April 13, 1937. W. A. MacDONALD 2,077,049

SIGNAL SELECTING SYSTEM

Filed Dec. 20, 1933 2 Sheets-Sheet 1

Fig. 1,

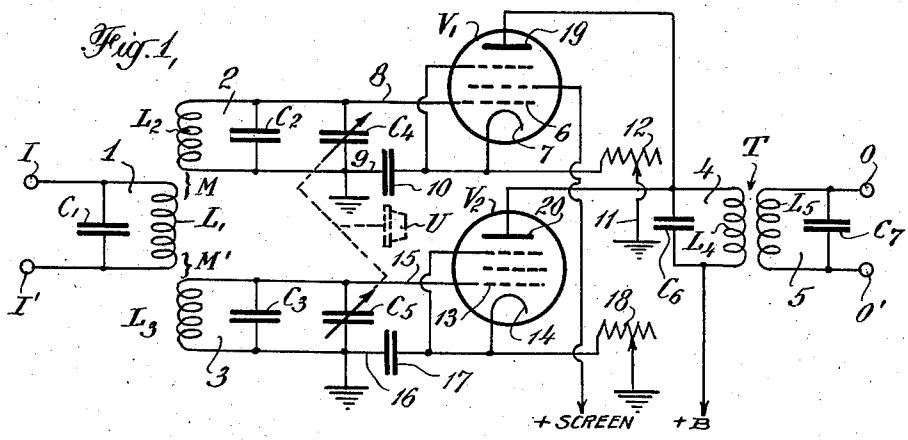


Fig. 2,

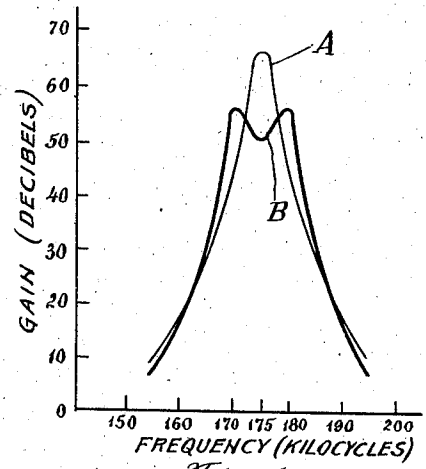


Fig. 3,

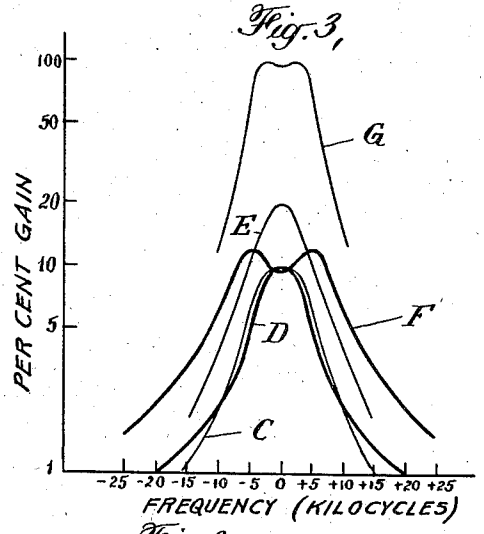


Fig. 5,

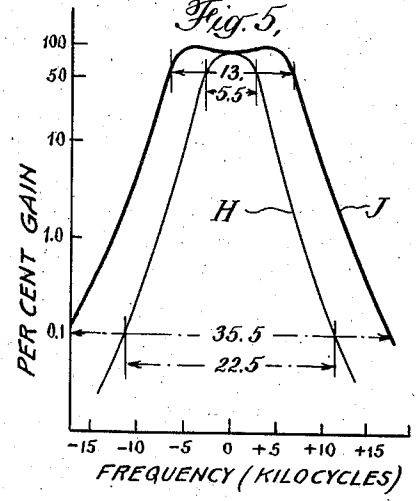
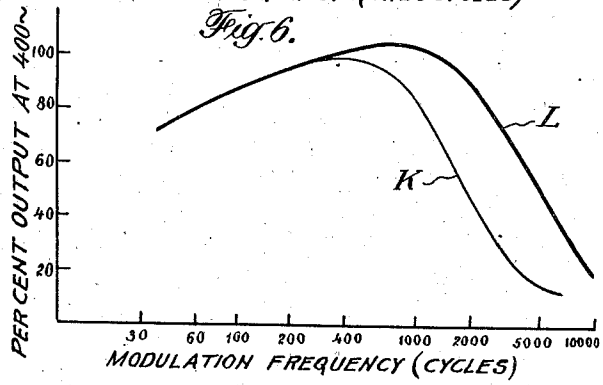


Fig. 6.



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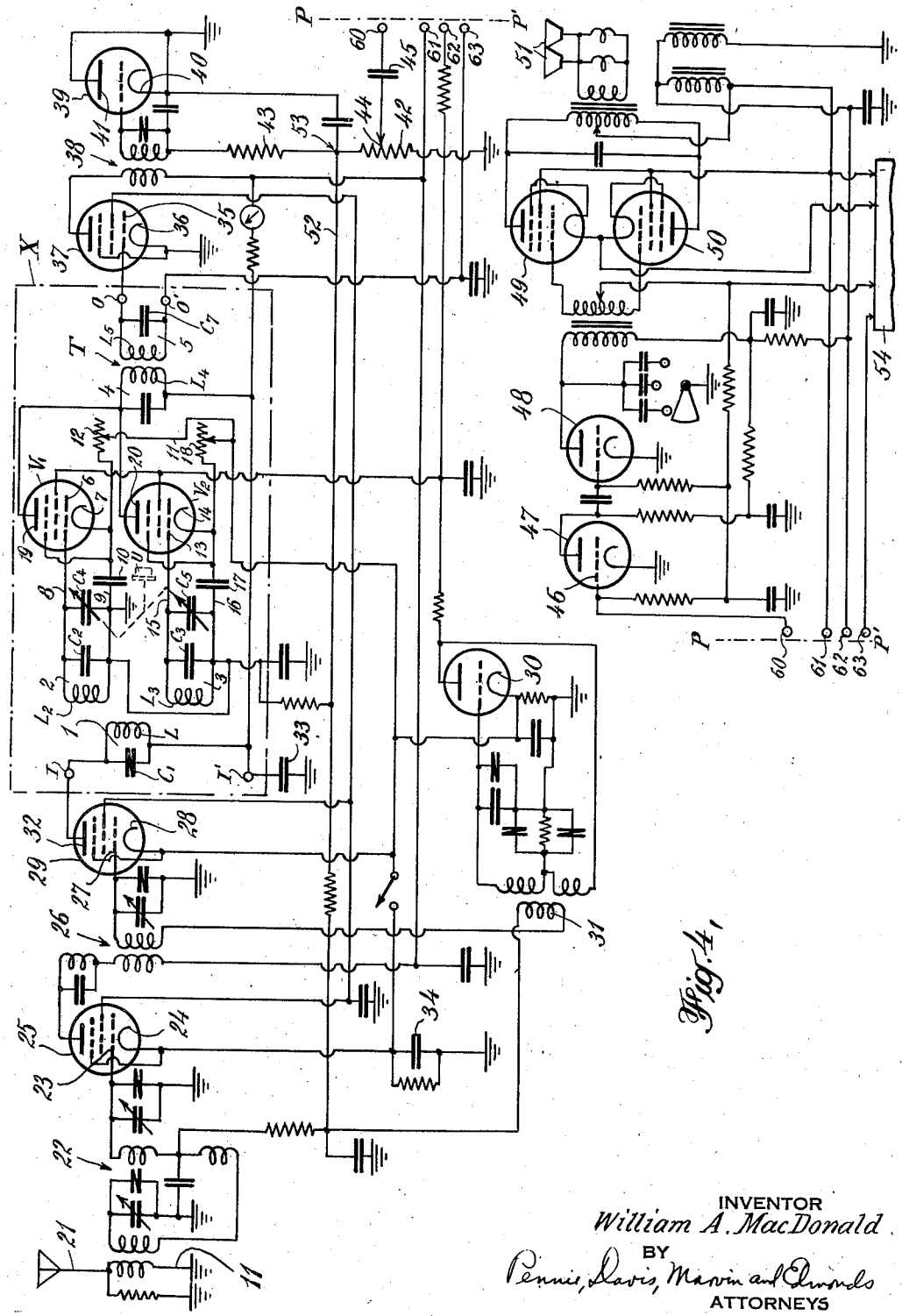


Fig. 4.

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UNITED STATES PATENT OFFICE

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SIGNAL SELECTING SYSTEM

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Application December 20, 1933, Serial No. 703,218

13 Claims. (Cl. 250—20)

This invention relates to the reception and selection of modulated carrier signals, and has for its principal objects to facilitate the selection of such signals and to improve the fidelity of reception thereof.

A radio broadcast signal is ordinarily transmitted on a carrier wave having two sidebands of modulation frequencies, which are of about 6 kilocycles in width on either side of the carrier. Under present broadcasting conditions, the different carrier frequencies are allocated at various positions throughout the broadcast range, usually 10 kilocycles apart, and in many instances the sideband frequencies of one signal channel either overlap those of an adjacent signal channel or else closely encroach upon them. In either case, it is difficult, when tuning a radio broadcast receiver to a desired signal in one such channel, to eliminate interference due to signals in the adjacent channels, particularly when such interfering signals are received with a strength comparable to that of the desired signal.

Operation without interference in such cases requires that the selecting system shall tune to a sufficiently narrow band of modulation frequencies to prevent appreciable passage of the interfering signals. Narrowing the selected band in this manner tends to impair fidelity of reception of the signals—voice, music and the like, since the sideband frequencies corresponding to the higher audio frequencies of modulation are suppressed. Accordingly, it is desired that the selected band width be allowed to remain narrow only when interfering signals are present, but in their absence, the selecting system should be adjusted to freely admit and pass all of the received sidebands of the desired signal, thus preventing sideband attenuation.

According to this invention, there is provided a sideband admission system adapted to adjust the selectivity to admit the carrier frequency and any portion of the two associated sidebands between a minimum band width and substantially the entire sideband width. The admission system comprises a selective coupling network for expanding or contracting at will the selected or admitted frequency band width, independently of the tuning to the signal carrier channel.

A feature of the invention is the use of a selective coupling network comprising a plurality of tunable circuits simultaneously adjustable by a unitary control means, or device. This control device is adapted to adjust the tunable circuits either to be all resonant to the desired carrier frequency, or to be resonant to different frequencies located somewhat above and below the said carrier frequency. When the tunable circuits are all adjusted to be resonant to the carrier frequency, the network passes a minimum band width; but when the resonance frequencies of the tunable circuits are shifted above and below the carrier frequency, the band width is increased until a maximum width is reached, which corresponds to the greatest separation of the resonances.

In tuning to the desired signal, the unitary control device is preferably adjusted to produce the condition of minimum band width, or greatest selectivity; and upon completing the tuning operation, the band width passed by the selective coupling network is increased by manipulation of the control device to provide any desired degree of fidelity.

In carrying out the invention, numerous combinations of tunable selective networks and vacuum tubes are possible. In the embodiment described in detail hereinafter, there is disclosed an arrangement including a pair of tunable circuits arranged effectively in parallel to supply signal voltage to the input circuits of each of a pair of repeating vacuum tubes.

In the drawings,

Fig. 1 illustrates an adjustable carrier frequency sideband admission system in accordance with this invention;

Fig. 2 illustrates the selectivity characteristics of the system of Fig. 1 under minimum and maximum expanded conditions;

Fig. 3 shows the selective characteristics of the several resonant circuits in the sideband admission system of Fig. 1;

Fig. 4 illustrates an embodiment of the invention in a superheterodyne radio receiver;

Fig. 5 indicates the overall selectivity characteristics of the receiver of Fig. 4 as influenced by the side band admission system of this invention; and

Fig. 6 shows fidelity characteristics at the output of the receiver of Fig. 4 as influenced by the sideband admission system.

Fig. 1 shows a sideband admission system adapted to be incorporated into a modulated carrier frequency portion of a signal translating system. The selecting system is provided with input terminals I and I' which will usually be connected to the output of a preceding vacuum tube. There is connected between these input terminals a resonant input circuit 1 composed of a capacity C_1 and an inductance L_1 in parallel, the

resonant circuit being permanently tuned to the desired carrier frequency by the capacitively reactive and inductively reactive elements therein. The coil L_1 is coupled to each of two adjustable resonant circuits 2 and 3 by means of electromagnetic couplings M and M' to coils L_2 and L_3 situated respectively in circuits 2 and 3. Coil L_2 of circuit 2 is tuned by a fixed condenser C_2 and a variable condenser C_4, in parallel. Coil L_3 of circuit 3 is similarly tuned by a fixed condenser C_3 and a variable condenser C_5.

Resonant circuit 2 is connected between the control grid 6 and the cathode 7 of a pentode type vacuum tube V_1, by means of connections 8 and 9, the latter including a blocking condenser 10. The cathode 7 is connected to ground 11 through a variable resistor 12. The tuned circuit 3 is similarly connected between the control grid 13 and the cathode 14 of a pentode type vacuum tube V_2, by means of connections 15 and 16, the latter including the blocking condenser 17. The cathode 14 is connected to ground through a variable resistor 18. The anodes 19 and 20, respectively, of tubes V_1 and V_2 are connected together and to the primary circuit 4 of a carrier frequency coupling transformer T, which constitutes a resonant output, or signal response, circuit for tubes V_1 and V_2. The primary circuit 4 comprises a coil L_4 and a condenser C_6 in parallel, the lower end of this parallel combination being connected to a source of energizing voltage +B for the anodes of the tubes, and the upper end being connected to the anodes. The secondary circuit 5 of the tuned transformer T comprises a secondary coil L_5 coupled to coil L_4, and a condenser C_7 connected across coil L_5. The tuned circuits 4 and 5 are each made resonant at the carrier frequency to be passed; and these circuits, and also circuit 1, are designed to transmit the associated sidebands of modulation as well as the carrier frequency. The frequency band-width transmitted by these circuits may be artificially broadened by damping or other means, if desired. The output terminals O, O' of the selecting system are connected across condenser C_7, and will ordinarily be connected to the input of a carrier frequency amplifier tube.

Although there are shown no cathode heating means or actual sources of operating potentials for the tube electrodes, these are all well known to those skilled in the art, and therefore no further discussion is necessary here.

There is provided a mechanical uni-control device, or unitary means, indicated by the dotted lines and knob U for simultaneously operating the variable condensers C_4 and C_5. These latter condensers are so related to each other by the mechanical, or manual, uni-control device that when one of them is in the condition of maximum capacity value, the other has a minimum capacity value. To place the resonant circuits 2 and 3 in the operative condition, the mechanical control device U is moved into one of its extreme positions, so that one of the variable condensers C_4 and C_5 is at a maximum while the other is at a minimum. In this condition, the tuned circuits 2 and 3 are each adjusted to be sharply resonant at the carrier frequency.

Upon moving the uni-control device out of the extreme position in which the above-mentioned adjustment was made, the capacity of one of the variable condensers decreases while the capacity of the other variable condenser increases. Hence, the resonance frequency of one of these circuits decreases somewhat while that of the other of these circuits increases. The result of this operation is to spread the individual resonance peaks of resonance circuits 2 and 3 by an amount dependent upon the adjustment of the device U. Since the anode circuits of tubes V_1 and V_2 are combined at circuit 4 of transformer T, these individual resonance peaks of selecting circuits 2 and 3 appear at the output terminals O, O'. Therefore circuits 2 and 3 operate effectively in parallel between the input and output terminals, and the width of the band of frequencies at the output terminals may be the overall width of the individual resonance characteristics of circuits 2 and 3. By adjustment of the continuously adjustable mechanical device U, the width of the selected frequency band may be continuously varied from a minimum to a maximum, the minimum condition being that of greatest selectivity in which the two resonance peaks lie at the same frequency, and the maximum condition being that of greatest fidelity, in which the resonance peaks, or transmitted bands, are displaced furtherest apart.

Fig. 2 is an illustrative chart plotted in decibels gain against carrier frequency in kilocycles, and shows characteristic curves of the transmission efficiency of the coupling network shown in Fig. 1. Curve A is the sharp resonance characteristic obtained under the condition of greatest selectivity obtained when the mechanical control device U is at the extreme position which causes the individual peaks of circuits 2 and 3 to be both situated at the same carrier frequency. Under the condition of characteristic A, only a portion of the usual full sideband of frequencies are freely transmitted, this following from the fact that the circuits 2 and 3 individually pass only a portion of the full band. This carrier frequency to which the system is tuned to produce the characteristics of the chart is 175 kilocycles, this being a convenient carrier frequency for use in the intermediate frequency amplifiers of superheterodyne receivers. Curve B shows the double peak effect obtained by movement of the control device U to the opposite extreme position from that which gives characteristic A. The position of the control device which provides characteristic A is called the position of minimum band width, or minimum position, and the position which gives curve B is called the position of maximum band width, or maximum position. It is observed that in moving to the maximum position, one of the individual peaks has changed its position approximately 5 kilocycles upward in the frequency scale to about 180 kilocycles, while the other peak has changed its position downward by the same amount to about 170 kilocycles.

It is noted that greater gain at the carrier frequency is obtained in the position of minimum band width than in the position of maximum band width; this is due to the coincidence of the two peaks composing characteristic A. The change in gain between the selective and expanded conditions may be largely compensated by a system of automatic volume control, an appropriate form of which will be described hereinafter.

Fig. 3 is a chart of curves showing selectivity relationships between the resonant circuits 2 and 3 and the transformer T, of Fig. 1. In this figure, the ordinates represent percentage gain plotted on a logarithmic scale, and the abscissas represent modulation sideband frequencies plotted on a linear scale. The frequency marked "0" represents the carrier frequency, while those frequencies on either side of the carrier represent

the modulation frequencies of the sidebands in terms of the corresponding audio frequencies.

Curve C is a resonance curve of the double tuned transformer T. It is observed that this curve shows only a single peak which is the characteristic for such a transformer when the mutual coupling between the tuned circuits 4 and 5 does not exceed the optimum value. Curve D is a resonance curve of one of the adjustable resonant circuits 2 or 3 of the selective coupling network, when tuned to the carrier frequency. Curve E is the resonance characteristic of circuits 2 and 3, in combination, when both are tuned to the carrier frequency under the condition of maximum selectivity. It is observed that curve E is simply a summation of two curves of the type of curve D, and corresponds to curve A of Fig. 2. The fact that the characteristics of circuits 2 and 3 are additive is due to the fact that these circuits are arranged effectively in parallel at the input circuits of tubes V_1 and V_2, respectively.

Curve F is the resonance characteristic of the combination of circuits 2 and 3 when one of these circuits is resonant 5 kilocycles above the carrier frequency and the other circuit is resonant 5 kilocycles below the carrier frequency. Curve F is a summation of two curves such as D when displaced 10 kilocycles apart, as mentioned, and corresponds to curve B of Fig. 2.

Curve G is the overall resonance characteristic of the system including the double tuned transformer T and the adjustable circuits 2 and 3 when adjusted to be resonant 10 kilocycles apart. In other words, curve G is the resultant of curves C and F. Curves C and F are combined with each other geometrically to produce the resultant curve G, since transformer T is arranged in tandem through the vacuum tubes V_1 and V_2 with respect to circuits 2 and 3. Hence, curve G is the product (instead of the sum) of curves C and F.

Although curves C and F have been multiplied directly to produce curve G, it should be understood that the chart of Fig. 3 is simply intended to illustrate relative characteristics. The actual amount of gain at the output terminals O, O' relative to the input terminals I, I' will depend upon the amplification of tubes V_1 and V_2. Hence, the illustration of the peaks of curve G at approximately 100% gain and the illustration of the peaks of curves C, D and F at approximately 10% gain is simply for the sake of convenience.

It will be apparent that the gain with the adjustment represented by the curve F is very substantially less than that of curve E and may be of the order of one-half the latter, as clearly shown in Fig. 3, where the percent gain is plotted on a logarithmic scale. The reduction in gain, or responsiveness, which is incidental to the increasing of the band width, would result in unsatisfactory operation unless compensated for. The automatic volume control means, however, which is hereinafter described, provides the necessary compensation and maintains the output amplitude of the system at a constant level.

Fig. 4 shows a complete superheterodyne radio receiver in the intermediate frequency amplifier of which the sideband admission system in accordance with his invention is incorporated in the position shown at X. The receiver comprises a number of stages of vacuum tubes effectively coupled in tandem by coupling systems. The details of the receiver, other than those associated with the sideband admission system, are of no special significance in so far as this invention is concerned; hence, the receiver is described in general terms. In examining Fig. 4, it should be understood that the terminals 60, 61, 62 and 63 at the dot-dash line PP' beneath the first audio amplifier 47 are intended to be connected to, or identical with, the same-numbered terminals beneath the detector tube 39. The circuit arrangement has been broken at PP' simply for convenience in illustrating the circuit arrangement on a single sheet.

The receiver comprises a signal pick-up system including an antenna 21 and ground 11. The antenna pick-up system is coupled to a tunable radio-frequency preselector system 22, the output circuit of which is connected between the control grid 23 and cathode 24 of a radio-frequency amplifier tube 25. The output of amplifier 25 is impressed through a tunable radio-frequency coupling system 26 between the control grid 27 and the cathode 28 of a modulator tube 29. For the purpose of modulating the signals of the radio-frequency channel to produce a lower carrier frequency channel, known as the intermediate frequency in superheterodyne receivers, there is provided a local oscillator system including an oscillator tube 30. The output of the oscillator system appears in a coil 31 which is included in the grid-cathode circuit of modulator 29 for the purpose of producing the modulation in a manner well understood in the art. Since the assembling of such oscillator and modulator circuits is now well known, no details of these circuits need be given here, since they constitute no part of this invention.

In accordance with the well known phenomenon of modulation, there appears in the output circuit of the modulator, that is, the circuit including the anode 32 and the cathode 28, the products of modulation. These products of modulation include the band of frequencies which are the difference between the band of frequencies of the received signal channel and the local oscillator frequency. This band of difference frequencies is known as the intermediate frequency band, and comprises the intermediate carrier frequency and the upper and lower sidebands of modulation. Since ordinary radio broadcast carrier signals are modulated by audio frequencies up to about 6 kilocycles, each of these sidebands is about 6 kilocycles in width, and the upper and lower sidebands together occupy a channel band width of about 12 kilocycles. For example, if the frequency of the local oscillator 30 be adjusted to produce an intermediate carrier frequency of 175 kilocycles, as shown in the chart of Fig. 2, the frequencies of the intermediate frequency channel occupy the band of about 169 to 181 kilocycles.

Accordingly, the selective system of an intermediate frequency amplifier is proportioned to select and pass approximately the full band width of the order of 12 kilocycles. Such a full selected band width permits a high degree of fidelity of reception, but does not result in as high a degree of selectivity as would be provided by a more sharply tuned selecting system which would not permit the full sideband width to be passed. In accordance with this invention, it is possible to adjust the band of frequencies permitted to be passed and amplified by the intermediate frequency amplifier to any width between a maximum of approximately the full sideband width of 12 or more kilocycles to a minimum of a much lesser width.

The input terminals I and I' of the adjustable

sideband admission system X of this invention are effectively connected to the anode 32 and the cathode 28, respectively. Terminal I is directly connected to anode 32, and terminal I' is connected through a condenser 33 to ground, and thence to the cathode 28 through appropriate bypass condensers. By reason of the opposite variations of the capacities of variable condensers C_4 and C_5, when operated by the mechanical control device, the band of frequencies admitted by the cooperative action of resonant circuits 2 and 3 may be varied from a minimum of about 6 kilocycles to a maximum of over 12 kilocycles. Hence, the actual band width of the signals at the output terminals O, O' of the admission system varies according to the adjustment of condensers C_4 and C_5.

The output terminals O and O' are effectively connected to the control grid 35 and the cathode 36, respectively, of an intermediate frequency amplifier tube 37. The output of amplifier 37 is coupled through an intermediate frequency coupling system 38 to a diode type of detector 39. Although this diode type detector is shown with three electrodes, the cathode 40 and the plate 41 are connected together, as shown, to constitute a single electrode which is the cathode.

There is connected between the cathode 40 (the ground connection) and the low potential end of the secondary circuit of coupling system 38, a pair of series-connected resistances 42 and 43 across which are developed the rectified components of the detector output. The audio-frequency component is taken from that portion of resistor 42 between ground and the tap 44, and impressed through a condenser 45 upon the input grid 46 of an audio-frequency, or modulation frequency, amplifier tube 47. A second audio-frequency amplifier tube 48 is coupled to the output of tube 47 by resistance coupling, as shown. The last audio-frequency amplifier stage comprises audio-frequency amplifier tubes 49 and 50 arranged in the well-known push-pull relation. For the purpose of converting the audio-frequency currents into sound waves, there is connected at the output of the push-pull amplifier stage a double loudspeaker arrangement 51.

In addition to the above-mentioned circuits, the receiver is provided with a system of automatic volume control of the type described in United States Patent 1,879,863 to Harold A. Wheeler. This system comprises a connection 52 from the junction 53 between resistors 42 and 43, to the control grids 23, 27, 6 and 13 of tubes 25, 29 and V_1 and V_2, respectively. In this automatic volume control system, there is developed across resistor 42 a uni-directional voltage which varies with the average carrier voltage impressed on the diode detector 39. Due to the detector action, the current in resistor 42 flows from ground toward the point 53. Hence, the point 53, and therefore the control grids 23, 27, 6 and 13 become more negative when the signal strength at the dector increases, and vice versa. This causes the amplification of tubes 25, 29 and V_1 and V_2 to decrease when the signal strength at the detector increases, and to increase when the signal strength at the detector decreases. Consequently, the automatic volume control system functions to compensate for changes in the received signal intensity and also for changes in the transmission efficiency of the sideband admission system when the latter is adjusted between the maximum and minimum positions; and the output voltages of the detector 39 are maintained substantially constant.

For the purpose of furnishing operating voltages for the electrodes of the vacuum tubes, there is provided a power supply system indicated generally at 54. This may be a conventional power system adapted to operate from ordinary alternating current mains, such as the usual 60-cycle house current. Since suitable power systems for supplying proper electrode voltages and for heating cathodes of tubes are well known in the art, no detailed discussion is necessary.

Throughout the receiver there are employed condensers and resistors where their use improves the operation of the receiver.

Fig. 5 is an illustrative chart of percentage gain plotted on a logarithmic scale against modulation sideband frequencies plotted on a linear scale. This chart shows the overall response of the receiver of Fig. 4 under the conditions of minimum band width and of maximum or expanded band width. In this chart, the frequency marked "0" represents the carrier frequency, while those on either side represent the modulation frequencies of the sidebands in terms of the corresponding audio frequencies. Curve H indicates the selectivity characteristic of the receiver under the condition of greatest selectivity, that is, when the adjustable resonant circuits 2 and 3 are both tuned to the intermediate carrier frequency. Curve J shows the selectivity characteristic of the receiver when the sideband admission system is expanded to admit the maximum band width. For the purpose of easy comparison, the peaks of both curves have been brought to approximately the same 100% level, which would be the effect of the automatic volume control operation described above. Curves H and J illustrate the rapid expansion of the band near the peak of the characteristic in comparison with the expansion near the base where there is high attenuation at all adjustments. It is observed that at 50% of unity, or peak gain, the total width of the two sidebands which is admitted is 5.5 kilocycles, for the highly selective adjustment, while for the maximum expanded adjustment, it is about 13 kilocycles. This represents a band width expansion of 136%. At .1% of the peak gain, however, the band width is expanded from 22.5 kilocycles to 35.5 kilocycles in passing from the most selective to the most expanded adjustment. This represents an expansion of only 58%.

Fig. 6 is a chart which shows the overall fidelity characteristic as measured at the output of the audio amplifier under the most selective and most expanded conditions. In this chart, the percentage of audio-frequency output at 400 cycles is plotted against the modulation frequencies, or audio frequencies, of the entire audio-frequency range. Curve K illustrates the fidelity characteristic under the highly selective adjustment of the admission system, and curve L shows the fidelity characteristic when the selector is in its expanded adjustment. From these curves, it is observed that the upper limit of the audio-frequency range is expanded by about 3 kilocycles in passing from the selective condition to the expanded condition.

I claim:—

1. In a signaling system, means for selecting a band of frequencies, said means comprising two parallel paths each of which selects at least a portion of said band, and means for changing the position in the frequency scale of one of said

portions relative to the other portion, whereby the resultant width of the selected band may be varied.

2. A signal selecting system comprising a pair of frequency band selecting paths arranged effectively in parallel between a pair of input terminals and a pair of output terminals, and adjustable tuning means for displacing said bands relatively to each other so that the resultant band transmitted to said output terminals may be varied from a narrow width to a substantially greater width.

3. A modulated carrier frequency band selecting system comprising a tuned input circuit which is tuned to select and pass said carrier frequency and substantially the entire range of the sidebands of modulation, and a tuned output circuit, a pair of adjustable selecting circuits arranged effectively in parallel between said input and output circuits, and means for adjusting one of said selecting circuits relative to the other so that their resonant periods may be made to coincide or to become displaced relatively to each other, whereby the resultant band width at said output circuit may be expanded from a minimum width.

4. A modulated carrier frequency band selecting system comprising a pair of adjustable band selecting paths arranged effectively in parallel between a pair of input terminals and a pair of output terminals, each of said paths comprising a resonant circuit having an adjustable element connected between a control grid and cathode of a vacuum tube, each of said tubes having an anode, which anodes are connected together in aiding phase and coupled to said output terminals, said adjustable elements being simultaneously operated by a single control device which shifts the resonance frequencies of said circuits in opposite relative directions in the frequency scale, whereby the band width of frequencies transmitted to said output terminals may be varied.

5. A modulated carrier frequency signal selecting system comprising a resonant input circuit and a resonant output circuit each tuned to select the carrier frequency and associated sidebands, a pair of parallel adjustably tuned circuits coupled to said input circuit, each of said adjustable circuits being coupled to the input circuit of a vacuum tube, the output circuits of said tubes being connected together and to said resonant output circuit, and a manual control device for simultaneously varying the resonance frequency of said adjustable circuits oppositely relatively to each other, whereby the frequency band width at said output circuit may be regulated.

6. In a signal selecting system, a first and a second selective circuit, said circuits being arranged in parallel with common input and common output connections and each circuit including inductively reactive and capacitively reactive elements, means for adjusting the resonant frequencies of the elements in each of said circuits to be the same, and unitary control means whereby the resonant frequency of said first circuit may be decreased and the resonant frequency of said second circuit may be increased.

7. In a radio receiver, means for preventing sideband attenuation by broadening the frequency admission band comprising a pair of adjustably selective resonant circuits connected in parallel and a signal responsive circuit connected to said parallel circuits, vacuum tube repeater means connected between said selective and responsive circuits, and unitary means for simultaneously increasing the resonant frequency of one of said selective circuits and decreasing the resonant frequency of the other of said selective circuits.

8. In a carrier current amplifier, a plurality of vacuum tubes and a plurality of coupling systems for coupling said tubes in tandem, a first of said coupling systems being resonant to the frequency of the carrier current to be received, a second of said systems comprising a plurality of circuits connected in parallel and resonant to frequencies somewhat greater and less than said carrier current, and continuously adjustable unitary control means for altering the resonant frequencies of said parallel circuits relatively to each other.

9. In a carrier current amplifier, a plurality of vacuum tubes and a plurality of coupling systems for coupling said tubes in tandem, the gain of the first of said coupling systems being maximum at the frequency of the carrier current, the second of said coupling systems including a plurality of circuits connected in parallel and tunable to different resonant frequencies whereby the gain of said second coupling system is maximum for frequencies higher and lower than that of said carrier current, and continuously adjustable unitary control means for simultaneously tuning said parallel circuits individually in opposite senses to change the frequencies at which the gain in said second coupling system becomes maximum.

10. In a carrier current amplifier, a plurality of vacuum tubes and a plurality of coupling systems for coupling said tubes in tandem, means for resonating the first of said systems to the frequency of a carrier current, and a second of said coupling systems including a plurality of circuits connected in parallel and means for resonating said circuits to the same resonant frequency, the second of said means comprising a continuously adjustable control member for said parallel circuits for simultaneously changing the resonant frequencies of said circuits individually to higher and lower frequencies than said first system.

11. In a carrier frequency amplifier, a plurality of selective coupling systems coupled effectively in tandem, one of which includes at least two adjustable resonant circuits connected in parallel, and a uni-control device associated with said resonant circuits for simultaneously shifting the resonant frequencies thereof from said carrier frequency, where the selected band width is a minimum, individually to frequencies above and below said carrier frequency, where the selected band width is a maximum, whereby the ratio of the said maximum to the said minimum band width at 50% of the peak gain is substantially greater than at .1% of the peak gain.

12. In a carrier current amplifier, a plurality of vacuum tubes and a plurality of coupling systems for coupling said tubes in tandem, means for permanently resonating at least one of said coupling systems to the frequency of the carrier current, another of said coupling systems comprising a plurality of resonant circuits connected in parallel, and means including a continuously adjustable unitary control member for simultaneously altering similar reactive elements of said resonant circuits individually in opposite senses to change the resonant frequencies of said last-named resonant circuits individually in opposite senses between the limits of the carrier current frequency and 10 kilocycles removed therefrom.

13. In a signaling system adapted to amplify a carrier frequency signal and the associated side-

bands of modulation, a first and a second detector, a vacuum tube amplifier and a plurality of coupling systems arranged in tandem between said detectors, means for causing said coupling systems to be resonant at said carrier frequency so that the transmission efficiency is greater at the carrier than at the sideband frequencies, one of said coupling systems including a plurality of tunable coupling circuits connected in parallel and having adjustable reactance elements operated by a unitary control device for reducing the transmission efficiency at the carrier frequency relative to that at the sideband frequencies, and means for applying a variable bias voltage to a control element of a tube in said amplifier, said bias voltage becoming less negative to increase the amplification when the transmission efficiency at the carrier frequency is decreased relative to that at the sideband frequencies.

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