

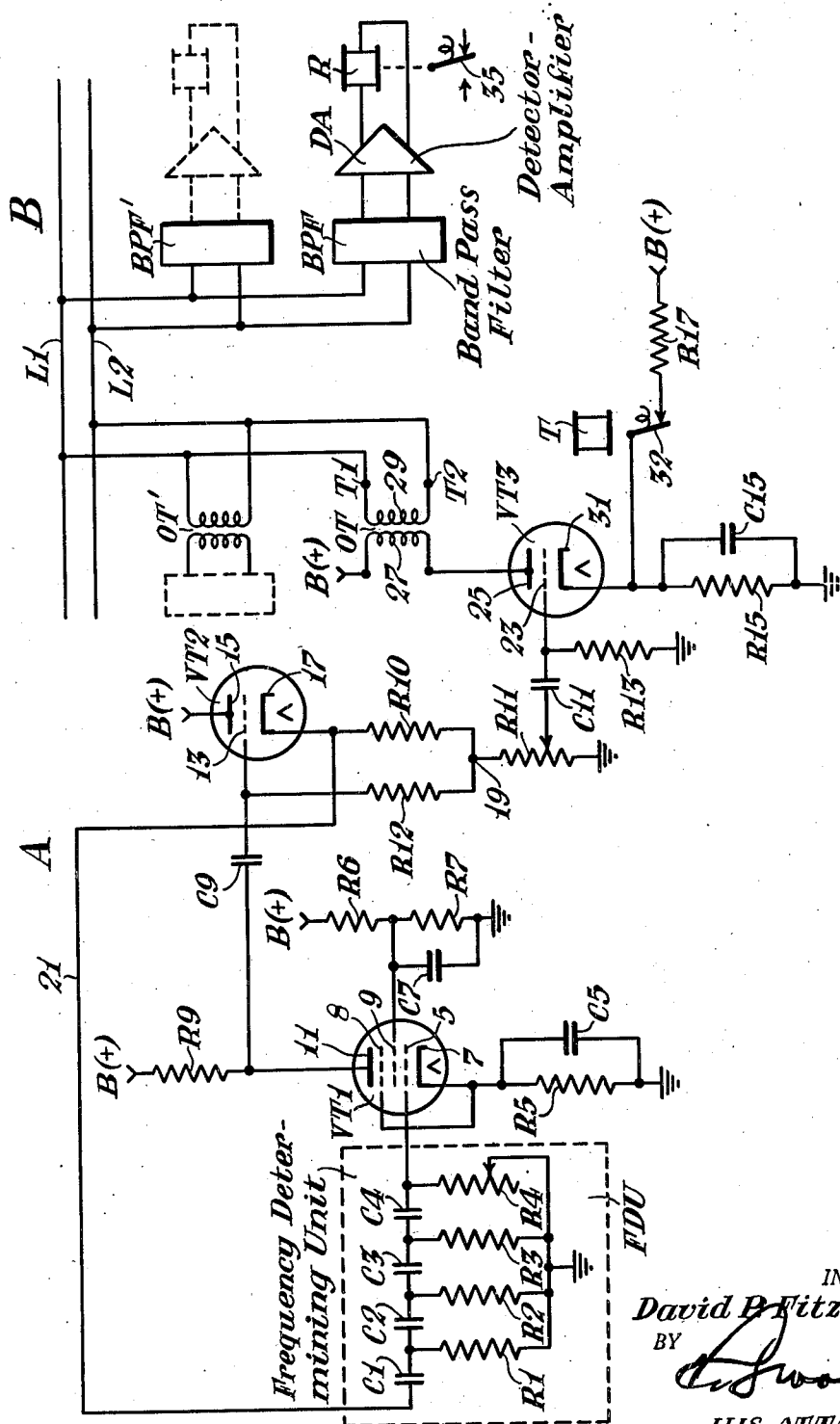
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D. P. FITZSIMMONS

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TRANSMITTER FOR CODE COMMUNICATION SYSTEMS

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INVENTOR.
David P. Fitzsimmons
BY *David P. Fitzsimmons*
HIS ATTORNEY

UNITED STATES PATENT OFFICE

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TRANSMITTER FOR CODE COMMUNICATION SYSTEMS

David P. Fitzsimmons, Trafford, Pa., assignor to
The Union Switch & Signal Company, Swiss-
vale, Pa., a corporation of Pennsylvania

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My invention relates to code communication systems, and particularly to an improved type of transmitter for a code communication system employing signaling currents in the voice frequency range.

In systems of the type commonly described as carrier current communication systems, various frequency bands or channels for speech and for code signaling are provided, over which independent communication may be established without interference.

It is an object of my invention to provide for use in systems of this character, an improved code transmitter which is particularly adapted to transmit code pulses of alternating current of different frequencies within the voice frequency range, in a reliable manner.

Another object of my invention is to provide a plurality of non-interfering code transmitters suitable for use in carrier current systems of the type in which a voice frequency or speech channel is subdivided to provide a plurality of closely spaced code communication channels, each of which includes receiving apparatus selectively responsive to energy of a different frequency.

Another object of my invention is to provide an improved alternating current code transmitter in which the alternating current circuits, with the exception of a single frequency determining unit, are non-reactive, enabling similar transmitters to be employed for generating any one of a plurality of different frequencies by the insertion of a removable unit adjusted to the desired frequency.

A further object of my invention is the provision of improved means for graduating the rise and fall of the alternating currents constituting the code pulses delivered by the different transmitters so as to minimize the transient components having frequencies different from the assigned frequency, thereby decreasing the effect upon adjacent channels and enabling the channels to be more closely spaced. This is accomplished by the provision of novel means for causing the output current to rise and fall gradually to form the code pulses, which possesses an advantage over transmitters employing resonant filters for that purpose in that the output frequency is maintained constant during the periods of changing amplitude and transient components of the output current due to filter reaction are avoided.

A feature of my invention is the provision of an improved oscillator which is particularly adapted to generate alternating currents of a substantially

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pure sine wave form, free from harmonics, so that resonant filters are not needed in the output circuits of the different transmitters for the suppression of such harmonics.

A further object of my invention is the provision of an oscillator for generating voice frequency current which is stabilized so as to deliver current of constant voltage and frequency regardless of ordinary variations in the supply voltage or temperature.

Other objects of my invention and features of novelty therein will be apparent from the following description taken in connection with the accompanying drawing.

I shall describe one form of transmitter embodying my invention and shall then point out the novel features thereof in claims.

In practicing my invention, I provide a vacuum tube oscillator of the phase shift type, the output of which is supplied to a second vacuum tube arranged in the manner of a cathode follower and a portion of the output of the cathode follower is supplied as feed back energy to the input circuit of the phase shift oscillator. Another portion of the output of the cathode follower is supplied to a third vacuum tube, constituting a buffer amplifier, the output of which is supplied through an output transformer to the communication channel. The oscillator operates to generate alternating current continuously as long as power is supplied thereto, while the buffer amplifier serves as a keying amplifier and supplies amplified alternating current to the output transformer only when the contact of a transmitting relay occupies one of its two positions. When the transmitter relay contact is in the other of its two positions, it completes a circuit by which a positive potential is applied to the cathode of the keying amplifier tube which is sufficient to render the tube non-conducting. A resistance-capacity network associated with the keying amplifier cathode circuit causes this tube to change gradually from its conducting to its non-conducting state when the positive biasing voltage is applied by the closing of the transmitting relay contact, and similarly causes the keying amplifier to change gradually from its non-conducting to its conducting state when the positive biasing voltage is cut off by the opening of the transmitting relay contact, the frequency of the alternating current output remaining constant during both these periods.

The single accompanying drawing is a diagrammatic view showing a preferred embodiment of my invention.

Referring to the drawing, the communication channel to which coded voice frequency currents are supplied by the apparatus of my invention comprises the line wires L1 and L2, extending between two spaced locations designated by the reference characters A and B. The communication channel is here shown as comprising a physical pair of wires supplied with energy from the transmitter output terminals T1 and T2, but it is to be understood that the communication channel may be extended to include a speech channel, for example, constituting the input channel of a carrier current system or radio link, or it may be one of the speech channels of a multi-channel carrier current communication system.

At location A a transmitting relay T is shown, the winding of which is supplied with energy by a circuit, not shown, so that the contacts of relay T are operated in accordance with the code signals to be transmitted from location A to location B. At location B there is provided a receiving relay R, the contacts of which are to be operated in step with the code pulses transmitted from location A. The circuits for controlling relay T and those controlled by the contacts of relay R form no part of my invention, and may be conventional telegraph circuits, or circuits for a code type of remote control system, for example, various types of which are well known. As shown, the contacts of relays T and R are normally biased to their right-hand position.

The transmitter comprises an oscillator tube VT1 having associated therewith a frequency determining unit FDU, a cathode follower tube VT2, a buffer or keying amplifier tube VT3, and an output transformer OT, together with the necessary resistors and condensers associated with the vacuum tubes. High voltage direct current energy is supplied from a suitable source, not shown, the positive terminal of which is designated by the reference character B(+) and the negative terminal of which is grounded. The circuits for supplying energy to the heaters of the tubes have not been shown in order to clarify the drawing.

The oscillator tube VT1 may be of any suitable type but as here shown is a pentode, having control circuits of the phase shift type. The control grid 5 of tube VT1 is supplied with energy by tube VT2 through a phase shifting network, or frequency determining unit FDU, comprising condensers C1, C2, C3 and C4, and resistors R1, R2, R3 and R4. The cathode 7 of tube VT1 is provided with a cathode bias resistor R5 bypassed by condenser C5 to afford a ground connection of relatively low impedance to the alternating current components of the tube current. A suppressor grid 8 is connected to the cathode, as in a conventional pentode amplifier circuit, and a screen grid 9 is supplied with a positive potential of a suitable value by means of a voltage divider comprising resistors R6 and R7 connected between terminals B(+) and ground. A by-pass condenser C7 effectively grounds the screen grid insofar as the alternating current component of the tube current is concerned.

The plate 11 of tube VT1 is supplied with high voltage direct current from the terminal B(+) of the power supply through resistor R9, and is connected through a coupling condenser C9 to the grid 13 of vacuum tube VT2.

From the foregoing it will be apparent that the tube VT1 and its associated condensers and resistors comprises a single stage pentode ampli-

fier, the output of which is supplied to the grid 13 of the cathode follower tube VT2. As explained below, the energy supplied through the frequency determining unit FDU to the input circuit of tube VT1 is of the proper phase to maintain the oscillations.

The vacuum tube VT2 is connected in the well known manner of a cathode follower, which differs from a conventional amplifier in that the output is taken from the cathode circuit rather than from the plate circuit, and a portion thereof is applied to the input circuit to provide a negative feedback for stabilizing purposes. The plate 15 is directly connected to terminal B(+) and the cathode 17 is connected to ground through resistors R10 and R11. A grid resistor R12 is connected at the junction point 19 of resistors R10 and R11.

It will be clear from a consideration of the circuits that the potential applied to grid 13 due to the drop across resistor R12 is decreased by the drop across resistor R10 in the output circuit of tube VT2 to provide the negative feedback referred to.

The output voltage of tube VT2 as measured across resistors R10 and R11 is nearly equal to the input voltage supplied by tube VT1, and differs but slightly in phase due to the drop across the coupling condenser C9 which preferably is of relatively large capacity. This output voltage is impressed on the frequency determining unit by reason of the connection from condenser C1 over wire 21 to the cathode 17 and from the resistors R1 to R4 and R11 to ground. Each condenser C1 to C4 in the unit is in series with an associated resistor R1 to R4 and is adapted to cause a phase shift which varies in accordance with the impressed frequency. At a particular frequency the total shift in phase is 180 degrees as required to maintain the oscillations in tube VT1 and it will be apparent therefore that the tube will oscillate at a frequency determined by the constants of the frequency determining unit. It will also be apparent that since the required phase shift is not obtained for frequencies which are multiples of the predetermined frequency, harmonics will be suppressed and the current delivered by tube VT1 will be of a substantially pure sine wave form.

It will also be apparent that the frequency at which the circuit oscillates may be adjusted by proper selection of the values of the condensers and resistors in the frequency determining unit, since the response of the output circuits of tubes VT1 and VT2 is independent of the frequency. In practice the frequency determining unit FDU is constructed as a self-contained removable unit, so that the frequency of the transmitter may be readily changed by using different frequency determining units therein. The resistor R4 may be of the adjustable type, to permit a variation in the resistance thereof to be made, in order to compensate for variation in the components due to manufacturing tolerances, and thereby enable each unit to be more accurately tuned to its specified frequency.

The use of a cathode follower rather than a conventional amplifier following the oscillator stage is advantageous from the standpoint of frequency response, because although the cathode follower is inherently degenerative, and has an amplification factor less than unity, it is capable of providing power amplification, and is essentially non-inductive so that for different frequencies of oscillation the energy level of the

output of the cathode follower remains substantially the same. Additionally, its characteristics are such that changes in the plate resistance of the cathode follower tube and variations in the load resistance with temperature as occur in practice do not cause sufficient change in the oscillating circuit to cause detrimental variations in the frequency or output energy level.

Since the normal bias voltage for the grid of the vacuum tube VT1 constitutes the drop across the cathode resistor R5, it will be apparent that a sudden change in the voltage of the direct current energy supplied to the transmitter will cause a corresponding change in the normal bias voltage. This would interfere with operation if sufficient to cause the bias voltage to go beyond the "cut-off" value of the tube VT1, and accordingly, to prevent this occurrence, tube VT1 is arranged to have a "remote cut-off," that is, the value of grid voltage at which the tube remains conducting is in excess of that reached due to ordinary variations in the high voltage power supply.

From the foregoing, it will be seen that the oscillator is in continuous operation and the energy supplied therefrom to the cathode follower tube appears as a voltage across the cathode resistors R10 and R11. A portion of the output voltage of tube VT2 is supplied over an adjustable connection on resistor R11, to the grid circuit of the amplifier tube VT3. This grid circuit comprises a coupling condenser C11 and a grid resistor R13 of relatively high value, connected to the grid 23 of vacuum tube VT3 in the usual manner. The plate 25 of vacuum tube VT3 is connected to the positive terminal B(+) of the high voltage power supply through a primary winding 27 of the output transformer OT which has a secondary winding 29 connected to the output terminals T1 and T2 of the transmitter.

The cathode 31 of tube VT3 is connected to ground through a biasing resistor R15 and bypass condenser C15 in multiple, and is supplied with a positive biasing voltage from the high voltage power supply by a circuit including a resistor R17 and contact 32 of the transmitting relay T, whenever this contact is closed.

By this means, the cathode 31 of vacuum tube VT3 is maintained at a relatively high positive potential when contact 32 of relay T is in its normal position, as shown. As a result, the tube VT3 is normally non-conducting. When relay T is energized and opens contact 32, the supply of bias voltage to the cathode 31 is interrupted. However, the condenser C15 and resistor R15 are selected so that a definite time interval is required until the condenser C15, which previously had been charged through resistor R17, discharges sufficiently to cause tube VT3 to become conductive. It will also be apparent that the rate of change in the direct current supplied to tube VT3 will be graduated further due to the fact that this is supplied through an inductive reactance comprising the primary winding 27 of transformer OT. When tube VT3 is conducting, it acts as a conventional amplifier, so that the voice frequency output of the oscillator and cathode follower is amplified and supplied to the output terminals T1 and T2 through the output transformer OT.

Considering now the location B, at which the voice frequency alternating current supplied over the line wires L1 and L2 by the transmitter at location A is received. The band-pass filter BPF at location B is tuned to the frequency of the transmitter just described and accordingly selec-

tively passes the energy supplied over the line wires from terminals T1 and T2 to the detector amplifier DA, where the voice frequency energy is amplified and rectified and then supplied to the winding of relay R, so that the contact 35 of relay R is operated between its normal and reverse positions substantially in unison with the contact 32 of the corresponding transmitter relay T.

It will be understood that each time relay T closes its contact 32, it reestablishes the circuit previously described for supplying a positive bias voltage to the cathode 31 of vacuum tube VT3. However, since the condenser C15 is substantially discharged at this time, the voltage across the condenser will rise at a relatively slow rate when energy is supplied thereto over the circuit including resistor R17 and contact 32 of relay T. Accordingly, the voltage of cathode 31 will rise at a correspondingly slow rate so that the plate current of tube VT3 is not cut off abruptly when contact 32 closes, but decreases gradually at a rate determined by the inductance of winding 27 and by the values of resistances R15 and R17 and condenser C15. It will be readily apparent that during the periods when the current supplied to the terminals T1 and T2 of the transmitter is varying, that is to say, at the beginning and end of each of the code pulses, the frequency is maintained constant at its steady state value because this is determined by the voltage supplied by the oscillator to the grid circuit of tube VT3.

From the foregoing, it will be seen that the operation of contact 32 of relay T causes pulses of voice frequency energy to be supplied from the transmitter at location A over the line wires L1 and L2 to location B, where the pulses are selectively filtered by the band-pass filter BPF and thus amplified and detected by the detector amplifier DA, and supplied to the winding of relay R, so that the contacts of relay R accurately repeat the code operation of the contacts of relay T.

As indicated by the output transformer OT', other voice frequency transmitters similar to the one described but tuned to different frequencies may be connected to the line wires L1 and L2, the additional frequencies being selectively filtered at the receiving location by sharply tuned band-pass filters BPF', etc., similar to filter BPF, each selectively responsive to a different one of a plurality of frequencies provided by different frequency determining units FDU.

The output transformer OT is arranged so that it presents a relatively high impedance to the currents supplied to the line wires L1 and L2 by other transmitters, thereby minimizing the loss of energy when the number of transmitters is relatively large.

As previously explained, the band-pass filters are preferably sharply tuned, and the number of available channels is increased by allotting a relatively narrow band to each channel. If the transmitter circuits were arranged to cause a sharp rise and fall in the voice frequency pulses, as would be the case, for example, if condenser C15 were omitted, the correspondingly abrupt changes in the currents supplied to the receiving filters would lessen their discriminating characteristics and possibly lead to the false operation of relays R associated with adjoining channels.

This difficulty remains, to a lesser degree, when resonant circuit elements and filters are interposed in the transmitter output circuit to reduce the rate of change of the currents constituting

the code pulses for the reason that such devices inherently produce transient currents in response to changes in amplitude of the impressed current, having frequencies which differ from their steady state resonant frequency. It will be clear that the transmitter of my invention is adapted to produce a minimum of transient disturbance in the receiving filters of adjacent channels, during the transmission of code pulses, so that the discrimination of the filters with respect to pulses constituting code signals is nearly the same as for steady state conditions, and that consequently the code channels may be more closely spaced. This is particularly desirable when the available frequencies are limited by the transmission characteristics of a carrier current telephone system, for example, as those within a band of frequencies of the minimum width acceptable for speech transmission.

Although I have herein shown and described only one form of voice frequency transmitter for a code communication system, it is to be understood that various changes and modifications may be made therein within the scope of the appended claims without departing from the spirit and scope of my invention.

Having thus described my invention, what I claim is:

1. In combination, an electron tube amplifier having a cathode, a grid and a plate, an output circuit for said tube extending from the plate of said tube through an impedance element to the positive terminal of a direct current source and from the cathode of said tube through a biasing resistor and condenser in parallel to the negative terminal of said source, an input circuit for said tube comprising a source of alternating current of substantially constant amplitude and frequency connected between the grid of said tube and said negative terminal, and keying means for at times causing said tube to be conductive to supply amplified alternating current to said output circuit and at other times causing said tube to be non-conductive, said keying means comprising a transmitting contact which in one position completes a connection from the cathode of said tube to the positive terminal of said source through a series resistor to supply a positive potential to the cathode of said tube, the parts being so proportioned that the tube is rendered non-conducting when said positive potential is supplied to the cathode and is rendered conducting when said connection is interrupted, said biasing resistor and condenser having a selected time constant for predetermining the rise and fall of the voltage of the direct current supplied to the cathode of said tube in response to the periodic operation of said transmitting contact.

2. A code transmitter comprising, in combination, a source of alternating current of substantially constant predetermined amplitude and frequency, an amplifier tube having a plate to cathode circuit connected to a source of direct current and a grid circuit supplied with an alternating current potential from said source of alternating current, an output transformer having a primary winding in said plate circuit and a secondary winding connected to the output terminals of said transmitter, and keying means for said transmitter comprising a transmitting relay adapted for code operation at a rate less than said predetermined frequency, means including a contact of said transmitting relay for supplying a positive biasing voltage to the cathode circuit of said amplifier tube and means comprising a resistance

capacitance network connected between said cathode and the negative terminal of said source to decrease the rate of rise and fall of said biasing voltage due to the operation of said transmitting contact whereby there is supplied to said output terminals code pulses of alternating current each pulse of which builds up and dies down according to the rise and fall of said biasing voltage.

3. A transmitter for use in a code communication system employing code pulses of alternating current, comprising a source of alternating current of substantially constant amplitude and frequency, an amplifier tube having a control grid, an anode, and a cathode, means for continuously applying a positive potential to said anode from a direct current source and an alternating current potential to said control grid from said source of alternating current, keying means for producing said pulses comprising a transmitting contact operable to a first and a second position at a given code rate for applying a positive biasing potential to the cathode of said amplifier tube at its first position whereby said tube is rendered non-conductive and at its second position removing said biasing potential so that said tube is rendered conductive, a resistance-capacitance network associated with the cathode of said tube for delaying the biasing and unbiassing of said tube, and an output transformer having a primary winding supplied with energy from the anode of said tube.

4. In a code transmitter for supplying code pulses of alternating current to a communication channel, the combination comprising a source of alternating current of substantially constant amplitude and frequency, an output transformer having a secondary winding connected to said communication channel, and keying means for supplying code pulses of alternating current from said source to a primary winding of said output transformer, said keying means comprising an amplifier tube having a plate circuit which includes the primary winding of said output transformer, a grid circuit connected to said source of alternating current, a transmitting contact which in one position connects the cathode of said tube to a source of direct current to thereby render said tube non-conductive, and a resistance capacity network for predetermining the rate of change of potential of said cathode in response to the periodic operation of said keying contact.

5. In a code transmitter for supplying code pulses of alternating current to a communication channel, the combination comprising, a source of alternating current of a given amplitude and frequency; an amplifier tube having a plate, a cathode and a control grid; a transformer having a primary and a secondary winding, said plate connected to the positive terminal of a source of direct current through said primary winding, said secondary winding connected to said channel, said grid connected to one terminal of said source of alternating current, a biasing circuit including a resistor and a capacitor in multiple, said cathode connected to the negative terminal of said direct current source and to the other terminal of said alternating current source through said biasing circuit, a contact adapted for operation to a first and second position at a given code rate, means including said first position of said contact and another resistor to connect said cathode to the positive terminal of said direct current source for alternately rendering said tube non-conductive and conductive at said code rate to supply code pulses of said alternating current to said channel,

and said biasing circuit proportioned for a time constant that provides a given rate at which said amplifier tube changes from its conductive to its non-conductive condition and vice versa.

DAVID P. FITZSIMMONS.

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