July 6, 1943. J. VAN SLOOTEN ET AL 2,323,634

LOW FREQUENCY AMPLIFIER

Filed Aug. 7, 1937 2 Sheets-Sheet 1

Fig. 1

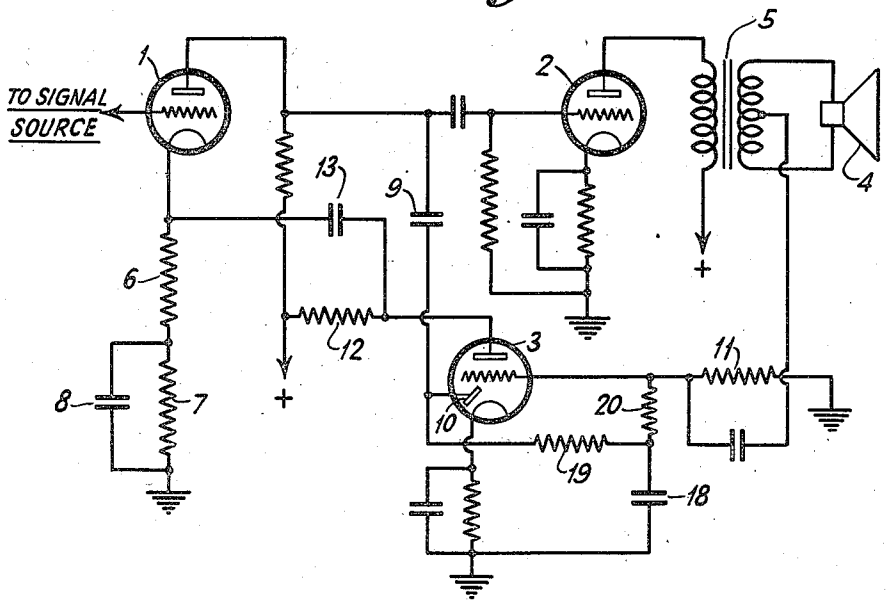
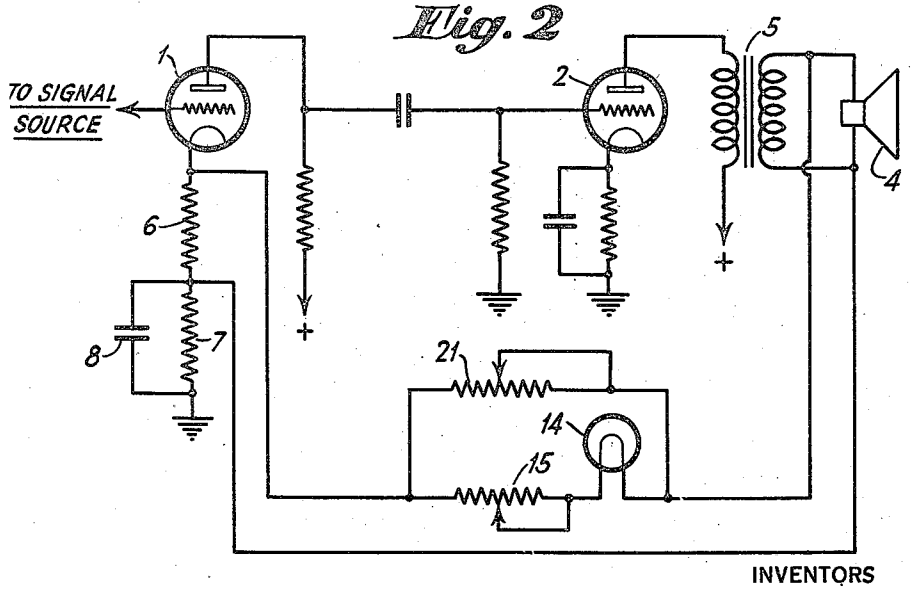


Fig. 2



INVENTORS
JACOB VAN SLOOTEN
AND RUDOLF F. VOLZ

BY

ATTORNEY

July 6, 1943. J. VAN SLOOTEN ET AL 2,323,634

LOW FREQUENCY AMPLIFIER

Filed Aug. 7, 1937 2 Sheets-Sheet 2

Fig. 3

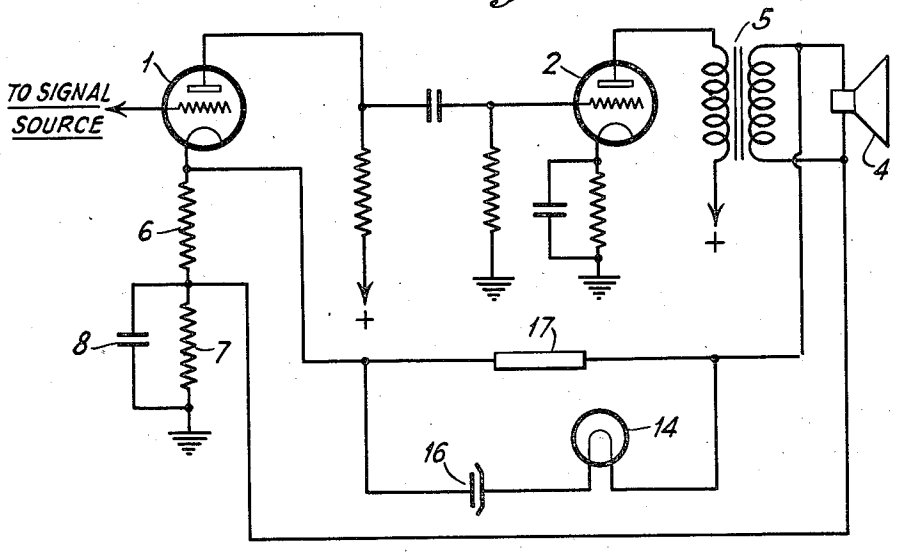
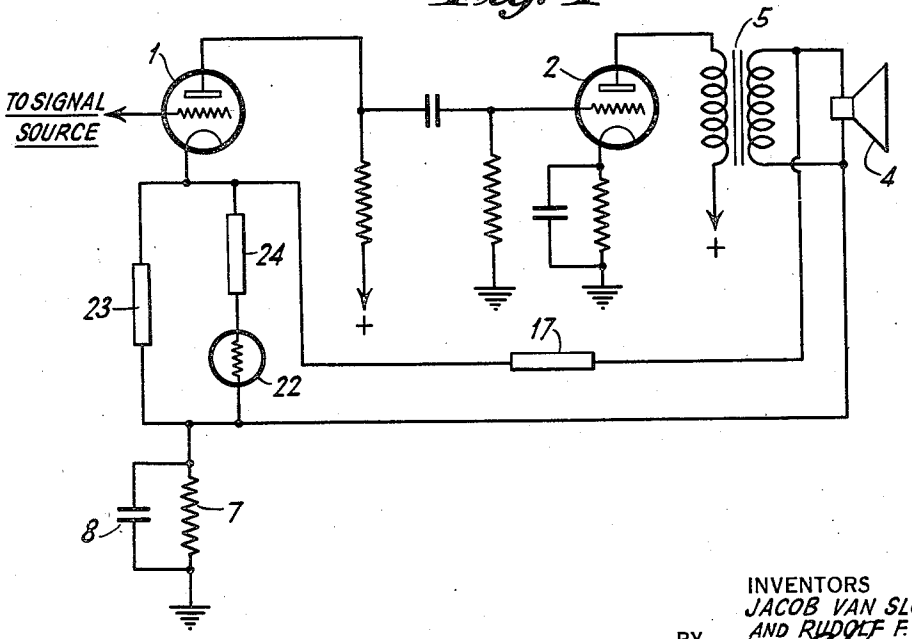


Fig. 4



INVENTORS
JACOB VAN SLOOTEN
AND RUDOLF F. VOLZ

BY

ATTORNEY

Patented July 6, 1943 2,323,634

UNITED STATES PATENT OFFICE

2,323,634

LOW FREQUENCY AMPLIFIER

Jacob van Slooten and Rudolf Friedrich Volz, Eindhoven, Netherlands, assignors, by mesne assignments, to Radio Corporation of America, New York, N. Y., a corporation of Delaware

Application August 7, 1937, Serial No. 157,927
In Germany August 11, 1936

3 Claims. (Cl. 179—171)

The present invention relates to low frequency amplification systems.

It has for its object to ensure a greater amplification of the strong than of the weak signals, owing t. which the reproduction comes nearer to reality. Such systems are known; thus, for example, it has previously been proposed to connect a resistance having a high positive temperature coefficient in parallel with the output circuit.

Many known systems, especially that above referred to, cause difficulties if, in addition, use is made of negative retroaction, because this reduces again the variations in intensity. The invention consists in rendering the retroaction dependent on the signal amplitude, namely in such manner that with a small amplitude of the signal to be amplified the retroaction is greater than with a large amplitude. This may be achieved by feeding back through an auxiliary tube whose amplification depends on the signal amplitude. A very simple means of rendering the retroaction dependent on the signal amplitude consists in leading part of the output current through an element connected in the retroactive circuit, and having a resistance which depends on the current intensity. As such an element use should preferably be made of a resistance having a high temperature coefficient.

The invention will be explained more fully with reference to the accompanying drawings which represent, by way of example, four embodiments of the invention, in Figs. 1, 2, 3 and 4, respectively.

Figure 1 represents a system comprising two amplifying tubes 1 and 2 which are coupled by means of resistances and a condenser. The output circuit of tube 2 includes the primary winding of a transformer 5, to the secondary winding of which is connected the load, e. g. a loudspeaker 4. According to the invention, retroaction is effected through a tube 3 whose amplification depends, as may appear from the following, on the signal amplitude.

The tube 3 comprises an auxiliary anode 10 which is connected by a condenser 9 to the anode of tube 1. The rectified current passes through a plurality of resistances amongst which there is a resistance 11 across which an increasing drop of voltage is produced when the signal amplitude increases. One of the ends of the resistance 11 is connected to the grid of the tube 3. Upon simple consideration, it will appear that with an increasing signal amplitude the voltage of the grid of the tube 3 becomes more negative due to the potential drop across the resistance 11, with the result that the amplification by this tube decreases. The voltage across the grid and the cathode of the tube 3 is operative at the load 4. The anode of the tube 3 is connected through a resistance 12 to the positive terminal of the source of supply, and, in addition, by a condenser 13 to the cathode of the tube 1. The anode current of this tube 1 flows through resistances 6 and 7 which are connected into the supply lead of the cathode, and which form at the same time part of the input circuit of the tube 1.

The resistance 7, which has a condenser 8 connected in parallel with it, serves to apply a negative bias to the grid of the tube 1. The resistance 6 acts as a coupling resistance between the anode circuit of the tube 3 and the input circuit of the tube 1. As will be clear from the above, part of the signals operative in the secondary transformer winding is amplified by the tube 3 and supplied to the input circuit of the tube 1, a negative retroaction being thus obtained. This negative retroaction is known per se and may be employed for the suppression of non-linear distortions in the amplifier. A condenser 18, as well as resistances 19 and 20, prevent the low-frequency oscillations supplied to the anode 10 from reaching the grid of the tube 3. In addition, they prevent the oscillations of the output circuit from attaining the anode 10.

Since the amplification by the tube 3 depends on the signal amplitude the retroaction also depends thereon, namely in such manner that with an increasing signal amplitude the negative retroaction decreases. The negative retroaction results in a decrease of the amplification. With large signal amplitude this decrease is consequently less than with small signal amplitudes. The consequence thereof is that with large signal amplitudes the amplification is greater than with small amplitudes, with the result that the contrast between strong and weak passages is increased and the reproduction becomes more faithful.

With the system shown in Fig. 2 use is made, instead of an amplifying tube, of a resistance having a positive temperature coefficient, for example an incandescent lamp 14. In the system shown, this lamp is located between one of the ends of the secondary winding of the output transformer 5 and the cathode of the tube 1. If required, there may be included, in addition, a resistance 15 or/and a resistance 21 which serve to control the effect. These resistances are, however, not absolutely necessary. Furthermore, there is provided a connection between the other end of said transformer winding and one end of the resistance 6 which serves for the coupling. With strong passages the incandescent lamp 14 is traversed by a current of higher intensity than with weak passages and the temperature of the filament is consequently higher, so that also the resistance has a higher value. With strong passages the retroaction is consequently comparatively less than in the case of weak passages

with the result that the contrast between these passages is increased.

In the case of a low output energy it is generally desirable to make the low frequencies more prominent than the high frequencies. According to the invention, this may be effected by connecting into the retroactive circuit one or more impedances which depend on the frequency. Such a circuit arrangement is shown in Figure 3. It substantially corresponds to that shown in Figure 2 except, however, that a condenser 16 is connected in series with the incandescent lamp, and that in parallel with this series-connection is located an impedance 17 which may be capacitative or inductive according to the effect desired. With the system represented, the negative retroaction is in the case of weak passages comparatively greater for the high than for the low frequencies. As the impedance 17 there may be employed, for example, an inductance owing to which it is ensured that the range of the high frequencies is made somewhat more prominent. The capacity of the condenser 16 is so chosen that in the case of weak passages, that is to say when the filament has a comparatively low temperature, the impedance is for low frequencies large with respect to the resistance of the filament; whereas in the case of strong passages the resistance in the retroactive circuit is substantially determined by that of the filament. The condenser 16 should have in general a high value; an electrolytic condenser should preferably be utilized therefor.

Instead of a resistance having a positive temperature coefficient there may also be employed a resistance with a negative temperature coefficient. This resistance may be connected in series with the resistance 7. Such a circuit arrangement, with which, in addition, the retroaction is dependent on the frequency, is represented in Fig. 4. In this figure the resistance with a negative temperature coefficient is denoted by 22, and impedances by 23 and 24. Relatively to an amplifier wherein the resistance with positive temperature coefficient is connected in parallel with the loudspeaker, the amplifier according to the invention affords the advantage that the energy consumed for the control of the sound intensity is greatly reduced.

Suppose impedance 23 is absent or very high, and 24 is shorted or very low. Also, let 17 be a resistance. Then the greater the speaker voltage the more current flows through 22, and hence the less its resistance. Since the speaker voltage is divided between the drop through 17 and the drop through 22 a smaller proportion will appear across 22 as the resistance of 22 decreases. As the drop across 22 is the degenerative feed back voltage this means less degeneration is secured as output increases, or in other words range expansion is had.

If, now, 17 is made inductive, as in Fig. 3, it will by virtue of its impedance increasing with frequency automatically reduce the degenerative feed back as frequency increases so that at very high frequencies there is never much degeneration at any amplitude, and, hence, relatively little volume expansion as compared to the expansion for low frequencies. On the other hand, if 17 is a capacity the effects are the opposite, and there is relatively little expansion at low frequencies so that at low intensities the low tones are relatively more prominent than the higher frequency tones.

The dependence of the amount of expansion on frequency may be adjusted to follow more nearly to any desired law by providing further frequency discriminatory elements such as 23 and 24. For example, if 17 and 24 are capacities, while 23 is an inductance, a high pass filter structure is formed whose input receives voltage from the speaker and whose output is connected to 22. With this arrangement a whole range of low frequencies may be substantially freed from degenerative feed back variations resulting from amplitude variation while a wide range of higher frequencies are fully expanded with respect to amplitude. Contrariwise the use of resistors at 23 and 24 reduces the amount of variation with frequency that a condenser at 17 tends to introduce into the expansion by reducing the amount of current through 22, and also by reducing the variation of the total resistance in series with 17 resulting from changes in volume.

What is claimed is:

1. In an audio amplifier system of the type comprising at least two cascaded amplifier tubes, a volume range expander network comprising a negative audio feedback path connected between the output circuit of the second tube and the input circuit of the first tube, means operatively associated with said path for decreasing the feedback of audio voltage to said input circuit in response to increase of the audio amplitude, and additional means operatively associated with said feedback path for increasing the feedback of audio voltage of high audio frequencies to a greater extent than voltage of low audio frequencies in response to a decrease of the said amplitude.

2. In an audio amplifier system of the type comprising at least two cascaded amplifier tubes, a volume range expander network comprising a negative audio feedback path connected between the output circuit of the second tube and the input circuit of the first tube, means operatively associated with said path for decreasing the feedback of audio voltage to said input circuit in response to increase of the audio amplitude, and additional means operatively associated with said feedback path for increasing the feedback of audio voltage of high audio frequencies to a greater extent than voltage of low audio frequencies in response to a decrease of the said amplitude, said first means comprising a resistance device having a positive temperature coefficient, and said additional means including a reactive impedance connected across the resistance device.

3. In an audio amplifier system of the type comprising at least two cascaded amplifier tubes, a volume range expander network comprising a negative audio feedback path connected between the output circuit of the second tube and the input circuit of the first tube, means operatively associated with said path for decreasing the feedback of audio voltage to said input circuit in response to increase of the audio amplitude, and additional means operatively associated with said feedback path for increasing the feedback of audio voltage of high audio frequencies to a greater extent than voltage of low audio frequencies in response to a decrease of the said amplitude, said first means comprising the filament of an incandescent lamp, said additional means including a reactive impedance in shunt with the lamp, and a condenser in series with the latter.

JACOB VAN SLOOTEN.
RUDOLF FRIEDRICH VOLZ.