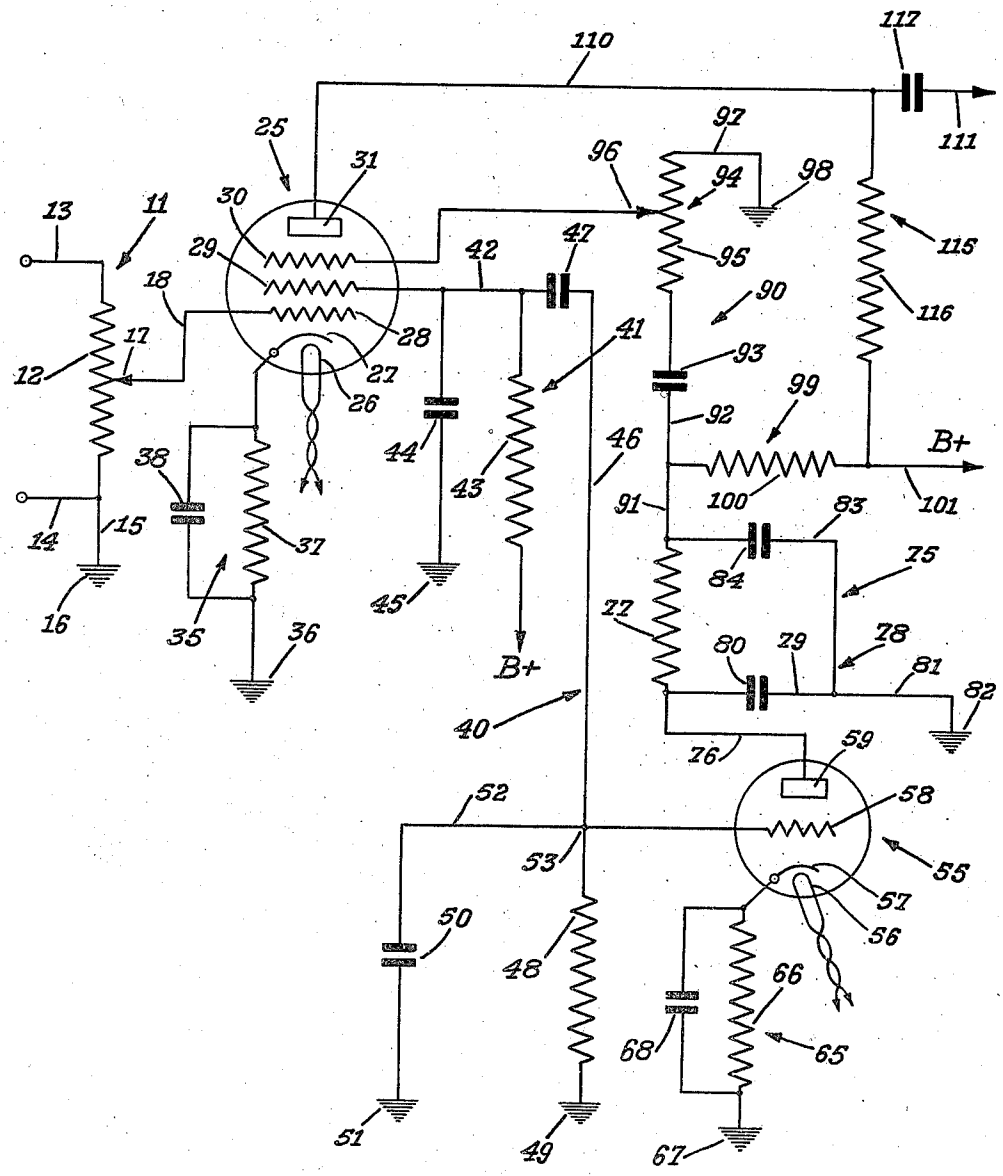
Feb. 11, 1941. L. M. BARCUS 2,230,996

CORRECTED PHASE INTERNAL COMPENSATING BOOSTER FOR AUDIO AMPLIFICATION

Filed July 20, 1937

FIG. 1.



Inventor.
L. M. Barcus
By Hazard & Miller
Attorneys.

Patented Feb. 11, 1941 2,230,996

UNITED STATES PATENT OFFICE

2,230,996

CORRECTED PHASE INTERNAL COMPENSATING BOOSTER FOR AUDIO AMPLIFICATION

Lester Mitchell Barcus, Long Beach, Calif., assignor of forty per cent to Walter P. Limacher, Pasadena, Calif.

Application July 20, 1937, Serial No. 154,589

10 Claims. (Cl. 179—171)

My invention relates to internal compensating boosters for audio amplification of which the present application may be considered as an improvement or further development along the lines of my patent application for Internal compensating booster for audio amplification, Serial No. 132,597, filed March 23, 1937. My present invention controls phase displacement in an internal booster circuit to obtain desired attenuation and waveform characteristics and an improved method of deriving a signal to feed the separate booster channel, the output of which is merged with the main signal and given further amplification in the conventional manner.

In my application above mentioned, I detail the reasons for amplifying part of the signal above the rest, this being due to the bass usually being insufficient. Therefore, on dividing the signal, a portion thereof is passed through a separate amplifying channel which contains a frequency filter which filters out the undesired high frequencies and passes the desired low frequencies. For practical purposes, only the frequencies below 70 cycles need be amplified by the booster channel. In the designation internal booster the signal as to the low frequency portion is given additional amplification within the main amplifier system.

However, in using amplifying tubes or so-called thermionic valves, in regulating and controlling the valves by a grid circuit, the output of one part of the signal to be separately amplified or boosted is put out of phase with the other branch of the signal. Therefore it is desirable to again bring these into phase before the two parts of the signal are united in the output for reproduction or further amplification. Otherwise there may be opposing phases which cause a nullification of the signal or a reduction of its intensity or serious waveform distortion.

Therefore a main object and feature of my invention relates to a double phase inversion in the booster channel which brings the filtered portion of the signal back in phase with the unfiltered signal. Considered more specifically, my invention pertains to a phase change of approximately 180 degrees as to one amplifier tube and a second phase change of 180 degrees bringing a phase reversal of 360 degrees of the filtered portion of the signal and therefore bringing correct phase relationship with the unfiltered portion of the signal. In accomplishing this, the portion or part of the signal to be filtered operates through a filter branch circuit deriving its energy from a grid of a so-called mixing tube. This grid of the mixing tube, operating as an anode has an output approximately 180 degrees out of phase with the input signal. This output of the mixing tube is used to control the amplification of the booster tube which again reverses the phase approximately 180 degrees so that the output from this latter amplification of the filtered signal brings it into approximately correct phase with the unfiltered signal through what might be termed the unfiltered branch of the signal circuit. In this action, however, there is somewhat of a phase displacement in the action of the amplifier tubes so that if reliance were made on the tubes alone, there would not be a correct phase relationship in the combined part signals. This phase displacement however, is corrected by the characteristics of the filtered circuit. Such an arrangement eliminates any wave form distortion due to part of the signal being out of phase for certain frequencies which would cause a cancellation or reduction of the signal volume when reproduced in sound.

However, this phase displacement may be taken advantage of in obtaining sharp values of attenuation in the low pass filtering by causing the phase of the low frequency signals to reverse in phase over the band of frequencies passed by the booster circuit. More specifically, while the lowest frequencies passed are in correct phase relationship with the unfiltered signal circuit, as the upper limits of the booster frequency range are approached, the phase angle of the frequencies gradually is reversed so that they tend to oppose the unfiltered signals and produce a sharper cut-off than could be obtained by the low pass filter alone. This phase reversal is achieved by slight alterations in the values of the components of the booster circuit, and takes advantage of a natural tendency of the amplifying tubes to produce such a phase reversal.

Another object and feature of my present invention relates to splitting the incoming signal and passing this through two branch circuits and in which, by means of a so-called mixing tube the signal to be filtered is taken off from a second grid, the first grid of which controls the whole incoming signal. The output from this second grid is taken to the grid of a booster tube, this amplifying the whole of this part signal and reversing the phase approximately 180 degrees. The part signal which is the output of the booster tube is then passed through a low pass filter which as above mentioned, eliminates the undesired high frequencies and passes only

for instance, frequencies below 70 cycles. Of course this may be regulated and controlled in accordance with the low frequencies it is desired to amplify or boost.

Another feature of my invention relates to impressing the output from the booster tube and the low pass filter on a third or what might be called the second control grid of the mixing tube. Therefore by my invention I may use a type of mixing tube having a first control grid for the whole signal, a second grid functioning somewhat as an anode for a takeoff to feed the booster channel and dividing the complete signal to obtain that portion, and a third grid known as the second control grid to feed back the filtered and amplified signal from the booster channel into the main unfiltered signal.

My invention is illustrated in the accompanying drawing, in which:

The single figure is an electrical diagram showing a low pass filter internal booster circuit.

In my invention I employ a potentiometer control 11 which has a high resistance 12 connected to opposite sides of the input leads 13 and 14 which receive the signal. A lead 15 from the resistor is grounded at 16. The variable tap is indicated at 17. The whole signal has the line connection 18 to a mixing tube designated by the assembly numeral 25. This tube has a heating filament 26, a cathode 27, a first grid 28, a second grid 29, a third grid 30 and the anode 31. The incoming signal by the line connection 18 is connected to the first grid 28 which is the main control grid for the whole signal. The cathode 27 has a resistance capacitance coupling 35 to the ground 36 and employs a resistor 37 bridged by a capacitance 38.

The grid 29 has certain functions as an anode and takes off a portion of the whole signal amplified to a certain extent. This may be considered as the feed to the filter signal circuit designated by the numeral 40 and includes a resistance capacity coupling designated 41 which in the lead wire 42 from the second grid 29 has a resistor 43 leading to B plus, giving a high potential for the second grid 29.

Since the screen 29 of the tube 25 is hooked up for the normal operating of a pentode as an amplifier with the condenser 44 to ground 45, it follows that the input to tube 55 through condenser 47 is preponderately of the lower frequencies.

There is also a capacitance coupling 44 to ground 45 connected to the lead 42. In some cases this may be omitted. In the lead 46 there is also a capacitance 47, a resistor 48 connected to ground 49 and a bridging capacitance 50 with a connection to ground 51, this capacitance being in the lead circuit 52 having a connection 53 with the lead 46. This brings the part of the circuit to be filtered to a booster amplifier tube designated by the assembly 55, such tube being provided with a heating filament 56, a cathode 57, a grid 58 and the anode 59. The cathode has a resistance capacitance coupling to ground designated 65 with the resistor 66 leading to ground 67 and bridged by a capacitance 68. By this connection the part signal is taken from the grid 29, which as above mentioned operates in partial function as an anode, this part of the signal being impressed on the grid 58 and thus controlling the amplification in the booster tube 55.

The amplified signal having the output at the plate 59 undergoes filtering through the low pass filter designated by the assembly numeral 75, the connection being by the lead 76 to the resistor 77 bridged by the condenser circuit 78 having one branch 79 with a condenser 80 therein with a ground lead 81 to ground 82 and the lead 83 with the condenser 84 therein. This is designed to pass the low frequencies and filter out the high frequencies obstructing for instance all the frequencies above for instance a cycle of 70. Thus the frequencies below 70 which have been amplified are passed through the filter.

The filtered signal operates through the resistance coupling designated by the assembly numeral 90 having the lead 91 from the low pass filter circuit. This employs a side 92 with a capacitance 93 and a potentiometer 94 in series, the potentiometer having a tapped resistance 95 with a lead 96 to the third grid 30 of the mixing tube 25. A connection 97 from the resistor is to ground at 98. The other side 99 of this resistance coupling has a resistor 100 connected to the lead 91 and connected to a B-plus potential indicated at 101.

The third grid 30 is in reality a second control grid of the amplifier tube 25 and again brings into the signal circuit that portion which is passed through the filter and thus again brings the distinct low frequency component of the complete signal into the complete signal circuit having its output from the anode 31. By means of a lead 110 the output passes to a second stage of audio frequency amplification, the connection being indicated at 111, there being a resistance capacity coupling 115 having the resistor 116 connected between the B-plus potential 101 and the lead 110 and having a capacitance 117 in the line of the output complete signal.

The manner of operation and functioning of my invention is substantially as follows: The volume of the complete signal at the input may be controlled by the potentiometer 11 which impresses the complete signal on the first control grid 28 of the mixing tube or valve 25. The grid 29 as above mentioned, has a function as an anode and takes off part of the complete signal approximately 180 degrees out of phase with the incoming signal which as above mentioned, operates through the resistance capacitance coupling 41. This part of the signal is used to control the booster tube 55 being impressed on the grid 58. In this amplification the phase is again changed substantially 180 degrees. This would cause the output from the anode 59 to be approximately in phase with the main signal as fed to the grid 28 of the tube 25. However the output passes through the low pass filter 75 so that only the low frequencies are impressed on the second control grid 30 which is the third grid in the tube 25. Hence in any further audio amplification this output being in phase as to all frequencies has no tendency to either cancel out low frequencies or to diminish or change such frequencies in volume and thus gives the desired reproduction and sound of the complete signal properly amplified and having impressed in the correct phase the amplified low frequencies. It may be desirable however to have such phase displacement to obtain needed attenuation characteristics as heretofore described.

In connection with my equipment above described, I have found the following or substantially the equivalent electrical factors satisfactory. In the main volume control the resistor 12 of 500,000 ohms; the bias resistor for the tube 25, this being the resistance 37, 2,000 ohms; the bias for the grid No. 2 of tube 25, such being the re-

sistance 43, 100,000 ohms, this being the load resistor; the low note volume control resistor 95, 500,000 ohms; the plate load for the tube 25, the resistor 116, 100,000 ohms; the resistor 100, that is, the plate load for the tube 55, 100,000 ohms; the resistor 48, such being a grid resistor for tube 55, 250,000 ohms; the resistor 66, such being a bias resistor of the tube 25, 4,000 ohms and the filter resistor 77 for the low frequencies, 10,000 ohms.

The condenser values are substantially as follows: 38, the by-pass condenser of tube 25, 10 M. F. (micro-farad) or larger; 47, the blocking condenser of the second grid of tube 25, .1 M. F.; 93 the plate blocking condenser of tube 55, .1 M. F. or larger; 117, the plate blocking condenser of tube 25, .1 M. F.; 84, one of the low pass filter condensers, .5 M. F.; 80, the other low frequency filter condenser, .1 M. F.; 68, the bias by-pass condenser of tube 55, 10 M. F. or larger; 50, the by-pass condenser, .1 M. F.

As to the tubes, I have found a mixing tube designated in the trade as 6L7 and the booster tube 55 designated as 6C5, or 6F5, or 6J7 as satisfactory.

Various changes may be made in the details of the construction without departing from the spirit or scope of the invention as defined by the appended claims.

I claim:

1. In a device as described, the combination of an input means for a complete signal having a potentiometer volume control, a mixing tube having a first control grid, a second control grid, a third grid operative as an anode, a connection from the first control grid to the said potentiometer, a filter circuit connected to the third or anode grid and including a low pass filter having the characteristics of a resistor bridged by condensers and said filter circuit having a booster tube, the anode grid having the characteristics of taking off part of the complete signal out of phase and the booster tube having the characteristics of again changing the phase, a connection between the second control grid and the output of the filter circuit, such output having a second potentiometer, the second control grid feeding the desired frequencies to the mixing tube in correct phase with the unfiltered part of the signal, the mixing tube having an anode for the output of the complete signal including the filtered and unfiltered portion in correct phase.

2. In a device as described, the combination of a mixing tube having a cathode with a resistance capacitance coupling to ground, a first, second and third grid and an anode, with means to heat the tube, an input connection for a complete signal to the first grid, an output connection from the second grid with a filter circuit therein, such filter circuit including a booster tube having a control grid and a low pass filter, an input connection from the filter circuit to the third grid, the first and third grids being operative to control the amplification of the mixing tube and the output of the complete signal being from the anode of such tube, the elements and connections of the mixing and booster tube having the characteristics of developing an out of phase relation in the filter circuit and another change of phase to bring the unfiltered and filtered portion of the signal into correct phase in the output from the mixing tube.

3. In a method of audio amplification in which a mixing tube having a first and a second control grid and an anode type of grid is employed comprising impressing the complete signal as to all its frequencies on the first control grid, taking off part of the signal with a change of phase from the anode type of grid, filtering such portion of the signal, impressing the filtered portion of the signal on the second control grid and producing an output of the complete signal as to all frequencies from the anode and in the filtered part of the signal causing a second change of phase to develop the correct phase of the unfiltered and filtered part of the signal in the output.

4. In a device as described comprising in combination a mixing tube or valve having a first, second and a third grid, an input means and connections to the first grid for the complete signal, a partial output circuit from the second grid for the lower range of frequencies of the whole signal characterized by the natural preponderance of the lower audio frequencies, means for amplifying the portion of the whole signal taken off at the second grid and connections for re-applying the amplified portion of the whole signal to the third grid.

5. In a device as described and claimed in claim 4, means to control the phase of the portion of the signal taken off at the second grid in relation to the whole signal impressed on the the first grid.

6. In a device as described and claimed in claim 4, means to control the phase of the portion of the signal taken off at the second grid in relation to the whole signal impressed on the first grid whereby the signal taken off is out of phase with the whole signal impressed on the first grid and in the amplifying means reversing the phase whereby the partial signal impressed on the third grid is in phase with the main signal.

7. In a device as described, comprising in combination a mixing tube or valve having a first, second and a third grid, an input means and connections to the first grid for the complete signal, a partial output circuit from the second grid for the lower range of frequencies of the whole signal, means for controlling the phase of the portion of the signal taken off from the second grid whereby such portion is out of phase with the main incoming signal to the first grid at the desired operating range of low frequencies and is in phase as to other undesired high frequencies, the output of the second grid being naturally rich in the lower audio frequencies, a tube with suitable connections to amplify the portion of the signal taken off from the second grid, such tube having means for reversing the phase of such amplified portion of the signal, and connections for inserting such an amplified portion of the signal into the whole signal by a connection to the third grid whereby the main and the re-inserted portion of the signal having frequencies in phase have an additive effect and the residual frequencies added by the re-inserted circuit have a subtractive effect.

8. In a device as described, comprising in combination a mixing tube or valve having a first, second and a third grid, an input means for a complete signal having a connection to the first grid, means for deriving a portion of the whole signal as to the lower frequencies from the second grid, the circuit from the second grid having the characteristics of controlling the phase of the portion of the whole signal taken off from the second grid so that it is out of phase with the main incoming signal to the first grid at the de-

sired low audio frequency range and is in phase at higher audio frequencies, the output of the second grid having the further characteristic of being naturally rich in the lower audio frequencies, a tube with suitable connections to amplify the portion of the signal taken off from the second grid, such tube having means for reversing the phase of such amplified portion of the signal, means for filtering the frequencies in the circuit from the second grid so that only a desired range of frequencies remain to provide desirable response characteristics in the booster circuit and means for re-inserting the amplified and filtered portion of the whole signal taken off from the second grid by connection to the third grid whereby the signal re-inserted in the third grid as to the desired low audio frequencies is in phase with the incoming whole signal.

9. In a device as described, a compensating amplifying tube provided with a cathode and anode and a first, second and third grid in which the second grid functions as an anode, means to derive a signal from the second grid, the phase of which varies with different frequencies due to inherent electronic action within the tube, means to amplify and to treat the phase of such signal and means to feed such signal to the third grid whereby the phase relationships within the tube are such that certain desirable frequencies are additive and other undesirable frequencies are cancelled.

10. In a method of audio amplification in which the amplifying tube provided with a cathode and anode has a first, second and third grid in a sequence between the cathode and the anode and the second grid functions as an anode as a source of a partial signal which does not interfere with the normal response characteristics of the tube, this signal being of correct phase for external amplification, phase inversion and frequency selection, after which it is fed to the third grid in correct relationship with the electron stream to obtain desirable additive frequency compensation.

LESTER MITCHELL BARCUS.