

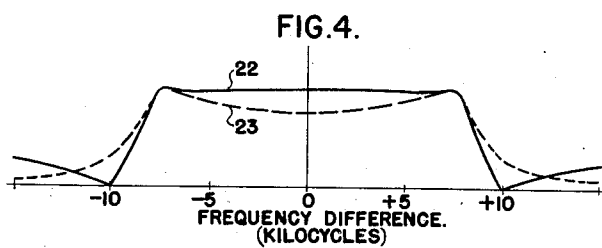
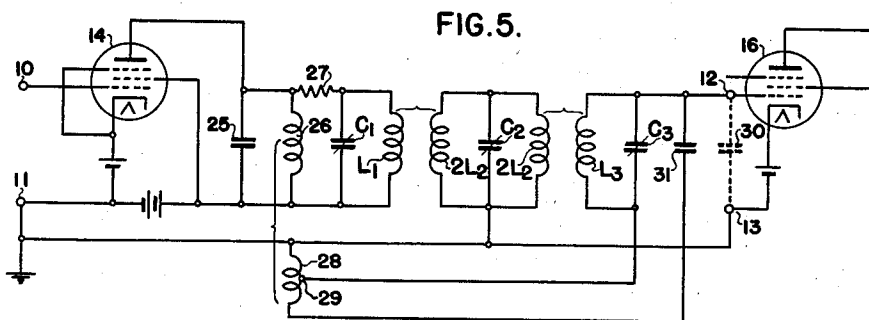
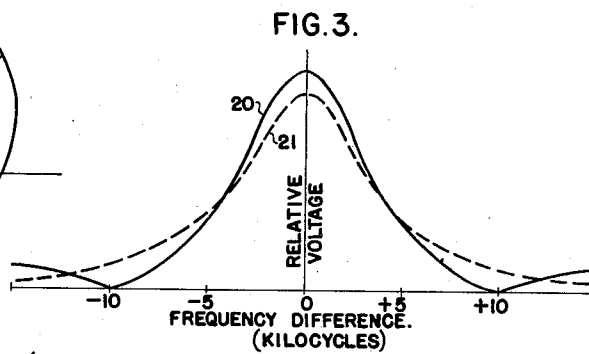
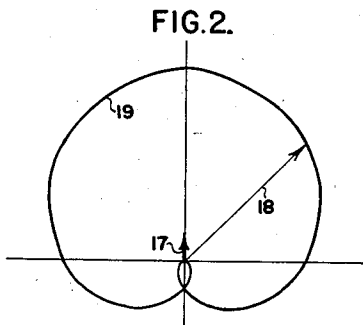
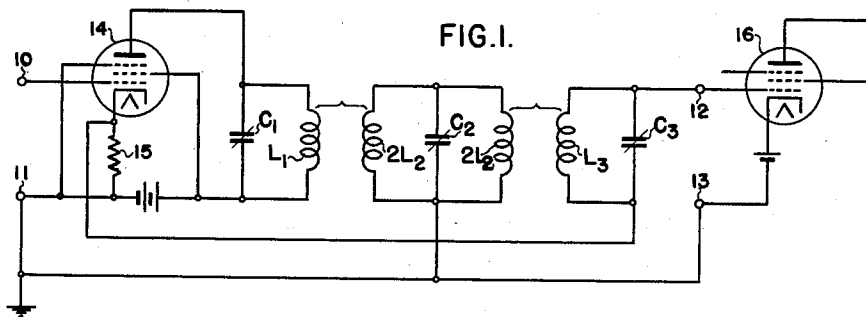
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BAND-PASS SELECTOR

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BAND-PASS SELECTOR

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10 Claims. (Cl. 178-44)

This invention relates to band-pass selectors having a high degree of selectivity against interference of frequencies near the desired frequency band and, while it is of general application, it is particularly suitable for use in the intermediate-frequency channel of modulated-carrier signal receivers of the superheterodyne type.

If the selector circuits of the intermediate-frequency channel of a superheterodyne receiver are not highly selective against interference of frequencies near the desired band, a signal on a channel adjacent to the channel of the desired signal is likely to cause objectionable interference resulting in unsatisfactory reproduction. To eliminate such interference, trap circuits have been used in the signal channel of the receiver tuned 10 kilocycles above and below the mean resonant frequency of the channel frequency. Because of inherent resistance in the tuned circuits, such trap circuits are inherently incapable of completely attenuating the interfering signal.

It is an object of the present invention to provide a band-pass selector circuit having a high degree of selectivity against interference on frequencies near the desired band.

It is another object of the invention to provide a band-pass selector having infinite attenuation at the limiting frequencies of the band without the use of any tuned circuits resonant outside the band.

In accordance with the invention, a band-pass selector system is provided including three or more coupled tuned circuits, one of which is included in the input circuit and another of which is included in the output circuit of the system. Means are provided for deriving a voltage which bears a predetermined relationship to, and is in phase with, the input current of the first tuned circuit of the selector and for combining such voltage with the voltage of said output tuned circuit substantially in phase at the mean resonant frequency of the system. As the frequency of the input to the selector is varied, the phase of the voltage across the output tuned circuit varies so that, at the limiting frequencies of the desired band, this voltage is in phase opposition to the input current of the first tuned circuit of the selector. The system is balanced so that, at these limiting frequencies, the first voltage exactly balances out the voltage across the output tuned circuit of the selector, whereby infinite attenuation is procured at these frequencies.

For a better understanding of the invention, together with other and further objects thereof,

reference is had to the following description taken in connection with the accompanying drawing, and its scope will be pointed out in the appended claims.

Referring now to the drawing, Figs. 1 and 5 are circuit diagrams of band-pass selectors including different embodiments of the invention; and Figs. 2, 3, and 4 are diagrams illustrating certain of the operating characteristics of the selector circuit of Fig. 1.

Referring now more particularly to Fig. 1 of the drawing, there is shown a selector circuit having input terminals 10, 11 and output terminals 12, 13. There is provided a vacuum tube 14, which may be an amplifier tube in the intermediate-frequency channel of a superheterodyne receiver, having input electrodes coupled to terminals 10, 11 and output electrodes coupled to a first tuned circuit C_1L_1 of the selector system. There is also provided a second tuned circuit comprising condenser C_2 and inductance L_2 , the inductance L_2 physically comprising two inductances $2L_2$ coupled in parallel and one of the inductances $2L_2$ being inductively coupled to the inductance L_1 of the first tuned circuit. A third tuned circuit C_3L_3 is provided having its inductance L_3 inductively coupled to one of the inductances $2L_2$ of the second tuned circuit. A cathode-biasing resistor 15 is provided for tube 14. The parallel circuit C_3L_3 is connected, in series with resistance 15, to the output terminals 12, 13 of the system. The output terminals 12, 13 are connected to the input circuit of a vacuum tube 16 which also may be an intermediate-frequency amplifying tube or the detector tube of a superheterodyne receiver. Suitable operating potentials are provided for tubes 14 and 16 in a conventional manner. The operation of the selector just described may best be understood by reference to Figs. 2 and 3.

Fig. 3 is a vector diagram indicating the relationship between the voltages across the resistor 15 and across the tuned circuit C_3L_3 . The voltage across resistor 15 is represented by the reference vector 17, the phase of which does not vary with the frequency of the signal input to the terminals 10, 11 of the system. Vector 18 represents the voltage across the tuned circuit C_3L_3 , which voltage varies in phase and magnitude with the frequency of the signal input to terminals 10, 11. The system is adjusted so that, at the mean resonant frequency of the selector, the vectors 17 and 18 are in phase. The diagram 19 represents the locus of the vector 18 as the fre-

quency of the signal input to the system is varied above and below the mean resonant frequency of the selector. Thus, it will be seen that, at two frequencies, one above and one below the mean resonant frequency of the selector, the voltage across the tuned circuit C_3L_3 is exactly in phase opposition to the voltage represented by vector 17 which is the voltage across resistor 15. The constants of the circuit are so chosen that, at these frequencies, the vectors 17 and 18 are equal in magnitude.

Thus it will be seen that the vectors 17 and 18 are in phase at the means resonant frequency of the circuit and, inasmuch as the tuned circuit C_3L_3 and resistor 15 are in series across the output terminals 12, 13, the sum of these voltages appears across the output terminals 12, 13. As the frequency applied to the selector is varied from the mean resonant frequency of the system, vector 18 becomes displaced in phase with respect to vector 17 and also decreases in magnitude, until a frequency is reached at which these vectors are equal and opposite and infinite attenuation is obtained in the system. For frequencies further removed from the mean resonant frequency than these frequencies, there is a slight output from the system, the voltage approaching that of the voltage across resistor 15. This is illustrated in the curves shown in Fig. 3, wherein the points at which infinite attenuation occurs have been chosen as 10 kilocycles above and below the mean resonant frequency of the system, as this is the frequency at which interfering signals are most troublesome in a superheterodyne receiver. The output voltage of the selector of Fig. 1 is represented by curve 20 of Fig. 3, while curve 21 represents the output voltage which would be obtained from the system without the addition of the constant voltage represented by vector 17 comprising the voltage drop across resistor 15.

Fig. 4 illustrates the output voltage frequency characteristics which may be obtained by the well-known expedient of increasing the coupling of the tuned circuits of the selector or by symmetrically detuning two of the circuits of the selector. These expedients are fully explained in a paper entitled "High fidelity receivers with expanding selectors", by Harold A. Wheeler and J. Kelly Johnson, published in the Proceedings of the Institute of Radio Engineers for June, 1935. Thus, curve 22 represents the output voltage frequency characteristic of the selector incorporating the invention, while curve 23 illustrates the output characteristic which would be obtained if the resistor 15 of the invention were not included in series with the tuned circuit C_3L_3 .

It will be understood that each of the three tuned circuits of the selector is preferably tuned to the mean frequency of the band to be passed by the system. It will be further understood that, if the voltage drop across the resistor 15 is in phase with the signal current input to the first tuned circuit C_1L_1 , as shown in the embodiment of Fig. 1, there must be an even number of 90 degree reactive couplings between the several tuned circuits of the selector. If an odd number of couplings is required for any reason, the additional coupling must be a resistance coupling (producing zero phase shift) or a vacuum-tube coupling (producing 180 degree phase shift).

Fig. 5 illustrates another embodiment of the invention and differs only slightly from the embodiment shown in Fig. 1, like elements being

given the same reference numerals in the two figures. The arrangement of Fig. 5 differs primarily from that of Fig. 4 in the method of obtaining a voltage in phase with the reference voltage across tuned circuit C_3L_3 at the mean resonant frequency of the system. For deriving this voltage, there is provided a tuned circuit 25, 26 connected in the output circuit of tube 14 and coupled to circuit C_1L_1 through resistor 27. There is also provided an inductance 28 inductively coupled to inductance 26 and having one terminal connected to the output terminal 13. A portion of inductance 28 is connected in series with tuned circuit C_3L_3 by means of a connection between tap 29 and the low potential terminal of circuit C_3L_3 . The inherent input capacitance of tube 16 is represented by the condenser 30 shown in dotted lines in Fig. 5. For neutralizing the effect of the capacitance of condenser 30, a voltage from the lower portion of inductance 28 is applied through neutralizing condenser 31 to the grid of tube 16.

While four tuned circuits are shown in Fig. 5, only the three corresponding to the tuned circuits of Fig. 1 contribute to the phase shifting incidental to the attenuating action. The first tuned circuit is merely used to derive the reference voltage and the relatively constant voltage corresponding to the drop across resistor 15 of Fig. 1 and to couple this voltage to the output terminals. Inductance 28 is closely coupled to the inductance 26 across which the constant voltage is developed. Circuits 25, 26 and C_1L_1 may be moderately broadly tuned, while circuits C_2L_2 and C_3L_3 may be sharp and closely coupled or symmetrically detuned to provide a flat-top over-all frequency-response characteristic in the manner described with reference to Fig. 1.

While there have been described what are at present considered to be the preferred embodiments of the invention, it will be apparent to those skilled in the art that various changes and modifications may be made therein without departing from the invention, and it is, therefore, aimed in the appended claims to cover all such changes and modifications as fall within the true spirit and scope of the invention.

What is claimed is:

1. A band-pass selector system for transmitting frequencies of a given frequency band, comprising means for deriving a first voltage variable in phase in accordance with the frequency of the input to the system, means for deriving a second voltage which varies less rapidly in phase than said first voltage with the frequency of the input to said system, the constants of said selector being so proportioned that said two voltages are in phase at a frequency near the center of said band and opposite in phase at frequencies near each of the limiting frequencies of said band, and means for deriving an output voltage variable in accordance with the vectorial sum of said first and said second voltages.

2. A band-pass selector system for transmitting frequencies of a given frequency band, comprising means for deriving a first voltage variable in phase and magnitude in accordance with the frequency of the input to the system, means for deriving a second voltage which varies in phase and magnitude with the frequency of the input to said system less rapidly than said first voltage, the constants of said selector being so proportioned that said first voltage is in phase with said second voltage at the mean resonant frequency of said band and opposite in phase and equal in

magnitude to said second voltage at the limiting frequencies of said band, and means for deriving an output voltage variable in accordance with the vectorial sum of said first and said second voltages.

3. A band-pass selector system for transmitting frequencies of a given frequency band, comprising means including a network of coupled tuned circuits for deriving a first voltage variable in phase and magnitude in accordance with the frequency of the input to the system, means for deriving a second voltage which varies in phase and magnitude with the frequency of the input to said system less rapidly than said first voltage, the constants of said system being so proportioned that said first voltage is in phase with said second voltage at the mean frequency of said band and opposite in phase and equal in magnitude to said second voltage at the limiting frequencies of said band, and means for deriving an output voltage variable in accordance with the vectorial sum of said first and said second voltages.

4. A band-pass selector system for transmitting frequencies of a given frequency band, comprising means including a network of coupled tuned circuits each tuned to the mean frequency of said band for deriving a first voltage variable in phase and magnitude in accordance with the frequency of the input to the system, means for deriving a second voltage which varies in phase and magnitude with the frequency of the input to said system less rapidly than said first voltage, the constants of said selectors being so proportioned that said first voltage is in phase with said second voltage at the mean frequency of said band and opposite in phase and equal in magnitude to said second voltage at the limiting frequencies of said band, and means for deriving an output voltage variable in accordance with the vectorial sum of said first and said second voltages.

5. A band-pass selector system for transmitting frequencies of a given frequency band, comprising means including an odd number of inductively coupled tuned circuits for deriving a first voltage variable in phase and magnitude in accordance with the frequency of the input to the system, means for deriving a second voltage which varies in phase and magnitude with the frequency of the input to said system less rapidly than said first voltage, the constants of said selector being so proportioned that said first voltage is in phase with said second voltage at the mean frequency of said band and opposite in phase and equal in magnitude to said second voltage at the limiting frequencies of said band, and means for deriving an output voltage variable in accordance with the vectorial sum of said first and said second voltages.

6. A band-pass selector system including input and output terminals for transmitting frequencies of a given frequency band, comprising a vacuum tube having input and output electrodes, said input electrodes being connected to said input terminals, means coupled to said output electrodes for deriving a first voltage variable in phase and magnitude in accordance with the frequency of the input to the system, additional means connected in circuit with said output electrodes for deriving a second voltage which varies in phase and magnitude with the frequency of the input to said system less rapidly than said first voltage, the constants of said selector being so proportioned that said first voltage is in phase with said second voltage at the mean frequency

of said band and opposite in phase and equal in magnitude to said second voltage at the limiting frequencies of said band, and means for deriving an output voltage variable in accordance with the vectorial sum of said first and said second voltages.

7. A band-pass selector system including input and output terminals for transmitting frequencies over a given frequency band, comprising a vacuum tube having input and output electrodes, said input electrodes being connected to said input terminals, a network of coupled tuned circuits coupled to said output electrodes for deriving a first voltage variable in phase and magnitude in accordance with the frequency of the input to the system, additional means connected in circuit with said output electrodes for deriving a second voltage which varies in phase and magnitude with the input to said system less rapidly than said first voltage, the constants of said selector being so proportioned that said first voltage is in phase with said second voltage at the mean frequency of said band and opposite in phase and equal in magnitude to said second voltage at the limiting frequencies of said band, and means for deriving an output voltage variable in accordance with the vectorial sum of said first and said second voltages.

8. A band-pass selector system including input and output terminals for transmitting frequencies of a given frequency band, comprising a vacuum tube having input and output electrodes, said input electrodes being connected to said input terminals, means coupled to said output electrodes for deriving a first voltage variable in phase and magnitude in accordance with the frequency of the input to the system, means comprising a resistor connected in circuit with the output electrodes of said tube for deriving a second voltage the phase and magnitude of which are substantially independent of the frequency of the input to said system, the constants of said selector being so proportioned that said first voltage is in phase with said second voltage at the mean frequency of said band and opposite in phase and equal in magnitude to said second voltage at the limiting frequencies of said band, and means for deriving an output voltage variable in accordance with the vectorial sum of said first and said second voltages.

9. A band-pass selector system including input terminals for transmitting frequencies of a given frequency band, comprising a vacuum tube having input and output electrodes, said input electrodes being coupled to said input terminals, a network of coupled tuned circuits coupled to said output electrodes for deriving a first voltage variable in phase and magnitude in accordance with the frequency of the input to said system, means comprising a tuned circuit coupled to said output electrodes and an inductance coupled to said tuned circuit for deriving a second voltage which varies in phase and magnitude with the frequency of the input to said system less rapidly than said first voltage, the constants of said selector being so proportioned that said first voltage is in phase with said second voltage at the mean frequency of said band and opposite in phase and equal in magnitude to said second voltage at the limiting frequencies of said band, and means for deriving an output voltage variable in accordance with the vectorial sum of said first and said second voltages.

10. A band-pass selector system including input and output terminals for transmitting fre-

quencies of a given frequency band, comprising a network of coupled tuned circuits coupled to said input terminals for deriving a first voltage variable in phase and magnitude in accordance
5 with the frequency of the input to said system, means comprising a tuned circuit coupled to said input terminals and an inductance coupled to said tuned circuit for deriving a second voltage which varies in phase and magnitude with the
10 frequency of the input to said system less rapidly than said first voltage, the constants of said selector being so proportioned that said first voltage is in phase with said second voltage at the mean

frequency of said band and opposite in phase and equal in magnitude to said second voltage at the limiting frequencies of said band, means for deriving a voltage variable in accordance with the vectorial sum of said first and said second voltages
5 and applying it between said output terminals, a vacuum tube having input electrodes coupled to said output terminals, said tube having an appreciable input capacitance, and means including said inductance for coupling a voltage into the
10 input circuit of said tube for neutralizing the effect of said capacitance.

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