

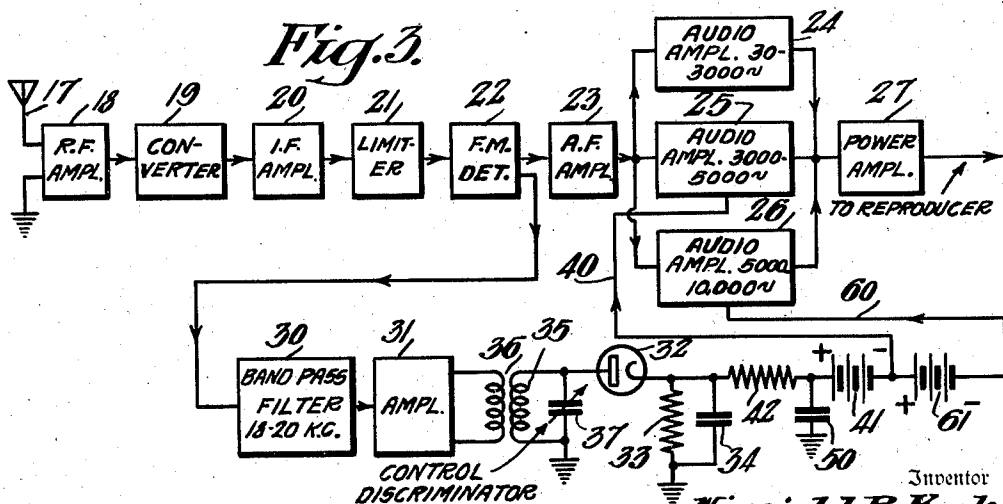
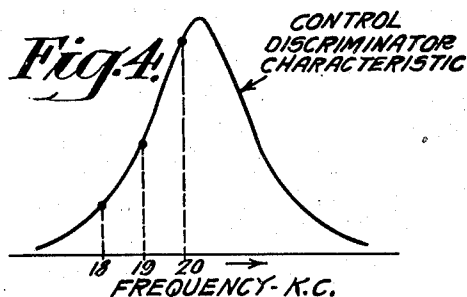
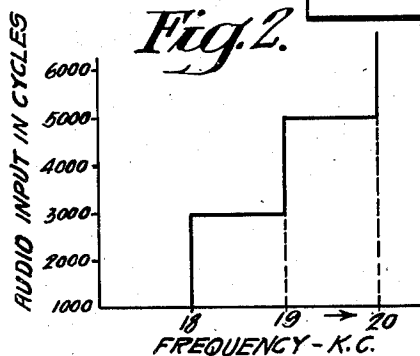
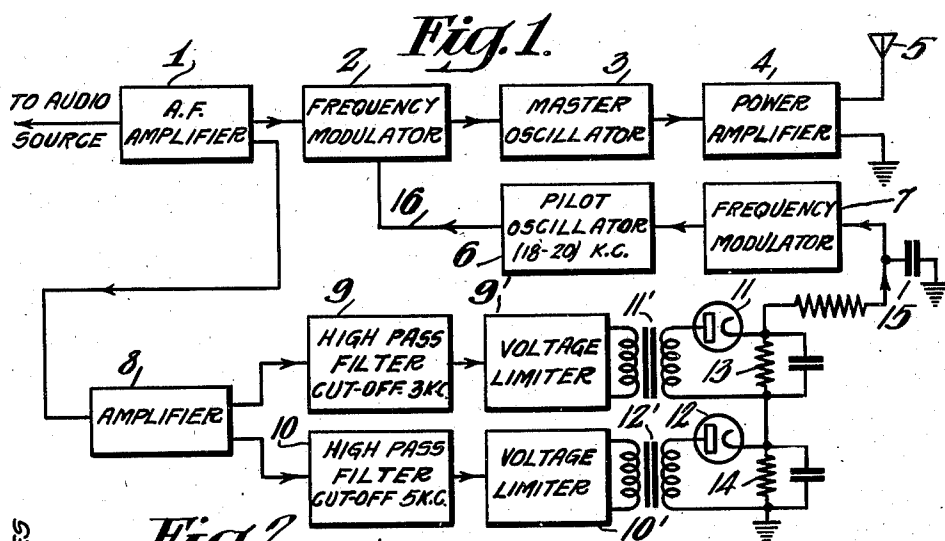
July 3, 1945.

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2,379,720

RECEIVER FIDELITY CONTROL SYSTEM

Filed July 4, 1942



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2,379,720

RECEIVER FIDELITY CONTROL SYSTEM

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Application July 4, 1942, Serial No. 449,771

15 Claims. (Cl. 250—6)

My present invention relates to a fidelity control system for radio receivers, and more particularly to a novel method of, and means for, controlling the audio pass band width of a receiver of angular velocity-modulated carrier waves.

In present frequency modulated carrier wave (FM) transmission there is employed a channel width of 200 kilocycles (kc.). The FM band itself extends from 42 to 50 megacycles (mc.). The carrier at the transmitter is actually deviated over a range up to a maximum of 75 kc. on either side of the carrier, or center, frequency. In other words, the channel width is considerably in excess of the audible modulation frequency range. Various proposals have been made in the past for receiving such high deviation FM waves in a receiver whose radio frequency pass band is a function of the frequency deviation of the received energy. The purpose of these systems has been to accommodate the radio frequency pass band of the receiver to the extent of deviation of the received FM wave energy thereby to insure a high degree of fidelity of modulation signal reproduction at the receiver. Many of these systems function to control the pass band width of the intermediate frequency (I. F.) network, where the FM receiver is of the superheterodyne type.

It may be stated that it is one of the main objects of my present invention to provide a radio transmission system wherein the receiving system is controlled so as to accommodate the pass band width of the audio channel section of the receiver to the frequency range of the modulation on the carrier so as to provide a high degree of fidelity of reproduction at the receiver.

Another important object of the invention is to provide an FM receiver which includes a circuit for automatically accommodating the audio amplifier pass band to the rate of frequency deviation of the received carrier energy thereby to provide a audio tone control for the receiver.

Yet another object of the invention is to provide a system of radio communication wherein carrier wave energy is frequency modulated with desired program modulation signals, the modulation of the carrier including in addition a super-audible modulation signal whose function it is to control the audio pass band width at the receiver so as to provide an audio channel width which corresponds directly to the frequency range of the modulation signals.

Still other objects are to improve generally the efficiency and fidelity of FM transmission, and more especially to provide high fidelity FM re-

ceivers which are economical to manufacture and assemble.

The novel features which I believe to be characteristic of my invention are set forth with particularity in the appended claims; the invention itself, however, as to both its organization and method of operation will best be understood by reference to the following description taken in connection with the drawing in which I have indicated diagrammatically several circuit organizations whereby my invention may be carried into effect.

In the drawing:

Fig. 1 shows schematically an FM transmitter embodying the invention,

Fig. 2 shows the modulation characteristic of the pilot oscillator at the transmitter,

Fig. 3 schematically shows the receiver used in the present system.

Fig. 4 shows the control tone discriminator characteristic of the receiver.

Referring, now, to the accompanying drawing, Fig. 1 schematically shows the various networks of an FM transmitter. This invention is in no way restricted to FM, since it can be readily applied to phase modulated carrier wave energy. The expression "angular velocity-modulated carrier waves" is to be understood as generically denoting either frequency or phase modulated carrier waves. The source of audio wave energy which is coupled to the audio frequency amplifier 1 may be a microphone, phonograph record pick-up, line or any other type of audio modulation source. Further, the modulation signals need not be at audio frequency, since modulation frequencies of a super-audible frequency range can be used. The control tone in that case may be at some frequency above the operating modulation signal frequency range.

The modulation signal energy is amplified at the amplifier 1, and the amplified modulation energy is used to vary the reactive effect of a frequency modulator 2. The latter, as is well known in the FM transmission art, may consist of a tube whose anode to cathode impedance simulates a reactance whose sign depends on the circuit connections. The applied modulation, usually applied to a control grid of the reactance tube, varies the simulated reactance. The latter is connected across the tank circuit of the master oscillator 3. The tank circuit is tuned so that the oscillations, in the absence of modulation, have a carrier frequency located in the 42 to 50 mc. band. The latter is the presently assigned FM broadcast band.

Of course, the invention is in no way restricted to operation in the 42 to 50 mc. band. Any higher, or lower, frequency band may be utilized. What is important is that the carrier frequency, say 49.9 mc. for example, be deviated in proportion to the amplitude of the modulation signals. The rate of carrier, or center, frequency deviation is a function of the modulation frequencies per se. In the present FM band of 42 to 50 mc. it is the practice to deviate the carrier frequency a maximum of 75 kc. to each side of the center frequency. The FM channel itself has a width of 200 kc. The FM wave energy is transmitted to a power amplifier 4, and then is radiated from the radiator 5. The latter may be a dipole, or a grounded antenna system.

In my application Serial No. 444,639, filed May 27, 1942, I have shown a method of including in the modulated carrier wave energy a super-audible frequency control tone. In that case the purpose of including the control tone was to employ a receiver having selector circuits which have pass band widths considerably narrower than the channel width. The control tone in that application was employed to vary the modulation amplification at the receiver in a sense to provide an expansion effect thereby to secure the benefits of high deviation modulation even though a narrow band FM receiver was employed.

In the present system there is, also, utilized a pilot oscillator 6, as in the case of the aforementioned application. The frequency thereof may be varied over a range of 18 to 20 kc. An auxiliary frequency modulator 7, which may be a reactance tube of the same type as is employed at the modulator 2, is utilized to vary the frequency of the pilot oscillator tank circuit. The reactive effect due to the modulator 7 is controlled in accordance with the audio frequency modulation applied to the modulator 2. Thus, the audio frequency amplifier 1 feeds a portion of its modulation energy output to a special amplifier 8. The output of amplifier 8 is passed through a pair of parallel filter networks 9 and 10.

The network 9 is a high pass filter having a cut-off frequency at 3 kc. The network 10 is a high pass filter having a cut-off frequency at 5 kc. In other words, the energy at the output terminals of the high pass filter 9 will extend from 3,000 cycles and upwards. The filter 10 will pass audio energy only above 5,000 cycles. A voltage limiter 9' is interposed between the high pass filter 9 and a diode rectifier 11. The voltage limiter 10' is interposed between the high pass filter 10 and its associated rectifier 12. The purpose of the voltage limiters is to suppress any amplitude variation which may exist in the audio energy thereby feeding to each of the rectifiers 11 and 12 audio energy which has a predetermined voltage when certain high frequency components are present. Those skilled in the art are fully aware of the manner of constructing the high pass filters 9 and 10. It is well known in the art of audio frequency transmission that audio filters can be designed to have a sharp cut-off frequency at any specified audio frequency value. Of course, each of the high pass filters 9 and 10 may be replaced by a band pass filter designed to pass the desired audio frequency band.

The rectifier 11 has its anode coupled to the audio transformer 11', while rectifier 12 has its anode coupled to the audio transformer 12'. The load resistor 13 is arranged in the space current path of diode 11, while the load resistor 14 is

arranged in the space current path of diode 12. Each of load resistors 13 and 14 is bypassed by a condenser having a low impedance to audio frequency currents. The anode end of load resistor 14 is grounded, while the cathode end of the resistor is connected to the anode end of load resistor 13. The cathode end of resistor 13 is connected to the control grid of the reactance tube of the modulator 7. The resistor-condenser filter network 15 is inserted in the control connection path between the load resistor 13 and the modulator 7.

The voltage developed across each of resistors 13 and 14 will depend upon the audio energy passing each of the input filters. Thus, when audio energy in the program modulation has no frequencies present greater than 3,000 cycles, there will be no audio energy passed to either of rectifiers 11 or 12. Hence, the frequency deviation of the carrier will be determined solely by the energy flowing from amplifier 1 to modulator 2. When the program modulation has no frequencies present greater than 5,000 cycles, there will be passed through filter 9 audio energy, since the filter passes audio frequencies above 3,000 cycles. There will be no transmission of audio energy through filter 10, because the latter transmits audio energy above 5,000 cycles. As a result voltage will be developed across resistor 13 which is positive with respect to ground. This voltage is applied to the control grid of the FM reactance tube 7 in a sense to increase the frequency of the pilot oscillator 6 up to 19 kc.

If, now, the program modulation has high frequencies above 5,000 cycles, audio energy will pass through filter 10, and, after limiting at 10', will be rectified by rectifier 12. As a result there will be developed additional positive voltage across resistor 14, and the frequency modulator 7 will cause the oscillator 6 to shift in frequency up to 20 kc. The filter 15 functions to prevent pulsating voltage components from passing to the modulator tube 7. It will be seen, reference being made to Fig. 2, that the pilot oscillator frequency is a function of the audio pass band from the audio source. The wider the audio frequency range of the audio energy, the higher will be the frequency of the pilot oscillator. The output of the pilot oscillator is fed over lead 16 to the frequency modulator 2, so that the current variation of the latter will include the pilot frequency as a component. It will now be appreciated that as the applied audio frequency energy from the audio source causes the carrier to deviate, there is concurrently embodied in the FM energy a component for determining the mode and extent of audio pass band width to be employed at the receiver. The control component corresponds to a specific rate of frequency deviation of the carrier which is proportional to the audio frequency range of the program modulation.

At the receiver there may be employed the usual FM receiving circuit. The collector 17 feeds the collected FM wave energy to the usual networks up to the demodulator designated as "FM Det." The demodulator may be preceded by the customary amplifiers. Where the receiver is of the superheterodyne type, as is universally the case, the amplifier 18 may embody the usual number of ultra-high frequency amplifiers feeding a converter 19 whose intermediate frequency (I. F.) is passed through one or more I. F. amplifiers 20 followed by amplitude modulation limiter 21. The limited I. F. energy is fed to the FM detector 22 to provide the modulation signals which were

originally applied to the amplifier 1 at the transmitter. Each of the tuned selector circuits up to the detector 22 will have a pass band sufficiently wide to pass the maximum frequency deviation of the carrier. In other words, the tuned selector circuits should be in excess of 150 kc. in width. Of course, the control system shown in my aforementioned application may be employed, and, in that case, a separate super-audible frequency control modulation would be required on the carrier. The center frequency of the I. F. energy may be, for example, 4.3 mc. The detected FM wave energy is passed through a stage of audio frequency amplification 23 prior to impression of the energy upon either of the plurality of parallel audio frequency amplifier channels 24, 25 and 26.

The audio channel 24 is an amplifier capable of passing energy of 30 to 3,000 cycles efficiently. Channel 25 passes audio energy lying in the range of 3,000 to 5,000 cycles most efficiently. Audio amplifier 26 passes audio energy from between 5,000 to 10,000 cycles most efficiently. The amplified audio output of amplifier 23 is fed to the input terminals of each of channels 24, 25 and 26. The output terminals of these three channels are connected in common to feed the input terminals of the audio power amplifier 27, and the latter will feed any desired type of reproducer. It is believed that those skilled in the art are fully acquainted with the manner of constructing each of channels 24, 25 and 26. For example, they may be of one or more stages in each channel.

The audio amplifier channel 24 has normal and invariable gain. In other words, it is not subjected to gain control action by the super-audible control tone. However, each of channels 25 and 26 is subjected to gain control. This is accomplished by deriving from the output of the demodulator 22 the modulation component corresponding to the super-audible control tone. A band pass filter, capable of efficiently passing 18 to 20 kc., is designated by numeral 30. It passes the control tone energy to an amplifier 31. It is now only necessary to convert the variable-frequency control tone energy into a uni-directional voltage whose magnitude is a measure of the effective audio channel width to be employed. This is accomplished by employing a rectifier 32 of the diode type. The cathode of diode 32 is connected to ground through a load resistor 33 which is bypassed by the condenser 34 for alternating current components. The anode of diode 32 is connected back to ground through the secondary winding 35 of transformer 36. The primary winding of the transformer 36 is connected in the output circuit of amplifier 31.

Coil 35 is shunted by a condenser 37. The tuned circuit 35—37 acts as a discriminator to convert the frequency-variable control tone energy into corresponding amplitude-variable control tone energy. In Fig. 4, I have shown the control discriminator characteristic. It will be seen that circuit 35—37 is tuned to the peak of the resonance curve shown therein. The peak frequency is somewhat above the 18–20 kc. frequency variation range of the control tone energy. In other words, discrimination takes place because the mean frequency of the control tone energy is located at an intermediate portion of the sloping side of the response curve. It will be recognized that this is a well known and simple form of discriminator action. The output of discriminator 35—37 is a minimum when the control tone has a frequency of 18 kc., and is a maximum when the frequency is of 20 kc.

Hence, the voltage across resistor 33 is a maximum at the 20 kc. frequency of the control tone energy, and is a minimum at the 18 kc. frequency. Amplifier 25 has a gain control connection 40 to the cathode end of resistor 33 through a path which includes the negative biasing source 41 and the filter resistor 42. The junction of resistor 42 and the positive terminal of source 41 is connected to ground through a filter condenser 50. Hence, amplifier 25 normally has a negative bias applied thereto which is determined by the magnitude of biasing source 41. Amplifier 26 has a gain control connection 60 to the cathode end of resistor 33, but the biasing source for that amplifier includes biasing source 41 in series with biasing source 61. As shown, source 41 and 61 may be a single source with appropriate connections to the various networks.

In operation, each of channels 25 and 26 will normally be non-conductive by virtue of the respective bias voltages applied thereto over connections 40 and 60. Let it be assumed that the program modulation derived from the FM detector 22 has no frequencies above 3,000 cycles present. In that case, the super-audible control tone will have a frequency of 18 kc. Accordingly, because of the discriminator characteristic very little voltage is developed across rectifier load resistor 33. Hence, the amplifier channels 25 and 26 will be cut off due to the cut-off bias applied from sources 41 and 61. However, where the program modulation includes frequencies above 3,000 cycles, the discriminator characteristic shown in Fig. 4 will cause the rectifier to develop increased positive voltage across resistor 33.

For audio frequencies between 3,000 and 5,000 cycles and the corresponding control tone of 19 kc. there will be sufficient positive voltage developed at the cathode end of resistor 33 to overcome the bias due to source 41, and, therefore, render channel 25 operative. As the audio frequencies present increase above 5,000 cycles up to 10,000 cycles, the control tone will become 20 kc., and there will be an increased input level at rectifier 32. The positive voltage across resistor 33 will then be sufficient to overcome the cut-off bias applied due to source 61. Hence, channel 26 will be rendered operative. Accordingly, it will be seen that in such case all three channels will be operative, and there will be fed to power amplifier 27 a wide range of audio frequencies up to 10,000 cycles.

It will now be appreciated that the audio pass band at the receiver is directly dependent upon the magnitude of the super-audible control tone frequency. Furthermore, it will be appreciated that the super-audible control tone frequency is a direct function of the audio frequency range of the energy applied to the frequency modulator 2 at the transmitter. In other words, the audio network of the receiver is automatically accommodated to the frequency range of the audio modulation at the transmitter. As the transmitter audio frequency range is expanded, there will occur an automatic expansion of the audio pass band width at the receiver. Should the audio frequency range be compressed at the transmitter, there will be an automatic compression of the audio band pass at the receiver. As a result, high frequency noises, which would otherwise occur and be reproduced, are prevented from reaching the speaker. On the other hand, when program material of high fidelity is placed on the carrier at the transmitter, the receiver will auto-

atically be accommodated to high fidelity reproduction.

While I have indicated and described several systems for carrying my invention into effect, it will be apparent to one skilled in the art that my invention is by no means limited to the particular organizations shown and described, but that many modifications may be made without departing from the scope of my invention as set forth in the appended claims.

What I claim is:

1. In a system for communicating with angular velocity-modulated carrier waves, the method which includes the following steps: generating carrier oscillations of substantially constant amplitude; deviating the frequency of the oscillations in accordance with modulation signals; generating a control tone whose frequency lies outside the range of the modulation signal frequencies, varying the frequency of the control tone in accordance with changes in the frequency range of the said modulation signal frequencies; modulating said carrier oscillations with said control tone, and transmitting the modulated carrier oscillations.

2. In a system for communicating with angular velocity-modulated carrier waves, the method which includes the following steps: generating carrier oscillations of substantially constant amplitude; deviating the frequency of the oscillations in accordance with modulation signals; generating a control tone whose frequency lies outside the range of the modulation signal frequencies, varying the frequency of the control tone in accordance with changes in the frequency range of the said modulation signal frequencies; modulating said carrier oscillations with said control tone and transmitting the modulated carrier oscillations; detecting the transmitted carrier oscillations at a receiving point; separating energy of said control tone from the detected oscillations, deriving from the control tone energy a control voltage whose magnitude is dependent upon the frequency of said control tone, and automatically adjusting the modulation pass band width at the receiving point in accordance with the magnitude of the control voltage.

3. In a receiver of frequency modulated carrier waves wherein one of the modulation components is a super-audible control tone whose frequency is a proportionate function of the frequency range of the modulation on the received carrier, a demodulator for deriving from the modulated carrier energy demodulation signals and said super-audible control tone of variable frequency, a plurality of audio transmission channels of different frequency range, and means responsive to variations in frequency of said control tone for rendering predetermined ones of said channels effective.

4. In a frequency modulation communication system, producing frequency modulated carrier wave energy, embodying in the energy a control component whose frequency magnitude is a continuously controlled frequency-variable function of the frequency range of the modulation frequencies, demodulating the frequency modulated carrier wave energy at a receiving point to provide the modulation signal frequencies and said control component, and utilizing the frequency variations of said control component at the receiving point to regulate the modulation range subsequent to demodulation.

5. In a system for communicating with modulated carrier waves, the method which includes generating carrier oscillations, deviating the fre-

quency of the oscillations in accordance with the audio modulation signals, generating a control tone whose frequency lies outside the range of the audio modulation signal frequencies, varying the frequency of the control tone in accordance with changes in the width of the frequency range of the said modulation signal frequencies, modulating said carrier oscillations with said control tone, and transmitting the modulated carrier oscillations.

6. In a system for communicating with angular velocity-modulated carrier waves, the method which includes deviating the frequency of carrier oscillations in accordance with audio signals, varying the frequency of a control tone in accordance with changes in the frequency range of the said audio signal frequencies, modulating said carrier oscillations with said control tone, and transmitting the modulated carrier oscillations.

7. In a receiver of frequency modulated carrier waves wherein one of the modulation components is a super-audible control tone whose frequency is a function of the frequency range of the modulation on the received carrier, means for deriving from the modulated carrier energy demodulation signals and said super-audible control tone of variable frequency, at least two audio transmission channels of different frequency ranges, and means responsive to variations in frequency of said control tone for rendering predetermined ones of said channels effective.

8. In a system for communicating with angular velocity-modulated carrier waves, the method which includes the following steps: deviating the frequency of constant amplitude oscillations in accordance with modulation signals; generating a control tone whose frequency lies outside the range of the modulation signal frequencies, varying the frequency of the control tone in accordance with changes in the extent of the frequency range of the said modulation signal frequencies; modulating said carrier oscillations with said control tone; and transmitting the modulated carrier oscillations.

9. In a system for communicating with angular velocity-modulated carrier waves, the method which includes generating carrier oscillations, swinging the frequency of the carrier oscillations in accordance with modulation signals, generating a super-audible control tone, varying the frequency of the control tone in accordance with changes in the frequency range of the said modulation signal frequencies, modulating said carrier oscillations with said control tone, transmitting the modulated carrier oscillations, detecting the transmitted carrier oscillations at a receiving point, separating energy of said control tone from the detected oscillations, deriving from the control tone energy a control voltage whose magnitude is dependent upon the frequency of said control tone, and automatically adjusting the modulation pass band width at the receiving point in accordance with the magnitude of the control voltage.

10. In a receiver of frequency modulated carrier waves wherein one of the modulation components is a control tone whose frequency is a function of the frequency range of the modulation on the received carrier, a demodulator, a plurality of audio transmission channels of respectively different frequency ranges, and means responsive to variations in frequency of said control tone for rendering predetermined ones of said channels effective.

11. In a frequency modulation communication

system, producing frequency modulated carrier wave energy, embodying in the energy a control component whose frequency magnitude is a controlled function of the frequency range of the modulation frequencies, demodulating the frequency modulated carrier wave energy at a receiving point to provide the modulation signal frequencies and said control component, and utilizing said control component at the receiving point to regulate the modulation range subsequent to demodulation.

12. In a method of signalling, deviating the frequency of carrier oscillations in accordance with modulation signals, generating a super-audible control tone, varying the frequency of the control tone in accordance with changes in the frequency range of the said modulation signal frequencies, modulating said carrier oscillations with said control tone, and transmitting the modulated carrier oscillations.

13. A radio communication method comprising deviating the frequency of the carrier oscillations in accordance with modulation signals, generating a control tone whose frequency lies outside the range of the modulation signal frequencies, varying the frequency of the control tone in accordance with changes in the frequency range of the said modulation signal frequencies, modulating said carrier oscillations with said control tone, transmitting the modulated carrier oscillations, detecting the transmitted carrier oscillations at a receiving point, separating energy of said control tone from the detected oscillations, deriving from the control tone energy a control voltage whose magnitude is dependent upon the frequency of said control tone, and automatically adjusting the modulation pass band width at the

receiving point in accordance with the magnitude of the control voltage.

14. In a receiver of frequency modulated carrier waves of the type which embody a superaudible control tone of variable frequency as a modulation component, a demodulator for deriving from the modulated carrier energy modulation signals and said super-audible control tone of variable frequency, a plurality of audio transmission channels of different frequency ranges, and means responsive to variations in frequency of said control tone for rendering predetermined ones of said channels effective.

15. In combination, means for generating carrier oscillations of high frequency, means for deviating the frequency of the oscillations in accordance with modulation signals, means for generating a control tone whose frequency lies outside the range of the modulation signal frequencies, means for varying the frequency of the control tone in accordance with changes in the frequency range of the said modulation signal frequencies, means for frequency modulating said carrier oscillations with said control tone, means for utilizing the resultant frequency comprising means for detecting the resultant modulated carrier oscillations, means for separating energy of said control tone from the detected oscillations, means deriving from the control tone energy a control voltage whose magnitude is dependent upon the frequency of said control tone, and means for automatically adjusting the modulation pass band width subsequent to said detecting means in accordance with the magnitude of the control voltage.

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