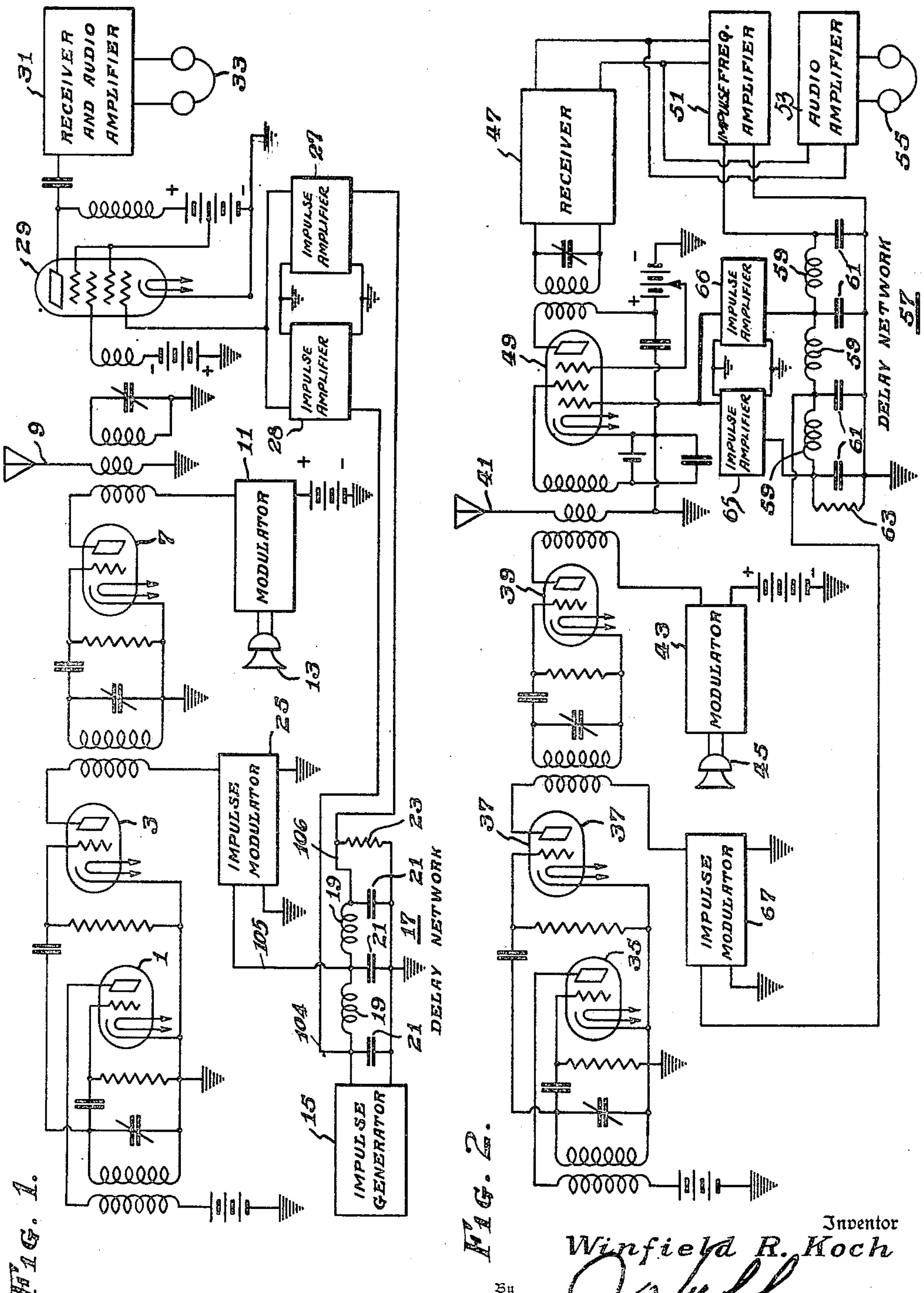
SINGLE CHANNEL TWO-WAY COMMUNICATION SYSTEM

Filed Nov. 27, 1936 3 Sheets-Sheet 1



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SINGLE CHANNEL TWO-WAY COMMUNICATION SYSTEM

Filed Nov. 27, 1936 3 Sheets-Sheet 2

FIG. 3.

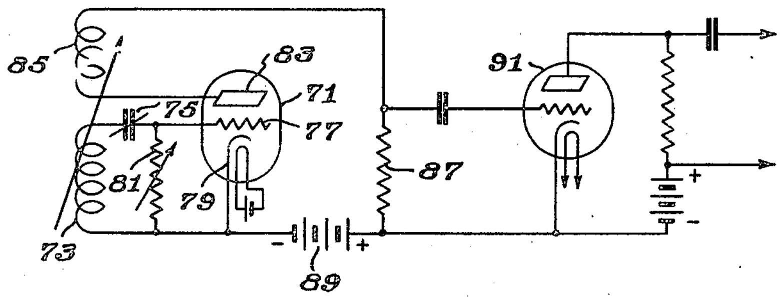
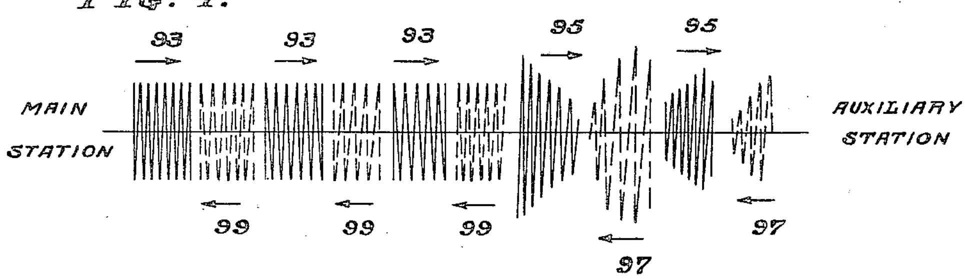


FIG. 4.



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Filed Nov. 27, 1936 3 Sheets-Sheet 3

FIG. 5.

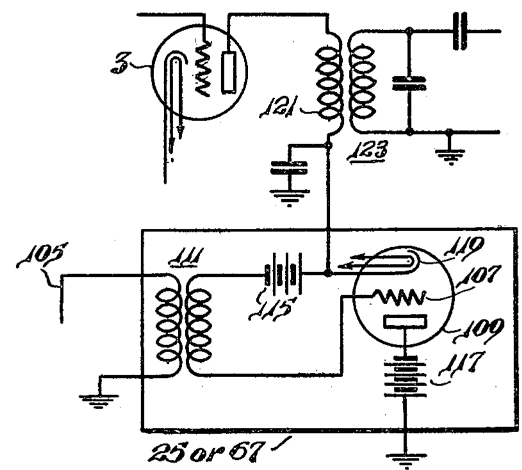
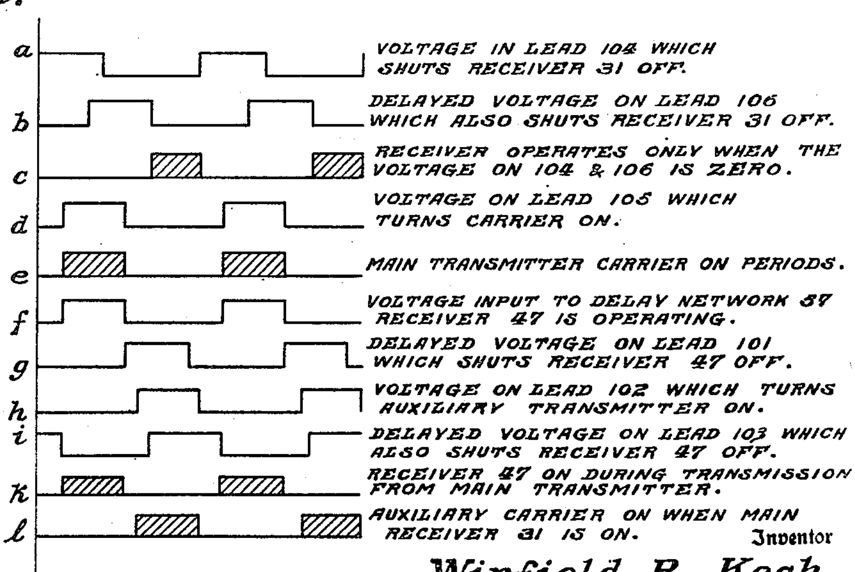


FIG. 6.



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UNITED STATES PATENT OFFICE

2,199,179

SINGLE CHANNEL TWO-WAY COMMUNICATION SYSTEM

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8 Claims. (Cl. 250—9)

My invention relates to a single channel two-way communication system and more specifically to a two-way ultra high frequency radio telephone system.

I am aware that two-way communication systems have been used with a pair of signal channels. The transmitters are arranged to operate at substantially different frequencies, whereby interference effects are avoided. Such systems have the objectionable feature of requiring a pair of communication channels which must be taken from a limited number of channels.

Communication systems have been used in which a single channel is employed but the receiving station cuts off its carrier during periods of reception and restores the carrier during periods of transmission. I propose to establish two-way communication on a single channel without establishing undesired feedback effects, and by alternately and automatically establishing the carrier for discrete periods from station to station.

One of the objects of my invention is to provide a method and means for establishing two-way communication over a single channel.

Another object is to provide a method and means for alternately and automatically establishing for discrete periods a carrier wave between stations in a communication system.

Another object is to provide means for automatically suppressing reception at the transmitting station during periods of transmission, whereby feedback effects are avoided.

A further object is to provide a single source for automatically controlling discrete periods of carrier transmission from two or more stations in a communication system.

My invention may be best understood by referring to the accompanying drawings in which Fig. 1 is a schematic circuit diagram of one station for a communication system,

Fig. 2 is a schematic circuit diagram of a station which is associated with the station illustrated in Fig. 1 to form one embodiment of my invention,

Fig. 3 is a circuit diagram of an impulse generator,

Fig. 4 is a schematic illustration of the operation of the discrete carrier wave impulse employed in the communication system of my invention,

Fig. 5 is a circuit diagram of an impulse modulator, and

Fig. 6 is a schematic illustration of the sequence of events and the various timing impulses present in the main and the auxiliary stations.

Referring to the circuit diagram (Fig. 1) which will hereafter be referred to as the main station, a carrier frequency generator 1 is coupled to a radio frequency amplifier 3. The radio frequency amplifier 3 is coupled to a second amplifier 7 which is coupled to an antenna system 9. The anode circuit of the second amplifier 7 includes a modulator 11 which is connected to a microphone 13 or any source of signals.

An impulse generator 15 is connected to a delay network 17 which comprises inductors 19, capacitors 21, and a terminating resistor 23. A connection 105 is made from a point intermediate the ends of the delay network 17 to an impulse modulator 25. The impulse modulator 25 is included in the anode circuit of the first radio frequency amplifier 3. The input and the output of the delay network 17 are respectively connected to impulse amplifiers 27 and 28 by leads 104 and 106. The outputs of the impulse amplifiers 27 and 28 are connected in parallel and to a control grid of a radio frequency amplifier 29 which is preferably connected between the antenna 9 and the radio receiver 31. The radio receiver 31 may include a detector and audio frequency amplifier. The audio frequency amplifier output is impressed on telephones 33 or other signal indicator.

Before describing the operation of the main station, the schematic circuit arrangement of an auxiliary station will be considered. Fig. 2 is the circuit diagram of an auxiliary station which is not unlike the main station. In the auxiliary station, a carrier frequency generator 35 is coupled to a radio frequency amplifier 37. The radio frequency amplifier 37 is coupled to a second radio frequency amplifier 39 which is coupled to an antenna system 41. The anode circuit of the second radio frequency amplifier 39 includes a modulator 43. A microphone 45 is connected to the input of the modulator 43.

The receiver 47 at the auxiliary station is coupled to the antenna 41 by a radio frequency amplifier 49. The receiver 47 includes a detector which is connected to an impulse frequency amplifier 51 and to an audio frequency amplifier 53. The audio frequency output is impressed on telephones 55 or the like. The output of the impulse frequency amplifier 51 is connected to a delay network 57 which is comprised of inductors 59, capacitors 61, and a terminating resistor 63. The first and third sections of the delay network are connected to an impulse amplifier 65 by leads 101 and 103, respectively. The output circuit of the impulse amplifier 65 is connected between the cathode and a control grid of the radio frequency amplifier 49. A connection 102 is made from the second section of the delay network 57 to the input of an impulse modulator 67. The output of the impulse modulator 67 is connected in the anode circuit of the first radio frequency amplifier 37.

The operation of the system is dependent upon the impulses created by an impulse generator. One form of impulse generator circuit is illustrated in Fig. 3, in which the thermionic tube 71 is connected as an oscillator. The grid circuit comprises an inductor 73 which is coupled through a grid capacitor 75 to the grid electrode 77. The grid electrode is connected to cathode 79 through an adjustable grid-leak resistor 81. The anode 83 is connected through an inductor 85, which is mutually coupled to the grid inductor 73, and through a resistor 87 to the positive terminal of a B battery 89. The output currents flowing through resistor 87 establish impulses which may be further amplified and phased by one or more amplifiers 91. The oscillator starts to generate oscillatory currents but the values of the associated elements, in particular the capacitor 75 and grid resistor 81, are chosen so that the oscillator blocks. The charge on the grid capacitor 75 leaks off through the grid resistor 81 to ground, and again the oscillator starts. These cycles continue and form "on" impulses for a discrete period and discrete "off" intervals. I prefer to generate the "off" intervals and "on" impulses at a superaudible rate.

Figure 5 shows one form of impulse modulator which is found in Patent No. 1,631,670, issued June 7, 1927, to I. F. Byrnes. The impulse voltage is applied to the input of a thermionic tube 109 through a transformer 111. The grid electrode 107 is connected through transformer 111 and a biasing battery 115 to the cathode 119. Anode potential is supplied by a battery 117, or the like. The cathode 119 is connected to the anode of the controlled amplifier 3 through the primary 121 of the coupling transformer 123. The cathode potential of the modulator tube 109 is the source of the voltage for energizing the anode of amplifier tube 3.

In operation, the tube 109 is normally biased to cut-off. A positive impulse from the time delay network decreases the negative cathode-to-grid bias, causing the tube to draw anode current. Consequently, the potential of cathode 119 becomes positive with respect to ground, and a positive potential is impressed on the anode of amplifier 3, so that a signal impulse is passed to amplifier 7.

Referring to Figs. 1 and 2, assuming the impulse generator 15 is operating at the start of an "on" impulse. This impulse is first transferred by lead 104 through the impulse amplifier 28 in a phase which biases the control grid of amplifier 29 to cut-off. After a slight delay the "on" impulse is impressed on the impulse modulator 25 by connector 105. The impulse modulator 25 is arranged to supply the anode current for the radio frequency amplifier 3 for the duration of the "on" impulse. Since the anode current is thus supplied, the carrier currents from carrier generator 1 will be transferred through the first amplifier 3 to the second amplifier 7. The output currents of the second amplifier 7 are impressed on the antenna 9 and radiated. If a signal is impressed on the microphone 13 during the "on" impulse, the signal currents from the microphone are amplified by the modulator 11 and thereby vary the amplitude of the carrier currents.

When the first delayed "on" impulse from 105 ceases, the carrier is no longer transferred, and modulation currents from the microphone 13 have no effect. Before the original impulse stops, however, the second delayed impulse from the second section of the delay circuit 17 is applied to the impulse amplifier by lead 106. The amplifier 29, therefore, remains off. In the meantime, the delayed impulse which turned the carrier "on" ceases. Therefore, the receiver is shut off by the two subsequent impulses for the full duration of the transmitter "on" period. Finally, the impulse transferred by lead 106 to the amplifier 27 is reduced to zero and thus the radio frequency amplifier 29 is restored to operating condition after the carrier has substantially completely died out. The impulse generator 15 being in the "off" cycle or interval, no carrier currents are radiated and the receiver 29, 31 is sensitive to incoming currents. This sequence is graphically represented by Fig. 6 at *a* to *e*.

The carrier waves, either modulated 95 or unmodulated 93, are radiated from the main station antenna to the auxiliary station (see Fig. 4). These waves create carrier currents in the antenna at the auxiliary station (see Fig. 2). The received currents are amplified by the radio frequency tube 49 and the receiver 47. The amplified currents which are detected by the receiver include two components: First, the discrete "on" impulses, and second, the signal impulses. The "on" impulses are amplified by the impulse frequency amplifier 51 and are passed through the delay network 57.

The delay network 57 at the auxiliary station operates over a longer time interval than the delay network 17 at the main station. The delay network 57 preferably has three distinct periods. The first period operates by lead 101 to impress currents through the impulse amplifier 66 to cut off the amplifier 49 just after the received "on" impulse ceases. The second period starts as soon as the amplifier has been cut off, and provides an impulse which is impressed by lead 102 through the impulse modulator 67 on the first radio frequency amplifier 37. Irregularities in the wave form of this impulse may be smoothed out or eliminated by a limiting device located within the impulse modulator 67. This impulse is phased to supply anode current to the anode circuit of the amplifier for a time period which is substantially equal to the period of the "on" impulses at the main station but these "on" impulses at the auxiliary transmitter are so delayed that they occur during the "off" intervals of the carrier impulses at the main transmitter.

During the "on" periods at the auxiliary station, the modulator 43 may be operated to modulate the carrier frequency currents from generator 35 which are transferred through the first 37 and second 39 radio frequency amplifiers to the antenna 41. The radiated carrier waves, modulated 97 and unmodulated 99, are illustrated in Fig. 4. The third delay period, connector 103, is used to continue the cut-off bias on the radio amplifier 49 at the receiver until the carrier at the auxiliary station has substantially completely died out. During the "off" intervals at the auxiliary station, the radio frequency amplifier 49 is in operating condition to transfer signals impressed on the antenna 41 to the receiver 47 in the conventional manner. This sequence of events is graphically illustrated by Fig. 6, *f* to *l*.

Thus, I have described a two-way communication system in which a single carrier wave is transmitted from a main station to an auxiliary station during discrete periods which preferably occur at a superaudible rate. During intervals when the main station carrier is not radiated, the carrier from the auxiliary station is radiated. During the period of carrier radiation from either station, the receiver at that station is rendered inoperative whereby feedback and blocking effects may be eliminated. While the signal frequencies are not fully transmitted, I have found that the details omitted during the "off" intervals are hardly noticeable because of the superaudible rate at which discrete groups of carrier waves are radiated.

While I have described the modulators as operating in the anode circuits of the several tubes, it will be understood by those skilled in the art that grid modulation may be used. Likewise, while the carrier radiation is described as modulated or unmodulated, the carrier may be suppressed at the auxiliary station during periods of no modulation by methods which are familiar to those skilled in the art. In installations where feedback and blocking effects are negligible, the one or more of the connections from the delay networks to the radio frequency amplifier in the receivers may be omitted. In some instances the delay network at the main station may be completely omitted, and a single delay network employed to phase the radiation of the carrier at the auxiliary station. The main and auxiliary carrier generators do not have to be synchronized because they are never radiated at the same time. It should also be understood that my invention is not limited to the impulse generator illustrated in as much as any means of timing the discrete periods of transmission may be used. The system described is not limited to a main station and one auxiliary station. A plurality of auxiliary stations may be used to transmit carriers during successive intervals concurrent with the "off" intervals of the main carrier wave.

I claim as my invention:

1. The method of communication between a main station and an auxiliary station which comprises radiating a carrier wave from said main station for discrete periods separated by discrete intervals, receiving said radiated carrier at said auxiliary station, radiating a carrier wave from said auxiliary station during a portion of the interval between said discrete periods, receiving said carrier wave from said auxiliary station at said main station during said portion of the interval between said discrete periods when no carrier is radiated from said main station, controlling the operation of said auxiliary station by successively delaying a controlling impulse derived from the carrier radiated from said main station, applying an intermediate period of said delayed controlling impulse to cause radiation from said auxiliary station, and applying prior and subsequent periods of said delayed controlling impulse to limit reception of said main carrier at said auxiliary station.

2. The method of communication between a main station and an auxiliary station which comprises radiating a carrier wave from said main station during discrete periods which recur at a superaudible rate, receiving said radiated carrier at said auxiliary station, radiating a carrier wave from said auxiliary station during a portion of the interval between said discrete periods, receiving the carrier wave from said auxiliary station during said portion of the interval between said discrete periods, controlling the operation of said auxiliary station by successively delaying a controlling impulse derived from the carrier radiated from said main station, applying an intermediate period of said delayed controlling impulse to cause radiation from said auxiliary station, and applying prior and subsequent periods of said delayed controlling impulse to limit reception of said main carrier at said auxiliary station.

3. In the method described by claim 2 the additional steps of modulating said carrier waves.

4. The method of communication between a main station and an auxiliary station which comprises generating a carrier current, amplifying said current during discrete periods, cutting off said carrier for discrete intervals at a superaudible rate, modulating said amplified carrier, radiating said interrupted and modulated carrier, receiving said modulated carrier at said auxiliary station, generating a carrier at said auxiliary staton, amplifying said carrier for discrete periods, cutting off said carrier when the carrier from said main station is being received at said auxiliary station, modulating said auxiliary carrier, radiating said modulated carrier during a portion of said discrete interval when said carrier is cut off at said main station, limiting the radiation of said carrier from said auxiliary station to the portion of said discrete interval by one of a series of differently timed controlling impulses, and limiting the reception at said auxiliary station by other and differently timed impulses.

5. The method of communication between a main station and an auxiliary station which comprises generating a carrier current at said main station, generating a plurality of discrete impulses at a superaudible rate, successively delaying said discrete impulses to obtain a series of differently timed discrete impulses, controlling the radiation of said carrier from said main station by one of said series of differently timed discrete impulses, whereby said carrier is radiated for discrete periods and is cut off for discrete intervals, receiving said radiated carrier at said auxiliary station, generating a carrier at said auxilary staton, radiating said carrier from said auxiliary station for discrete periods within said cut-off intervals at said main station, said radiation from said auxiliary station being controlled by deriving an impulse from the carrier received at said auxiliary station, successively delaying said derived impulse to obtain a series of discrete impulses, and applyng one of said delayed impulses to cause radiation from said auxiliary station, and applying prior and subsequent impulses to shut off reception at said auxiliary station for a period concurrent with but slightly exceeding said period of transmission at said auxiliary station.

6. The method of communication between a main station and an auxiliary station which comprises generating a carrier current at said main station, generating a plurality of discrete impulses at a superaudible rate, successively delaying said discrete impulses to obtain a series of differently timed discrete impulses, controlling the radiation of said carrier from said main station by one of said series of differentially timed discrete impulses, whereby said carrier is radiated for discrete periods and is cut off for discrete intervals, receiving said radiated carrier at said auxiliary station, generating a carrier at said auxiliary station, radiating said carrier from

said auxiliary station for discrete periods which occur during said cut-off intervals at said main station, interrupting reception at said main station when said carrier is radiated therefrom by successively delaying said discrete impulses to obtain a series of discrete impulses starting at successive time intervals, applying an intermediate impulse to control the "on" periods of said carrier and applying prior and subsequent impulses to shut off reception at said main station for a period concurrent with but slightly exceeding said period of transmission, said radiation from said auxiliary station being controlled by deriving an impulse from the carrier received at said auxiliary station, successively delaying said derived impulse to obtain a series of discrete impulses, and applying one of said delayed impulses to cause radiation from said auxiliary station, and applying prior and subsequent impulses to shut off reception at said auxiliary station for a period concurrent with but slightly exceeding said period of transmission at said auxiliary station.

7. A communication system comprising a main station and an auxiliary station, said main station comprising means for generating a carrier current, means for generating impulses at a superaudible rate and corresponding to discrete "on" periods and discrete "off" intervals, means including said impulse generating means for interrupting said carrier current, means for modulating said carrier, means for radiating said carrier during said discrete "on" periods, means for receiving at said station, a delay circuit connected to said impulse generating means, and means connected between said delay circuit and said receiver whereby said receiver is cut off during said "on" periods, and is restored during said "off" intervals, said auxiliary station comprising means for receiving the carrier radiated from said main station, means for deriving impulses from said received carrier, means for delaying said derived impulses until the "on" impulse at the auxiliary station corresponds to the "off" interval at said main station, means for generating a carrier current at said auxiliary station, means for radiationg said carrier from said auxiliary station, and a connection from said delay means to confine the radiation of said carrier from said auxiliary station to periods corresponding substantially to the "off" intervals at said main station.

8. A communication system comprising a main station and an auxiliary station, said main station comprising means for generating a carrier current, means for generating impulses at a superaudible rate and corresponding to discrete "on" periods and discrete "off" intervals, means including said impulse generating means for interrupting said carrier current, means for modulating said carrier, means for radiating said carrier during said discrete "on" periods, means for receiving at said station, a delay circuit connected to said impulse generating means, and means connected between said delay circuit and said receiver whereby said receiver is cut off during said "on" periods, and is restored during said "off" intervals, said auxiliary station comprising means for receiving the carrier radiated from said main station, means for deriving impulses from said received carrier, means for delaying said derived impulses until the "on" impulse at the auxiliary station corresponds to the "off" interval at said main station, means for generating a carrier current at said auxiliary station, means for radiating said carrier from said auxiliary station, a connection from said delay means to confine the radiation of said carrier from said auxiliary station to periods corresponding substantially to the "off" intervals at said main station, and a connection from said delay means and said means for receiving said auxiliary station to cut off the receiver at said auxiliary station during periods during which the carrier is radiated from said auxiliary station.

WINFIELD R. KOCH.