

Sept. 7, 1937.

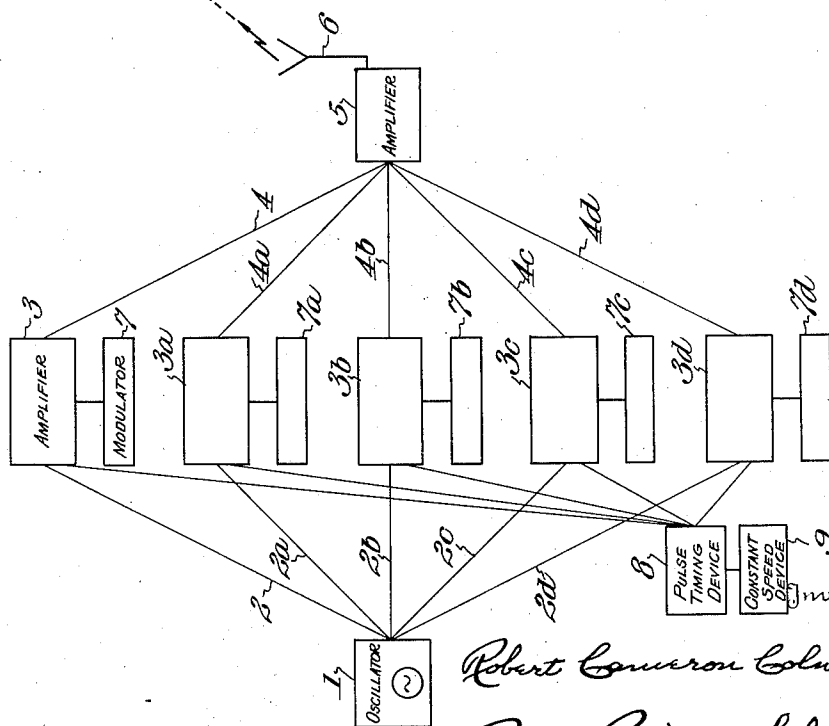
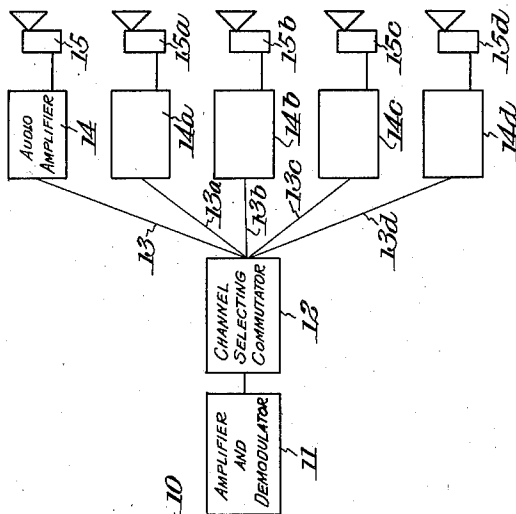
R. C. COLWELL

2,092,442

COMMUNICATION SYSTEM

Filed July 7, 1936

2 Sheets-Sheet 1



Robert Cameron Colwell,

By Potter, Pierce & Scheffler,
Attorneys.

Attorneys.

Sept. 7, 1937.

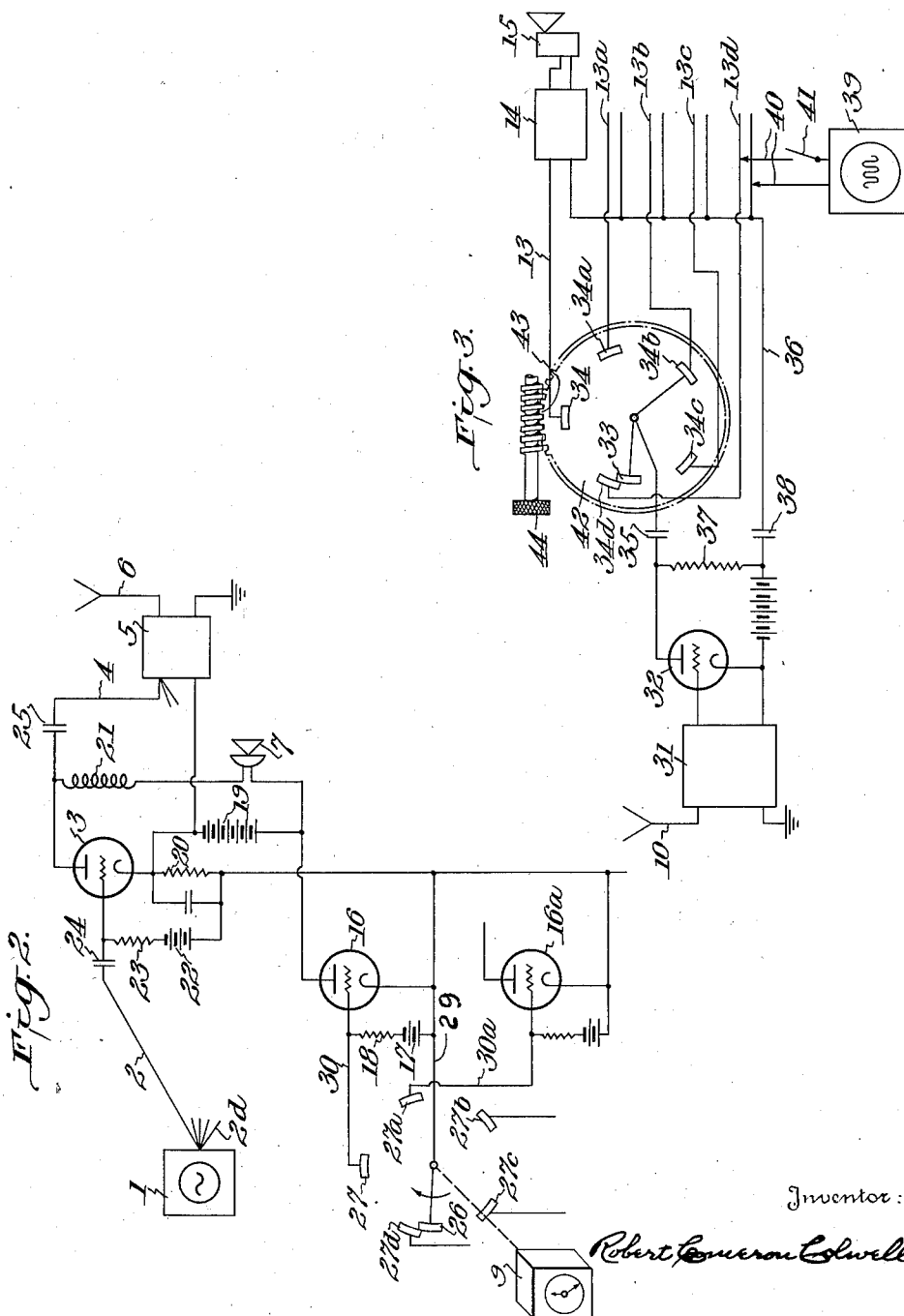
R. C. COLWELL

2,092,442

COMMUNICATION SYSTEM

Filed July 7, 1936

2 Sheets-Sheet 2



By Potter, Pierce & Schaffler,
Attorneys.

By Potter, Pierce & Scheffler
Attorneys.

UNITED STATES PATENT OFFICE

2,092,442

COMMUNICATION SYSTEM

Robert Cameron Colwell, Morgantown, W. Va.

Application July 7, 1936, Serial No. 89,411

7 Claims. (Cl. 250-9)

This invention relates to signalling systems and more particularly to systems of the type in which the plurality of signals, either telephone or telegraph, are transmitted by exceedingly short "square" pulses of carrier frequency energy. The time interval between consecutive pulses carrying one signal modulation is long, in comparison with the duration of each energy pulse, and the energy pulses of the several groups which each constitute a transmission channel are staggered and non-overlapping.

This method of effecting a substantially simultaneous transmission of messages, at the same or at different carrier frequencies, has been previously proposed but, so far as I am aware, the apparatus previously developed was unsatisfactory, being either impractical and difficult to adjust and maintain in operation, or definitely restricted to such low speed of operation as to result in a defective integration of the spaced sections of any one signal.

Objects of this invention are to provide a signalling or communication system including a sending station having simple and efficient timing mechanism for restricting the transmission of a signal to short closely spaced pulses of energy, and a receiving station for integrating the pulses of signal energy. An object is to provide a signalling system of the type stated in which the timing mechanism separates the transmitted energy into short and sharply defined pulses, the cut-off being so steep that the time interval between two consecutive energy pulses of one signal or transmitting channel permits the transmission of one or more pulses which constitute additional transmission channels.

A further object is to provide a radio signalling system, of either the single or multiplex type, which includes pulse timing mechanism for transmitting and for selectively receiving spaced pulses of carrier frequency energy, the length of the energy pulses and their spacing being so related as to exclude the reception of energy reflected from the ionosphere, thus eliminating fading and distortion. More specifically, an object is to provide a multiplex radio signalling system including a plurality of signal or modulating channels associated with a single antenna, and pulse timing means for effecting a transmission from said antenna of short spaced carrier energy pulses from the several signal channels; the pulse timing means being characterized by the use of at least one vacuum tube for each signal channel to obtain a short square energy pulse from that channel.

These and other objects and advantages of the invention will be apparent from the following specification when taken with the accompanying drawings in which:

Fig. 1 is a schematic view of a transmitting and receiving station of a multiplex communication system;

Fig. 2 is a fragmentary circuit diagram showing one communication channel of the transmitting station and the impulse system for timing the transmission along that and the associated channels; and

Fig. 3 is a fragmentary circuit diagram of the receiver equipment.

In the drawings, the reference numeral 1 identifies an oscillator and buffer unit for generating carrier wave energy of a predetermined, or if desired, an adjustable frequency. The oscillator is connected, through parallel leads 2, 2a, etc. to a plurality of amplifiers 3, 3a, etc. which work through leads 4, 4a, etc. into a common radio amplifier 5 and transmitting antenna 6. Each of the parallel amplifiers has its individual modulator 7, 7a, etc., which may be either a telegraph key or a microphone, and the transmission of signals through the several parallel channels is controlled by a pulse timing device 8 that is actuated by a constant speed driving device 9, such as a clockworks motor or a synchronous motor operating from a constant frequency source of alternating current power.

The receiving stations of the multiplex communication system may be adapted to receive one message transmitted from the sending station but, as shown in Fig. 1, each receiving station may include means for the simultaneous reception of all messages sent on the several transmission channels. The antenna 10 of a multiplex receiving station works into a radio amplifier and demodulator 11 that is followed by a channel selecting commutator 12 that passes the successive impulses of each message through leads 13, 13a, etc. to a plurality of audio amplifiers 14, 14a, etc. that each work into an individual reproducer 15, 15a, etc. Five channels are indicated in the drawings, but a greater or less number of channels may be used.

It will be apparent that, if the impulse timing device 8 operates to energize the several parallel transmitting channels in succession at short and sharply separated intervals, the energy transmitted from the antenna 6 will be in the form of spaced current impulses which, by appropriate selection at the receiving station or stations, may be integrated as successive pulses of a plurality

of messages. The method of operation may be best understood by first considering the transmission of a telegraph code message on one channel. If the impulse timing device is operated at such speed as to produce, for example, 500 current impulses per second in each channel, a receiver selectively responsive to any one channel will produce a 500 cycle note that is chopped into dots and dashes in accordance with the operation of the key of the modulating device 7 of that transmitting channel. The successive 500 cycle current impulses of the several channels are intermingled in transmission from the common antenna 6 but, by the synchronous operation of the impulse timing device 8 of the transmitter and the commutation device 12 at a receiving station, the impulses for each transmission channel are selectively distributed to individual receiving channels and reproducers.

The invention thus provides means for the simultaneous transmission of a plurality of messages between any two points or, when multiplex transmitters and receivers are located at a plurality of points, a simultaneous communication between a plurality of pairs of stations operating on the same frequency. It is obvious that the current impulses of the several channels must be sharply separated to prevent an overlapping of the different messages, and that this sharp separation must take place at a superaudible frequency in the transmission of speech over one or more of the channels.

Various forms of substantially inertia-free circuits for producing sharp or square-topped current impulses at high frequency may be obtained by the use of vacuum tubes. The particular arrangement illustrated in Fig. 2 includes a commutation tube 16 for each signal channel, the tube being normally biased to cutoff by a voltage source 17 which is connected between the tube grid and cathode through a bias resistor 18; the plate circuit of the commutation tube including a voltage source 19 and a resistor 20 that is also an element of the grid-cathode circuit of the modulating radio frequency amplifier tube 3 of one of the signalling channels. The plate circuit battery 19 of the commutation tube 16 may also serve as the plate current source for the amplifier tube 3, the positive terminal of the battery being connected to the plate of tube 3 through the modulating device 7 and a choke 21, while the negative terminal is connected to the cathode of tube 3. The grid circuit of tube 3 includes the resistor 20 in series with a bias voltage source 22 and resistor 23, this direct current circuit being isolated from the oscillator 1 by a condenser 24. A blocking condenser 25 is included in the lead 4 from the plate of tube 3 to the common amplifier 5 which works into the antenna 6. The wiring for only one signal channel is shown and it is to be understood that similar elements and circuits are included in each of the plurality of signal channels.

The commutation tube 16 and amplifier 3 are both normally biased to cutoff, and these blocking biases are momentarily removed by the impulse timing device 8 which may comprise a contact arm 26 rotated at constant speed by a mechanical clockwork of high precision, a synchronous motor operating from an alternating current power source of constant frequency or equivalent means, the contact arm sweeping over a plurality of uniformly spaced contacts 27, 27a, etc. The rotating contact arm 26 is connected by a lead 29 to the cathode of the commutation tubes,

and the several contacts are connected through leads 30, 30a, etc. to the grids of the commutation tubes. The switch or timing device therefore operates to short out the biasing circuits of the commutation tubes, thus successively removing the blocking bias potentials and permitting a flow of current in the plate circuits of those tubes. This flow of space current through the resistors 20 produces a potential drop across those resistors which reduces the bias on the amplifier tubes 3, 3a, etc. to values appropriate for normal amplification. The tubes 3, 3a, etc. therefore pass carrier wave energy from the oscillator 1 in short sharply-timed impulses, and this carrier wave energy is modulated by the devices 7, 7a, etc.

It is particularly to be noted that the short-circuit current pulses resulting from the successive shorting of the biasing circuits of the several commutation tubes are sharply timed as the minute currents do not cause sparking when the moving contact 26 leaves a stationary contact. The tubes 16 have a substantially instantaneous response to the reduced bias voltage and, consequently, the unblocking of the amplifier tubes 3 is substantially coextensive with the short intervals during which contact arm 26 engages the stationary contacts. An accurate timing of the short current pulses of the several signalling channels is thus obtained and there is no tendency for a carrier wave pulse to persist beyond the interval during which its commutation tube is unblocked by the pulse timing device.

It would be possible to transmit current pulses of adjacent channels with substantially no intervening gap in the case of wired transmission but, with radio transmission through space, a sharp separation of successive current pulses at the transmitting station is not effective to prevent an overlapping of different signal pulses at a receiving station. The current pulses directly transmitted between the stations will be sharply separated but reflections from the ionosphere could result in the reception of the primary current pulse of one channel simultaneously with a reflected current pulse of the preceding signal channel. This overlapping of signals is eliminated by spacing successive current pulses from each other by a substantial time interval, i. e. by providing an appreciable gap between successive stationary contacts 27 of the pulse timing device.

In the case of telegraph signals, the pulse timing device may operate at such speed as to produce about 500 pulses per second for each channel, with contacts 27 of such length and so spaced as to produce current pulses of the order of a few microseconds or milliseconds. Any reflections from the short current pulses of one channel will disappear before the current pulses of the next channel reach the receiver. The current pulses for any one channel may therefore be integrated at a receiver to produce a signal which is not confused by energy transmitted along other channels.

The equipment at the receiving station, Fig. 3, includes a radio frequency amplifier 31 working into a demodulator 32 that is followed by the channel selecting commutator 12. This unit may be a switch having a rotating contact arm 33 which sweeps over the series of relatively stationary contacts 34, 34a, etc. that are connected by leads 13, 13a, etc. to the filter and audio frequency amplifiers 14, 14a, etc. of the separate reproducers 15, 15a, etc. The contact

arm of the commutator is connected to the plate of the demodulator 32 through a condenser 35, and the common low potential side 36 of the several audio amplifier units is similarly connected to the cathode terminal of the demodulator plate impedance 37 by the blocking condenser 38.

A cathode ray tube 39, or tube and amplifier, may be connected across one of the receiver channels, by detachable leads 40, a telephone plug or the like, to check the synchronous operation of the commutating devices at the transmission and receiving stations. The cathode ray tube may be operated continuously on one channel while receiving signals on one or more of the other channels, or a switch 41 may be provided for bringing the cathode ray tube into and out of operation without disturbing the connections to the signal channel.

The contact arm 33 of the channel selecting commutator is rotated by a clockwise mechanism, not shown, or other constant speed device operating in exact synchronism with the pulse timing device of the transmitter. A lack of exact synchronism will be indicated by the image produced on the screen of the cathode ray tube, and appropriate adjustments may be made in the speed of rotation of the commutating device at the receiver. Changes in the time of commutation, but without change in the frequency, may be effected by mounting contacts 34 to 34d on a head 42 having a worm edge 43 in mesh with an adjusting screw 44.

Operation at exact synchronism thus permits the simultaneous transmission of a plurality of messages between two stations, or the simultaneous transmission of different messages from one sending station to each of a plurality of receiving stations. The equipment at each station will preferably include both a transmitter and a receiver and it is thus possible for a number of stations in the communication system to carry on a number of two-way communications simultaneously on the same wave length. Ships A and B may use two channels for their messages, while ships C and D are using two other channels, or messages may be exchanged between five pairs of ships when each pair operates on a single channel.

While the frequency of transmission need not be the same for each channel, it is believed that the additional expense of installing and maintaining equipment for operating on different frequencies for the different channels will be greater than any advantage which might be obtained. Complete separation of the signals results when the time interval between successive signal pulses is of such length that all appreciable reflection of one pulse from the ionosphere has passed the receiver before the succeeding signal pulse is received.

The drawings illustrate equipment for the radio transmission of signals but it is to be understood that the stations may be connected by wires for the transmission of either telegraph or telephone signals. The frequency of the signal pulses must be above the audio range of reproduction in the case of telephone signals and, when the system is to be used for both telephone and telegraph signals, some form of chopper may be used to produce an audio frequency note at the receivers.

It is to be understood that the invention is not limited to the exact circuits herein shown and described as the exact form and relation-

ship of the component parts are subject to wide variation without departure from the spirit of my invention as set forth in the following claims.

I claim:

1. In a multiplex signalling system, the combination with an oscillator for generating a carrier frequency, and a transmission system, of a plurality of amplifiers providing parallel paths between said oscillator and transmission system, means normally biasing each of said amplifiers to block transmission therethrough, a separate signal producing means for each of said amplifiers, and timing means for successively unblocking the several amplifiers at a frequency of an order substantially higher than any signal frequency to be transmitted; said timing means including a commutator tube for each amplifier and operative upon the flow of space current therethrough to reduce the bias on that associated amplifier to permit transmission therethrough, means normally biasing each commutation tube to prevent the flow of space current therethrough, and commutation means for successively reducing the bias on the several commutation tubes in recurrent cycles, thereby effecting a successive transmission of current pulses by said amplifiers.

2. In a multiplex signalling system, the combination with a source of carrier frequency energy, a transmission system, and a plurality of amplifiers connected in parallel between said source and said transmission system, of modulating means for each amplifier, means normally blocking the transmission of carrier frequency energy through the several amplifiers, and pulse timing means successively unblocking the amplifiers to transmit carrier energy in short pulses spaced apart by time intervals which exceed the transmission time of energy pulses reflected from the ionosphere.

3. In a multiplex communication system, a source of carrier frequency energy, a transmission medium, a plurality of modulating radio frequency amplifiers connected in parallel between said energy source and said transmission medium, each amplifier including a vacuum tube having a grid-cathode resistor and means biasing the tube to cut-off, and pulse timing means for rendering said amplifiers operable in succession; said pulse timing means including for each amplifier a commutation vacuum tube having in its plate-cathode circuit the grid-cathode resistor of the associated amplifier, means biasing the several commutation vacuum tubes to cut-off, and timing means for successively reducing the bias on said commutation tubes to render the same conductive, thereby to establish potential drops across said grid-cathode resistors to unblock the associated amplifier tubes.

4. In a multiplex communication system, a source of carrier frequency energy, an antenna, a plurality of modulating radio frequency amplifiers connected in parallel between said energy source and said antenna, each amplifier including a vacuum tube having a grid-cathode resistor and means biasing the tube to cut-off, and pulse timing means for rendering said amplifiers operable in succession for intervals spaced apart by time periods in excess of the transmission time of signals reflected from the ionosphere; said pulse timing means including for each amplifier a commutation vacuum tube having in its plate-cathode circuit the grid-cathode resistor of the associated amplifier, means biasing the several commutation vacuum tubes to cut-off, and timing

means for successively reducing the bias on said commutation tubes to render the same conductive, thereby to establish potential drops across said grid-cathode resistors to unblock the associated amplifier tubes.

5 5. The method of multiplex transmission of signals from a radio transmitter to one or more receivers which comprises transmitting a succession of carrier energy current pulses from the transmitter, modulating the successive current
10 pulses in groups by different signals, selectively reproducing at a receiver the modulation corresponding to one signal, and spacing successive current pulses by time intervals which prevent
15 the simultaneous reception of one current pulse by direct transmission and of the preceding current pulse by reflection from the ionosphere.

20 6. In the multiplex transmission and reception of signals by modulating successive pulses of carrier wave energy with different signals, the method of preventing a simultaneous reception of two signals corresponding to the signal modu-

lation impressed upon successive current pulses which comprises separating successive current pulses by time intervals of greater extent than the time required for transmission of current pulses by reflection from the ionosphere.

5 7. In the multiplex transmission of signals to a receiver by the process which comprises modulating successive carrier wave pulses of transmitted energy with different signals and selectively reproducing at the receiver the modulation of time
10 spaced energy pulses corresponding to a single signal, the method of preventing the overlapping reception of two signals which comprises spacing successive energy pulses to prevent the simultaneous arrival at the receiver of a directly
15 transmitted energy pulse and of a preceding energy pulse by reflection from the ionosphere, and restricting the intervals of signal reproduction at the receiver to time periods corresponding to the arrival of directly transmitted signals.
20

ROBERT CAMERON COLWELL.