

June 15, 1937.

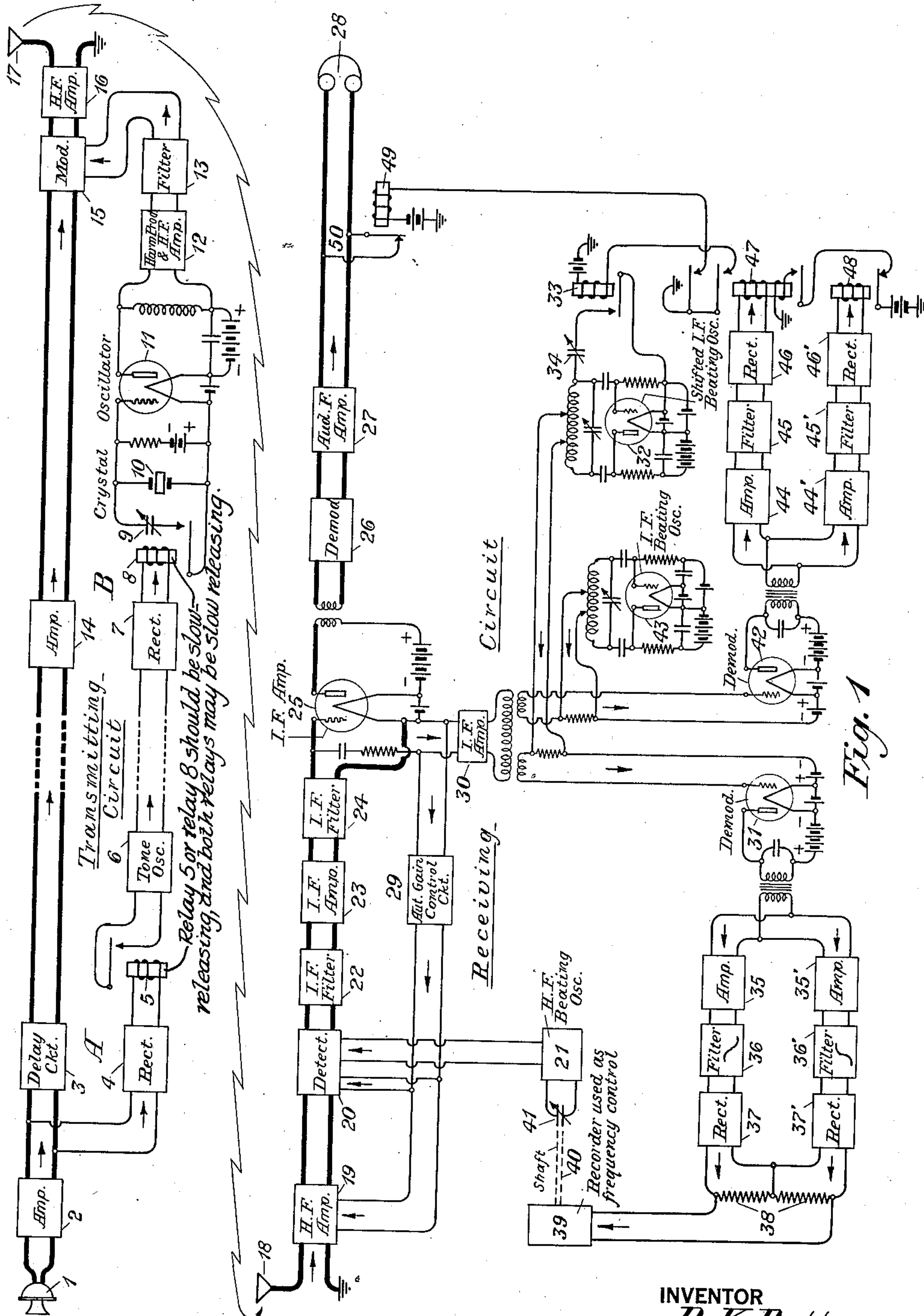
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2,083,666

HIGH FREQUENCY SIGNALING SYSTEM

Filed Sept. 30, 1933

2 Sheets-Sheet 1



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2 Sheets-Sheet 2

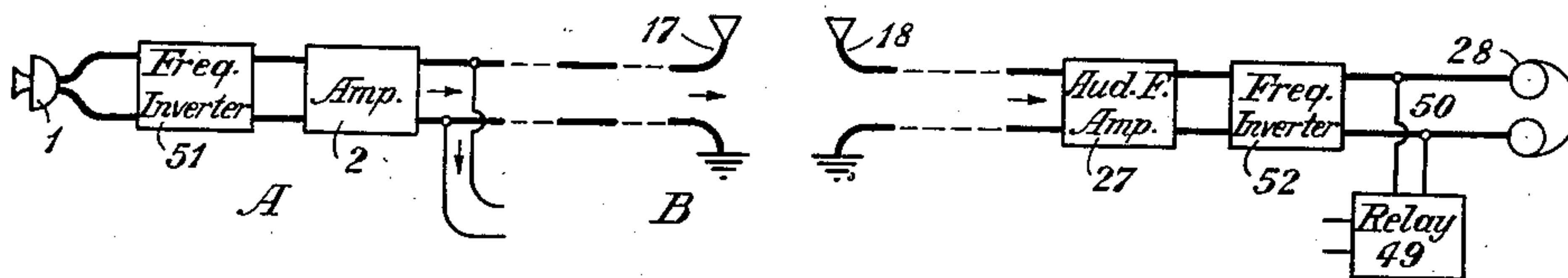


Fig. 2

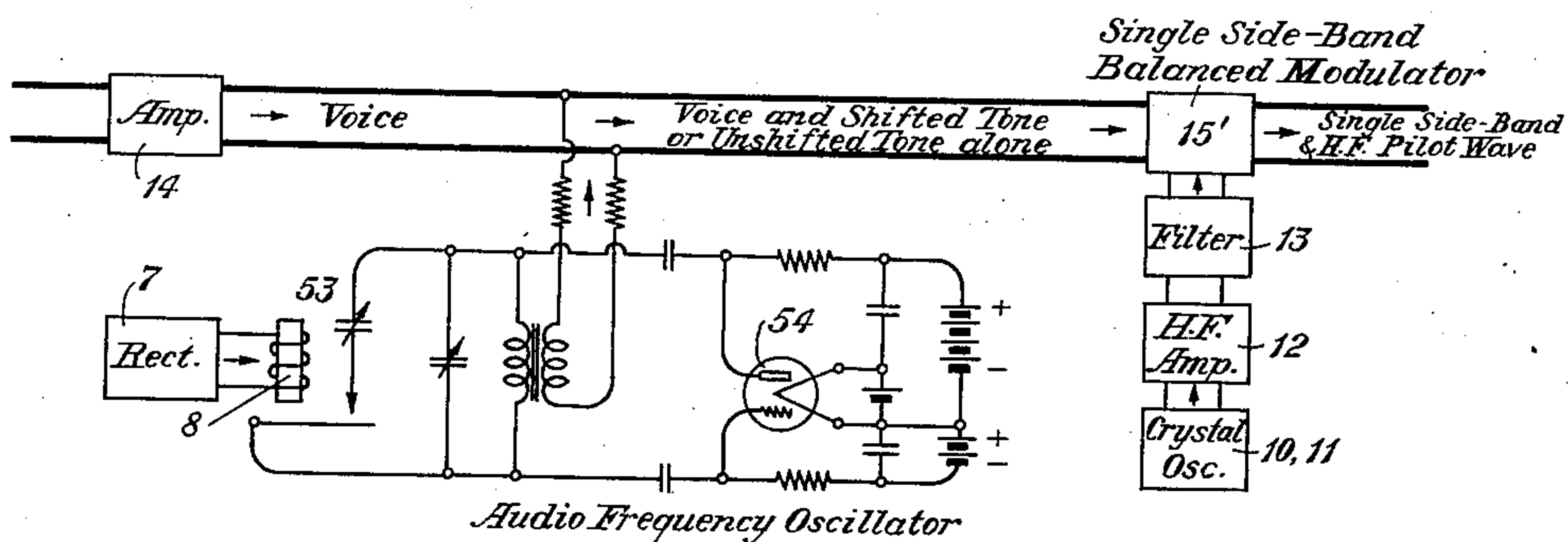


Fig. 3

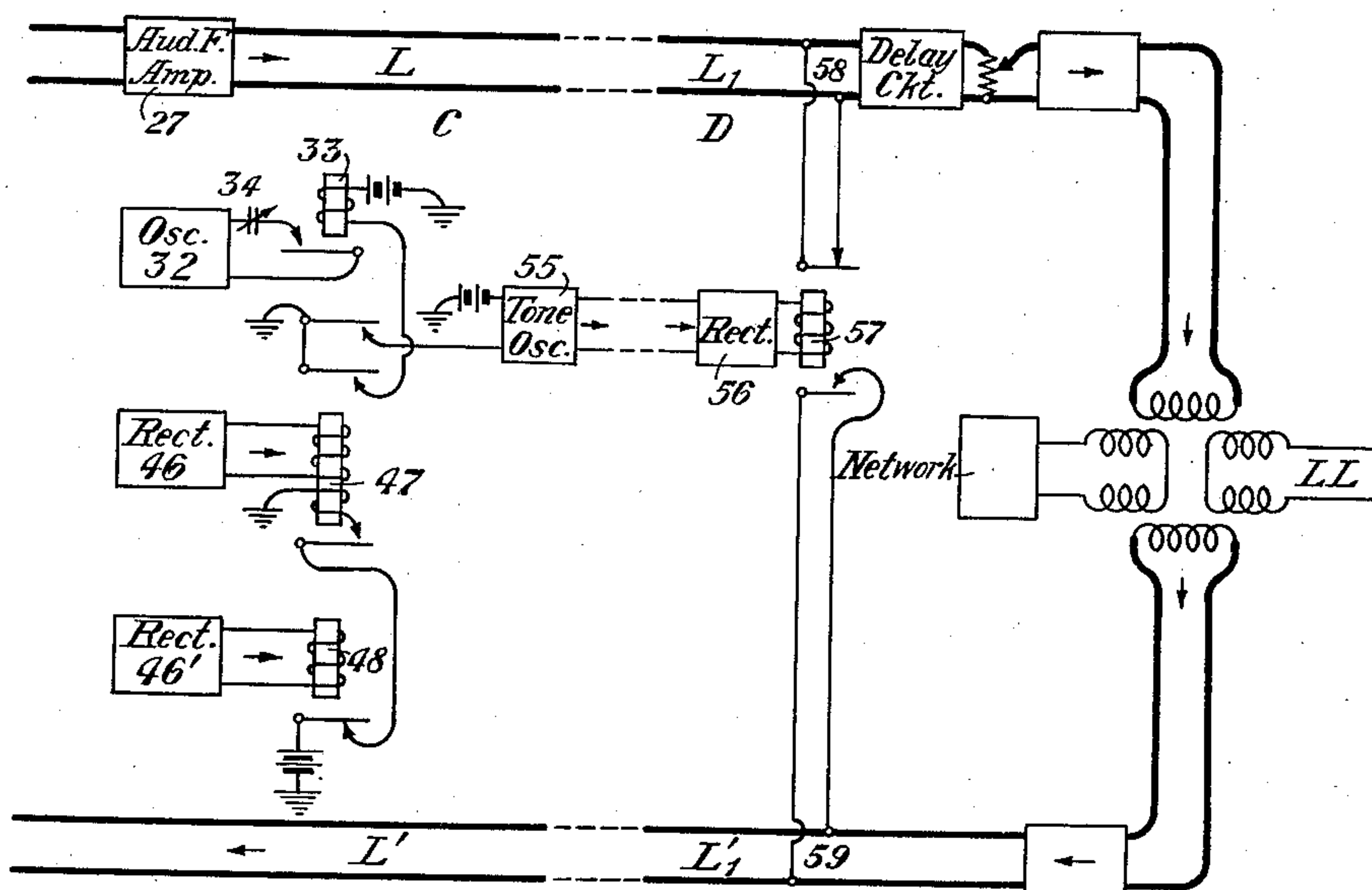


Fig. 4

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2,083,666

HIGH FREQUENCY SIGNALING SYSTEM

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30 Claims. (Cl. 178—44)

This invention relates to high frequency transmission systems and, more particularly, to high frequency signaling systems. The invention is particularly applicable to long radio telephone circuits in connection with which there is a requirement of automatic remote control of transmission channels.

As is well understood in the art, it is desirable, especially in long two-way signaling systems, to exercise remote control of transmission channels, usually in direct or indirect response to the application of the signal energy to some part of the system. For instance, in a long two-way telephone system comprising a radio link and wire paths for transmission in each direction at each end of the radio link, it may be desirable to have a wire receiving channel normally disabled and the oppositely directed wire transmitting path normally in operative condition. When it is desired to transmit the signals over the receiving path it becomes necessary, of course, to provide for the clearing of that path and, if echoes are to be prevented, for the disabling of the oppositely directed transmitting path. The operation of the apparatus which directly clears the one path and disables the other may, as is well understood in the art, be produced in response to the voice energy (suitable delay being introduced in the transmission of the signal energy), or by some type of special control energy. This control energy, according to the prior art, may be applied during the signal periods or during the silent periods, and numerous methods have been devised in accordance with which the control is exercised in response to the application of the signal energy to the system. Furthermore, various methods have been proposed for utilizing the carrier wave for control purposes.

The principal purpose of this invention is to provide for the satisfactory use of the carrier (or an equivalent high frequency wave) as a control channel whereby there may be produced a control of transmission channels such as that outlined hereinabove. Another purpose of the invention is to provide a satisfactory remote control without the loss of advantages such as continuous automatic tuning and automatic gain control.

In general, the applicant, in accomplishing the desirable results suggested hereinabove, produces at the transmitting end of the system sustained high frequency oscillations, shifts or changes the frequency of these oscillations when signal energy is applied to the system, transmits to the receiving end of the system alternately the series

of oscillations of the original or reference frequency and the series of oscillations of the shifted or changed frequency, and utilizes the frequency shift or change to control the signal transmission channel or channels at the receiving end. Thus, in place of using a change of amplitude of a control wave, the applicant uses for his control the shift or change of frequency of a continuously transmitted "pilot" wave which may be the carrier or an equivalent series of high frequency oscillations. If the applicant's method is viewed somewhat differently, there are transmitted alternately two high frequency waves, one or both of which may be utilized for the remote control.

It is proposed to discuss first the application of the applicant's invention to the use of the carrier as the control wave or as the reference or the shifted control frequency. Subsequently, it will be pointed out that the invention may be applied equally well with the use of high frequency oscillations which are strictly distinguishable from the carrier.

It is desirable to point out some of the features and advantages of the applicant's methods of and means for obtaining the remote control. While the arrangement is primarily for use in systems in which different carrier frequencies are employed for the two directions of transmission, it is also applicable to systems in which there is a common carrier frequency for transmission in the two directions. As has been suggested hereinabove, the applicant's arrangement, as distinguished from other arrangements found in the prior art, utilizes a shift or change of frequency of the carrier (or equivalent high frequency wave) in place of a change in amplitude.

The apparatus required for the practice of the applicant's invention is comparatively simple, involving relatively minor additions to apparatus now used in systems to which the invention is applicable. It will be understood further that the applicant's use of a continuously transmitted high frequency with a shift or change of frequency to produce the control channel, provides for comparatively high signal power for a given frequency band width and, consequently, a comparatively great signal to noise ratio in this channel. Also, the methods of the invention provide comparatively great protection against false operation of controlled devices due to fading with the resultant departure from complete and satisfactory control of the transmission path or paths. Furthermore, as has been suggested hereinabove, applicant's control methods permit the satisfac-

tory use of constant automatic tuning and of automatic gain control at the receiver.

The invention will be clearly understood when the following description of one desirable embodiment is read with reference to the accompanying drawings.

Figure 1 of the drawings shows diagrammatically and, in part, schematically, the transmitting and receiving ends of a high frequency telephone circuit to which the invention is applied;

Figs. 2 and 3 indicate schematically and, in part, diagrammatically, certain modifications which may accompany the use of frequency inversion and the modulation of a tone on a single side-band, respectively, and

Fig. 4 indicates diagrammatically and, in part, schematically, the application of the novel control to a two-way telephone system.

Like characters of reference in the several figures of the drawings designate corresponding elements or points of the circuits.

With particular reference to Fig. 1, there is shown at the top of the figure a satisfactory arrangement of the apparatus at the transmitting station of a telephone circuit, some of the apparatus being located at a point A, which may be the terminal station, and the rest of the apparatus being located at a point B, which is the radio transmitting station. The lower part of Fig. 1 shows one desirable arrangement of the apparatus at the receiving station.

It is believed that the apparatus and the circuit connections as well as the methods involved, will be best understood from a discussion of the operation of the system in accordance with the invention.

Voice energy from the transmitter 1 at the station A passes through an audio-frequency amplifier 2 and is divided at the output thereof. The major part of the energy travels over the main transmission path and is impressed on a delay circuit 3. The remaining part of the energy is diverted into an auxiliary path and is impressed on a rectifier 4. The output of this rectifier operates a relay 5 which, upon operation, completes the circuit of a tone oscillator 6, for example. The tone (or any other type of interrupted signal) travels to the radio station B and is there impressed on a rectifier 7. The output of rectifier 7 operates a relay 8, which completes a circuit through a small capacity 9 bridged across the crystal 10 of a crystal oscillator including the tube 11. It will be understood, of course, that the condenser 9 might be normally bridged across the crystal 10 and the circuit including the condenser opened by the operation of relay 8. The important point to be understood is that the crystal oscillator normally generates oscillations of a high frequency which may be termed the "reference" frequency and that when relay 8 operates, this frequency changes or shifts to a value which may be termed the "shifted" frequency. The output of the oscillator 11 passes through a harmonic producer and high-frequency amplifier 12, and a filter 13 to the modulator 15. It will be understood that the oscillations of the reference frequency are impressed on the modulator 15 when the relay 8 is unoperated, that when relay 8 operates the oscillations impressed on the modulator are of the shifted frequency, and that this shift or change of frequency takes place before the voice energy reaches the modulator since this energy is delayed in transmission by the delay circuit 3. After passing through the delay circuit the voice

energy is amplified in the audio-frequency amplifier 14 and then passes on to the modulator. In 15 the voice is modulated on the carrier of the shifted frequency, and the product of the carrier and side bands is passed through the high-frequency amplifier and is radiated from the antenna 17. It should be understood that the antenna 17 is thus radiating alternately waves representing the unmodulated reference high frequency and the shifted high frequency modulated with the voice. Sufficient delay is provided in the release of relay 5 or relay 8 or both to insure a continuance of the shifted frequency oscillations from the oscillator 11 until the arrival of voice energy at the modulator 15 has ceased.

The energy is picked up at the receiving end of the system by the antenna 18 and travels through the high-frequency amplifier 19, the detector 20, the intermediate-frequency filter 22, the intermediate-frequency amplifier 23, the intermediate-frequency filter 24, the intermediate-frequency amplifier 25, the demodulator 26, and the audio-frequency amplifier 27 to a receiver 28. Associated with the detector 20 is the high-frequency beating oscillator 21.

The auxiliary circuits at the receiving end of the system include an automatic gain control circuit 29, which is of the type disclosed in the patent to Friis, No. 1,675,848, issued July 3, 1928; an automatic tuning circuit including the recorder 30, which is preferably a Leeds and Northrup recorder and regulator, well known in the art; the demodulator 31; and the control circuit including the demodulator 42.

It will be understood that whether the received carrier is of the reference frequency or of the shifted frequency, both of these having corresponding amplitudes, the intermediate-frequency energy impressed on the gain control circuit results in the adjustment of the grid biasing voltages of the tubes of the high-frequency amplifier 19 and the detector 20, as is well understood in the art, with the resultant substantially constant output of the amplifier and the detector 20.

It will be understood, of course, that the beat in the detector 20 of the output of the high-frequency beating oscillator 21 with the output of the high-frequency amplifier 19 produces an intermediate frequency which is finally impressed on the intermediate-frequency amplifier 30. The output of this amplifier is divided, one part being impressed on the demodulator 31 associated with the automatic tuning circuit and the other part on the demodulator 42 associated with the control circuit.

It will be understood that this output shifts in frequency with correspondence to the shift of frequency at the transmitting end of the system resulting from the operation of relay 8.

It is now proposed to discuss the operation of the control circuit. Along with the output of the intermediate-frequency amplifier 30, there is impressed on the demodulator 42 a constant intermediate-frequency wave from the beating oscillator 43. The result is alternate series of low frequency oscillations, one series being separated from the other as to frequency by the amount of the change or shift of frequency introduced at the transmitting end. The output of demodulator 42 is impressed on the amplifiers 44 and 44', which feed into filters 45 and 45', respectively. The filter 45' is designed to pass the unshifted frequency while the filter 45 is designed to pass the shifted frequency; that is, with

reference to the transmitting end of the system, filter 45' passes the frequency corresponding to the output of the oscillator 11 when relay 8 is unoperated during the silent periods, while filter 45 passes the frequency corresponding to the output of the oscillator 11 when the relay 8 operates in response to the application of signal energy to the system. Energy passed through filter 45 is impressed on rectifier 46, the output circuit of which includes the upper winding of the relay 47. Likewise, the energy passing filter 45' is impressed on the rectifier 46', the output of which operates the relay 48. For example, let it be assumed that the normal or unshifted intermediate signal frequency is f_0 cycles and that the shifted frequency is $f_0 + 150$ cycles. Let it be assumed further that the frequency of the intermediate-frequency beating oscillator 43 is $f_0 - 1000$ cycles. With such values, a 1000-cycle tone will appear at the output of demodulator 42 during the periods of the application of signal energy to the system and a 1150-cycle tone will appear during the silent periods. Accordingly, filter 45 will be designed to pass a range of frequencies from 950 cycles to 1050 cycles, for example, while filter 45' will be designed to pass frequencies in the range from 1100 to 1200 cycles. Thus, as the carrier (or other high) frequency shifts back and forth, these two tones appear alternately, and the winding of relay 48 and the upper winding of relay 47 will be energized alternately. It will be noted that when the upper winding of relay 47 is energized, ground through the two armatures above the electromagnet is connected to complete circuits through relays 49 and 33, and a locking circuit is completed from ground through the lower winding of relay 47, the armature of that relay below the electromagnet and the contact and armature of relay 48 (provided relay 48 has not operated). Thus, as the circuit is specifically disclosed, relay 47 will be operated when energy passes the filter 45 and, through the operation of the locking circuit, will remain energized even though the tone which will pass filter 45 fades out, providing relay 48 has not been operated by the other tone which will pass filter 45'. If energy does pass filter 45', the locking circuit for relay 47 is broken through the operation of relay 48, and relay 47 will release in the absence of the tone which passes filter 45. The net result is the positive action of relay 47 when such action is desired, and, consequently, the positive operation of relays 49 and 33. It will be noted that the receiving channel at the output of the audio-frequency amplifier 27 is normally disabled at the point 50. When relay 49 operates, this disability is removed and, accordingly, the receiving channel is cleared for the passage of the signal. The function of relay 33 will be considered hereinafter.

In accordance with the arrangement as described hereinabove, the operation of the control circuit is as follows:

During the silent periods—, that is, the periods when no signal energy is applied to the system—the unshifted output of the intermediate-frequency amplifier 30 beats with the output of oscillator 43 in the demodulator 42 and the resultant low frequency passes through filter 45' and causes the operation of relay 48. This relay operation breaks the locking circuit of relay 47, which latter relay is unoperated because no energy is passing filter 45. When the high frequency is shifted by the operation of relay 8 at

the transmitting end, the shifted intermediate-frequency output of amplifier 30 beats with the output of oscillator 43 in the demodulator 42 and the resultant low frequency passes through filter 45 and energizes the upper winding of relay 47. It will be understood that, by this time, energy has ceased to pass through filter 45' and that relay 48 is unoperated. Accordingly, relay 47 locks up through the circuit described hereinabove, including the armature and contact of relay 48. Relay 49 is operated upon the completion of the circuit through the uppermost armature of relay 47, the disability normally placed on the receiving channel at point 50 is removed and the channel is, accordingly, cleared for the passage of the signal to the receiver 28. As stated hereinabove, relay 33 is also operated at this time. If, now, there should be fading of the energy passing filter 45 before the arrival of the next series of oscillations of the unshifted or reference frequency, relay 47 remains operated because of the maintenance of the locking circuit and the receiving channel remains cleared at point 50. This locking circuit of relay 47 is broken only when the next series of oscillations of the unshifted or reference frequency arrives.

It remains to describe and discuss the operation of the automatic tuning circuit as associated with the applicant's control arrangement. As has been stated above, the intermediate frequency is produced by the beat in the detector 20 of the output of the high frequency beating oscillator 21 with the output of the high frequency amplifier 19. A part of the output of the intermediate frequency amplifier 30 is impressed on the demodulator 31 along with the output of the "shifted" intermediate frequency beating oscillator 32. When the carrier (or other high) frequency shifts, the frequency of the oscillator 32 is changed or shifted by the operation of relay 33, which, as stated hereinabove, follows the operation of relay 47. This change or shift of frequency in the oscillator 32 is equal to the change or shift of frequency in the output of the amplifier 30. The output of demodulator 31 passes through amplifiers 35 and 35' and is impressed on filters 36 and 36'. These two filters, as is indicated in the drawings, have loss characteristics sloping in opposite directions over the frequency range. A frequency drift in the one direction will increase the output of one filter and decrease the output of the other while a frequency drift in the other direction will have the opposite effect. Consequently, the opposed outputs of rectifiers 37 and 37', upon which the energy passing filters 36 and 36' is impressed, will result in a net potential across the resistance 38 in one direction or the other, in accordance with the frequency of the output of demodulator 31. This drop across resistance 38 actuates the recorder 39 and, as stated hereinabove, this element 39 may take the form of a Leeds and Northrup recorder and regulator, well known in the art. This element 39 is designed to operate through a shaft 40 to adjust a condenser 42 connected across the high frequency beating oscillator 21. The result is a compensation for any drift in the frequency of the output of demodulator 31. The result of the combination of this automatic tuning circuit with the control of oscillator 32 through the operation of relay 33 and the adjustment of the condenser 34, is the maintenance of the same relative tuning of the receiver with the carrier (or other high frequency wave) in the normal and in

the shifted positions. The frequency of the local "reference" oscillator 32 is shifted by the same amount as the received high frequency wave by the operation of the control switching circuit, and the selection introduced by the filters 36 and 36' results in the maintenance of the same relative tuning, as stated hereinabove.

It will be understood that in place of the arrangement discussed hereinabove, provision can be made for automatic tuning of the high frequency beating oscillator 21 only during the silent periods, when no signal energy is transmitted. For instance, if the condenser 34 is omitted from the circuit, the operation of relay 33, which takes place when the shifted control frequency arrives in response to the voice energy, will short-circuit the oscillator 32 and thereby stop the oscillations, with the result that no low frequency will appear at the output of demodulator 31 and the net voltage across 33 will be substantially zero so that the frequency control will cease. This will, of course, result in automatic tuning during the silent periods and the absence of automatic tuning during the signal intervals.

From the descriptions given hereinabove of the operations of the control circuit and the automatic tuning circuit, it will be understood that when the unshifted intermediate frequency beats with the output of oscillator 43 in the demodulator 42, the filter 45' passes the low frequency energy, relay 43 operates, relay 47 remains unoperated and, since relay 33 is, consequently, unoperated, the condenser 34 is not connected across the oscillator 32. Accordingly, the unshifted output of amplifier 30, which is impressed on the demodulator 31, beats with the unshifted frequency output of oscillator 32 and there is produced in the output of the demodulator the low frequency discussed hereinabove. When, on the other hand, the frequency change takes place, relays 47 and 33 operate and the condenser 34 is connected across the oscillator 32. The result is the change or shift of frequency of oscillations in the oscillator 32 corresponding to the shift in frequency of the incoming energy. Therefore, the frequency at the output of the demodulator 31, in view of this compensation, remains constant and the automatic tuning to take care of the drift in the high frequency oscillators 11 at the transmitter and 21 at the receiver is unaffected by the frequency shift used for the control purposes. It is of course necessary that the response of the tuning device 39 be slow compared to that of the relay 33; otherwise some compensation for the frequency shift will be effected by 39 before the frequency of oscillator 32 is shifted.

While the description and discussion, especially of the transmitting circuit, contained hereinabove, contemplate the use of a shift or change in the frequency of the carrier itself for control purposes, it is to be understood that the only essential of the control system in this respect is that there be transmitted from the transmitting station to the receiving station alternate series of high frequency oscillations distinguished only by the frequency difference. Instead of the transmission heretofore contemplated in which the carrier is transmitted with the normal double side band, any one of the following methods may be employed:

There may be single side band transmission with the carrier partially suppressed and shifted in the manner already described. Control effected by this shifted carrier would be accomplished in

the way already described in connection with the normal carrier and two side band cases. Since with short wave transmission, for instance, it is necessary to use a pilot channel of some sort, the partially suppressed carrier in the case under consideration is used to control the frequency of a local "carrier" oscillator (in the manner described in connection with 32 of Fig. 1) at the receiving station and also for the automatic gain control. For the purpose of utilizing the suppressed carrier to best advantage, a special narrow band filter of sufficient width to pass the reference and shifted oscillation frequencies may be employed.

The normal use of the single side band and the partially suppressed carrier does not provide the privacy available in single side band alone. A method which gives the desired privacy is one in which the signal frequencies are inverted at the transmitting end and reinverted at the receiving end. This arrangement is indicated schematically in Fig. 2 of the drawings in which the signal energy from the transmitter 1 passes through the frequency inverter 51 and the amplifier 2 at point A and on to the point B, where radiation takes place. At the receiving end, where the waves are picked up by the antenna 18, the audio-frequency amplifier 27 is followed in the transmission circuit by the frequency inverter 52, which restores the normal signal. It will be understood, of course, that relay 49, operated as described hereinabove in connection with Fig. 1, controls the receiving channel at point 50, for instance, between the frequency inverter 52 and the receiver 28.

Another method which may be employed consistently with the use of applicant's control methods is that in which a tone is modulated on the single side band. The modification of the transmitting circuit, as compared with Fig. 1, is shown diagrammatically and, in part, schematically in Fig. 3. As is the case with Fig. 1, in this modified arrangement of Fig. 3 the low frequency signal is impressed on the amplifier 14 and a tone oscillator controlled by a switch such as the relay 5 of Fig. 1 impresses a tone on the rectifier 7. An audio-frequency oscillator 54 is associated with the transmission path on the output side of amplifier 14 and the frequency of the output of oscillator 54 is shifted or changed when a condenser 53 is connected across the oscillator circuit or disconnected by the operation of relay 9, which relay is controlled by the output of rectifier 7. Thus the energy impressed on the input of the modulator 15' from the transmission path, after signal energy is impressed on the system, represents the voice and the shifted tone from the oscillator 54. The demodulator 15' is a single side band balanced modulator upon which the output of the crystal oscillator 10, 11 is impressed through the high frequency amplifier 12 and the filter 13. Accordingly, the output of the modulator 15' will be the single side band plus a high frequency pilot wave of constant amplitude.

While the disclosure made hereinabove with reference to Fig. 1 of the drawings takes into account specifically only one-way transmission, for the purpose of simplification, it is to be understood that the applicant's control methods and means are applicable to two-way transmission and would usually be applied to systems providing such transmission. In the arrangement of Fig. 4, which may be read with reference to Fig. 1, there are shown parts of one end of a four-wire circuit (the end corresponding to the "receiving" station of Fig. 1) forming a section of a two-way

signaling system. It will be noted that the right end of this four-wire circuit is connected to a two-wire line LL by the use of the usual hybrid coil and the usual network which tends to balance the line LL. Transmission from left to right is over the "receiving" path L, L₁ to the hybrid coil and on over the line LL, while transmission from right to left is from the line LL through the hybrid coil and on over the "transmitting" path L₁', L'. Suitable one-way amplifiers are indicated. The operation of relay 47 in response to the shift in frequency of the high-frequency wave transmitted from the remote station at the left end of the two-way system, controls the circuit of a tone oscillator 55 at the point C. The output of this oscillator is transmitted over an auxiliary channel to the point D, where it is impressed on a rectifier 56. The output circuit of rectifier 56 includes the winding of a relay 57. It will be noted that the receiving section L₁ of the four-wire circuit is normally disabled at point 58, as by a shunt completed through the closed contact and upper armature of relay 57, and that the transmitting section L₁' of the four-wire circuit is normally cleared. When the relay 57 operates in response to the application of the remote control, the receiving section L₁ is cleared at point 58 by the removal of the shunt, and the transmitting section L₁' is disabled at point 59 by the completion of a shunt through the lower armature and contact of relay 57. Thus, in indirect response to the application of signal energy to the system at the remote station at the left end, the receiving channel at the right end of the system is rendered operative for the transmission of that energy and the oppositely directed transmitting channel at the right end is disabled. As is well understood in the art, this type of control serves to prevent echoes due to unavoidable unbalance between the impedances of the line LL and the "balancing" network.

It is to be understood that the direct control of the receiving channel or of the transmitting channel or of both channels at the end of the system which is distant from the point of the original shift of frequency may be effected in ways different from the simple relay operation specifically disclosed hereinabove; the prior art discloses numerous methods of such direct control.

It should be noted in connection with the application of the applicant's control methods and means to two-way transmission that the carrier (or other high) frequency can be shifted in one sense to provide the control channel in one direction and in the opposite sense to provide the control channel in the opposite direction. Such an arrangement serves to prevent "cross-talk".

While the applicant's invention has been disclosed in one specific embodiment with certain modifications thereof, it is to be understood that the invention is capable of embodiment in many and widely different forms within the scope of the appended claims.

What is claimed is:

1. In a high-frequency transmission system, the method of control which consists in producing at one end of the system a first series of oscillations of a reference frequency, shifting the reference frequency by a constant amount to produce a second series of oscillations differing from the first series only by the degree of the frequency shift, reproducing at the opposite end of the system alternately said two series of oscillations involving the frequency shift, and utiliz-

ing said frequency shift to control at said opposite end a transmission channel connecting the ends of the system.

2. In a high-frequency transmission system, the method of control which consists in transmitting from one end of the system to the opposite end thereof alternately two series of high-frequency oscillations differing from each other only by a frequency shift of constant amount and utilizing the frequency shift to control at said opposite end a transmission channel connecting the ends of the system.

3. In a high-frequency transmission system, the method of control which consists in producing at one end of the system two series of high-frequency oscillations differing from each other only by a frequency shift of constant amount, transmitting said series of oscillations alternately to the opposite end of the system, and utilizing the frequency shift to control at said opposite end a transmission channel connecting the ends of the system.

4. In a high-frequency transmission system, the method of control which consists in producing at one end of the system sustained high-frequency oscillations, shifting the frequency of said oscillations by a constant amount, reproducing at the opposite end of the system the oscillations so produced and shifted in frequency at the first end, and utilizing the frequency shift to control at said opposite end a transmission channel connecting the ends of the system.

5. In a signaling system, the method of control which consists in producing at one end of the system sustained oscillations of a reference high frequency, shifting the frequency of said oscillations by a constant amount when signal energy is applied to the system, transmitting to the opposite end of the system alternately the series of oscillations of the shifted frequency, and utilizing the frequency shift to control at said opposite end a signal transmission channel connecting the ends of the system.

6. In a signaling system designed to transmit a group of frequencies having a component varying in amplitude in accordance with signal energy applied to the system, the method of control which consists in producing at the transmitting end of the system a series of oscillations of a reference high frequency and fixed amplitude, transmitting said high frequency oscillations to the receiving end while no signal energy is applied to the system, shifting the frequency of said oscillations by a constant amount when signal energy is applied to the system, transmitting the series of oscillations of the shifted frequency during the periods of application of the signal energy, and utilizing the alternately transmitted series of high-frequency oscillations, one of the reference frequency and the other of the shifted frequency, as a channel for controlling the transmission of the group of frequencies involving the amplitude variation.

7. In a signaling system designed to transmit a group of frequencies having a component varying in amplitude in accordance with signal energy applied to the system, the method of control which consists in producing at the transmitting end of the system a series of oscillations of a reference high frequency and fixed amplitude, transmitting said high frequency oscillations to the receiving end while no signal energy is applied to the system, shifting the frequency of said oscillations by a constant amount when signal energy is applied to the system, transmitting the se-

ries of oscillations of the shifted frequency during the periods of application of the signal energy, and utilizing each of the alternately transmitted series of oscillations, one of the reference frequency and the other of the shifted frequency, as a channel for controlling the transmission of the group of frequencies involving the amplitude variation.

8. In a signaling system designed to transmit a group of frequencies having a component varying in amplitude in accordance with signal energy applied to the system, the method of control which consists in producing at the transmitting end of the system a series of oscillations of a reference high frequency and fixed amplitude, transmitting said high frequency oscillations to the receiving end while no signal energy is applied to the system, shifting the frequency of said oscillations by a constant amount when signal energy is applied to the system, transmitting the series of oscillations of the shifted frequency during the periods of application of the signal energy, and utilizing one of said two alternately transmitted series of high-frequency oscillations, one of the reference frequency and the other of the shifted frequency, as a channel for controlling the transmission of the group of frequencies involving the amplitude variation.

9. In a signaling system, the method of transmission which consists in producing at one end of the system and transmitting therefrom to the opposite end sustained oscillations of a reference high frequency, shifting the frequency of the oscillations so produced and transmitted when signal energy is applied to the system, utilizing the oscillations at the shifted frequency as the carrier of the applied signal energy, and utilizing the shift of frequency to control at said opposite end a transmission channel connecting the ends of the system.

10. In a telephone system, the method of transmission which consists in producing alternately at one end of the system a series of oscillations of a reference high frequency and a series of oscillations of a frequency representing a shift from the reference frequency, transmitting said series of oscillations alternately to the other end of the system and utilizing the series of oscillations of the shifted frequency as the carrier of the voice-frequency signal energy and as a control signal channel.

11. In a telephone system, the method of transmission which consists in producing alternately at one end of the system a series of oscillations of a reference high frequency and a series of oscillations of a frequency representing a shift of constant amount from the reference frequency, transmitting said series of oscillations alternately to the other end of the system, utilizing one of said series of oscillations as the carrier of the voice-frequency signal energy, and utilizing said two series of oscillations as a control channel.

12. In a telephone system, the method of transmission which consists in producing alternately at one end of the system a series of oscillations of a reference high frequency and a series of oscillations of a frequency representing a shift of constant amount from the reference frequency, transmitting said series of oscillations alternately to the other end of the system, utilizing one of said series of oscillations as the carrier of the voice-frequency signal energy, and utilizing each of said series of oscillations as a control channel.

13. In a telephone system, the method of transmission which consists in producing alternately

at one end of the system a series of oscillations of a reference high frequency and a series of oscillations of a frequency representing a shift of constant amount from the reference frequency, transmitting said series of oscillations alternately to the other end of the system, utilizing one of said series of oscillations as the carrier of the voice-frequency signal energy, and utilizing one of said series of oscillations as a control channel.

14. In a transmission system designed to transmit intelligence-bearing energy, the method of transmission which consists in producing alternately at one end of the system a series of oscillations of a reference high frequency and a series of oscillations of a frequency representing a shift from the reference frequency, transmitting said series of oscillations alternately to the other end of the system and utilizing the series of oscillations of the shifted frequency as the carrier of the intelligence-bearing energy and as a control signal channel.

15. In a transmission system designed to transmit intelligence-bearing energy, the method of transmission which consists in producing alternately at one end of the system a series of oscillations of a reference high frequency and a series of oscillations of a frequency representing a shift of constant amount from the reference frequency, transmitting said series of oscillations to the other end of the system, utilizing one of said series of oscillations as the carrier of the intelligence-bearing energy, and utilizing said two series of oscillations as a control channel.

16. In a transmission system designed to transmit intelligence-bearing energy, the method of transmission which consists in producing alternately at one end of the system a series of oscillations of a reference high frequency and a series of oscillations of a frequency representing a shift of constant amount from the reference frequency, transmitting said series of oscillations to the other end of the system, utilizing one of said series of oscillations as the carrier of the intelligence-bearing energy, and utilizing each of said series of oscillations as a control channel.

17. In a transmission system designed to transmit intelligence-bearing energy, the method of transmission which consists in producing alternately at one end of the system a series of oscillations of a reference high frequency and a series of oscillations of a frequency representing a shift of constant amount from the reference frequency, transmitting said series of oscillations to the other end of the system, utilizing one of said series of oscillations as the carrier of the intelligence-bearing energy, and utilizing one of said series of oscillations as a control channel.

18. In a transmission system designed to transmit intelligence-bearing energy, the method of transmission which consists in producing alternately at one end of the system a series of oscillations of a reference high frequency and a series of oscillations of a frequency representing a shift from the reference frequency, the two series of oscillations being without distinction as to amplitude, transmitting said series of oscillations alternately to the other end of the system, and utilizing the series of oscillations of the shifted frequency as the carrier of the intelligence-bearing energy and as a control signal channel.

19. In a two-way high-frequency transmission system, the method of control which consists in producing at one end of the system sustained high-frequency oscillations, shifting the frequency

of said oscillations by a constant amount, reproducing at the opposite end of the system the oscillations so produced and shifted in frequency at the first end, and utilizing the frequency shift to control at said opposite end a transmission channel connecting the ends of the system.

20. In a two-way high-frequency transmission system, the method of control which consists in producing at one end of the system sustained high-frequency oscillations, shifting the frequency of said oscillations by a constant amount, reproducing at the opposite end of the system the oscillations so produced and shifted in frequency at the first end, and utilizing the frequency shift to control at said opposite end the transmission channels connecting the ends of the system.

21. In a two-way high-frequency transmission system including paths adapted for transmission in opposite directions, the method of control which consists in producing at one end of the system sustained high-frequency oscillations, shifting the frequency of said oscillations, reproducing at the opposite end of the system the oscillations so produced and shifted in frequency at the first end, and utilizing the frequency shift to control at said opposite end the oppositely directed transmission paths connecting the ends of the system.

22. In a high-frequency transmission system, the method of control which consists in producing at one end of the system a first series of oscillations of a reference frequency, shifting the reference frequency by a constant amount to produce a second series of oscillations differing from the first only by the degree of the frequency shift, reproducing at the opposite end of the system alternately said two series of oscillations involving the frequency shift, utilizing said frequency shift to control at said opposite end a transmission channel connecting the ends of the system, and utilizing both of said series of oscillations to produce a constant control of the transmission gain at said opposite end.

23. In a high-frequency signaling system including a transmitting station, a receiving station and means at the receiving station for automatically tuning the receiving circuit, the method of control which consists in producing at the transmitting station a first series of oscillations of a reference frequency, shifting the reference frequency by a constant amount to produce a second series of oscillations differing from the first only by the degree of the frequency shift, reproducing at the receiving station alternately said two series of oscillations involving the frequency shift, utilizing said frequency shift to control at said receiving station a transmission channel connecting the two stations, and maintaining uninterrupted the automatic tuning of the receiving circuit.

24. In a high-frequency transmission system, a transmitting station and a receiving station, means for producing at the transmitting station and for transmitting therefrom to the receiving station alternately two series of high-frequency oscillations differing from each other by a fixed frequency shift, and means at the receiving station responsive to said frequency shift for controlling at said station a transmission channel connecting the ends of the system.

25. In a high frequency transmission system, a sending station and a receiving station, means at the sending station for producing sustained oscillations of a reference high frequency, means adapted to shift the frequency of said oscillations

by a constant amount when there is applied to the system the energy to be transmitted for the production of the desired over-all effect, means for transmitting the series of high frequency oscillations from the sending station to the receiving station, and means at the receiving station for controlling thereat a transmission channel connecting the ends of the system in accordance with the shift of the high-frequency oscillations between the "reference" and the "shifted" frequencies.

26. In a high-frequency transmission system, a transmitting station and a receiving station, means for producing at the transmitting station and for transmitting therefrom to the receiving station alternately two series of high-frequency oscillations differing from each other by a frequency shift of constant amount, means at the receiving station responsive to said frequency shift for effecting a control at said station over a transmission channel connecting the ends of the system, and means responsive to the oscillations of either frequency for controlling the gain in the receiving channel at said station.

27. In a high-frequency transmission system, a transmitting station and a receiving station, means for producing at the transmitting station and for transmitting therefrom to the receiving station alternately two series of high-frequency oscillations differing from each other by a frequency shift, means at the receiving station responsive to said frequency shift for effecting a control at said station over a transmission channel connecting the ends of the system, means at the receiving station for automatically tuning the receiving circuit, and means responsive to said frequency shift for maintaining the operation of said tuning means.

28. In a two-way high-frequency transmission system, two paths adapted for transmission in opposite directions, means for producing at one end of said system and for transmitting therefrom to the opposite end of the system alternately two series of high frequency oscillations differing from each other by a frequency shift, and means at said opposite end responsive to said frequency shift for controlling at said end the two oppositely directed transmission channels connecting the ends of the system.

29. In a two-way transmission system designed to transmit intelligence-bearing energy, two stations, two paths interconnecting said stations and adapted for transmission in opposite directions, means at one of said stations for producing sustained oscillations of a reference high frequency, means adapted to shift the frequency of said oscillations when the intelligence-bearing energy is applied to the system at said station, means for transmitting the series of high-frequency oscillations from said station to the other station at the opposite end of the system, and means at said last-named station for controlling thereat, in accordance with the shift of the high frequency oscillations between the "reference" and the "shifted" frequencies the two oppositely directed channels for transmitting the intelligence-bearing energy from one station to the other.

30. In a transmission system designed to transmit intelligence-bearing energy, a transmitting station and a receiving station, an oscillator at said transmitting station adapted to produce oscillations of a reference high frequency, means adapted to shift the frequency of said oscillator by a constant amount in response to the applica-

tion to the system of the intelligence-bearing energy, means for modulating the shifted high-frequency oscillations with the signal, means for transmitting over the system alternately the oscillations of the reference frequency and a product of the modulation between the oscillations of the shifted frequency and the signal, means at said receiving station for directly affecting

thereat the path for transmitting the intelligence-bearing energy between the two stations, and means for controlling the operation of said transmission affecting means in accordance with the shift between the reference and the shifted high frequencies. 5

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