April 6, 1926. 1,579,299

J. C. GABRIEL

TWO-WAY COMMUNICATION SYSTEM

Filed Feb. 1, 1924

Fig. 1

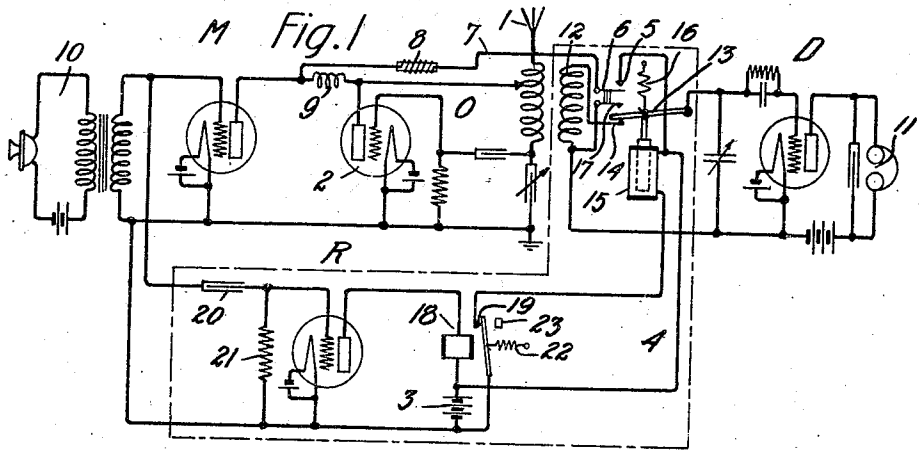


Fig. 2

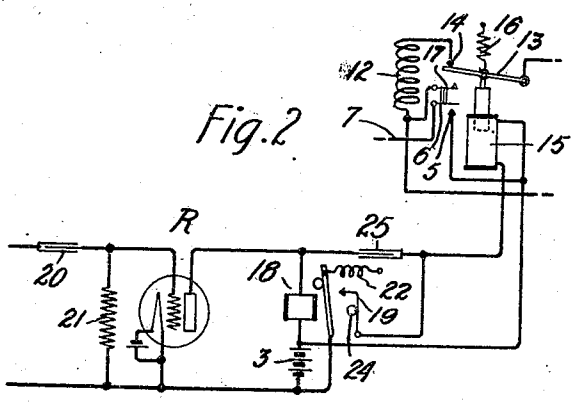


Fig. 3

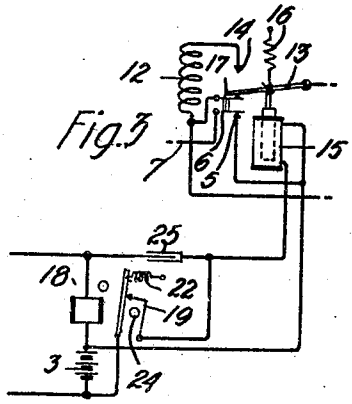
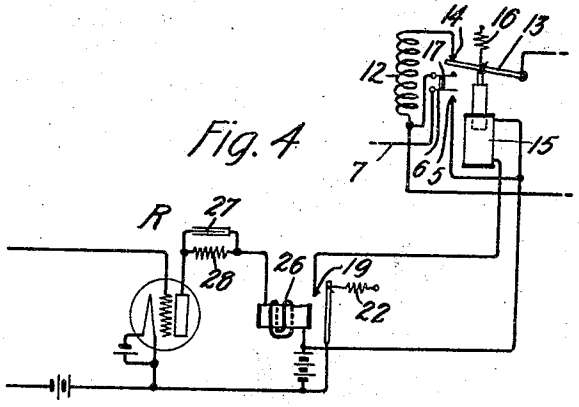


Fig. 4



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UNITED STATES PATENT OFFICE.

JOHN C. GABRIEL, OF NEW YORK, N. Y., ASSIGNOR TO WESTERN ELECTRIC COMPANY, INCORPORATED, OF NEW YORK, N. Y., A CORPORATION OF NEW YORK.

TWO-WAY COMMUNICATION SYSTEM.

Application filed February 1, 1924. Serial No. 689,851.

To all whom it may concern:

Be it known that I, JOHN C. GABRIEL, a subject of the King of Great Britain, residing at New York city, in the county of New York and State of New York, have invented certain new and useful Improvements in Two-Way Communication Systems, of which the following is a full, clear, concise, and exact description.

This invention relates to two-way communication systems.

An object of the invention is to avoid the production of side tone in a receiver at a two-way communication station by energy from the local transmitter.

A further object is to control the responsiveness of the receiver and the operation of the transmitter directly by sound energy without the use of manually operated switches.

The success of two-way communication systems is dependent on the efficacy of the means used for avoiding side tone in the receiver from the local transmitter. The development of satisfactory means to accomplish this result has been attended by certain difficulties which are peculiar to high frequency, and especially to radio, systems. For example, distributed and certain other forms of casual and unavoidable capacity, are substantially non-effective as impedance elements except at relatively high frequencies. In radio systems, the relatively great difference between the energies concerned in the transmitting and receiving functions, and the consequent relatively great difference in the sensitivity of the respective transmitting and receiving apparatus, makes the presence of side tone currents especially hazardous to the receiving apparatus.

One type of practicable means involves the use of commutating devices to render the transmitting and receiving circuits alternately operative and in which the necessary commutating functions are accomplished by relay actuated switches, the relays themselves being actuated by a portion of the sound or other form of energy used for signal modulation. In such an arrangement, the speaker's voice, in a radio telephone system, performs a function that otherwise would be performed by manually operated means. The means, by virtue of which the actuating energy is automatically applied, makes the control inherently more positive and efficient than by manually operable means, and in fact, makes the ultimate result of the operation of such a system comparable with that of the ordinary low frequency telephone circuit.

However, the sensitivity of the relays ordinarily necessary for the efficient operation of such systems, results in at least two functional defects. When the circuit is in transmit condition, a very slight pause or momentary great decrease in the amplitude of the impressed sound waves, such as might readily occur during regular transmission, may result in a momentary actuation of the switches to receive condition with corresponding loss of transmission. A somewhat similar result occurs in the particular form of the system in which the speech rectifier and relay are arranged so that the impressed sound energy results in a decrease in the current through the relay. Certain explosive sounds, such as the consonants p and t, have peculiar effects in such a system in that they cause a momentary increase instead of a decrease in the rectifier output (and hence relay current), and consequently a chattering of the relay contact or even an actuation of the switches to their alternative positions.

It is a further object of the invention to provide a system otherwise as described in which these two effects are avoided.

These objects are realized, for example, in circuits in which the switching operation affecting the signal condition is performed by the secondary relay of an arrangement of primary and secondary relays having a lost motion means between, whereby the movable element of the primary relay is capable of considerable movement without affecting the second relay.

The timing element provided by this feature results in the substantial elimination of the first mentioned defect. If the primary relay is actuated so as to have a falling characteristic when sound waves are impressed, so that the last mentioned defect may tend to be present, this defect may also be substantially eliminated.

In an alternative arrangement, in which the primary relays (or if only one relay is used, the relay) are actuated so as to have a rising characteristic, the timing element is provided by a short circuited coil on the re-

lay core. This coil resists the deenergization of the core, which would otherwise result when there is a momentary cessation or extreme decrease in amplitude of the impressed speech waves.

In the drawing, Fig. 1 illustrates a two-way telephone system employing the principle of the invention:

Figs. 2 and 3 illustrate a circuit which may be used alternatively to the portion of the circuit of Fig. 1 which is enclosed in dashed lines, the two figures differing only as illustrating different phases of operation of the circuit, and

Fig. 4 illustrates a still further alternative circuit which may be similarly substituted for the same portion of the circuit of Fig. 1.

Referring to Fig. 1, tuned antenna 1 is associated with a three-element electric discharge device 2 in such a manner that the combination of the elements constitutes an oscillator O of well known type. (See for example, page 360, vol. 38 No. 3 of the Proceedings of the A. I. E. E.) The characteristic feature of this type of oscillator is that the antenna, including the capacity of the aerial to ground, constitutes its frequency determining circuit. The space current circuit of the oscillator may be traced from the cathode, through space current source 3, conductor 4, contact 5 of normally open relay switch 6, conductor 7, constant current choke coil 8, high frequency choke coil 9, to the anode of device 2.

The output current of the oscillator is modulated by modulator M in accordance with variations of the signal current in circuit 10. The system of modulation which is used is that usually denominated "constant current modulation system". It is described in the paper of the Proceedings of the A. I. E. E. supra.

In brief, the operation is as follows: Signal variations are impressed on the input circuit of the modulator and are reproduced in its output circuit in amplified form. This signal variation current flows through choke coil 8, which is common to the space current paths of both the oscillator and modulator, and accordingly, produces a corresponding potential drop therein, which results in a corresponding variable potential being impressed from space current source 3 on the anode of the oscillator tube. These variations of potential are reproduced as amplitude variations of the generated high frequency wave. High frequency choke coil 9 prevents the high frequency currents from flowing in the low frequency modulating circuits. However, the coil 9 does not have sufficient impedance to prevent the flow of current of the modulating frequency therethrough.

The receiving circuit includes detector D and indicator 11. The detector is normally connected to coil 12, which is coupled to the antenna, through armature 13 and contact 14 of relay 15. The relay is normally energized to actuate the armature 13 by means to be explained later. Armature 13 of the relay is biased upwardly by spring 16. When relay 15 is deenergized, the receiving circuit is opened at contact 14 and the transmitting circuit is closed at contact 5, the transmitting and receiving circuits accordingly being made alternately operative. Side tone in the receiver resulting from the locally transmitted energy is thereby avoided.

To further insure a complete absence of side tone, coincidental with the opening of the receiver circuit, or shortly thereafter, the grid-cathode circuit of the detector is short circuited. This is accomplished by the contact 17, which is connected to the cathode side of the coil 12. The circuit is closed through contact 17 before the transmission circuit is made operative and is opened after the transmission circuit is made inoperative, so that, so far as the short circuiting means can prevent it, the receiving circuit is at no time subjected to the hazards of side tone currents.

The operation of relay 15 is made responsive to signal variations from circuit 10 through rectifier R and primary relay 18. The coil of relay 18 is energized by the space current of rectifier R, which normally is sufficient to hold up its armature to close a circuit through the relay 15 at contact 19.

Rectifier R functions in such a manner that impressed alternating currents, as from source 10, result in a decrease of its space current. In order to give the tube this falling characteristic, use is made of the rectifying characteristic of the input circuit in conjunction with the grid condenser 20 and leak resistance 21.

The operation of the rectifier is similar to that of a detecting circuit having the same elements and is well known. The rectifying characteristic of the input circuit results in a preponderancy of increase over decrease of grid-filament current. The resulting increment of negative charge on the grid, after each cycle of impressed potential, is trapped thereon on account of the condenser 20. The charge on the grid therefore tends to accumulate and continually to depress the potential of the grid from its normal value when no potential is impressed, the space current decreasing correspondingly.

When the space current becomes sufficiently low, traction of spring 22 exceeds the magnetic traction of the coil and the circuit is closed at contact 19, the armature falling back to its stop 23. The coil of relay 15 releases its armature 13, which

is actuated upwardly by spring 16 to change the condition of the circuit as a whole from receive to transmit.

Any momentary cessation of the impressed signal, not sufficient to cause actuation of the armature of relay 18 to its circuit closing position, will not be effective to change the condition of the transmitting and receiving circuits. Further, the time constant CR of impedance elements 20 and 21 is made sufficiently large so that a reasonable time must elapse, after the cessation of signals, before the current in the coil of relay 18 is sufficient to initiate a movement of its armature away from its stop; and so that the acceleration of its movement between stop 23 and contact 19 is small. In other words, the relay 18 is, in effect, a link between the source 10 and relay 15, the operation of this link being characterized by lost motion.

It has been found that the influence on the microphone of explosive sounds, such as the consonants p and t, results in an effect somewhat similar to that of a cessation of signal current. That is, it causes the space current of rectifier R to increase instead of decrease. This results from the fact that the waves corresponding to these sounds (and accordingly the potential waves impressed on rectifier R) are highly damped. Accordingly, even though by the operation of the rectifier the potential of the grid is progressively lowered by successive cycles of impressed potential, a preponderant positive impulse, such as might characterize the first half cycle of a highly damped wave might drive the grid so far positive that an appreciable time, measured by many cycles of impressed potentials, would have to elapse before the space current were again sufficiently lowered to actuate the relay 18. The spacing of contact 19 and stop 23 is made so great that impulses of this kind are insufficient to actuate the armature to contact 19.

Although in the description of Fig. 1 particular means for alternately rendering the transmitting and receiving circuits operative have been assumed, there are many other means for accomplishing an equivalent result. In particular, any one of the means disclosed in U. S. patent to Heising 1,488,006, March 25, 1924, over the invention of which the present invention may be considered an improvement, may be used without requiring any material change in operation of the system or the relation of the relays and their associated circuits. Also, the falling characteristic of the space current can be obtained without the grid condenser and leak by operating over a particular portion of the grid-potential-space-current curve.

Figs. 2 and 3 illustrate an alternative lost motion means which may be substituted for that in Fig. 1, the circuit of Fig. 2 being substituted for that portion of Fig. 1 enclosed in dashed lines. Fig. 2 illustrates the circuit when in receive condition and Fig. 3 a portion of the circuit of Fig. 2 when the circuit as a whole is in transmit condition. Elements having functions similar to those of Fig. 1 are similarly labeled.

In the operation of the system which includes the circuit of Figs. 2 and 3, the circuit through relay 15 is normally broken at contact 19, so that spring 16, instead of relay 15, normally maintains the switches in receive position. Relay 15 is energized when the space current in the coil of relay 18 is decreased sufficiently to permit spring 22 to actuate its armature to circuit closing position, when the relay 15 will actuate the switches to transmit position. Contact 19 is resiliently held against stop 24. When the circuit is closed through this contact it is resiliently forced back a distance approximately equal to the spacing between 19 and 23 of Fig. 1 (about $\frac{1}{16}$ of an inch in a practical case). When the space current momentarily increases, as by either of the causes described, the armature can accordingly move this distance without disturbing the condition of any of the circuits. When contact has been made at 19, subsequent pulses of current, which would otherwise flow in the relay, are by-passed around it through condenser 25. This tends to prevent chattering when the contact is made. This condenser is effectively disconnected when the armature of the relay is in its normal position, so that it does not retard the operation when the signal is applied.

In the alternative circuit arrangement of Fig. 4, the incidence of the signal current on the rectifier results in an increase in space current on account of the rectifier characteristic of the space current circuit under varying grid potentials. The primary relay accordingly operates on a rising characteristic. That the rectifier may operate in this manner is apparent from the absence of a grid condenser and leak. The increase in space current is sufficient to actuate the relay 18 to circuit closing position. The subsequent operations are the same as in the system of Fig. 2.

The additional winding 26 on relay 18 has the effect of a damping coil. Its purpose is to prevent a reverse actuation of relay 18 by a momentary cessation or change in amplitude of the signal currents impressed on the rectifier. This winding is preferably of very low resistance, and may, for example, be a single turn of copper conductor or a copper sheath. It tends to oppose any change of flux threading therethrough by setting up an opposing flux.

The impedance elements 27 and 28 together constitute what is commonly called an impulse circuit. Condenser 27 has low

impedance to the first impulse of the alternating current component of space current, which will accordingly flow therethrough and through the relay coil. After the relay has been actuated, the much smaller average current through the resistance 28 will be sufficient to hold the relay in operated position. By the use of this arrangement, since the current through the coil of the relay for the steady state will be less than that corresponding to the initial impulse, and since it is a steady current that determines the necessary biasing pull of spring 22, a smaller biasing spring can be used with consequent increase in flexibility and sensitivity. From another point of view, the use of the resistance makes possible the use of a space current source having a large potential without unduly increasing the relay current during the steady state. On account of the condenser 27 the whole of this large potential is momentarily available to actuate the relay when the first impulse of current is impressed on the rectifier. A somewhat similar use of an impulse circuit is disclosed in Fig. 12 of U. S. patent to Deardorff No. 1,474,408, granted November 20, 1923.

Obviously, the various features disclosed, respectively, as applied to individual circuits can be used in others of the circuits, or a combination of features disclosed in separate circuits may be used in a single circuit. For example, the lost motion contact member of Fig. 2 can be used in the system of Fig. 4 by making contact 19 resilient; the impulse circuit of Fig. 4 can be applied to a circuit having the lost motion means of either Fig. 1 or Fig. 2; the system of Fig. 4 can be caused to operate on a falling characteristic, the contacts being rearranged accordingly in a manner taught by Fig. 2; etc.

What is claimed is:

1. A station of a two-way signal system comprising means for transmitting a signal, means for receiving a signal, and relay-including means actuated in response to the initiation and cessation of said signal transmission to respectively render said station operative for signal transmission and reception, said means including circuit closing means whereby said relay operates to initiate the change in condition of said station a predetermined time after the cessation of the previous condition of signal operation.

2. A station of a two-way signal system comprising means for transmitting a signal wave, means for receiving a signal wave, and signal actuated means for rendering said station exclusively operative for transmission during signal transmission, said means comprising mechanical lost-motion means whereby said station becomes inoperative for transmitting a predetermined time after the cessation of signal transmission.

3. A sound controlled relay system comprising signal transmitting means, signal receiving means, circuit closing means for rendering the signal transmitting means operative when in circuit closing position, circuit closing means for rendering the signal receiving means inoperative when in circuit closing position, a normally energized relay in cooperative relation to both of said means to normally render said transmitting means inoperative and said receiving means operative, a circuit closer in circuit with said relay, a normally energized relay for maintaining said last mentioned circuit closer in circuit closing position, biasing means for each of said circuit closers, means responsive to signal transmission for de-energizing said last mentioned relay whereby said last mentioned circuit closer is biased to open circuit condition, and a stop to limit the traverse of said last mentioned circuit closer between its normally open and normally closed positions.

4. A sound controlled relay system comprising a source of modulating current, an electrical discharge device for generating high frequency waves, an electrical discharge device for modulating said high frequency waves in accordance with said modulating current, a space current circuit including a switch for at least one of said devices, a normally operative receiving circuit including an electrical discharge device, circuit means including a switch for shortcircuiting at least a portion of said receiving device, a biased normally energized relay for maintaining each of said switches in non-circuit closing position, an electrical discharge device containing a cathode, an anode, and an impedance control element, an input circuit in energy transfer relation to said modulating current source and to said cathode and control element, and including a capacity element in series with said control element, and a high impedance induction path between said cathode and control element, a space current circuit between said cathode and said anode, and including a relay, a switch in circuit with said first mentioned relay and in energy transfer relation to the last mentioned relay, and a stop to limit the traverse of said last mentioned switch between its actuated and non-actuated positions.

5. A sound controlled relay system comprising an antenna, means for producing and radiating from said antenna a signal modulated high frequency wave including an electrical discharge device having a switch-containing space current circuit, a circuit including an electrical discharge detector for receiving signal modulated high

frequency waves in energy transfer relation to said antenna, a switch connecting said receiving circuit with said antenna, a switch-containing short-circuiting means for said detector, biasing means for each of said switches, a normally energized relay, said switches and biasing means being so arranged that, when said relay is energized, the second mentioned switch is in circuit closing position and the first and third mentioned switches are in open circuit position, a circuit closer in circuit with said relay, a normally energized relay for maintaining said circuit closer in actuated position, means responsive to signal transmission to deenergize said last mentioned relay, whereby said switches and circuit closer are biased to their respective alternative positions, and a stop to determine the open position of said circuit closer.

In witness whereof, I hereunto subscribe my name this 31st day of January A. D., 1924.

JOHN C. GABRIEL.