Jan. 7, 1941. V. D. LANDON 2,227,590

FREQUENCY SELECTIVE NETWORK

Filed Nov. 30, 1938 2 Sheets-Sheet 1

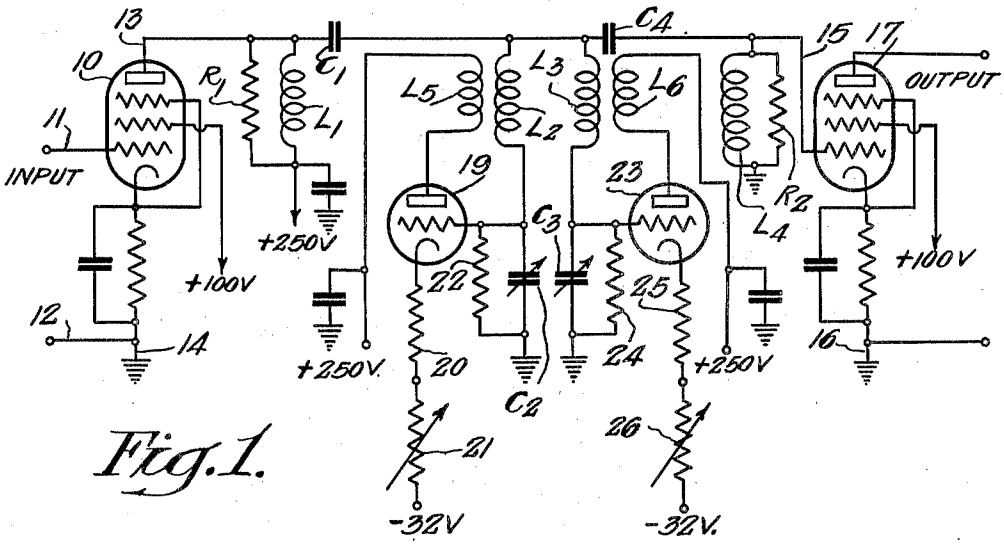


Fig. 1.

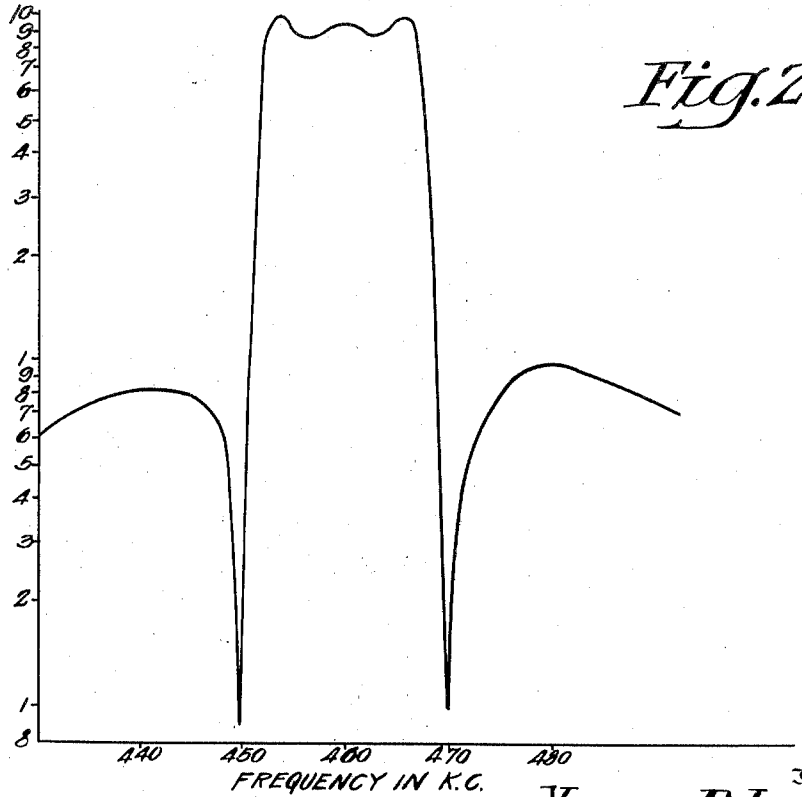


Fig. 2.

Inventor
Vernon D. Landon

By

Attorney

Jan. 7, 1941. V. D. LANDON 2,227,590

FREQUENCY SELECTIVE NETWORK

Filed Nov. 30, 1938 2 Sheets-Sheet 2

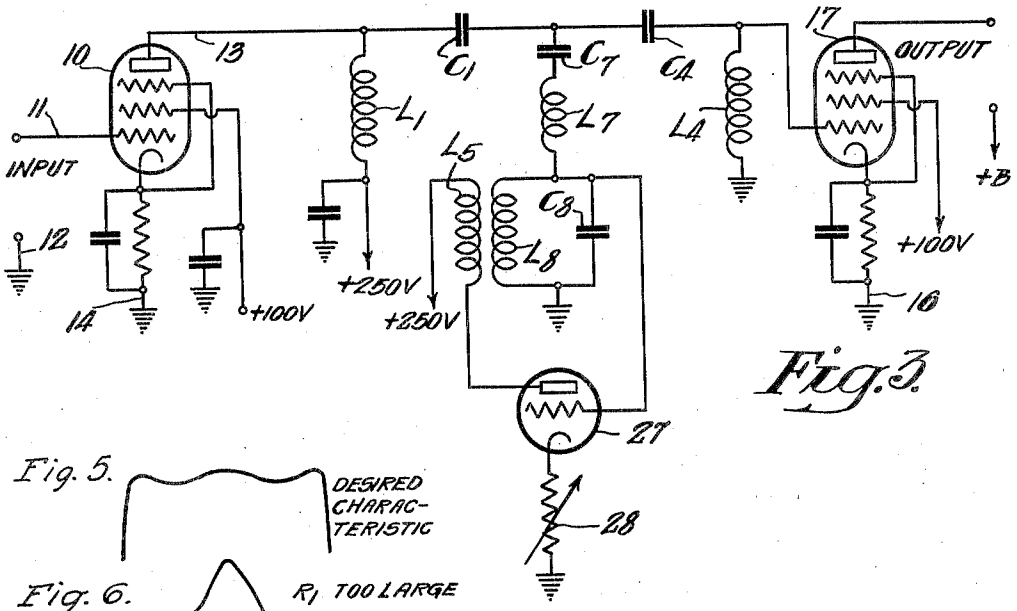


Fig. 3.

Fig. 5. DESIRED CHARACTERISTIC

Fig. 6. R_1 TOO LARGE

Fig. 7. R_1 TOO SMALL

Fig. 8. R_2 TOO LARGE R_1 ADJUSTED FOR EQUAL PEAKS

Fig. 9. R_1 & R_2 TOO SMALL

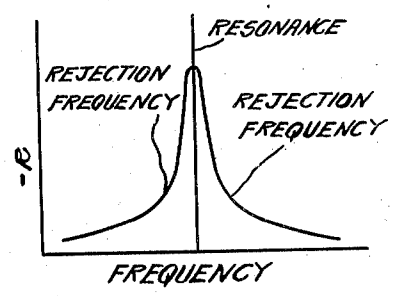
Fig. 10. $\frac{1}{2\pi\sqrt{L_4 C_4}}$ TOO SMALL

Fig. 11. $\frac{1}{2\pi\sqrt{L_4 C_4}}$ TOO LARGE

Fig. 12. $\frac{1}{2\pi\sqrt{L_1 C_1}}$ TOO LARGE

Fig. 13. $\frac{1}{2\pi\sqrt{L_1 C_1}}$ TOO SMALL

Fig. 4.



Inventor

Vernon D. London

Attorney

Patented Jan. 7, 1941

2,227,590

UNITED STATES PATENT OFFICE

2,227,590

FREQUENCY SELECTIVE NETWORK

Vernon D. Landon, Haddonfield, N. J., assignor to Radio Corporation of America, a corporation of Delaware

Application November 30, 1938, Serial No. 243,213

4 Claims. (Cl. 178—44)

This invention relates to frequency selective networks, such as are utilized to pass a desired frequency band and to reject undesired frequency bands. It has for its principal object the provision of an improved frequency selective network and method of operation whereby the frequency-amplitude characteristic of the passed frequency band is rendered substantially flat and a sharp line of demarcation is maintained between the passed and rejected bands.

It is well known that (1) a frequency selective network usually includes reactors and capacitors, (2) the lower the effective resistance of these elements, the more complete the transmission and rejection of the respective desired and undesired frequencies, and (3) the size and cost of these elements increase as their resistance is reduced.

In accordance with U. S. Patent 1,725,154 of Lester O. Marsteller, it is proposed to regenerate a frequency selective network for the purpose of reducing the effective resistance. To this end, the network currents are utilized to produce, at the network reactors and capacitors, potentials of such phase and magnitude as to minimize or obviate the effect of the resistance of these elements.

The present invention is in some respects similar to that of the aforesaid Marsteller patent, but differs therefrom in that it involves simplified and improved means for deriving the regenerative potentials whereby the effective resistance of the network is maintained at the relatively low value required for efficient operation of the network. More specifically stated, the present invention involves the provision of means whereby regeneration of the network is stabilized and the deleterious variations otherwise encountered in the operation of the network are avoided.

The invention will be better understood from the following description considered in connection with the accompanying drawings, and its scope is indicated by the appended claims.

Referring to the drawings:

Figure 1 is a wiring diagram of a frequency selective network wherein separate amplifiers are utilized to regenerate the different circuits through which the undesired frequency bands are rejected;

Figure 2 is the frequency-amplitude characteristic curve of the network of Figure 1;

Figure 3 is a wiring diagram of a modified network wherein a single amplifier is utilized to regenerate the rejector circuits of the network;

Figure 4 is a curve illustrating certain operating characteristics of the modified network of Figure 2; and

Figures 5 to 13, inclusive, are a series of explanatory diagrams relating to the adjustment of the filter network.

Broadly considered, the networks of Figs. 1 and 3 include two acceptor circuits C_1L_1 and C_4L_4, tuned to the center of the desired frequency band, and two rejector circuits C_2L_2 and C_3L_3 (Fig. 1), tuned respectively on the opposite sides of the pass band. As indicated by the curve of Fig. 2, this well known circuit gives a flat top or three slight peaks with steep sides in the pass band part of the frequency-amplitude characteristic. With high loss reactors or with a narrow pass band, the shoulders of this characteristic tend to droop. Regeneration of the rejector circuits C_2L_2 and C_3L_3 functions to maintain the desired flat pass band characteristic irrespective of the reactor losses and the pass band width.

The network of Fig. 1 includes an electron discharge amplifier 10 which is provided with input terminals 11—12 and with output terminals 13—14 coupled through reactor-capacitor units C_1L_1 and C_4L_4 to the input terminals 15—16 of an amplifier 17. A resistor R_1 of the order of 100,000 ohms may be connected in shunt to the reactor L_1 for reducing the center peak of the curve of Fig. 2 to about the same height as the other two peaks, and a resistor R_2, which may be smaller than the resistor R_1, may be connected in shunt to the reactor L_4.

Interposed between the acceptor or coupling units C_1L_1 and C_4L_4, and connected in shunt to the main signal channel, are the low frequency filter or rejector C_2L_2 and the high frequency filter or rejector C_3L_3. Regeneration of the low frequency rejector C_2L_2 is effected by means including an amplifier 19 provided (1) with an input circuit including a cathode lead series resistor 20—21 and a grid leak resistor 22 connected in shunt to the capacitor C_2 and (2) with an output circuit including the resistor 20—21, a suitable plate voltage source and a feedback coil L_5 which is inductively coupled to the reactor L_2. Regeneration of the high frequency rejector C_3L_3 is likewise effected by means including an amplifier 23 having in its input circuit a cathode lead series resistor 25—26 and a grid leak resistor 24 which is connected in shunt to the capacitor C_3, and in its output circuit the resistor 25—26, a plate voltage source and a feedback coil L_6 inductively coupled to the reactor L_3.

It will be noted that regeneration is effected through the tickler coils L_5 and L_6 in the usual manner except that the regenerative effect is stabilized by the cathode lead resistors **20—21** and **25—26**. The lower terminals of these stabilizing resistors are subjected to a negative potential such as −32 volts for neutralizing the d. c. drop of the resistor and maintaining a normal voltage of about +3 volts on the feedback amplifier cathodes.

The cathode lead resistor **20—21**, for example, has a stabilizing influence in two ways. First, any change in the plate voltage or mutual conductance of the feedback tube results in a compensating change in the grid bias potential of the tube and, as a result, the tube mutual inductance varies but slightly. In addition, this small change in the effective tube characteristic is further reduced by the action of the resistor at radio frequency. When a radio frequency voltage is applied to the grid, a voltage appears upon the cathode of the same phase and almost equal amplitude. The true input to the tube is the difference between the grid and cathode voltages, and a radio frequency plate current flows due to this difference voltage. This plate current is used for regeneration through the tickler L_5 or L_6.

If the mutual conductance of the tube should decrease, a smaller voltage will appear on the cathode. Hence the difference between grid and cathode voltages is greater, giving a larger input voltage to the tube. Thus it can be seen that the variation in plate current is a very much smaller percentage than the variation in tube characteristic. Thus the cathode resistor is the means of stabilizing the amplification of the vacuum tube, and such amplification is then used as a means of applying regeneration to the rejector circuit. While a fixed coupling is shown between the plate and grid coils and regeneration is adjusted to a critical value by adjusting the cathode resistor section **21** and **26**, the same result could be obtained with a fixed cathode resistor and a variable tickler adjustment.

It is apparent that the present invention is distinguished from that of the Marsteller Patent 1,725,154 in that stabilization of regeneration is effected by means of the cathode resistors, whereas the circuit of Marsteller is adjusted to critical regeneration. If the plate voltage or tube mutual conductance of Marsteller varies, a different amount of regeneration is obtained and this results in undesirable variations in filter characteristics or oscillation which are avoided by the present invention.

The modified network of Fig. 3 differs from that of Fig. 1 in that the two shunt rejector circuits C_2L_2 and C_3L_3 are replaced by a shunt circuit which includes a capacitor C_7 and a reactor L_7 connected in series with the parallel connected capacitor C_8 and reactor L_8. In this modification, the parallel resonant circuit is regenerated through means including a single amplifier **27**, a cathode lead resistor **28**, and the ticker coil L_5 which is inductively coupled to the reactor L_8.

When the effective series resistance of C_8L_8 is slightly negative, the negative resistance component of this parallel resonant circuit is as indicated by the curve of Fig. 4. At the rejection frequencies, C_7, L_7, C_8 and L_8 form a series resonant combination and the effective series negative resistance of C_8L_8 should equal the resistance of C_7L_7. Oscillation does not occur because of the grid and plate coil resistances. In the pass band, the entire rejector circuit L_1—C_1—L_2—C_2 has a negative effective resistance, but suitable adjustment of the grid and plate circuit losses results in a flat pass band.

In lining up a single stage filter such as that of Fig. 1, a signal generator is connected to the grid of the amplifier tube and a tube voltmeter is connected to the output of the filter. The first operation is to line up the rejectors for maximum attenuation at the rejection frequencies. This involves adjusting both tuning and regeneration for maximum attenuation. The two acceptor circuits L_1C_1 and L_2C_2 are then tuned for maximum response in the center of the pass band. Alignment may be found easier if less than optimum damping is used for this preliminary tuning adjustment. A head and shoulders curve will then be obtained in the pass band. The steps involved in correcting this to the desired shape are indicated in Figs. 5 to 13, inclusive, and in which a series of curves are plotted. Each curve represents a possible shape of the pass band characteristic. (The relative height of one curve to another is of no significance here.) The top curve is assumed to be the desired one. The other curves are obtained when one or more circuit constants have inaccurate values as indicated on the figure.

If R_1 is too large, the curve shown in Fig. 6 is obtained. As R_1 is decreased, the curve assumes progressively the shape of the curve of Fig. 5 and the curve of Fig. 7. If R_2 is too large, the two valleys will be too deep after R_1 is adjusted for equal peaks.

If the curve of Fig. 8 is obtained and R_2 is decreased, a curve similar to that of Fig. 6 will result so that R_1 must also be decreased. The result is then as shown in Fig. 5.

If R_1 and R_2 are kept equal, the head (or central peak) of the curve is always higher than the shoulders no matter what value is chosen for R_1 and R_2 (Figs. 8 and 9).

To equalize the height of the two shoulders, the tuning of the low loss circuit L_4C_4 should be used (Figs. 10 and 11). Gain is increased in the shoulder toward which this circuit is tuned.

The high loss circuit L_1C_1 has the reverse effect, but to a much smaller extent. The major effect of mistuning L_1C_1 is to raise and lower the relative response in the valleys as indicated in Figs. 12 and 13.

I claim as my invention:

1. In a frequency selective network including a signal channel tuned to pass a predetermined band of frequencies, the combination of a rejector circuit including a capacitor and a reactor connected in shunt to said channel and tuned outside said band, a resistor, a tickler coil coupled with said reactor, and a rejector circuit regenerating amplifier provided with an input circuit including said resistor and capacitor and with an output circuit including said resistor and said coil.

2. In a frequency selective network including a channel tuned to pass a predetermined band of frequencies, the combination of a rejector circuit including a parallel connected capacitor and reactor and a series capacitor and reactor connected across said channel in series with said parallel connected capacitor and reactor, a resistor, a tickler coil coupled with one of said reactors, and a rejector circuit regenerating amplifier provided with an input circuit including said resistor and capacitor and with an output circuit including said resistor and said coil.

3. In a frequency selective network including a channel tuned to pass a predetermined band

of frequencies, the combination of a rejector circuit including a parallel connected capacitor and reactor and a series capacitor and reactor connected across said channel in series with said parallel connected capacitor and reactor, a resistor, a tickler coil coupled with said parallel connected reactor, and a rejector circuit regenerating amplifier provided with an input circuit including said resistor and capacitor and with an output circuit including said resistor and said coil.

4. In a frequency selective network, the combination of two acceptor circuits tuned to the center of a desired frequency pass band and means providing two rejector circuits tuned respectively on the opposite sides of said pass band, each of said rejector circuits including an inductive reactor and capacitor serially connected and providing a shunt circuit for each of said acceptor circuits, means providing a signal conveying coupling connection between said acceptor circuits, and means for introducing stabilized regeneration into said rejector circuits comprising in connection with each of said circuits an amplifier tube having an anode circuit inductively coupled to the inductive reactor therein, a grid circuit including the capacitor for said rejector circuit, and a cathode having a return connection to said anode and grid circuits, and a variable controlling resistor in said connection.

VERNON D. LANDON.