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J. G. CHAFFEE

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RADIO SIGNALING

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FIG. 1

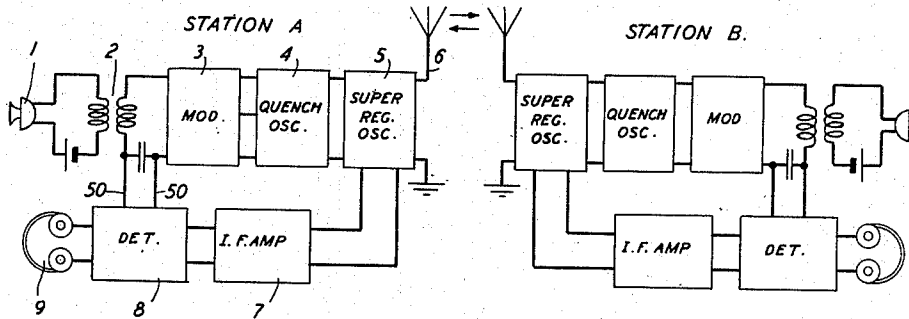
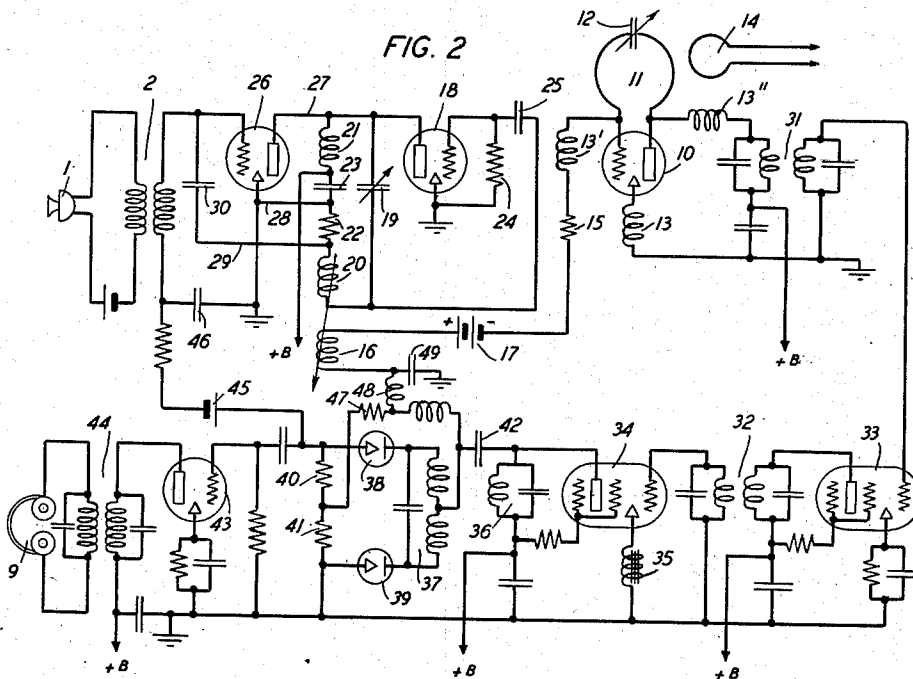


FIG. 2



INVENTOR
J. G. CHAFFEE
BY *G. H. Stevenson*
ATTORNEY

UNITED STATES PATENT OFFICE

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RADIO SIGNALING

Joseph G. Chaffee, Hackensack, N. J., assignor to
Bell Telephone Laboratories, Incorporated, New
York, N. Y., a corporation of New York

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5 Claims. (Cl. 250—6)

This invention relates to radio signaling systems and more particularly to two-way radio telephone systems for short range communication at ultra high frequencies.

The general objects of the invention are the simplification of the circuits and controls in two-way signaling systems and the reduction of the size and weight of the equipment necessary for reliable communication over short distances. Another object is the improvement of the noise characteristics in radio telephone systems using super-regenerative receivers.

In accordance with the invention, a super-regenerative oscillator directly coupled to the antenna at each terminal of a two-way system is used both for transmission and for reception of the high frequency carrier wave. This oscillator is arranged to generate waves of an ultra high frequency, which may, for example, be of the order of several hundred megacycles per second, and is alternately quenched and activated at a rate of several million cycles per second. The oscillators at the two terminals operate at approximately equal high frequencies, but with quenching rates which differ by a substantial amount, for example, 400 kilocycles per second.

Signaling is effected by modulating the frequency of quenching in accordance with speech, the radiated wave partaking of the character of a carrier wave modulated in amplitude by a frequency modulated subcarrier. At the receiving terminal the received wave, modulated in the above manner, is impressed on the super-regenerative oscillator, thereby giving rise in the well-known manner to a current corresponding to the amplitude variations of its envelope, that is, to the quenching frequency at the sending end. I have found that there is also produced a current corresponding to the difference in the quenching oscillation frequencies which, since the quenching oscillation at the sending end is frequency modulated by the speech signal, is likewise frequency modulated. In the systems of the invention, the signal is detected from this difference frequency current by any of the well-known frequency modulation detectors. By subjecting the current to amplitude limiting a substantial reduction of the noise commonly present in super-regenerative receivers is effected.

Antenna switching is eliminated by the use of the super-regenerative oscillator for both sending and receiving and at the same time the size and weight of the equipment is reduced. The power output and the receiving sensitivity of a super-regenerative oscillator using a receiver type tube is such that reliable communication over moderate distances may be maintained.

The use of ultra high frequency waves in the systems of the invention has the advantage that high frequency quenching rates, such as several

million cycles per second, can be employed without adverse effect upon the sensitivity of the super-regenerative receiver. This permits the quenching rates at the system terminals to differ by high super-audible frequencies and thereby simplifies the construction of the receiver circuits which carry the difference frequency currents. Similar circuits may be used in the receivers at both terminals, or in all receivers if additional stations are included. The high super-audible value of the difference frequency makes it easy to provide circuits of sufficiently broad selectivity to accommodate the full swing of the frequency modulation.

Other features of the invention will appear from the following detailed description and by reference to the accompanying drawing wherein:

Fig. 1 is a block schematic of a complete system according to the invention, and

Fig. 2 shows the circuit arrangement of the apparatus constituting one terminal station.

Referring to Fig. 1, which shows both terminals of a communication system, station A at the left-hand side of the figure comprises a transmission channel including microphone 1, audio transformer 2, frequency modulator 3, which may be of the well-known reactance tube type, quenching oscillator 4, super-regenerative oscillator 5, and antenna 6, all coupled in tandem. The receiving channel comprises an intermediate frequency selective amplifier 7, including amplitude limiting means, frequency modulation detector 8, and telephone receivers 9. The super-regenerative oscillator is preferably designed to generate waves of ultra high frequency, for example, of the order of 500 megacycles per second. The quenching oscillator may have a frequency of about four million cycles per second and its coupling to the super-regenerative oscillator may with advantage be arranged so that the latter is activated during only a relatively small part of the quenching cycle. In the receiving path amplifier 7 is selective to a fairly broad band, preferably 30 kilocycles or greater, in extent at a mean frequency of about 400 kilocycles, which, as already pointed out, corresponds to the difference of the quenching frequencies at the two terminal stations. Station B is identical with station A except that the quenching oscillator operates at a different frequency. The two super-regenerative oscillations operate at substantially equal frequencies, but synchronism is not necessary beyond the degree determined by the band widths of the antenna circuits.

In the operation of the system, speech currents from microphone 1 are impressed upon frequency modulating device 4, thereby causing the frequency of the quenching oscillator to vary in accordance with speech. For telephonic com-

munication a signal band of about 3,000 cycles per second is generally adequate; consequently a swing of the quenching frequency of about 15 kilocycles amplitude permits substantial noise reduction in the received signal. Assuming a normal quenching frequency of about 4 megacycles, this amplitude of swing is easily obtained by means of a reactance tube modulator coupled to the frequency determining circuit of the oscillator.

The waves generated by the super-regenerative oscillator under control of the modulated quenching oscillator take the form of a series of substantially uniform spurts of ultra high frequency oscillations occurring at the quenching rate and, therefore, modulated in frequency. They partake of the character of an ultra high frequency carrier wave modulated in amplitude by a frequency modulated subcarrier. If the oscillator and the antenna circuits have fairly broad response characteristics, the wave spurts will generally tend to be discrete, giving the radiated wave the character of a train of pulses modulated in their timing. Narrowing the selective characteristic of the antenna will tend to lengthen the duration of the pulses and to give the radiated wave a more nearly continuous amplitude variation. Either type of radiation may be used in the systems of the invention.

When waves from station B, modulated in the above manner, are received upon antenna 6, they are impressed upon the super-regenerative oscillator, and provided the local quenching oscillator is active, give rise to a current in the oscillator circuit corresponding to the amplitude modulations of the received wave, that is, to the quenching oscillator frequency at the second station. This is the ordinary well-known action of a super-regenerative receiver. There is also produced a second current having a frequency equal to the difference between the frequency of the received amplitude modulations and the frequency of the local quenching oscillator, that is, to the difference between the quenching frequencies of the two super-regenerative oscillators. This latter current is utilized in the systems of the invention and is selected by the receiving amplifier 7 which is tuned to the appropriate frequency. Thus, if the quenching frequency at station A is 4 megacycles and that at station B is 3.6 megacycles, the receiving amplifiers at both stations would be tuned to the difference frequency of 400 kilocycles per second. The difference frequency wave, after amplification and amplitude limiting in amplifier 7, is passed to frequency modulation detector 8 in which the signal is detected.

It is desirable that the mean frequency of the difference frequency wave should be maintained at a constant value in order that the wave may be kept within the passband of the receiving amplifier. This is accomplished in the system illustrated by an automatic control of the local quenching oscillator frequency whereby it is caused to vary in such a way as to counteract any tendency of the difference frequency to depart from the assigned mean value. For this purpose, the detector 8 may be of the balanced type in which the output voltage is zero when the frequency of the input has the desired mean value. Slow variations of the detector output voltage corresponding to drifts of the difference frequency are selected and are impressed upon modulator 3 through conductors 50, 50' in such

a way as to produce a compensating change of the quenching frequency.

It will thus be seen that two-way conversations may be carried on between the two stations on a common wave-length without the need of antenna switching, and without requiring any great accuracy of tuning of the ultra high frequency parts of the system. The system also has the advantage that side-tone is provided in the telephone receiver at each station when the quenching oscillator at the other station is in operation. This will be evident since the difference frequency current from which the signal is detected will follow the frequency modulations of both of the quenching oscillators.

Typical circuit arrangements for a complete terminal station such as is shown in Fig. 1 are illustrated schematically in Fig. 2. The super-regenerative oscillator comprises a triode vacuum tube 10 between the grid and plate terminals of which is connected an oscillatory loop circuit tuned by variable condenser 12. The circuit is of the type shown in Fig. 3 of my earlier Patent 2,141,376, issued December 27, 1938, and is suitable for the generation of oscillations of frequencies as high as 500 megacycles per second or more. Inductances 13, 13' and 13'' in the cathode, grid and plate leads are ultra high frequency chokes which prevent the loss of high frequency energy to the lower frequency portions of the circuit. A loop 14 coupled to the oscillatory circuit supplies the high frequency oscillations to an antenna or other radiator, not shown. The cathode heating circuits of the oscillator tube and also of the other tubes are omitted for the sake of simplicity. Quenching oscillations are impressed on the grid of tube 10 through grid resistor 15 from coil 16 which is adjustably coupled to the quenching oscillator circuit. A fixed normal bias voltage is applied to the oscillator grid from source 17, the magnitude of which determines the duration of the active period of the oscillator in each quenching cycle.

The quenching oscillator is of the well-known Hartley type. It comprises triode vacuum tube 18 and an oscillatory circuit constituted by variable condenser 19, inductances 20 and 21, resistor 22, and blocking condenser 23. 24 is a grid leak resistor and 25 is a blocking condenser in the grid lead to the oscillatory circuit. Adjustment of the quenching oscillator frequency to its desired normal or mean value is controlled by variable condenser 19.

Modulation of the quenching oscillator frequency in accordance with speech signals is effected by reactance tube 26, the grid circuit of which is coupled to microphone 1 through audio transformer 2. Voltages of the quenching frequency in quadrature relationship with each other are impressed on the plate-cathode and the grid-cathode circuits of the modulation tube through leads 27, 28 and 29, connected to the terminals of inductance 21 and resistor 22 in the quenching oscillator circuit. 30 is a high frequency by-pass condenser of low capacity which prevents the diversion of signal energy from the speech input path. The operation of the reactive tube as a frequency modulating device is now well known and understood and need not be described here. It may be noted, however, that its range of control is such as to enable the impressed speech voltages to produce a frequency deviation of the controlled oscillator of at least

15,000 cycles per second from a mean frequency of about 4 megacycles.

In the receiving channel, which is connected to the plate circuit of the super-regenerative oscillator, the intermediate frequency amplifier comprises coupling filters 31 and 32 and amplifier tubes 33 and 34. This amplifier, as already noted, selects currents of frequencies of the order of four or five hundred kilocycles per second corresponding to the difference of the two quenching frequencies. The filters should have pass-bands at least as wide as 30 kilocycles to accommodate the full range of the frequency modulation. Tube 34 acts not only as an amplifier but also to suppress amplitude variations of the oscillations and noise resulting therefrom in the signal output circuit. For this purpose a choke coil 35 or other suitable means having a high impedance at frequencies in the signal range is connected in the cathode lead as described in United States Patent 2,218,526, issued October 22, 1940, to O. E. DeLange. If desired, a similar connection may also be used for tube 33 to increase the suppression of amplitude variations.

The frequency modulation detector is of the type well known as a phase discriminator. It comprises a pair of coupled tuned circuits 36 and 37, both tuned to the mean frequency of the impressed waves, and two balanced rectifiers 38 and 39 differentially connected to equal output resistors 40 and 41. The output voltage of the tuned circuits is impressed upon the rectifiers in series and the input voltage is impressed upon the rectifiers in parallel through coupling condenser 42. The operation of the detector is such that the resultant voltage across output resistors 40 and 41 is zero when the frequency of the detected wave has its assigned or normal value and varies in magnitude and sign according to the extent and sense of the departure of the frequency from the normal value.

The detected signal is impressed on signal amplifier 43 and from thence passes to telephone receiver 9 through filter 44. This filter should pass only the desired signal frequencies, for example from 200 to 3000 cycles per second, and should suppress all higher frequencies.

The detector in addition to detecting the signal currents, provides two control voltages which are applied to the regulation of the transmitter circuits. The first of these is a frequency-regulating voltage which is obtained from the normal output of the detector and is applied to the grid of modulator tube 26 through lead 45 and resistance capacity filter 46. The time constant of the latter is such that only very slow variations of the detector output voltage can pass. The variations of the control voltage, which represent changes in the mean frequency of difference frequency waves in the receiving channel, act upon the modulator tube in such a sense as to produce compensating frequency changes in the local quenching oscillator, thereby keeping the difference frequency substantially constant. The proper polarity of the control voltage to produce a compensating action may, if necessary, be secured by changing the sign of the inductive coupling between tuned circuits 36 and 37.

The second control voltage is obtained from the summation of the rectifier outputs through a connection to the junction point of resistors 40 and 41. This voltage is applied to the grid of the super-regenerative oscillator through resistor 47, choke coil 48 and coupling inductance 16. Its

magnitude is proportional to the amplitude of the oscillations in the receiving channel and its action on the super-regenerative oscillator is such as to produce a compensating amplitude variation. Resistance 47, choke 48 and condenser 49 constitute a filter circuit which may be adjusted to pass only slow variations of the voltage, thereby providing an automatic volume control.

What is claimed is:

1. A two-way radio telephone system comprising at each terminal a super-regenerative oscillator circuit an antenna coupled to said circuit, means for periodically quenching the oscillations in said circuit at a high frequency rate, the quenching frequencies at the two terminals differing from each other by a super-audible frequency, means for modulating the quenching frequency in accordance with speech signals to be transmitted, a selective circuit coupled to said oscillation circuit responsive to oscillations of frequency equal to the difference of the quenching frequencies at the two terminals, a signal detector responsive to frequency variations of oscillations impressed thereover, and means for impressing on said detector oscillations selected by said selective circuit.

2. A system in accordance with claim 1 in which there is included in at least one of the terminals means responsive to slow derivations of the frequency of the oscillations in said selective circuit from an assigned value for producing a compensating change in the quenching frequency.

3. A system in accordance with claim 1 in which there is included in at least one of the terminals means for deriving from the signal detector a control voltage corresponding in sense and in magnitude to slow variations of the frequency of the oscillations in said selective circuit from an assigned value, and means for impressing the control voltage on said modulating means in such polarity as to produce a compensating change in the quenching frequency.

4. A system in accordance with claim 1 in which there is included in at least one terminal means for deriving from the signal detector a control voltage proportional to the amplitude of the oscillations in said selective circuit, and means for impressing slow variations of the control voltage upon said super-regenerative oscillation circuit to produce a compensating change in the average amplitude of the generated oscillations.

5. In a two-way radio telephone system comprising at each terminal an ultra high frequency super-regenerative oscillation circuit, an antenna coupled to said circuit, and quenching oscillation generators coupled to said circuits operating at different high frequency rates at the two terminals, the method of communication which comprises modulating the frequency of the quenching oscillations at one terminal in accordance with speech signals, radiating the quenched ultra high frequency oscillations, receiving the radiated oscillations at the second terminal, deriving from the super-regenerative circuit at the second terminal oscillations of the difference frequency of the quenching oscillations at the two terminals, and detecting the signal from the frequency variations of the difference frequency oscillations.

JOSEPH G. CHAFFEE.