

June 8, 1943.

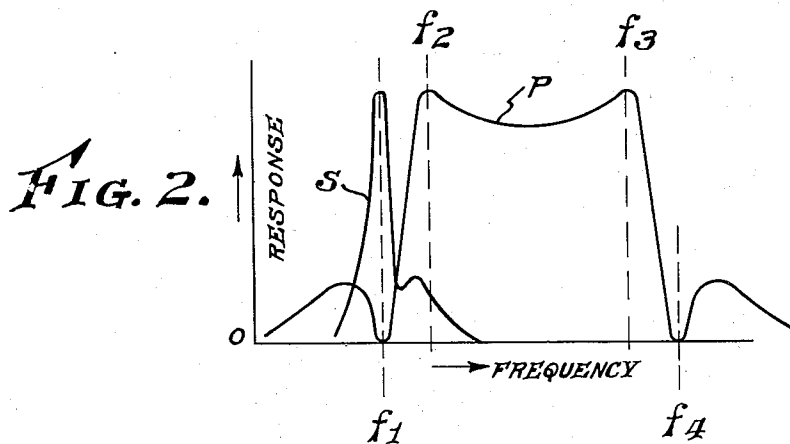
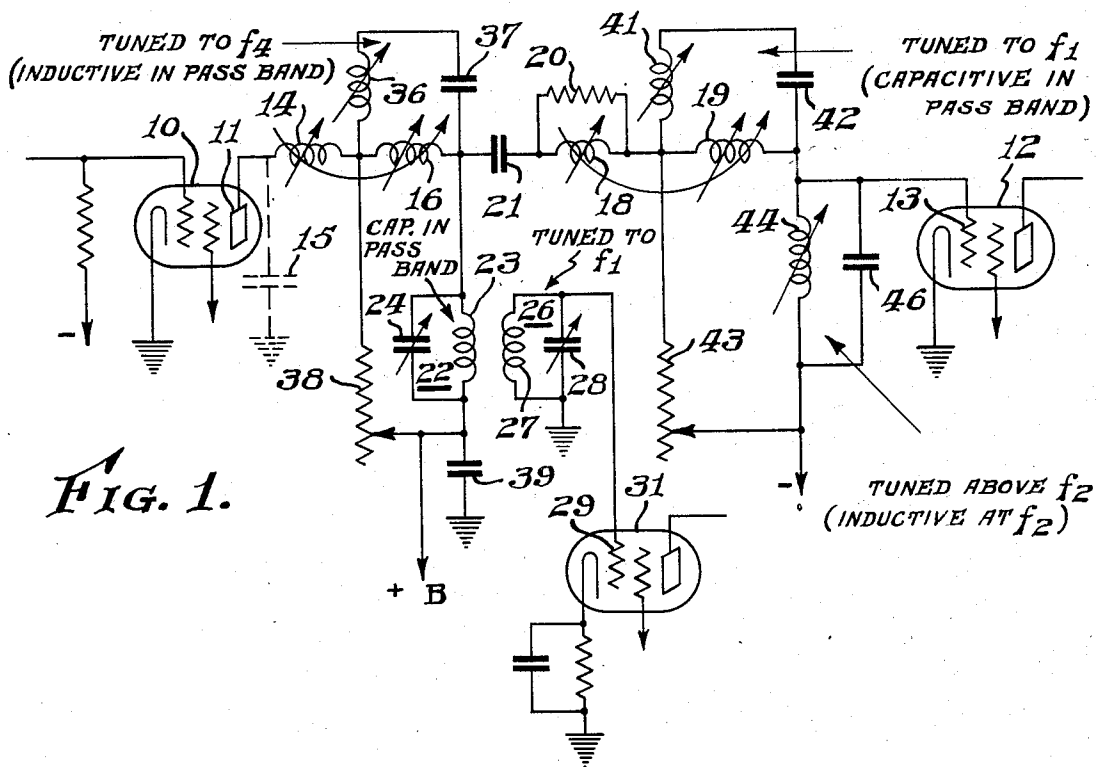
G. L. GRUNDMANN

2,321,291

BAND PASS AMPLIFIER

Filed Oct. 31, 1941

2 Sheets-Sheet 1



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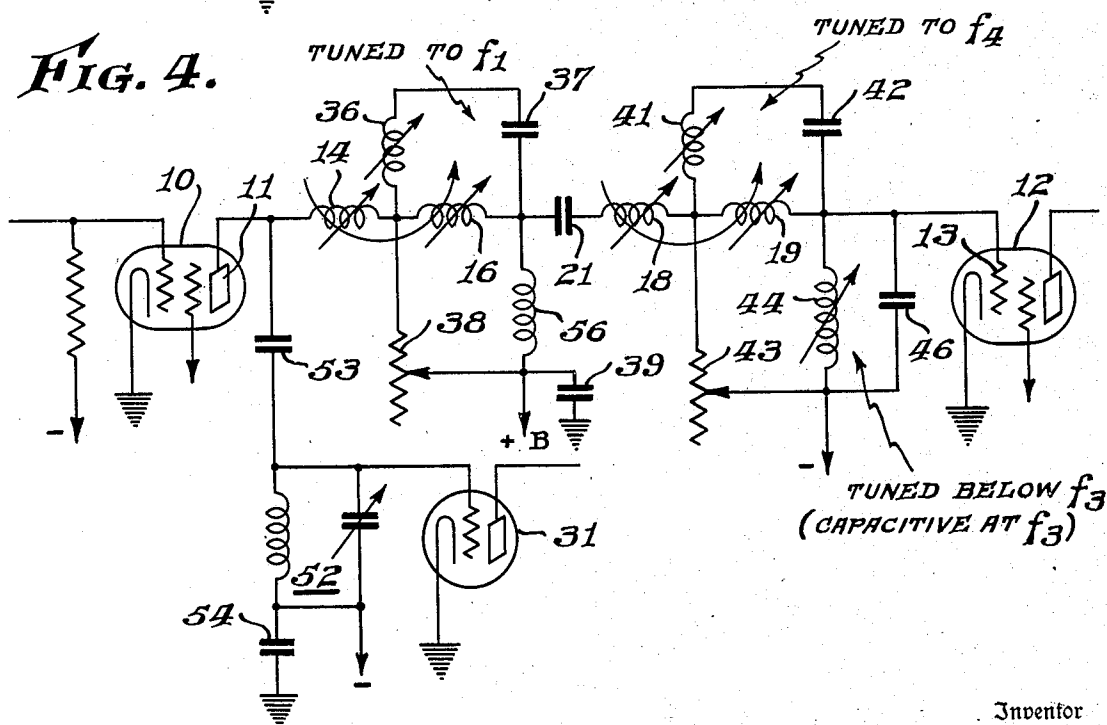
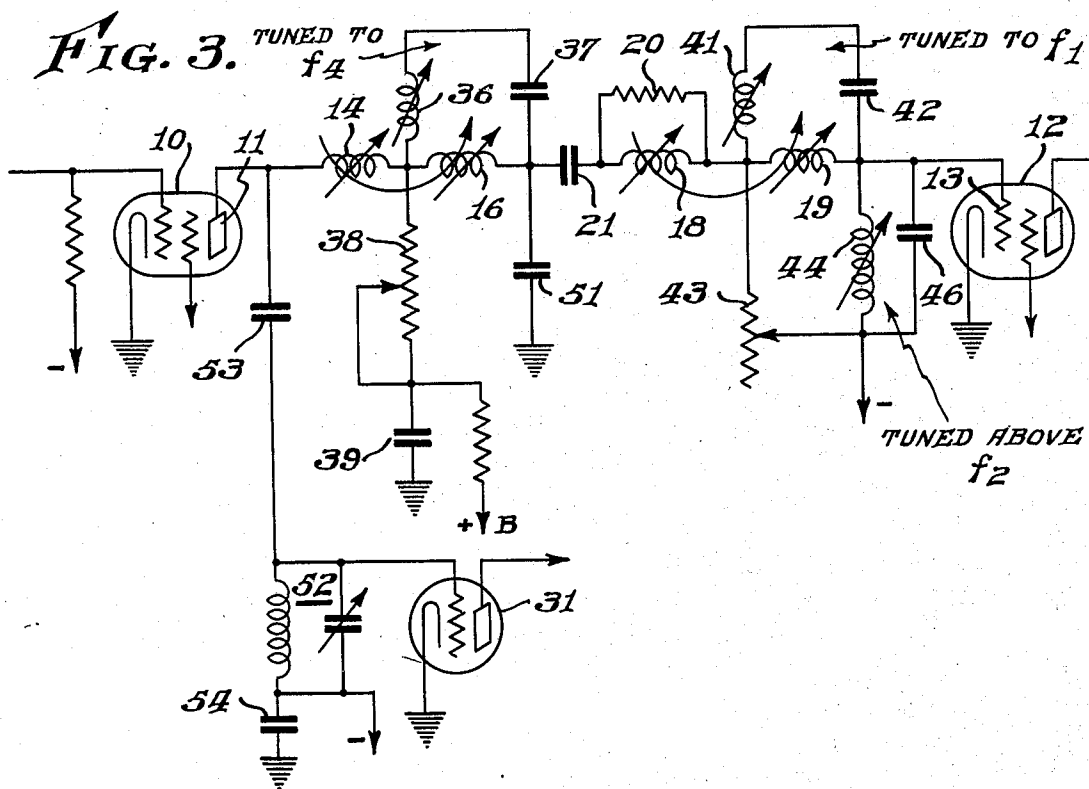
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2 Sheets-Sheet 2



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UNITED STATES PATENT OFFICE

2,321,291

BAND PASS AMPLIFIER

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Application October 31, 1941, Serial No. 417,227

6 Claims. (Cl. 179—171)

My invention relates to band pass amplifiers and particularly to amplifiers having sharp rejection on each side of the pass band.

The invention is particularly applicable to an intermediate frequency amplifier in a television receiver that is to receive and amplify the signal from a vestigial sideband transmitter which transmits the picture signal with the signal strength down 50 percent at the carrier frequency.

An object of the invention is to provide an improved amplifier that has sharp rejection at each side of the pass band and which, also, has a desired frequency response characteristic, such as a flat characteristic, over the pass range.

In a preferred embodiment of the invention, I preferably employ rejector circuits of the type described in my Patent 2,207,796, issued July 16, 1940. As explained in my patent, the resistance in these rejector circuits is balanced out whereby substantially 100 percent rejection of an unwanted signal may be obtained.

In the present invention, the amplifier circuit is so designed that two rejector circuits may be included in a single amplifier stage, one rejector being tuned to reject on the low side of the pass band and the other rejector being tuned to reject on the high side. In previous amplifier designs employing my rejectors, a rejector could be employed for rejection on either the low side or on the high side, but, in the first instance, the coupling between the primary and secondary circuits was inductive, and, in the second instance, it was capacitive. This would indicate that the use of a rejector on the low side would exclude the use of a rejector on the high side, and vice versa. However, I have overcome this difficulty in the present invention by utilizing, together with other design features, an additional tuned circuit at the output of the secondary circuit, this additional circuit being so tuned that it is either inductive or capacitive, as desired, at a predetermined frequency.

The invention will be better understood from the following description taken in connection with the accompanying drawings in which

Figure 1 is a circuit diagram of a preferred embodiment of the invention,

Figure 2 shows frequency response curves for the circuit of Figure 1, and

Figures 3 and 4 are circuit diagrams of other embodiments of the invention.

Like parts in the several figures are indicated by the same reference characters.

Figure 1 shows the invention applied to an I.-F. amplifier stage in the picture channel of a television receiver. The I.-F. amplifier includes an amplifier tube 10 having a plate 11 and an amplifier tube 12 having a control grid 13.

The coupling circuit between the tubes is by

means of coupled tuned circuits. They comprise a primary circuit which includes a primary circuit coil 14, and a rejector circuit coil 16, and a secondary circuit which includes a secondary circuit coil 18, preferably shunted by a damping resistor 20, and another rejector circuit coil 19. Each of the coils preferably is tunable by means of a magnetic core. A blocking condenser 21 keeps plate voltage off the grid 13.

The primary and secondary circuits are coupled by means of an impedance element common to the two circuits, this element being in the form of a tuned circuit 22 consisting of an inductance coil 23 and a tuning condenser 24. The tuned circuit 22 is tuned to a frequency below the pass band whereby it presents capacitive reactance throughout said band.

Coupled to the tuned circuit 22 is a second tuned circuit 26 consisting of an inductance coil 27 and a tuning condenser 28. This circuit is tuned to the sound carrier wave frequency f_1 accompanying the picture signal and is connected to the control grid 29 of a sound amplifier tube 31.

The primary and secondary circuits are tuned in part by the tube capacities; the tuning and coupling being such as to give, for example, a flat-topped response curve. In some receivers, the response curve may be peaked on one side or on both sides to compensate for lack of sufficient response in another stage whereby the overall amplifier response is made flat.

Before describing the circuit further, it will be helpful to refer to the response curves in Figure 2. The curve P is the frequency response curve taken at the grid 13 of the picture amplifier tube 12. Curve S is the frequency response curve taken at the grid 29 of the sound amplifier tube 31.

It will be seen that the response curve P has a rejection point f_1 and a second rejection point at frequency f_4 , the latter frequency being the sound carrier wave frequency in an adjacent television channel.

Also, at frequencies f_2 and f_3 , there are resonant peaks which sharpen the low frequency cut-off and the high frequency cut-off, respectively.

The rejector circuits and their relation to the rest of the circuit will now be described more specifically. The rejector in the primary circuit includes, in addition to coil 16, a tunable coil 36 and a condenser 37. This rejector circuit is tuned to the frequency f_4 whereby it presents an inductive reactance throughout the pass band.

As explained in my above-identified patent, the coils 14 and 16 are coupled to give negative mutual inductance at their junction point. The coil 16 is not coupled to any other coil.

An adjustable resistor 38 is connected from the junction point of coils 14 and 16 to a by-pass

condenser 39, and through condenser 39 to ground. This resistor is adjusted to balance out the resistance unavoidably present in the parallel resonant rejector circuit 16—36—37.

The rejector in the secondary circuit includes, in addition to the coil 19, a tunable coil 41 and a condenser 42. This rejector circuit is tuned to the frequency f_1 and, therefore, is capacitive over the pass band. As in the other rejector circuit, the coils 18 and 19 are coupled in the direction to give negative mutual inductance at their junction point. A balancing resistor 43 is connected from this junction point to ground through a biasing source (not shown).

In the input circuit of amplifier tube 12 there is a tuned circuit consisting of an inductance coil 44 and a tuning condenser 46. In some designs, the condenser 46 may be omitted, the tube capacity being sufficient for tuning the input circuit. In either case, the input circuit 44—46 is tuned to resonate at a frequency higher than frequency f_2 whereby the said circuit is inductive at f_2 .

Attention is now directed to the fact that the primary circuit must series resonate at either f_2 or f_3 and that the secondary circuit must resonate at the other of these two frequencies in order to obtain the resonant peaks at f_2 and f_3 as indicated in Figure 2. It is necessary that such resonance be present if the desired sharpness of cut-off is to be obtained.

In the circuit illustrated in Figure 1, the primary circuit resonates at f_3 and the secondary circuit resonates at f_2 . These series resonant circuits will now be traced.

The primary circuit may be traced from the plate 11 of tube 10 through primary coil 14, through the rejector circuit 16—36—37 which is inductive at f_3 , through the coupling impedance circuit 22 which is capacitive at f_3 , through the large bypass condenser 39 to ground and back to the plate 11 through the tube plate capacity indicated at 15. Thus there are the two inductive impedances 14 and 16—36—37, and the two capacitive impedances 22 and 15. These impedances may be adjusted to be series resonant at the desired frequency f_3 .

The secondary circuit may be traced from the blocking condenser 21 through secondary coil 18, through rejector circuit 19—41—42, which is capacitive at f_2 , to the control grid 13, through the tuned input circuit 44—46 which is inductive at f_2 , through the bias source (not shown) to ground, and from ground through bypass condenser 39 and the coupling impedance circuit 22 (capacitive at f_2) back to the blocking condenser 21. Thus there are the two inductive impedances 18 and 44—46, and the two capacitive impedances 19—41—42 and 22. These impedances may be adjusted to be series resonant at f_2 .

The required adjustment of the band pass amplifier may be made as follows with a tube voltmeter connected to the grid 13 of amplifier tube 12:

- (1) Set resistor 38 and resistor 43 to maximum values.
- (2) Adjust coil 36 to tune circuit 16—36—37 to give minimum output at f_4 .
- (3) Adjust resistor 38 to "zero balance" and check tuning of circuit 16—36—37.
- (4) Adjust coil 41 to tune circuit 19—41—42 to give minimum output at f_1 .
- (5) Adjust resistor 43 to "zero balance" and check tuning of 19—41—42.

(6) Adjust coil 44 to give maximum response at f_2 .

(7) Adjust condenser 24 to give maximum response at f_3 .

(8) Compare relative response of f_2 peak to f_3 peak. If not equal, adjust coil 14 and condenser 24 to get equal response.

(9) Adjust condenser 28 to give maximum response at sound amplifier grid 29 at f_1 .

Figure 3 shows an embodiment of the invention in which the coupling between primary and secondary circuits is provided by a condenser 51 common to the two circuits and in which sound signal is taken off through a tuned circuit 52 connected to the plate 11 through a coupling condenser 53. A bypass condenser is indicated at 54.

The circuit 52 is tuned to the sound carrier frequency f_1 . The other circuit elements are tuned substantially the same as in Figure 1, since in both Figure 1 and Figure 3 the common coupling impedance for the primary and secondary circuits is capacitive.

It may be noted that the adjustment for series resonance of the primary circuit at f_3 is made by adjusting the coil 14.

Figure 4 shows an embodiment of the invention which differs from those previously described in that the coupling impedance common to the primary and secondary circuits is inductive rather than capacitive. Because of this, the circuit elements are tuned differently. The said inductive coupling impedance is provided by a coil 56.

In Figure 4, the rejector circuit 16—36—37 is tuned to frequency f_1 and the rejector circuit 19—41—42 is tuned to the frequency f_4 whereby they are capacitive and inductive, respectively, in the pass band. Also, the input circuit 44—46 is tuned to resonate below f_3 whereby it is capacitive at f_3 . The procedure in adjusting this coupling circuit is similar to that described for Figure 1, but in this case the coil 44 is adjusted to give maximum response at f_3 and the coil 14 is adjusted to give maximum response at f_2 .

It should be understood that the invention is not limited to the specific circuits shown and described. For example, the rejector circuits may be of a bridged-T design other than the specific design illustrated, or they may be simple parallel resonant rejector circuits if the more complete rejection obtained by bridged-T circuits is not required.

From the foregoing, it will be apparent that I have provided a band pass amplifier stage having sharp rejection on each side of the pass band and also having a flat-topped characteristics or, if preferred, a suitably shaped characteristic for compensation in other stages.

I claim as my invention:

1. A band pass amplifier comprising a first amplifier tube having an anode, a succeeding amplifier tube having a control grid and a cathode, a network for so coupling said tubes that said amplifier has a certain band pass range, said network comprising a tuned primary circuit connected to said anode, a tuned secondary circuit connected to said control grid, and an impedance element common to said tuned circuits for so coupling them as to give a broad-topped frequency response characteristic, a parallel resonant rejector circuit located in said primary circuit and tuned to resonance at a frequency outside of but close to one end of said band pass range, and a parallel resonant rejector circuit located in said secondary circuit and tuned to

resonance at a frequency outside of but close to the other end of said band pass range, said secondary circuit including a parallel resonant circuit connected between the control grid and cathode of said succeeding tube.

2. A band pass amplifier comprising a first amplifier tube having an anode, a succeeding amplifier tube having a control grid and a cathode, a network for so coupling said tubes that said amplifier has a certain band pass range and upper and lower cut-off points, said network comprising a tuned primary circuit connected to said anode, a tuned secondary circuit connected to said control grid, and an impedance element common to said tuned circuits for so coupling them as to give a broad-topped frequency response characteristic, a parallel resonant rejector circuit located in said primary circuit and tuned to resonance at a frequency outside of but close to one end of said band pass range, and a parallel resonant rejector circuit located in said secondary circuit and tuned to resonance at a frequency outside of but close to the other end of said band pass range, said secondary circuit including a parallel resonant circuit connected between the control grid and cathode of said succeeding tube, said primary circuit being series resonant at a frequency within the pass band and close to one of said cut-off points, said secondary circuit being series resonant at a frequency within the pass band and close to the other cut-off point, said last parallel resonant circuit being tuned to present at said last frequency a reactance of opposite sign to the reactance presented by said common impedance element in the pass band.

3. A band pass amplifier comprising a first amplifier tube having an anode, a succeeding amplifier tube having a control grid and a cathode, a network for so coupling said tubes that said amplifier has a certain band pass range and an upper cut-off point and a lower cut-off point, said network comprising a tuned primary circuit connected to said anode, a tuned secondary circuit connected to said control grid, and a capacitive impedance element common to said tuned circuits for so coupling them as to give a broad-topped frequency response characteristic, a rejector circuit of a type electrically similar to the bridged-T type located in said primary circuit and tuned to resonance at a frequency above but close to said upper cut-off point, and a rejector circuit of a type electrically similar to the bridged-T type located in said secondary circuit and tuned to resonance at a frequency below but close to said lower cut-off point, said secondary circuit including a parallel resonant circuit connected between the control grid and cathode of said succeeding tube which is tuned to resonate at a higher frequency than that at which the secondary circuit is series resonant.

4. A band pass amplifier comprising a first amplifier tube having an anode, a succeeding amplifier tube having a control grid and a cathode, a network for so coupling said tubes that said amplifier has a certain band pass range and an upper cut-off point and a lower cut-off point, said network comprising a tuned primary circuit connected to said anode, a tuned secondary circuit connected to said control grid, and a parallel resonant coupling circuit common to said tuned circuits for so coupling them as to give a broad-topped frequency response characteristic,

said last circuit being so tuned as to be capacitive in said pass band, a parallel resonant rejector circuit located in said primary circuit and tuned to resonance at a frequency above but close to said upper cut-off point, a parallel resonant rejector circuit located in said secondary circuit and tuned to resonance at a frequency below but close to said lower cut-off point, and a parallel resonant circuit connected between the control grid and cathode of said succeeding tube which is tuned to resonate at a higher frequency than that at which the secondary circuit is series resonant.

5. A band pass amplifier comprising a first amplifier tube having an anode, a succeeding amplifier tube having a control grid and a cathode, a network for so coupling said tubes that said amplifier has a certain band pass range and an upper cut-off point and a lower cut-off point, said network comprising a tuned primary circuit connected to said anode, a tuned secondary circuit connected to said control grid, and a parallel resonant coupling circuit common to said tuned circuits for so coupling them as to give a broad-topped frequency response characteristic, said last circuit being so tuned as to be capacitive in said pass band, a rejector circuit of a type electrically similar to the bridged-T type located in said primary circuit and tuned to resonance at a frequency above but close to said upper cut-off point, a rejector circuit of a type electrically similar to the bridged-T type located in said secondary circuit and tuned to resonance at a frequency below but close to said lower cut-off point, and a parallel resonant circuit connected between the control grid and cathode of said succeeding tube which is tuned to resonate at a higher frequency than that at which the secondary circuit is series resonant.

6. A band pass amplifier comprising a first amplifier tube having an anode, a succeeding amplifier tube having a control grid and a cathode, a network for so coupling said tubes that said amplifier has a certain band pass range and an upper cut-off point and a lower cut-off point, said pass range being for a signal that occupies a wide frequency band, said network comprising a tuned primary circuit connected to said anode, a tuned secondary circuit connected to said control grid, and a parallel resonant coupling circuit common to said tuned circuits for so coupling them as to give a broad-topped frequency response characteristic, said last circuit being so tuned as to be capacitive in said pass band, a parallel resonant rejector circuit located in said primary circuit and tuned to resonance at a frequency above but close to said upper cut-off point, a parallel resonant rejector circuit located in said secondary circuit and tuned to resonance at a frequency below but close to said lower cut-off point, a parallel resonant circuit connected between the control grid and cathode of said succeeding tube which is tuned to resonate at a higher frequency than that at which the secondary circuit is series resonant, and a circuit coupled to said parallel resonant coupling circuit and tuned to a signal accompanying said first signal, said last signal occupying a narrow frequency band located just outside of said pass band.

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