

Oct. 8, 1940.

H. M. LEWIS

2,216,997

BAND-PASS SELECTOR SYSTEM

Filed March 21, 1936

2 Sheets-Sheet 1

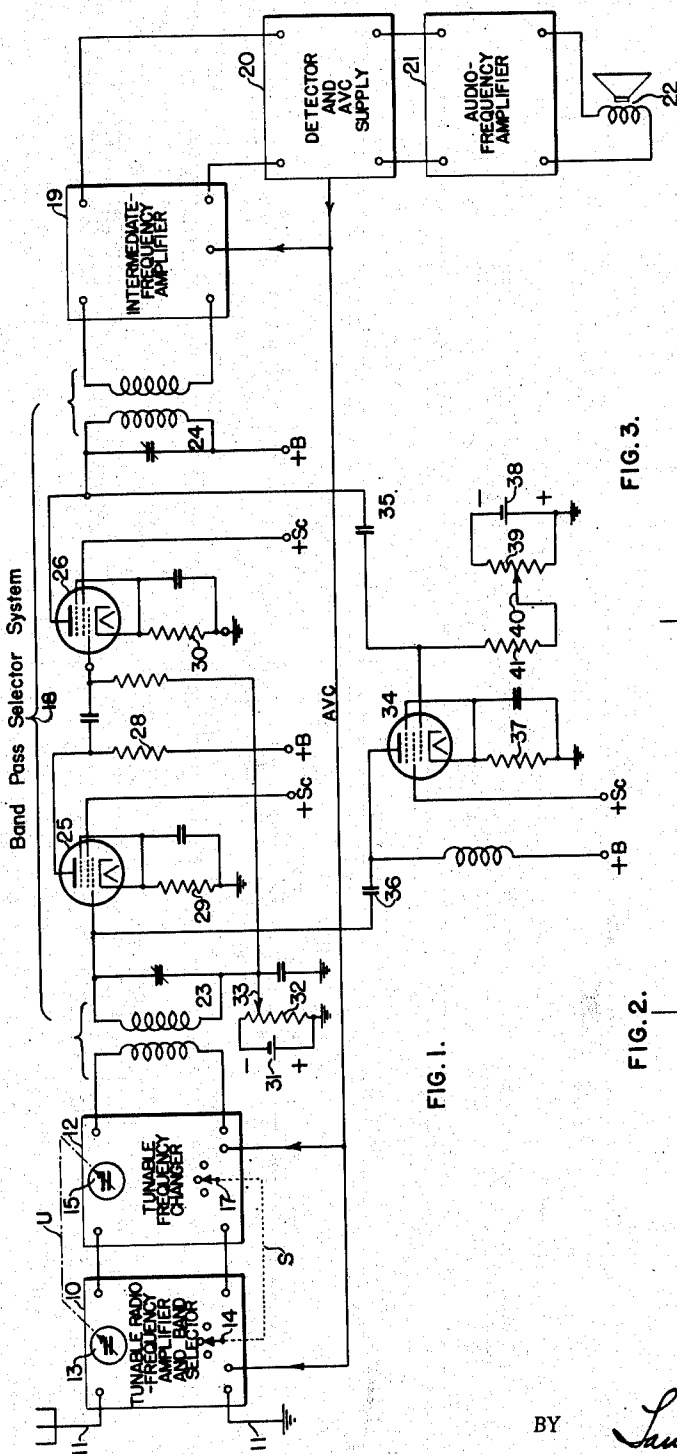


FIG. 1.

FIG. 3.

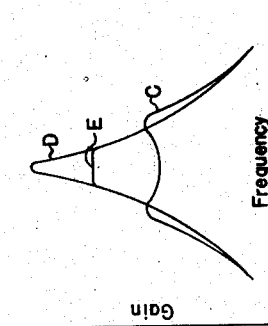
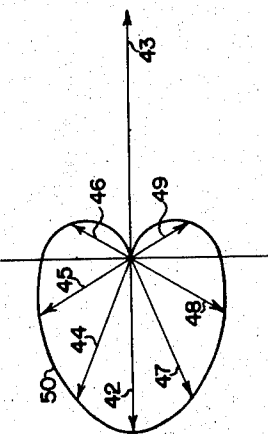


FIG. 2.



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2 Sheets-Sheet 2

FIG. 4.

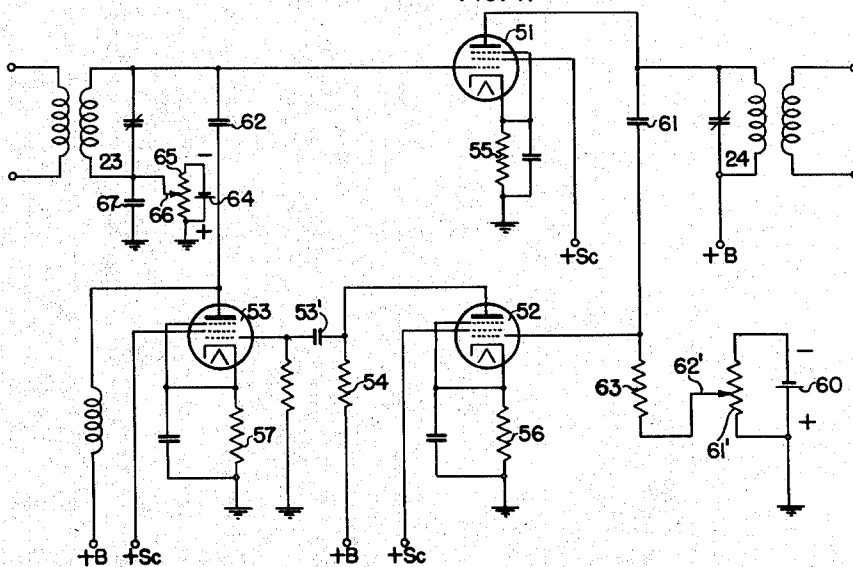
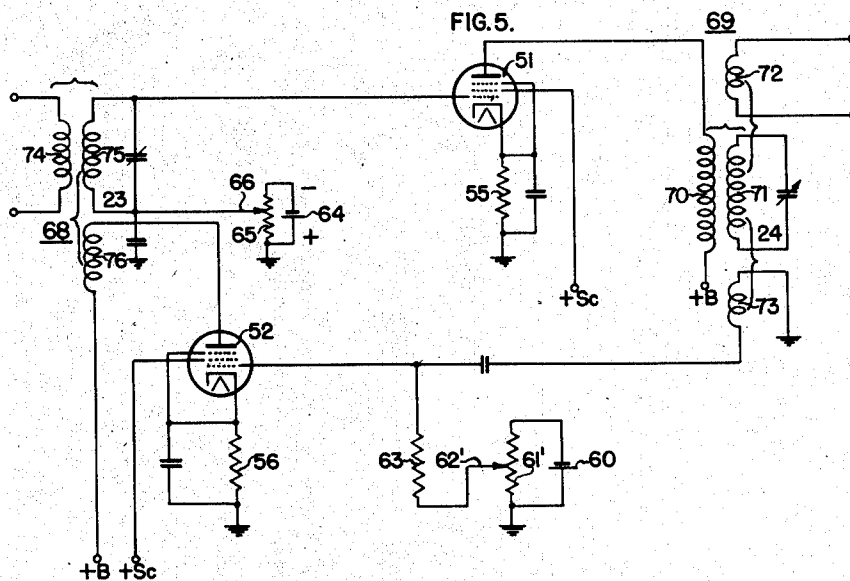


FIG. 5.



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BAND-PASS SELECTOR SYSTEM

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Application March 21, 1936, Serial No. 70,172

6 Claims. (Cl. 179-171)

5 This invention relates to high-frequency band-pass selector systems and, more particularly, to such systems in which the width of the frequency band transmitted through the system is adjustable. While band-pass selector systems constructed in accordance with the present invention are of general utility, they are particularly suitable for use in radio receivers of the well-known superheterodyne type for controlling the selectivity and fidelity of response of the receiver.

10 Band-pass selector systems of conventional design usually comprise a pair of resonant circuits tuned to the same or different frequencies and suitably coupled inductively, capacitively, or by a combination of these individual couplings. The two circuits are commonly referred to as input and output, or primary and secondary, circuits, depending upon which circuit is connected to the source of current of the high frequencies comprising the band to be transmitted. The responsiveness of this type of selector system is substantially constant over a band of frequencies in the vicinity of resonance of the individual circuits, while currents of all other frequencies are sharply discriminated against and are attenuated to a substantial degree through the system. In general, the width of the frequency band passed by such a system may be varied either by changing the coupling between the two circuits or by adjusting the resonant frequencies of the two circuits to different values. The coupling referred to is non-directive in nature, that is, either circuit may be made the input circuit and the other the output circuit without substantially affecting the characteristics of the system. Such a system is to be contrasted with the vacuum-tube coupling between the input and output circuits of a vacuum tube repeater, wherein the coupling is primarily unidirectional.

40 Band-pass selectors, wherein the non-directive form of coupling is employed, are, in general, open to the criticism that only mechanical or relatively complicated non-mechanical expedients are known for adjusting the width of the frequency band to be transmitted. Further, the type of coupling referred to is inherently incapable of producing amplification of the transmitted frequencies in the coupling path between the input and output circuits of the system.

50 It is an object of the present invention to provide an improved band-pass selector system of simple arrangement, in which the coupling between the input and output circuits of the system is directive in nature and which is capable of transmitting a desired band of frequencies

with sharp discrimination against all other frequencies.

It is another object of the invention to provide an improved band-pass selector system which is capable of amplifying in the coupling path the frequencies transmitted through the system.

It is a further object of the invention to provide an improved band-pass selector system, of the type described, which is easily adjustable to vary the width of the frequency band transmitted by the system.

More particularly, it is an object of the invention to provide an improved band-pass selector system, of the type described, in which the width of the frequency band passed by the system may be varied by adjusting the value of a biasing potential applied to a control electrode of a vacuum tube connected in the system.

Briefly stated, the above objects are attained in accordance with the present invention by providing a band-pass selector system comprising input and output circuits, resonant at frequencies within the pass band, coupled by directive coupling means in both the forward and the backward directions. The two coupling means together tend to provide a feed-back voltage in phase with the voltage across the input circuit at a frequency in the vicinity of such resonant frequencies. Nondissipative phase-reversing means are included between one of the circuits and one of the coupling means for reversing the phase of the feed-back voltage. The coupling means provided are substantially less frequency-selective than the above-mentioned input and output circuits and co-operate with the input and output circuits to provide a coupling reaction between the circuits which is degenerative at frequencies in the vicinity of the resonant frequency and regenerative at frequencies above and below the resonant frequency. The coupling between the above-mentioned input and output circuits in either direction may be independently adjustable if desired. To secure this form of coupling, elements having directive transconductance are included in both the forward and the backward coupling means. A vacuum tube having at least a cathode, a control grid, and an anode is one well-known form of element having this characteristic. With this form of coupling between the circuits, either the forward or the backward coupling may be varied at will by varying the value of the transconductance of the element included in the associated coupling means. The independence of control of the two couplings makes it possible to adjust the width of the frequency band

transmitted by adjusting the transconductance of only one of the coupling means, for example, that of the backward coupling means. The band-pass characteristic is symmetrically varied with respect to the mean resonant frequency of the system by adjusting the transconductance of the backward coupling means. The form of characteristic obtained is similar in all respects to that resulting from symmetrical detuning of the input and output tuned circuits, as described in the paper entitled "High-Fidelity Receivers with Expanding Selectors," by Wheeler and Johnson, published in the I. R. E. Proceedings, June 5, 1935, at pages 594-609.

Further in accordance with the invention, the resonant input and output circuits of the selector system are coupled together in the forward direction through a vacuum tube amplifier and are coupled in the backward direction by means of a feed-back path which includes a vacuum tube repeater having a controllable transconductance. The transconductance of the forward coupling path is substantially greater than that of the backward coupling path so that amplification of the transmitted frequencies is secured.

The novel features which are believed to be characteristic of this invention are set forth with particularity in the appended claims. The invention itself, however, both as to its organization and method of operation, together with further objects and advantages thereof, will best be understood by reference to the following specification, taken in connection with the accompanying drawings, in which Fig. 1 is a circuit diagram, partially schematic, illustrating a radio broadcast receiver of the superheterodyne type embodying a band-pass selector constructed in accordance with the invention; Fig. 2 and 3 illustrate certain operating characteristics of the band-pass selector shown in Fig. 1; and Figs. 4 and 5 illustrate modified forms of the invention.

Referring more particularly to Fig. 1 of the drawings, there is illustrated one form of the improved band-pass selector system, embodied in a multi-band radio broadcast receiver of the well-known superheterodyne type, for controlling the selectivity of the intermediate-frequency channel of the receiver. Briefly described, the receiver comprises a radio-frequency amplifier, indicated schematically at 10, connected to antenna-ground circuit 11 and coupled to a frequency changer unit, indicated schematically at 12. The radio-frequency selector and amplifier 10 may be of any conventional type and includes for each stage a variable tuning condenser 13 and band-selecting switching means 14. Similarly, the frequency changer unit 12 may be of any conventional type and includes in both its radio-frequency selector circuit and its local oscillator circuit a variable tuning condenser 15 and band-selecting switching means 17. The various tuning condensers may be ganged for unicontrol by a single control member, in the manner indicated by the dot-dash line U. Unicontrol means may also be provided for operating the band-selector switches, as indicated by the dotted lines S. Connected in cascade with the output circuit of the frequency changer unit 12 are a band-pass selector and intermediate-frequency amplifier 18, a detector and automatic amplification control 20, an audio-frequency amplifier 21, and a sound reproducer 22. The bias potential derived from the automatic amplification control source 20 may be applied

to one or more of the stages of the radio-frequency selector and amplifier 10, the modulator included in the frequency changer unit 12, and the various stages of the intermediate-frequency amplifier 19.

Considering first the operation of the receiver as a whole, without regard to the details of the band-pass selector and amplifier 18, per se, the desired received signal wave is selected and amplified in the radio-frequency selector and amplifier 10 and is converted into a modulated intermediate frequency by the frequency changer 12. The signal as thus converted is further selected in the band-pass selector 18, amplified in the intermediate-frequency amplifier 19, rectified by the detector 20, thereby producing the audio frequencies of modulation which are, in turn, amplified in the audio-frequency amplifier 21 and reproduced by the sound reproducer 22. The amplification of the received signal is subject to automatic control by the control bias potential derived from the source 20, according to the manner well understood in the art.

Referring now more particularly to the details of the band-pass selector system, indicated generally at 18 and constructed in accordance with this invention, the system comprises a resonant input or terminal circuit 23 and a resonant output or terminal circuit 24 which are coupled, respectively, to the output circuit of the frequency changer 12 and the input circuit of the intermediate-frequency amplifier 19, together with adjustable directive coupling means between the two circuits 23 and 24 coupling the two circuits in both the forward and the backward directions. Preferably very loose inductive coupling is provided between the input circuit 23 and the output circuit of the frequency changer, and between the output circuit 24 and the input circuit of the intermediate-frequency amplifier 19. The purpose of loosely coupling the indicated circuits is to minimize the effect on the circuits 23 and 24 of the circuits coupled respectively therewith.

For the purpose of coupling the input and output circuits 23 and 24 in the forward direction, there is provided a pair of cascaded vacuum tube repeaters or amplifiers 25 and 26 which are resistance-coupled by means of the resistor 28. Each of the tubes 25 and 26 is preferably of the well-known pentode type having no appreciable plate-to-grid coupling, due to the presence of the screen grid therebetween, and having adjustable directive transconductance. Biasing resistors 29 and 30, shunted respectively by bypass condensers, are provided for biasing the respective control grids of the tubes 25 and 26 to the correct potentials relative to the cathodes thereof. It will be noted that the resistance coupling between the tubes 25 and 26 renders the forward coupling means between the input circuit 23 and the output circuit 24 substantially non-selective with respect to frequency, this coupling means being so proportioned as to be substantially less frequency-selective than the resonant circuits 23 and 24.

For the purpose of varying the forward coupling between the circuits 23 and 24, there is provided means for varying the values of transconductance of the tubes 25 and 26. This means comprises a control circuit including a source of potential 31 shunted by a voltage divider 32 having an adjustable arm 33 connected to the control grids of the tubes 25 and 26, in the manner indicated.

In order to couple the input circuit 23 and the output circuit 24 in the backward direction, there is provided feed-back means which includes a vacuum tube repeater 34 having its input electrodes coupled to the output circuit 24 through a coupling condenser 35 and its output electrodes coupled to the input circuit 23 through a coupling condenser 36. The vacuum tube 34 is also preferably of the well-known pentode type having no appreciable plate-to-grid coupling but having adjustable directive transconductance. A biasing resistor 37, shunted by a by-pass condenser, is connected in the cathode circuit of the tube 34 for properly biasing the control grid of the tube. In order to adjust the bias on the control electrode of the tube 34, to vary the transconductance of the tube and thereby to change the value of the backward coupling between the circuits 24 and 23, there is provided a source of biasing potential 38 and a voltage divider 39 having an adjustable contact 40 connected to the grid of the tube 34 through a grid-leak resistor 41. Plate and screen voltages are supplied to the tubes 25, 26 and 34 through the several leads indicated at +B and +Sc, respectively.

In order to minimize distortion of the signal currents in the selector system, the tubes 25, 26 and 34 may be of the gradual anode-current cut-off, or variable-mu type.

The backward coupling means including the tube 34 is also substantially non-selective with respect to frequency, the circuit constants of the backward coupling circuit being so proportioned as to render this means substantially less frequency-selective than the resonant circuits 23 and 24. The purpose of making both the forward and backward coupling means substantially less selective than the input and output circuits 23 and 24 is to prevent the selector system from oscillating and to insure stability of operation at all frequencies within the band to be transmitted through the system.

In considering the operation of the selector system, it will be seen that, by utilizing the tubes 25 and 26 in cascade, the alternating voltages impressed on the input circuit 23 are twice reversed in phase so that the alternating voltages across the output circuit 24 are substantially in phase with the voltages across the input circuit 23, at frequencies in the vicinity of the resonant frequencies of the circuits 23 and 24, at which frequencies these circuits are substantially resistive. By including the single tube 34 in the backward coupling path, however, the feed-back voltages impressed on the input circuit 23 through this path are substantially reversed in phase, at the frequencies indicated, with respect to the input voltages impressed directly upon this circuit. If the circuits 23 and 24 have the same resonant frequencies, which is the preferred arrangement, the input and feed-back voltages will, under these conditions, be almost exactly in phase opposition. At these frequencies the circuits 23 and 24 also have their maximum impedance, so that the gains of the tubes 26 and 34 are a maximum and the voltages developed across the circuit 24 and the feed-back voltages are both a maximum. Therefore, the system is degenerative to the maximum degree at these frequencies.

At frequencies substantially above the resonant frequencies of the circuits 23 and 24, these circuits are capacitively reactive so that the voltage across circuit 24 lags the input voltage

by a value approaching 90°, while the feed-back voltage impressed upon the input circuit 23 is retarded by an additional amount also approaching 90° so that the feed-back voltages are substantially in phase with the input voltages. However, at these frequencies, the impedances of the circuits 23 and 24 are substantially less than at resonance, reducing the gains of the stages including tubes 26 and 34, and thus reducing the feed-back voltages. Therefore, the system is slightly regenerative. At frequencies intermediate those just discussed, the feed-back voltages have intermediate amplitudes and phase angles with respect to the input voltages and the feed-back characteristic of the system has a gradual transition from degeneration to regeneration. Obviously, at frequencies below the resonant frequencies of the circuits 23 and 24, the same relationships between the magnitude and phase of the feed-back voltages exist except that, at these frequencies, the feed-back voltages are subject to leading instead of lagging phase shift.

The above-described relationships are shown graphically in Fig. 2, which is a polar diagram in which the angular coordinates represent explicitly the phase angle (and implicitly the frequency) of the feed-back voltage relative to the input voltage, for any given frequency, and the radial coordinates represent the relative amplitude of the feed-back voltages. In this diagram, the vector 43 may be considered as the reference vector for each frequency component. In this figure also, the vector 42 represents the feed-back voltage at the mean resonant frequency of the system. The voltage vectors 44, 45 and 46 represent the relative feed-back voltages of frequencies increasingly higher than the mean resonant frequency of the system, while the vectors 47, 48 and 49 represent the relative feed-back voltages of frequencies increasingly lower than the mean resonant frequency. From this vector diagram it will be seen that, at frequencies in the vicinity of the mean resonant frequency of the system, the vectors representing feed-back voltages are opposite in phase to the reference vector representing the input voltage, and therefore the feed-back is degenerative. However, at frequencies displaced more than a certain amount above and below such mean resonant frequency, the resultants of the vectors representing feed-back voltages and the reference input voltage vector are greater than the input vector, and therefore the feed-back is regenerative.

In other words, the backward coupling between the circuits 23 and 24 operates to decrease the responsiveness of the system at frequencies within the band in the vicinity of the resonant frequencies of the two circuits, and to increase the responsiveness of the system symmetrically at frequencies substantially above and below the resonant frequencies.

The effect which may be procured by varying the transconductance of the tube 34 to vary the amount of backward coupling is illustrated graphically by the family of curves C, D and E of Fig. 3. Curve D corresponding to zero backward coupling, can be obtained by adjusting the arm 40 of the voltage divider 39 to increase the negative potential applied to the control electrode of the tube 34 to a sufficiently high value to reduce the transconductance of the tube to a negligible value. When the bias potential is adjusted to increase the transconductance of tube 75

34 at an intermediate value, the characteristic curve of the selector system is modified to approach the shape shown by curve E. As can be observed from this curve, with small feed-back voltages the degenerative action is appreciable at frequencies near the mean resonant frequency of the system, while the phase and magnitude of the feed-back voltage components of frequencies above and below the mean resonant frequency are such that the regenerative action is of no appreciable effect. A further increase in the transconductance of the tube 34 to increase the feed-back voltage causes an increase in the amplitude of the feed-back components to modify the response characteristic of the system to that in which the feed-back is considerably regenerative at frequencies substantially displaced from resonance, shown by curve C, accentuating the double peaks on either side of the mean resonant frequency.

From an inspection of the family of curves illustrated in Fig. 3, it will be appreciated that the improved selector system described provides a simple means for easily adjusting the selectivity of a receiver such as that shown in Fig. 1, by adjusting the width of the frequency band transmitted through the intermediate-frequency channel of the receiver. Thus, by adjusting the bias potential on the control electrode of the 34 tube in the manner described above, the width of the band transmitted through the intermediate-frequency channel of the receiver may easily be varied. Adjustment of the width of the frequency band passed by the system may also be obtained by adjusting the contact arm 33 of the voltage divider 32 to vary the trans-conductance of the tubes 25 and 26, thereby to vary the forward coupling.

One advantage of the adjustable coupling described above resides in the fact that the gain through the selector system for all frequencies within the band is lowered as the band is widened. Ordinarily, a wide band-pass characteristic is desired with strong signals, and the corresponding gain of the selector system is preferably relatively low. However, with weak signals a relatively narrow band and a higher gain is desirable. The family of curves described above shows that these conditions are satisfied when the band width is adjusted by adjusting the backward coupling between the circuits 23 and 24.

If it be desired that all frequencies within the band passed by the intermediate-frequency channel be amplified with substantially uniform gain, the excess attenuation of frequencies in the vicinity of the resonant frequency of the input and output circuits 24, exemplified in curve C, may be compensated for in succeeding amplifier stages included in the amplifier 19. This can readily be done by properly proportioning the interstage coupling circuits between the several stages in the intermediate-frequency channel, in the manner disclosed in United States Letters Patent No. 1,921,088 to William A. MacDonald, and further treated in the above-identified paper by Wheeler and Johnson.

Referring now to Fig. 4 of the drawings, there is illustrated a modified form of band-pass selector system embodying the present invention, in which a single vacuum tube 51 is included in the forward coupling means between the input circuit 23 and the output circuit 24 and a pair of resistance-coupled cascade-connected vacuum tube 52 and 53 are included in the means coupling the two circuits in the backward direction.

The coupling circuit between the two tubes 52 and 53 includes a condenser 53' and a resistor 54. Biasing resistors 55, 56 and 57, each shunted by a by-pass condenser, are provided in the cathode leads of the tubes 51, 52 and 53, respectively. Condensers 61 and 62 are provided for coupling the input electrodes of the tube 52 to the output circuit 24 and the output electrodes of the tube 53 to the input circuit 23, respectively. In order to vary the transconductance of the tube 52, thereby to vary the backward coupling in the manner described above, there is provided a direct-voltage source 60 shunted by a voltage divider 61' having an adjustable contact arm 62' connected through a grid-leak resistor 63 to the control electrode of the tube 52. Similarly, adjustable biasing means for the control electrode of the tube 51 are provided for varying the transconductance of the tube 51, thereby to vary the value of the coupling between the circuits 23 and 24 in the forward direction. This means includes a direct-voltage source 64 shunted by a voltage divider 65 having an adjustable contact arm 66 connected across a high-frequency by-pass condenser 67 and to the control electrode of the tube 51. Suitable anode and screen voltages are applied through the leads indicated at +B and +Sc to the respective anode and screen electrodes of the tubes 51, 52 and 53.

The operation of the system shown in Fig. 4 is fundamentally the same as that described above in connection with the arrangement of Fig. 1, and accordingly a detailed description thereof is deemed to be unnecessary. The desired phase relation between the feed-back voltage and the directly impressed voltage is preserved by including the three tubes connected in the manner shown. With this arrangement a single phase reversal occurs in the forward coupling means and a double phase reversal occurs in the backward coupling means, so that the components of the input and feed-back voltages at frequencies in the vicinity of the mean resonant frequency of the system are substantially in phase opposition. It will be observed that, if an even number of coupling tubes is included in one coupling path and an odd number of tubes is included in the other, this desired phase relation between the feed-back and input voltages is secured.

The circuit of Fig. 1 has an advantage over that of Fig. 4 in that additional amplification is obtained by including two tubes in the forward coupling path rather than in the backward coupling path.

If desired, transformer means may be employed in either or both of the forward and backward coupling paths for obtaining the desired polarity and amount of the forward and backward coupling. An arrangement constructed in accordance with the invention and including such means is illustrated in Fig. 5, the circuit shown being similar to that of Fig. 4 but differing therefrom in that the tube 53 is omitted and transformer means, indicated at 68 and 69 are provided for coupling the backward coupling means between the circuits 23 and 24, respectively. The transformer 69 comprises a primary winding 70 connected between the output electrodes of the tube 51 and inductively coupled to the winding 71, forming the inductive branch of the resonant output circuit 24. The winding 71 is coupled to a winding 72 which serves to couple the output circuit 24 to a succeeding utilizing circuit (not shown). A fourth winding 73 is provided for coupling the output circuit 24 to the input electrodes

of the tube 52. Reversal of the polarity of the voltage applied between the input electrodes of the tube 52 relative to the output voltage of the tube 51 is secured by so poling the inductance 73 with respect to the inductance 71. The transformer means 68 comprises a primary winding 74 connected to the preceding stage of the system and coupled to a secondary winding 75 which comprises the inductance of the resonant input circuit 23. This transformer is provided also with a tertiary winding 76 included in the output circuit of the tube 52 and coupled mainly to the secondary winding 75. The coupling between the windings 75 and 76 serves to impress the feed-back voltage on the input circuit with the correct polarity. The additional tube 26 of the circuit of Fig. 1, the additional tube 53 of the circuit of Fig. 4, and the transformer windings 73, 71 all perform equivalent functions; that is, each is effective to reverse the polarity of the feedback to the input circuit of the selector without introducing appreciable dissipation into the tuned input and output circuits of the system. As shown, the winding 76 of the transformer 68 and the winding 73 of the transformer 69 are untuned.

The operation of this circuit is fundamentally the same as that described in connection with the circuit shown in Fig. 1, and it is believed that no further amplification of the previous descriptive matter is necessary to a ready understanding thereof. It may be noted, however, that the use of transformer means for obtaining the correct relation between the phase and amplitude of the input and feed-back voltages substantially facilitates the design of the system to secure the best operating conditions.

While the invention has been described with particular reference to its use as an adjustable band-pass selector system in a radio receiver, it will be understood that it is equally applicable for use as a non-adjustable band-pass selector. By properly designing the circuit and properly proportioning the values of transconductances included in the forward and backward coupling paths, a non-adjustable band-pass selector may be constructed which is capable of passing any desired band of frequencies with sharp discrimination against unwanted frequencies outside the band.

While there have been described what at present are considered the preferred embodiments of the invention, it will be obvious 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 comprising input and output circuits resonant at frequencies within said band, directive coupling means coupling said circuits in one direction, separate coupling means coupling said circuits in the other direction, said coupling means together tending to provide a feed-back voltage substantially in phase with said input voltage across said input circuit at a frequency in the vicinity of said resonant frequencies, and transformer means included between one of said circuits and one of said coupling means for reversing the phase of said feed-back voltage, said coupling means being substantially less frequency-selective than said terminal circuits and co-operating with said input and output circuits to provide a coupling reaction between said circuits which is degenerative

at frequencies in the vicinity of said resonant frequencies and regenerative at frequencies above and below said resonant frequencies.

2. An adjustable band-pass selector system for passing a band of frequencies adjustable in width comprising, input and output circuits resonant at frequencies within said band, amplifier means including directive coupling means coupling said circuits in the forward direction and separate coupling means having an adjustable transconductance coupling said circuits in the backward direction, the transconductance of said forward coupling means being substantially greater than that of said backward coupling means, said coupling means being substantially less frequency-selective than said input and output circuits and co-operating with said input and output circuits to provide a coupling reaction between said circuits which is degenerative at frequencies in the vicinity of the mean frequency of said band and regenerative at frequencies above and below said mean frequency, and means for adjusting said adjustable transconductance to vary the width of the frequency band passed by said system and simultaneously to vary inversely the amplification of the predetermined frequencies within said band by said amplifying means.

3. An adjustable band-pass selector system for passing a band of frequencies adjustable in width comprising, input and output circuits resonant at frequencies within said band, amplifier means including a vacuum tube amplifier for coupling said circuits in the forward direction and separate coupling means coupling said circuits in the backward direction, the transconductance of said forward coupling means being substantially greater than that of said backward coupling means, and including a vacuum tube having input electrodes coupled to said output circuit and output electrodes coupled to said input circuit, the transconductance of said tube being included in the path provided by said backward coupling means, said coupling means being substantially less frequency-selective than said input and output circuits and co-operatively with said input and output circuits to provide a coupling reaction between said circuits which is degenerative at frequencies in the vicinity of said resonant frequencies and regenerative at frequencies above and below said resonant frequencies and which depends upon the value of said transconductance, and means for adjusting said transconductance to vary the width of the frequency band passed by said system and simultaneously to vary inversely the amplification at predetermined frequencies within said band.

4. An adjustable band-pass selector system for passing a band of frequencies adjustable in width comprising, input and output circuits resonant at frequencies within said band, amplifier means including means coupling said circuits in the forward direction and comprising a vacuum tube amplifier having an even number of stages, said amplifier including input electrodes coupled to said input circuit and output electrodes coupled to said output circuit, separate coupling means coupling said circuits in the backward direction and comprising a vacuum tube repeater having an odd number of stages, the transconductance of said forward coupling means being substantially greater than that of said backward coupling means, said repeater including input electrodes coupled to said output circuit and output electrodes coupled to said input circuit, said coupling means being substantially less frequency-selective than said input and output circuits and co-

operating with said input and output circuits to provide a coupling reaction between said circuits which is degenerative at frequencies in the vicinity of said resonant frequencies and regenerative at frequencies above and below said resonant frequencies, and means for adjusting the transconductance of at least one of the tubes included in said backward coupling means to vary the width of the frequency band passed by said system and simultaneously to vary inversely the amplification at predetermined frequencies within said band.

5. A band-pass selector system comprising input and output circuits resonant at frequencies within said band, directive coupling means coupling said circuits in the forward direction, directive coupling means coupling said circuits in the backward direction, said coupling means together tending to provide a feed-back voltage in phase with said input voltage across said input circuit at a frequency in the vicinity of said resonant frequencies, and nondissipative phase-reversing means included between one of said circuits and one of said coupling means for reversing the phase of said feed-back voltage, said coupling means being substantially less fre-

quency-selective than said input and output circuits and co-operating with said input and output circuits to provide a coupling reaction between said circuits which is degenerative at frequencies in the vicinity of said resonant frequencies and regenerative at frequencies above and below said resonant frequencies.

6. A band-pass selector system comprising, input and output circuits parallel resonant at frequencies within said band, a vacuum-tube repeater coupling said circuits in one direction having its input and output terminals individually coupled across said circuits and being effective to couple said circuits with one polarity, and a vacuum-tube repeater coupling said circuits in the other direction having its input and output terminals individually coupled across said circuits and being effective to couple said circuits with a polarity opposite said one polarity, said repeaters thereby providing a coupling reaction between said circuits which is degenerative at frequencies in the vicinity of said resonant frequencies and regenerative at frequencies above and below said resonant frequencies.

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