July 14, 1942. H. BOUCKE 2,289,821

DEGENERATIVE AUDIO AMPLIFIER

Filed Dec. 12, 1940

Fig. 1.

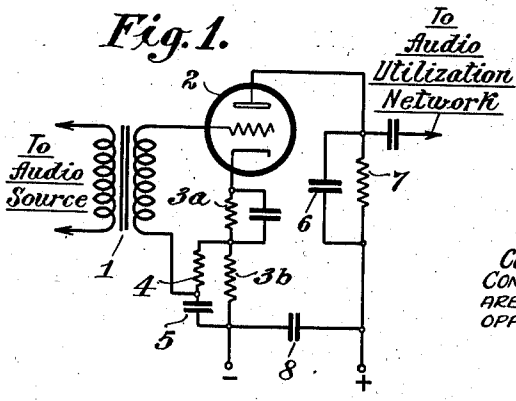


Fig. 2.

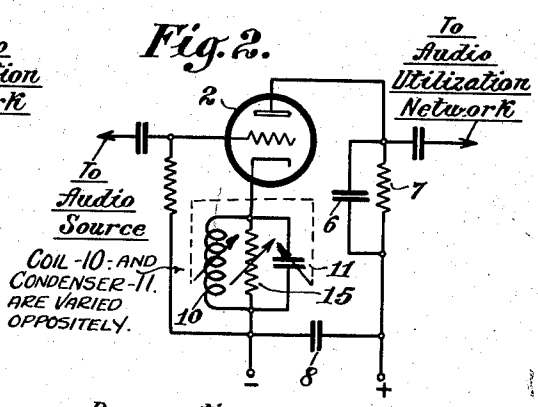


Fig. 3.

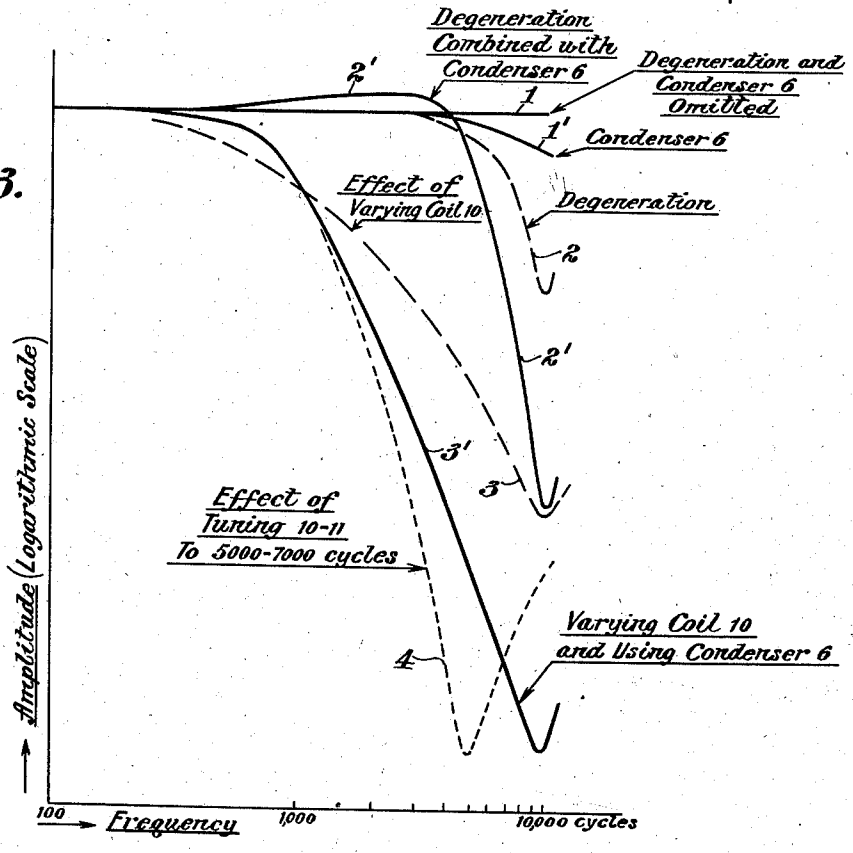
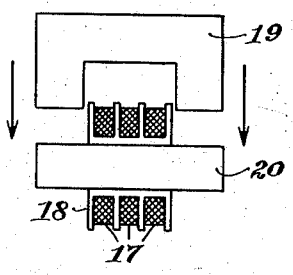


Fig. 4.



INVENTOR
HEINZ BOUCKE
BY H. B. Brower
ATTORNEY

Patented July 14, 1942 2,289,821

UNITED STATES PATENT OFFICE

2,289,821

DEGENERATIVE AUDIO AMPLIFIER

Heinz Boucke, Berlin, Germany, assignor to Telefunken Gesellschaft für Drahtlose Telegraphie m. b. H., Berlin, Germany, a corporation of Germany

Application December 12, 1940, Serial No. 369,817
In Germany December 13, 1939

3 Claims. (Cl. 179—171)

This invention relates to an audio frequency amplifier, and more particularly to the audio network of a receiver with selective negative feedback known in the art.

According to the invention a selective negative current feedback designed to attenuate the higher audio frequencies is combined in a tube, furnished with a single grid, with a capacitative shunt adapted to attenuate the high audio frequencies in the plate circuit of the same tube. What is essential is that a negative current feedback rather than a voltage feedback is used.

The basic features of the invention are known in the art. However, what happens by using the invention is a steeper decline, or droop, of the frequency response curve for the high audio frequencies; in fact, the same is more marked than where the same steps are used in distinct stages of the amplifier.

In the drawing:

Figs. 1 and 2 show respectively different embodiments of the invention,

Fig. 3 shows various frequency response curves relating to the invention,

Fig. 4 shows a further modification.

Fig. 1 shows a single-grid tube 2 provided with negative current feedback to input transformer 1. The cathode resistance 3*a* with parallel condenser in the customary way results in a grid biasing voltage. Across the cathode resistance 3*b* is taken off the negative feedback potential by way of a frequency-dependent voltage divider comprising resistance 4 and condenser 5, the said negative feedback potential increasing with increase of frequency. Condenser 8 serves as an alternating current by-pass of the anode source of current supply. Across the resistance 7 is taken off the amplified audio potential. Condenser 6, as known in the prior art, is so proportioned that its reactance, for the highest audio frequency to be reproduced, is roughly as high as, or higher than, the internal resistance of the tube (without negative feedback). Resistance 7, as also known in the earlier art, is chosen substantially higher. Now, since for the frequencies subject to negative feedback the internal resistance of the tube appearing enlarged as a result of negative current feedback is several times higher than the original internal resistance, the output potentials inside the band of frequencies subject to negative feedback (that is, inside the range of the higher frequencies) are attenuated more markedly than in the absence of negative regeneration. What is involved is a multiplicative influence of the negative feedback, on the one hand, and the change in internal resistance occasioned thereby, on the other hand, upon the output potential. As a consequence the frequency response curves exhibit a far steeper decline of their slopes.

So far as the audio part of a receiver is concerned, it is particularly advantageous to include for negative feedback a parallel resonant circuit tuned to 9 kilocycles (kc.) in the cathode lead, with the resistance of the winding resulting preferably in the grid biasing potential. This is shown in Fig. 2. Coil 10 and capacitor 11 together form the parallel resonant circuit tuned to 9 kc.

Curve 1 in Fig. 3 shows the frequency response curve obtained in the absence of the negative regeneration, and in the absence of condenser 6. By adding the condenser 6, in the absence of negative regeneration, there is found a curve 1' which shows but little droop. But when working with negative current feedback the addition of condenser 6 results in a curve 2' which is essentially steeper than curve 2 which is exclusively based upon negative feedback, for if there were no additional effect, then, because of the logarithmic scale, the distance of curves 2 and 2', at resonance frequency, would have to be the same as the distance between 1 and 1'.

It has been ascertained that in Fig. 2 by variations of inductance 10 band-width regulation within wide limits is obtainable, such regulation becoming particularly favorable because of the steep slope of the frequency-response curve resulting from the step here disclosed. To insure a change of the band-width from around 2 kc. to about 9 kc. it is necessary to alter the inductance roughly at a ratio such as 1:25. In practical tests made with a triode and a plate resistance 7 of about 200,000 ohms, and a parallel condenser 6 of 1000 micro-microfarads, favorable limiting values for the inductance 10 were found to be around 0.04 to 2 henry. Change of the inductance is possible by switching if the coil has taps. However, this incidentally results also in a change in the grid biasing voltage. Hence, it is of more practical advantage to tune the coil by change of the permeability.

Fig. 4 shows one such example. The winding 17 in a coil form 18 is arranged on a core 20 of high permeability material. By approaching a U-shaped core made of similar material, it is possible to alter the air path of the flux lines and thereby the effective permeability to a large extent. By transmitting the tuning force to the said U-shaped part by the intermediary of a cam

or equivalent means, it is possible to insure any desired interdependence between the band-width regulation and the tuning adjustment. This adjustment is most expediently combined with an adjustment for radio frequency band-width variation.

Another scheme to insure band-width regulation is to leave the coil 10 as well as the capacity in Fig. 2 unvaried and to alter only the coupling of the circuit, say, by the aid of taps on the coil or by a variable inductive coupling by means of a coupler coil included in the cathode lead. Finally, by the aid of a resistance 15 connected in parallel relation to the circuit 10—11 the damping may be varied, and thereby the degree of the negative feedback as a function of the frequency can be regulated.

Particularly advantageous has been found the scheme to carry an audio band-width variation into effect in a way as shown in Fig. 2, by causing opposite variation of the inductance and of the capacity of the resonant circuit simultaneously, say by means of a joint shaft, so that the resonance frequency stays constant. The lower in this scheme the inductance becomes the broader will become the transmitted frequency band, and the steeper, however, the slope because of decrease of the damping. This is shown by curves 3 and 3' (the latter covering the use of a condenser 6), compared with curves 2 and 2', respectively. This band-width variation in comparison to regulation by variation of the inductance only offers the merit that there is no parallel shift of the slope; in fact, the slope, in the presence of the broadest band-width, is made additionally broader. For this reason even for adjustment to quite a broad band-width marked suppression of the 9 kc. note is insured. Also in the case of approximate stabilization of the resonance frequency, double regulation is advantageous. Even if the inductance value that has been adjusted is high, the capacity value may be made so high that the resonance frequency lies around 5000 to 7000 cycles, as shown by curve 4 in Fig. 3.

What is claimed is:

1. In an amplifier provided with a tube having input and output circuits, means impressing currents of a wide frequency range on the input circuit, means common to the output and input circuits for providing degeneration of the higher frequencies of said range, said common means comprising reactances of opposite sign resonated to a high frequency of said range, means for varying the magnitudes of the reactances in opposite senses thereby to control the degree of degeneration, and additional means in said output circuit for attenuating the said higher frequencies thereby to provide a highly augmented attenuation of the higher frequencies.

2. In an audio frequency amplifier, a tube having input and output electrodes, an audio input circuit coupled to the input electrodes, an audio output circuit coupled to the output electrodes, a tuned circuit, common to the input and output electrodes of said tube, resonated to a frequency located in the upper portion of the audio range whereby said input circuit is degenerated for audio frequencies in said upper portion, means in said output circuit for augmenting the attenuation of said upper portion frequencies, and means for varying the reactances of said tuned circuit in opposed senses thereby to adjust the degree of said degeneration without changing said resonant frequency.

3. In an audio transmission network having input and output terminals, a resonant circuit, including capacity and inductance, common to the output and input terminals for providing a degenerative audio voltage feedback path, said circuit being tuned to an audio frequency lying in the upper end of the audio range thereby to render said path degenerative for the higher audio frequencies, means across the output terminals for augmenting the attenuation of said higher audio frequencies, and means for varying the magnitude of each of said inductance and capacity in opposite senses thereby to provide a wide regulation over the band-width of the degenerated frequencies.

HEINZ BOUCKE