

May 11, 1937.

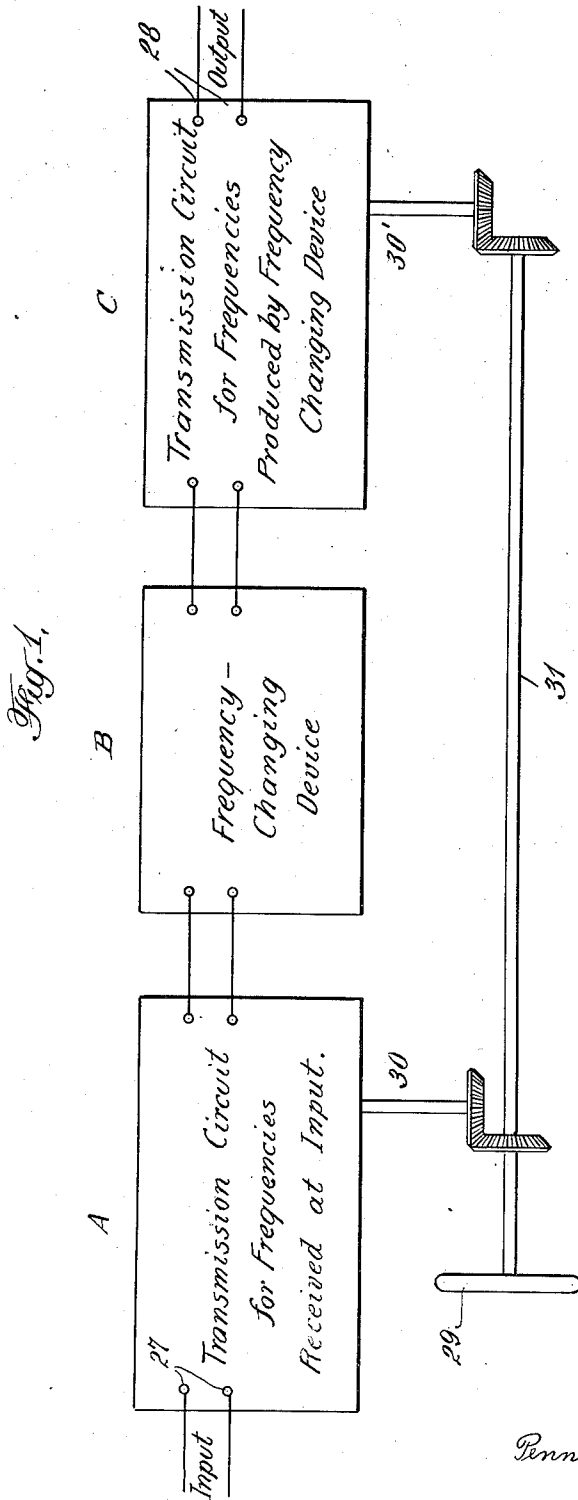
C. E. DEAN

2,080,115

CONTROL SYSTEM

Filed Jan. 28, 1931

4 Sheets-Sheet 1



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4 Sheets-Sheet 2

Fig. 2,

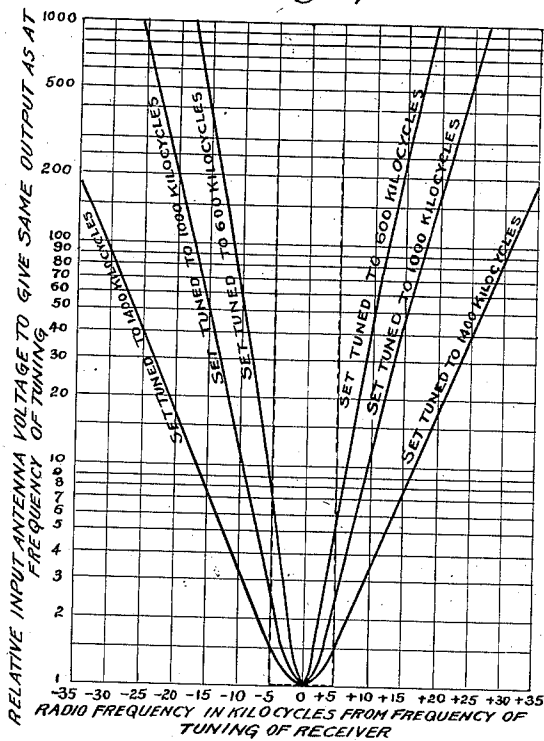


Fig. 3,

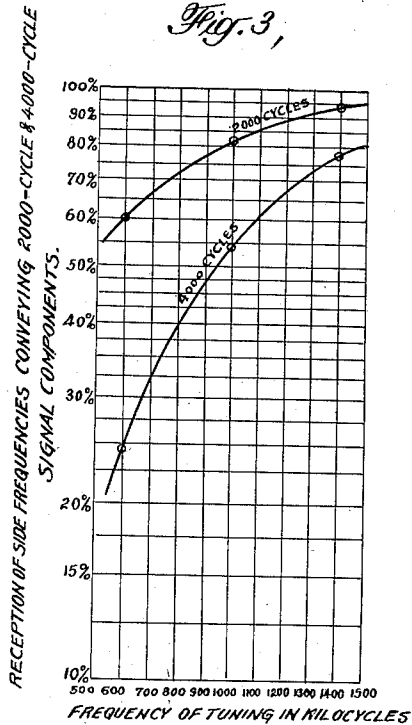
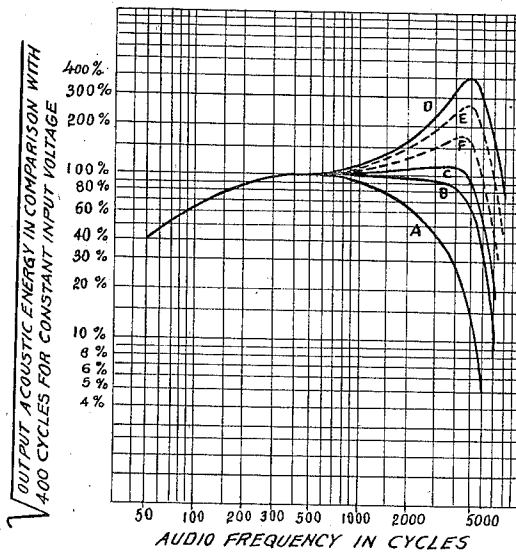


Fig. 4,



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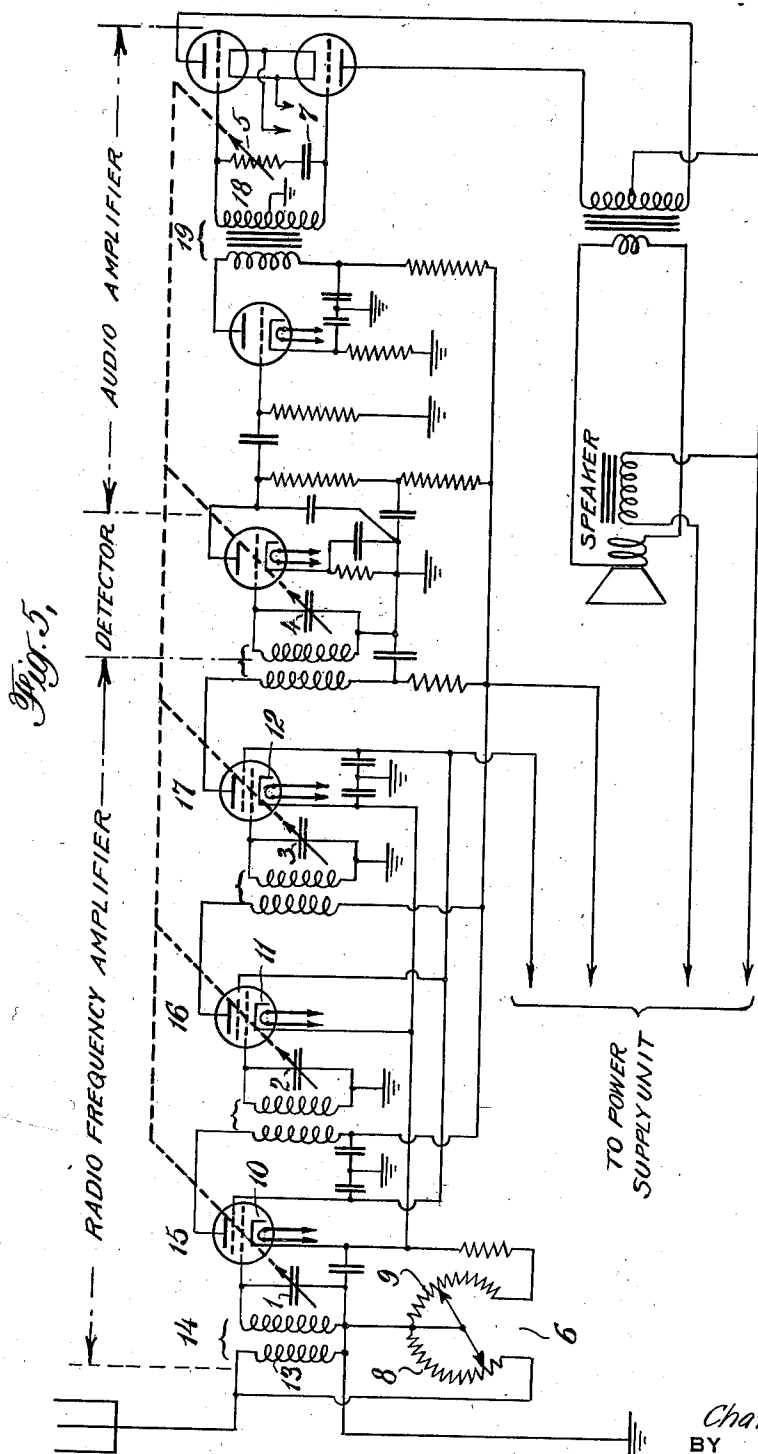
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4 Sheets-Sheet 3



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4 Sheets-Sheet 4

Fig. 6,

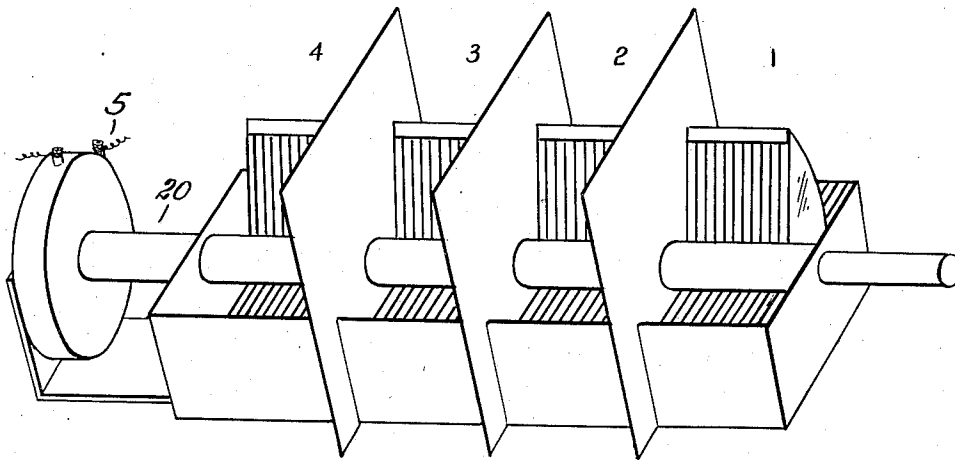
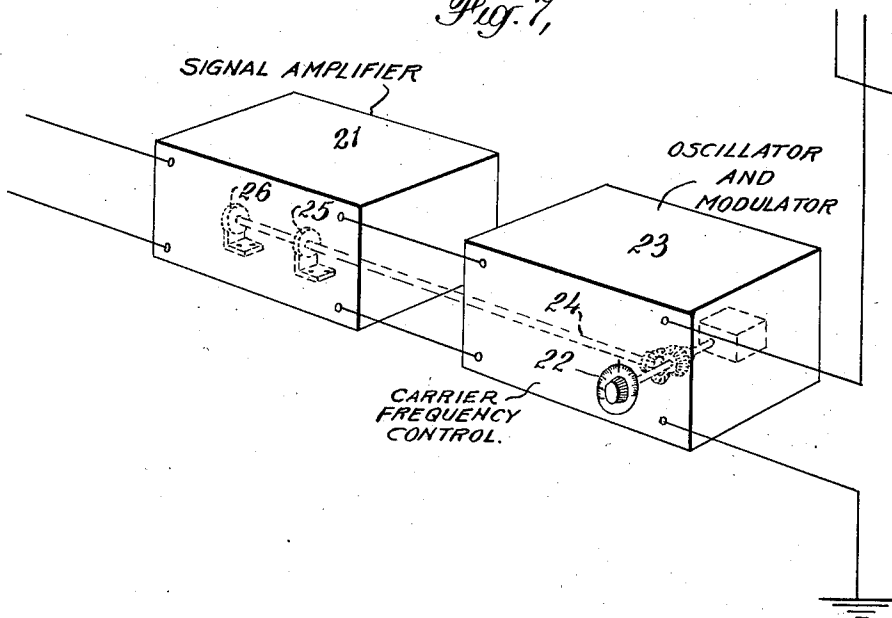


Fig. 7,



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UNITED STATES PATENT OFFICE

2,080,115

CONTROL SYSTEM

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Application January 28, 1931, Serial No. 511,715

22 Claims. (Cl. 250—20)

This invention relates to electrical communication or signal systems for the transmission of high or carrier frequencies, modulated by a band of audio or other signal frequencies, and more particularly to such systems as are tunable over a range of carrier frequencies. The invention includes means to automatically attenuate the higher audio or signal frequencies to offset the varying loss of components at the edges of the carrier frequency channel and thus obtain a substantially uniform overall audio-frequency response throughout said range.

The paramount object of this invention is to improve the operating characteristics of communication systems without increasing the amount of manipulation and adjustment necessary on the part of the user or operator.

A specific object of this invention is to provide an arrangement to alter the gain-frequency characteristic of the low-frequency or signal-amplifier portion of a radio receiver in accordance with the tuning of the radio-frequency portion of the receiver, whereby the tendency for attenuating the higher-frequency elements of the reproduced signal, which accompanies reception on the lower radio frequencies of the response range, is offset and the fidelity of signal reproduction is enhanced. There is thus provided in the case of broadcast receivers a species of tone control in which the gain-frequency response characteristic of the audio circuit is automatically altered to give faithful reception of broadcasts over the entire tuning range.

Well-designed receivers heretofore used for the reception of radio-telephone broadcasting have been characterized by sharper selectivity curves at the lower radio frequencies, resulting in diminution of the high pitches in the reproduced sound in comparison with reception at the higher radio frequencies. On account of the fact that the effect of over-emphasized high pitches is very disagreeable, the best design has been to provide for approximately accurate reproduction of these pitches at the upper frequency end of the broadcast range, leaving the reception deficient in this regard at the medium and especially the lower broadcast frequencies. This condition has been the more unfortunate because the better broadcasting stations generally transmit upon the low and medium frequencies in the broadcast range.

This condition is remedied by the application of the present invention which makes three provisions for increasing the tone fidelity characteristic of the receiver. The first is the provision of a specially designed audio-amplifier circuit, which

is electrically linked to the carrier frequency antenna circuit through means including a frequency changer or modulator, and which, except for the effect of the tone control, has an increased transmission efficiency characteristic for the high signal frequencies. The second is the provision of a tone control including a variable impedance for controlling the frequency response characteristic of the audio circuit. The third is the provision of a mechanical linkage between the tone control and the carrier-frequency tuning mechanism such that the ratio of high-to-low-frequency response of the audio circuit is automatically increased at a predetermined rate as the tuning circuit or circuits for the choice of stations is tuned to the lower radio-frequency carrier transmissions. In this way, a high and substantially uniform tone fidelity characteristic is obtainable over all of the plurality of radio-frequency channels constituting the broadcast range or frequency spectrum. Furthermore, this association of the two controls is done in such a manner that operation of the resulting single control simultaneously and automatically accomplishes both electrical effects.

The invention will be understood more fully and other objects made clear from the following description read in connection with the drawings, and from the appended claims.

Referring to the drawings, Fig. 1 represents the general principle of the invention;

Fig. 2 gives selectivity curves of a typical present-day broadcast receiver;

Fig. 3 shows the changing discrimination of such a receiver against side frequencies conveying pitches of 2000 and 4000 cycles per second received from radio stations transmitting upon various carrier frequencies;

Fig. 4 gives various fidelity curves showing the improvement effected by the invention;

Fig. 5 is a circuit diagram of a radio receiver embodying the present invention;

Fig. 6 is a view of the tuning condenser unit of the receiver of Fig. 5 showing the added control of the audio gain-frequency characteristic mounted on the tuning shaft;

Fig. 7 is a schematic diagram of the application of the invention to a radio transmitter.

In Fig. 1 are shown a pair of input terminals 27, a transmission circuit A, operating at frequencies received at the input terminals, a frequency-changing device B, a transmission circuit C, operating at some or all of the frequencies produced by the frequency-changing device B, a pair of output terminals 28, a control wheel 29, and shaft

31, and two shafts, 30 and 30' operated simultaneously by rotation of the wheel. The rotation of the shafts 30 and 30' produces changes in the transmission characteristics of the two transmission circuits, A and C, respectively, whence rotation of the control wheel changes the transmission characteristics of these two portions of the system simultaneously and accomplishes one of the objects of the invention.

The transmission characteristics caused to vary by motion of shafts 30 and 30' and the direction and amount of variation are chosen according to the requirements of the particular system. It has been known that the gain in circuit C might be advantageously varied in accordance with the gain in circuit A or in accordance with the position of a frequency selecting control in circuit A. It should be noted that a change in "gain" or in "simple gain" is a uniform change for all frequencies, for example, an increase of ten decibels, and does not introduce any change in the relative transmission efficiency for the various frequencies. The present invention is directed toward those cases in which a change of frequency characteristic or any change other than gain in circuit C is desirable, and toward those cases in which any change in the transmission characteristic of circuit C is desirable accompanying any change in circuit A except variation in gain or frequency selectivity. The term "frequency characteristic" or "gain-frequency characteristic" is used to designate transmission efficiency as a function of frequency, of which "frequency selectivity" is a special case in which a certain band of frequencies is received and all others are substantially rejected, the frequency band which is received usually being variable and located at any desirable position in a wider operating range. Variation in frequency selectivity is generally called "tuning".

For example, in the broadcast receiver described below, a change in frequency characteristic in circuit C accompanying a change in frequency selectivity in circuit A is highly desirable for the reason that a high degree of fidelity of reproduction may thus be obtained throughout the radio-frequency range over which the set can be tuned.

In other cases, such as picture transmission and television, the preservation of phase relations between the signal components is important and the invention can be used to effect desired automatic phase adjustments in one portion of the system accompanying change of transmission characteristics in another portion which is separated by a frequency-changing device. In still other cases it may be desired to vary the power handling capacity of one portion of a system in accordance with a transmission adjustment of another portion operating at a different frequency. Furthermore, any combination of changes in transmission characteristics may be obtained in one such portion, accompanying any combination of changes in the other portion.

Before describing the application of the invention to a broadcast receiver, it is desirable to consider certain characteristics and limitations of well-designed receivers of the present time. In Fig. 2 are given selectivity curves of such a receiver, plotted in the conventional manner. These curves are obtained by connecting the receiver to a standard antenna, feeding in current of a certain frequency, for example 600 kilocycles per second, tuning the receiver, and then noting the relative voltages at other frequencies neces-

sary to produce the same output without changing the tuning of the receiver. A low modulation frequency, 400 cycles, (the phrase "per second" is omitted here and hereafter in accordance with common practice) has been standardized for this purpose and permits the regular detector and audio amplifier of the receiver to be used as convenient auxiliaries to the output measuring equipment. The scale of ordinates used in plotting the results is logarithmic since this gives a much closer approximation to the intensity characteristics of the human ear than does a linear scale. The curves show the discrimination in the tuned circuits of the receiver against various frequencies when the set is tuned to the indicated frequency. For example, when the set is tuned to 1000 kilocycles it is seen that a frequency of 1020 kilocycles must have its voltage multiplied by 175 in order to produce the same effect as it would if its frequency were 1000 kilocycles. That is, an unwanted signal of 1020 kilocycles is reduced by a voltage ratio of one part in 175 if the set is tuned to 1000 kilocycles. In this way the signals from undesired stations are generally suppressed leaving only the desired speech or music. The discrimination against unwanted signals a given number of kilocycles away from the frequency of tuning is seen to be greater when the set is tuned to 600 kilocycles than when tuned to 1000 kilocycles, and greater when tuned to 1000 kilocycles than when tuned to 1400 kilocycles. This illustrates the well-known fact that the selectivity is greater when tuned to the lower broadcast frequencies.

It is well known in the radio art that a high-frequency current, whose envelope varies in accordance with the amplitude of a signal wave in the manner employed in a broadcast transmitter, is found upon mathematical or electrical analysis to consist of currents of the carrier frequency and of other frequencies located below and above the carrier frequency by intervals equal to the frequency components of the signal wave. Thus, a 1000-cycle tone with the second harmonic of 2000 cycles would be transmitted by a station on 1400 kilocycles with the simultaneous radiation of the transmission band comprising 1398, 1399, 1400, 1401 and 1402 kilocycles. As stated above, the 1400-kilocycle frequency is called the "carrier frequency". The other frequencies are called "side frequencies", and the group of side frequencies on each side of the carrier is called a "sideband". (The term "modulation frequencies" is sometimes used to designate side frequencies but also is frequently used to designate frequency components of the modulating signal.) The modulated wave may therefore be said to consist of a lower sideband, an unmodulated carrier component, and an upper sideband. In the case just considered where a 1000-cycle tone with a 2000-cycle harmonic is transmitted on a 1400-kilocycle carrier, the 1398 and 1399-kilocycle frequencies are the lower sideband and the 1401 and 1402-kilocycle frequencies are the upper sideband. In accordance with the general statement at the beginning of this paragraph, the 1399 and 1401-kilocycle components (in cooperation with the carrier of 1400 kilocycles) convey the fundamental of 1000 cycles, the essential point being that 1399 is 1 kilocycle or 1000 cycles below the carrier and 1401 is an equal interval above. Similarly, the frequencies of 1398 and 1402 kilocycles convey the second harmonic of 2000 cycles. Higher-frequency components of a signal are similarly conveyed in the transmitted high-frequency

quency wave by frequencies in the two sidebands lying farther from the carrier frequency.

In the case of speech and music the low pitches are conveyed in the transmitted wave by side frequencies near the carrier frequency, intermediate pitches are conveyed by side frequencies correspondingly more removed from the carrier, and the highest pitches are conveyed by the farthest removed side frequencies. Pitches between 3000 and 5000 cycles are conveyed by part of the lower sideband extending from a point 5 kilocycles below the carrier to a point 3 kilocycles below the carrier, and by part of the upper sideband occupying a symmetrical position extending from 3 to 5 kilocycles above the carrier.

Referring again to Fig. 2 it can be seen that the discrimination against other signals, (such as from other stations 10, 20, 30 kilocycles or more away in frequency) extends to some extent to frequencies within five kilocycles of the frequency of tuning. This condition results in attenuation of the farthest removed side frequencies of the desired signal, commonly called "sideband cutting" designating that the two sidebands are cut or reduced in amplitude at their edges, the lower sideband at its lower edge and the upper sideband at its upper edge.

In case the audio amplifier and speaker have approximately equal characteristics for the various audio frequencies, sideband cutting produces a diminution of the high pitches in the reproduced sound. This loss causes a reduction in the normal brilliance of music and crispness and clarity of speech, and thus mars the quality of the reproduced sound. To avoid this defect without altering the audio amplifier would require that all the selectivity curves of Fig. 2 have, between the limits -5 to $+5$ kilocycles, the rectangular band-pass characteristic indicated by the dotted line. Efforts toward the development of circuits with such characteristics have been made, but the results have been only partially successful and have not found wide acceptance.

At any one carrier frequency the loss of high pitches in a typical radio receiver may be compensated by suitably increasing the gain of the audio amplifier for the higher pitches without material change of the low pitch gain. However, as seen in Fig. 2, the selectivity changes with the location of the transmission band in the frequency spectrum, so that correction of the sideband cutting at one frequency still leaves it incorrect at all other frequencies.

In Fig. 3 are shown the effects of sideband cutting based upon the curves of Fig. 2 near the frequency of tuning. The upper curve in Fig. 3 gives the transmission of side frequencies conveying a 2000-cycle pitch through the tuned circuits of the receiver in terms of the transmission of the carrier frequency which is naturally taken as a standard. A logarithmic scale of ordinates is used here for the same reason as in Fig. 2. The upper curve here shows, for example, at 600 kilocycles that a pitch of 2000 cycles is reduced to 60% due to sideband cutting, and at 1000 kilocycles is reduced to 82%. The lower curve shows the much greater attenuation suffered in the reception of a pitch of 4000 cycles, and it may be seen that this is especially severe at the low-frequency end of the broadcast band. The serious character of the situation may be realized when it is noted that these curves are representative of good design of the present day. In fact this lack of fidelity in the reproduction of high pitches from stations on the lower broadcast frequencies

is the main fidelity defect of the typical good receiver of current manufacture. The defect is the more unfortunate since, as a result of various causes including the better propagation of radio waves of the lower frequencies in the broadcast band, the larger and more important broadcasting stations are generally found assigned to these frequencies.

In Fig. 4, curves A and B represent the overall fidelity of response, at 600 and 1400 kilocycles, respectively, of a representative present-day broadcast receiver, and show, as an example, the deficiencies encountered in tonal reproduction when receiving signals of the lower and intermediate broadcast frequencies. These curves include the effect of the characteristics of all components of the radio receiver including the speaker.

The ordinates for all the curves in Fig. 4 are obtained by applying a constant input voltage, noting the amount of output acoustic energy for the particular audio frequency, taking the square root thereof, and comparing this figure with the corresponding result for 400 cycles which is taken as 100%. Logarithmic graduations are used for both coordinate scales to approximate ear characteristics, and in the case of the frequency scale, also to prevent crowding of the lower frequencies.

In Fig. 4, curve C gives the characteristics of the audio system only, without the invention. The various curves coincide over the low-frequency range on account of the fact that the radio-frequency amplifier introduces no losses for low pitches, wherefore the audio-amplifier characteristic determines the overall characteristic for all frequencies of tuning. Curve D gives the characteristic of the audio system, with the invention, when the receiver is tuned to 600 kilocycles. Curves E and F give the characteristic of the audio system when the receiver is tuned to two higher frequencies in the broadcast band. As the tuning is changed from 600 kilocycles to 1400 kilocycles the characteristic of the audio system varies gradually from curve D, through curves E and F to curve C. By a suitable design of the means for varying the characteristic of the audio amplifier, the overall fidelity of the receiver may be made the same for all frequencies of tuning, and it may be made to have a curve such as B in the figure. In this way, as good fidelity is obtained over the entire broadcast range as was formerly had only at the higher frequency portion of the tuning range. Curve B represents a practical compromise between good high-pitch reproduction and desired attenuation of static and components of unwanted signals. For example, the upper side frequencies of the station on the next channel 10 kilocycles below, and the lower side frequencies of the station on the next channel 10 kilocycles above would produce some very high-pitched interference if there were not appreciable attenuation immediately above 5000 cycles.

Fig. 5 shows the circuit of a radio receiver of present-day design embodying this invention. A radio-frequency amplifier providing three stages of radio-frequency amplification in cascade, detector, or demodulator, and an audio-frequency amplifier providing two stages of audio-frequency amplification comprise the receiving system. The selective circuits of the high frequency amplifier may be tuned by any selective circuit elements as, for instance, variable condensers 1, 2, 3 and 4. It is to be understood that the application of the invention is not confined to receivers of the

type shown, but can be used with all systems well known in the art, where there is a radio-frequency tuning circuit for the choice of stations, a detector, rectifier, modulator, or other frequency changer, and an audio circuit conveying the detected signal. For the purpose of clarity the power supply unit is not shown here, as its function in relation to the receiving system is well-known in the art, and whether batteries or alternating current rectifying arrangements are used for the supply, it has no direct bearing on this invention. The volume control 6, increases the volume, as it is rotated to the right, due to a double action of increasing the shunting resistance 8, across the primary 13, of the antenna transformer 14, and also reducing the grid bias on the three radio-frequency amplifying tubes 15, 16 and 17, by reducing the bias resistance 9, included between the cathodes 10, 11 and 12 of these tubes and ground. This double volume control furnishes the necessary attenuation for satisfactory use of the set with very strong signals such as from powerful local stations, and also allows the employment of the high available sensitivity when desired. For the sake of simplifying the drawing the cathode heater and filament supply leads are omitted. These are connected to suitable windings on the power transformer in accordance with well-known practice. A tone control comprising a resistance 5 and a capacity 7 in series is electrically connected in shunt with the secondary of the transformer 19. The total impedance of the shunt path thus provided may be made adjustable by making either resistor 5 or capacity 7 variable.

As indicated by the heavy dotted line, the four variable tuning condensers 1, 2, 3 and 4, and the variable resistor 5, of the shunt path across the secondary 18 of the push-pull input transformer 19 are operatively connected and are therefore controlled simultaneously. As the capacitance of the condensers 1, 2, 3 and 4 is increased to tune the selective circuits from the high to the low frequency end of the tuning range, and stations on successively lower carrier frequencies are tuned in, the value of resistor 5 is increased, thus reducing the loss of the higher pitch audio currents through condenser 7 in series with the resistance 5 and gradually increasing the high-pitch audio-frequency gain. Without the loss for high pitches the audio amplifier has greater gain for high pitches than for low so that a material degree of compensation for the effects of sideband cutting is obtained. This greater audio gain for high pitches when receiving the lower broadcast frequencies is obtained by the lesser effect of resistance 5 and condenser 7 and also by the greater efficiency for high pitches of transformer 19. This transformer characteristic results from the appreciable leakage reactance of the transformer, sufficient to resonate with the distributed capacitance of the windings and the circuit capacitance at a frequency near the upper frequency of the band which it is desired to reproduce. By the use of low distributed capacitance and sufficient leakage reactance the voltage ratio of the transformer can be made 2 to 4 times as great at the resonant frequency as at low audio frequencies. In this way the invention may be employed to improve substantially the action of the receiver, although in the simple form depicted in Fig. 5 it may not accomplish the near-ideal compensation described in connection with Fig. 4. With selectivity curves approximately as shown in Fig. 2, and

under conditions such as usually found in present-day receivers the order of magnitude of the maximum value of resistor 5 may be 1 megohm and the order of magnitude of condenser 7 may be 0.003 microfarad. The determination of such values for any conditions by either computation or experiment is well known in the art and presents no difficulty.

Fig. 6 is a perspective drawing of the variable condenser unit of the receiver, the circuit of which has been indicated in Fig. 5, showing the variable resistance unit 5 mounted on the same shaft 20 with the condensers 1, 2, 3 and 4. This drawing serves to illustrate a simple mechanical assembly by means of which the variable resistor element can be attached to the tuning shaft in order to be actuated conjointly therewith and bring about the variation in the audio gain-characteristic in accordance with the position of the tuning control. Other equivalent devices may, of course, be employed.

It will be clear to any one skilled in the art of electrical communication that this invention may be applied to any desired extent in a radio receiver. For example, series selective elements may be employed in the audio amplifier and varied automatically by motion of the tuning element as already described. Additional variable shunt selective elements may also be utilized.

By the use of a suitable arrangement of series and shunt variable selective elements practically perfect fidelity to 5000 cycles can be obtained for all broadcast radio frequencies. A low-pass filter, with a sharp cut-off at 5000 cycles can be included, and thus the ideal combination of maximum fidelity and freedom from interference for the present 10-kilocycle separation of broadcasting stations can be obtained.

If it is desired to use the audio amplifier for the electrical reproduction of phonograph records, this may be done without serious loss of fidelity by arranging the phonograph switching control so as to be actuated by the tuning control immediately after the latter is moved beyond 1500 kilocycles. This switching arrangement, from radio reproduction to phonograph records, has been used in some types of receivers sold in the United States. With the present invention the audio system has nearly equal transmission characteristics for the various pitches when the tuning is at 1500 kilocycles. The only departure in a thorough application of the invention is a slight emphasis on the high pitches to offset the small amount of sideband cutting at 1500 kilocycles. If desired this may be corrected and any selective characteristics of the electric pick-up reproducer also corrected by the provision of a suitable selective circuit between the pick-up and the point where connection into the transmission circuit of the receiver is made.

It should be noted that the employment of this invention in a radio receiver does not preclude the use of a manual audio gain-frequency control, such as is generally called a tone control. That is, the use of the automatic tone control of this invention does not necessarily replace the usual tone control. Manual tone controls have already been used in radio receivers, and have certain advantages. By the use of them persons of defective hearing, who usually have greater loss for a certain pitch range, may strengthen this part in the reproduced sound. It may also be used to make changes to correct for the acoustics of the room where the receiver is used. An-

other use for a manual gain-frequency control is to reduce the high pitches when loud static is present, thus improving the general reception despite the partial absence of the high pitches in the reproduced sound. If any of the broadcasting stations heard are deficient in high pitches or low pitches, but not both, the manual control may be used to compensate for this deficiency.

Referring to Fig. 7, a signal amplifier 21 is associated with transmitting equipment 23, comprising an oscillator and a modulator. Desired carrier frequencies can be selected by rotation of the carrier-frequency control dial 22 which in turn rotates shaft 24 and thereby actuates gain-frequency control elements 25 and 26 of the signal amplifier 21. The transmission characteristic of the signal amplifier thereby can be varied in accordance with variations in the transmission characteristics of the carrier-frequency generator.

The invention claimed is:

1. In an electrical communication system having one portion operating at frequencies within a certain band, said band being variable in its location in the frequency spectrum, and another portion transmitting at least certain frequencies under all operating conditions, the combination of a control means to vary the frequency at which one portion operates, and means interconnected with said control means for altering the gain-frequency characteristic of said other portion as the location of said band is varied by said control.

2. A signaling system including a radio-frequency amplifier linked with an audio-frequency amplifier, each of said amplifiers being responsive over a frequency range, at least one of said amplifiers being adjustable to amplify selectively desired frequencies within its range, and means including a single control member associated with both amplifiers for varying the ratio of high-to-low frequency response of one of said amplifiers automatically as the frequency response of the other of said amplifiers is selectively adjusted.

3. In a radio signaling system operative over a plurality of radio-frequency channels, each of said channels comprising a radio-frequency carrier wave modulated by audio frequencies, a radio-frequency amplifier selectively tunable to said channels by a control member, an amplifier for said audio frequencies, and means associated with said audio-frequency amplifier and operable by said control member for varying the ratio of high-to-low audio-frequency response automatically as said radio-frequency amplifier is tuned from one to another of said channels.

4. In a radio signaling system operative over a range of adjacent radio-frequency channels, said range terminating in a high and a low end, each of said channels comprising a radio-frequency carrier wave modulated by a band of audio frequencies, a receiving system selectively tunable to said channels in which toward the lower end of said range a tendency for attenuating the higher audio frequencies is produced, including: a demodulator, an amplifier for said audio-frequencies, means associated with said amplifier for adjusting the audio-frequency response of said amplifier to accentuate the higher audio frequencies and a control member to operate said means simultaneously as said receiving system is tuned toward the lower end of said range, whereby the fidelity of reproduction is maintained substantially uniform.

5. A radio receiving system comprising a plurality of high-frequency amplifying stages in

cascade, tuning means for each of said stages for tuning said system over a range of frequencies, a detector, a plurality of stages of audio-frequency amplification, means associated with one of said audio-frequency amplifier stages for adjusting the ratio of high-frequency to low-frequency response of said audio-frequency amplifier stage, and means for simultaneously operating said last-mentioned means and said tuning means to adjust the frequency response ratio automatically as said receiving system is tuned over said range in frequencies.

6. In a radio receiving system, selective circuits tunable to respond to a range of frequencies, a detector connected thereto and followed by an amplifier for amplifying audio-frequency currents, adjustable means associated with said amplifier for altering the audio-frequency response thereof, and control means for tuning said circuits and simultaneously and gradually increasing the audio-frequency gain for high pitches as said circuits are tuned toward the lower-frequency end of their response range.

7. In a radio receiving system, the combination of a plurality of stages of radio-frequency amplifiers tunable conjointly by means of variable condensers, a detector connected thereto and followed by an audio-frequency amplifier, means operatively connected to said variable condensers and electrically associated with said audio-frequency amplifier for simultaneously varying the gain-frequency characteristic thereof with the tuning of said radio-frequency amplifying stages.

8. In a radio receiving system including radio-frequency amplifying stages tunable over a range of frequencies, a detector and an audio-frequency amplifier, the combination of means for tuning said amplifying stages, associated with said audio-frequency amplifier including a shunt path, for controlling the tone thereof, and means for simultaneously operating said last-mentioned means and the tuning means of said radio-frequency amplifying stages, whereby the ratio of high-to-low frequency response of said audio-frequency amplifier is automatically controlled as the system is tuned.

9. In a radio receiving system, selective circuit elements tunable to respond to a range of frequencies, a rectifier, an audio-frequency amplifier, means electrically connected to said amplifier comprising a shunt path which includes resistance and capacity in series, the total impedance of which is adjustable, and a single control means for conjointly and simultaneously adjusting said impedance and varying the tuning of said circuit elements.

10. In a radio signaling system operative over a plurality of radio-frequency channels, each of said channels comprising a radio-frequency carrier wave modulated by a band of audio frequencies, a radio-frequency amplifier selectively tunable over said range, whereby the modulation frequencies at the edges of said channel are attenuated, a rectifier, a plurality of stages of audio-frequency amplification, means associated with one of said audio-frequency amplifying stages for controlling the audio response thereof, and a single control means for simultaneously tuning said amplifier and operating said last-mentioned means and thereby automatically maintaining the overall response to audio frequencies substantially uniform as said radio-frequency amplifier is tuned over said range.

11. In a radio receiving system, a radio-frequency

quency amplifier tunable over a range of frequencies, a detector, an audio-frequency amplifier, circuit elements including a variable impedance associated with said audio-frequency amplifier, and a control member to vary simultaneously said impedance and the tuning of said radio-frequency amplifier, whereby the gain-frequency characteristic of said audio-frequency amplifier is varied in a predetermined manner with the tuning of said radio-frequency amplifier.

12. In a radio signaling system, a control member, a carrier-frequency generator adjustable by said control member over a range of frequencies, a modulator, a signal amplifier and means associated therewith and also operable by said control member for controlling the frequency response thereof simultaneously and at a predetermined rate as said generator is adjusted from one carrier frequency to another within said range.

13. In an electric system for the faithful transmission or reception of signals over a plurality of frequency channels, including two parts electrically linked by a frequency changing device, the method of operating said system which consists in varying the frequency selecting characteristic of one of said parts and simultaneously varying the fidelity characteristic of other of said parts.

14. The method of maintaining substantially uniform tone fidelity in radio receivers having radio and audio-frequency amplifiers, which comprises simultaneously varying the ratio of high-to-low frequency response of said audio-frequency amplifier and the tuning of said radio-frequency amplifier.

15. In a radio receiver, a tuning circuit for the choice of stations, a detector, an audio circuit, a tone control in said audio circuit, and a common control member for said tuning circuit and said tone control.

16. In a radio receiver, a stage of tuned radio-frequency amplification, tuning means in said stage, the selectivity of said stage being variable with tuning, a detector, an audio-frequency amplifier, means for controlling the tone of said amplifier, and additional means for rendering said tone control means simultaneously operative with said tuning means in such sense as to compensate for the effects of variation in selectivity of said radio-frequency stage with tuning.

17. In combination, a radio-frequency amplifier, means adapted to tune said amplifier over a band of frequencies and exhibiting a greater degree of selectivity at one end of said band of frequencies than at the other, a detector, and an audio-frequency transmission circuit, and means, mechanically linked with said tuning means, automatically increasing the transmission efficiency of the higher audio frequencies

through said transmission circuit as the selectivity of said radio-frequency amplifier is increased by tuning to said one end of said band of frequencies.

18. In a radio receiving system comprising tuning devices and means for intercepting, amplifying and rectifying modulated electrical oscillations of different transmission frequencies, means operative after rectification to reduce the transmission of relatively high audio-frequency oscillations and to produce characteristic output voltage curves which are substantially alike for all transmission frequencies, and connections between the last-named means and the tuning devices to enable said last-named means and the tuning devices to be adjusted in unison.

19. In a system comprising means for intercepting, selecting, amplifying and rectifying modulated electrical oscillations of different transmission frequencies, means including a variable shunt resistance operative after rectification to produce output voltage curves which are substantially alike for all transmission frequencies, and connections between the last-named means and the selecting means to enable the last-named means and the selecting means to be adjusted in unison.

20. In a system comprising means for intercepting, selecting, amplifying and rectifying modulated electrical oscillations of different transmission frequencies, means after rectification, comprising a condenser and a variable resistance in series therewith and forming a shunt circuit, operatively associated with the selecting means to be adjusted in unison with the latter to produce output voltage curves which are substantially alike for all transmission frequencies.

21. In a radio receiver, a stage of tuned radio-frequency amplification, tuning means in said stage, a detector, an audio-frequency amplifier, means for controlling the tone of said amplifier, and additional means for rendering said tone control means simultaneously operative with said tuning means, said tone control means transmitting the higher audio frequencies most efficiently when the tuning means is adjusted to the low frequency end of the receiver tuning range.

22. In a system comprising means for intercepting, selecting, amplifying and rectifying modulated electrical oscillations of different transmission frequencies, an amplifier for the rectified output, and means, comprising a condenser and variable resistance in series, in shunt with the input of said amplifier to effect characteristic voltage curves which are substantially alike for all transmission frequencies, said variable resistance being operatively associated with the selecting means to be adjustable in unison therewith.

CHARLES E. DEAN.