June 11, 1929. W. A. PHELPS 1,717,062

ELECTRIC SIGNALING

Filed July 31, 1926

Fig.1

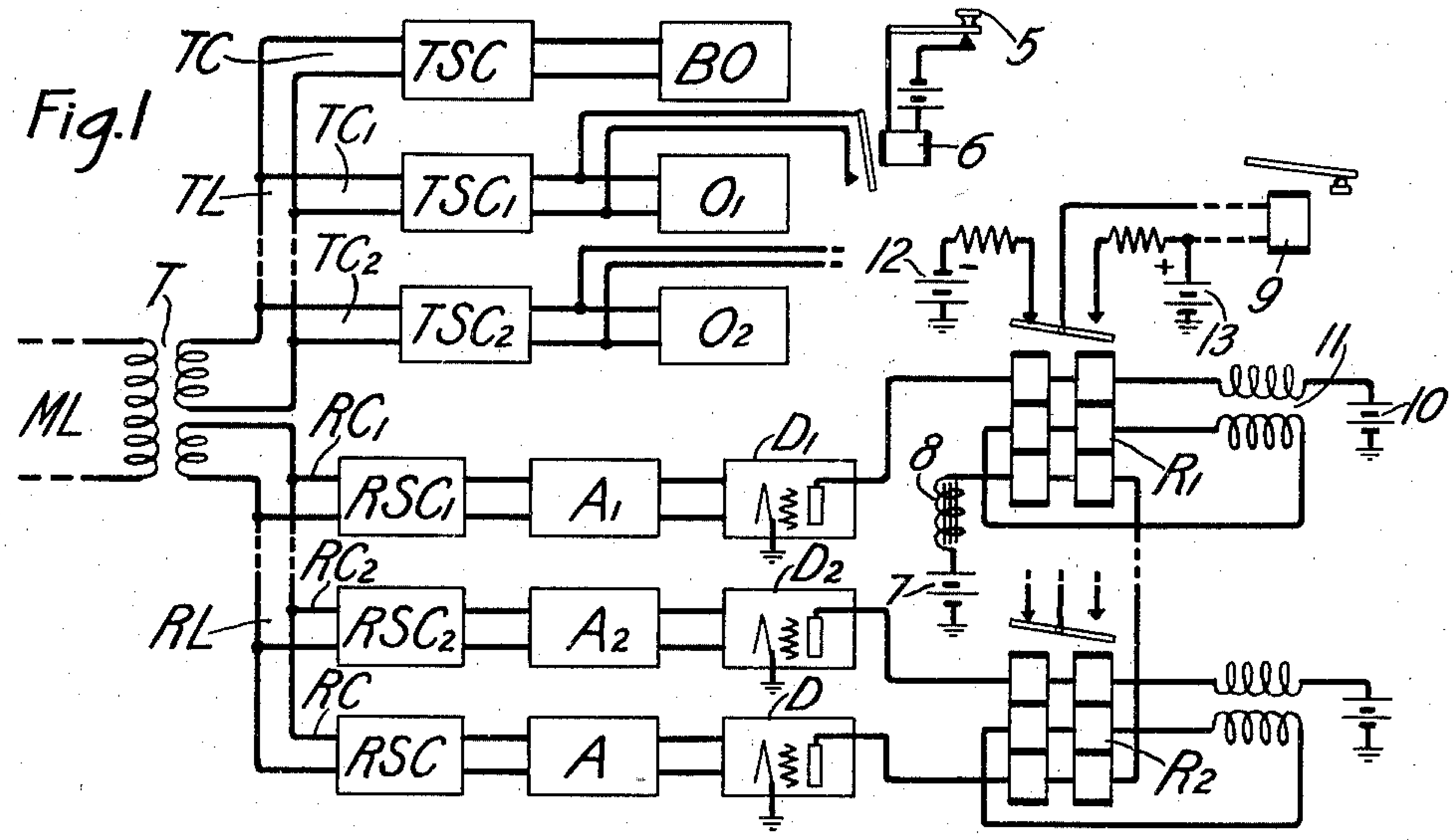


Fig.2

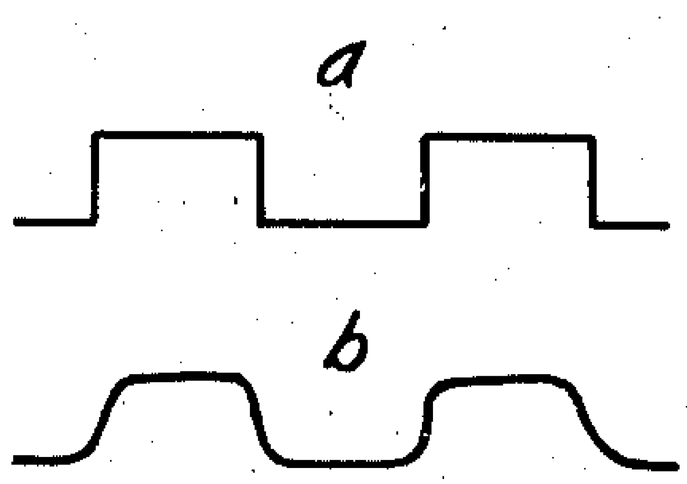


Fig.3

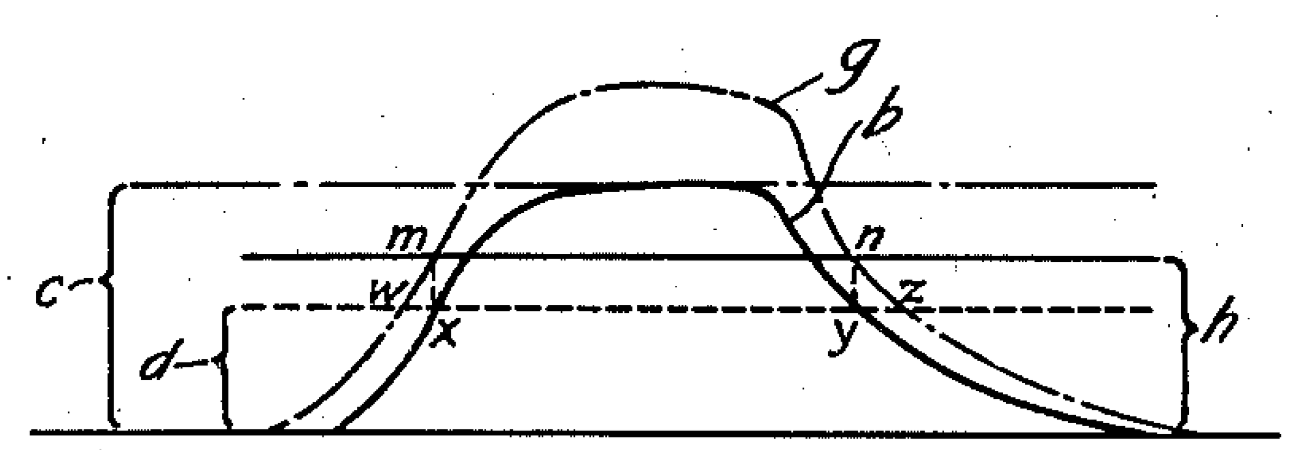
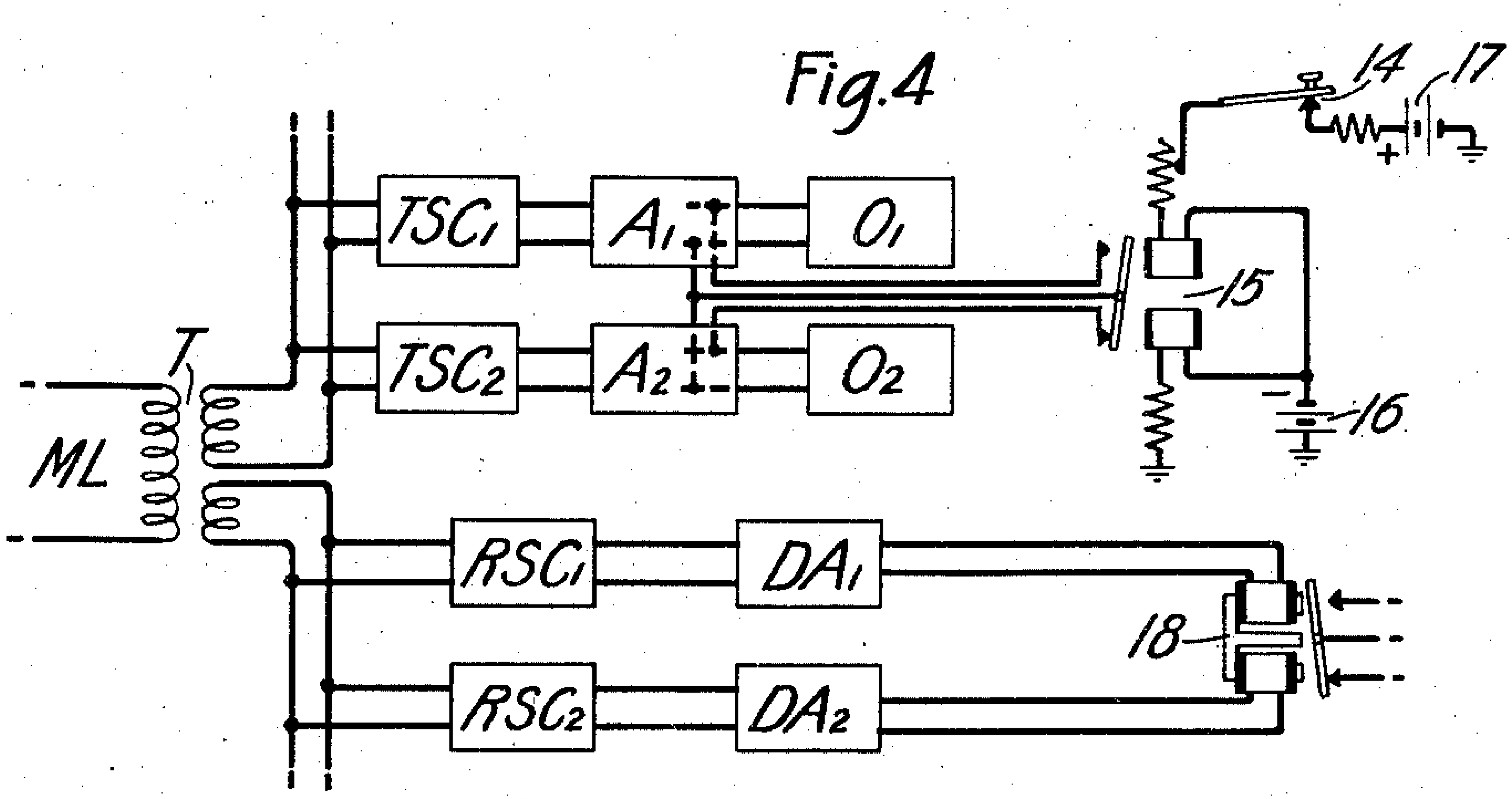


Fig.4



Inventor:
Walter A. Phelps
by W. Griggs
Attorney

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UNITED STATES PATENT OFFICE.

WALTER A. PHELPS, OF CLIFTON, NEW JERSEY, ASSIGNOR TO BELL TELEPHONE LABORATORIES, INCORPORATED, OF NEW YORK, N. Y., A CORPORATION OF NEW YORK.

ELECTRIC SIGNALING.

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This invention relates to electric signaling and particularly to carrier current telegraph systems.

An object of the invention is to stabilize the operation of carrier current telegraph systems.

A related object of the invention is to reduce distortion in such systems and thereby increase the speed of operation.

A specific object of the invention is to render the reception of signals substantially independent of changes in the attenuation of the medium over which the signals are transmitted.

According to common practice in carrier current telegraph systems, a relay in the receiving circuit is thrown to its marking position by the action of rectified incoming carrier current, corresponding to dots and dashes. No carrier current is received during a spacing interval, and the armature of the receiving relay is returned to its spacing position by the action of a direct current through an auxiliary biasing winding of the relay. A multiplex carrier current telegraph system of this type is shown in Fig. 55 of an article by Messrs. Colpitts and Blackwell entitled "Carrier current telephony and telegraphy" published in the Transactions of the American Institute of Electrical Engineers, vol. 40, 1921.

In systems of this type there is no constant relation between the restoring force on the armature of the receiving relay and the force which tends to throw the armature to the marking position. The former varies only with variations in the voltage of a local battery at the receiving station, while the latter depends mainly on the attenuation of the line over which the signals are transmitted. The amplitude of the received carrier current varies appreciably in response to changes in the attenuating properties of the transmission line, while the local biasing current remains unaffected by such changes, thus tending to produce distortion in the signals which makes it necessary to reduce the speed of operation of the system.

This difficulty is largely overcome by means of the present invention by causing the restoring current through the biasing winding of the receiving relay to vary approximately in the same way as the incoming carrier currents. In carrying out the invention, the biasing winding of each receiving relay at a terminal is supplied with a current transmitted over the line with the telegraph signals, but through a separate channel, so that changes in the line condition will affect equally the transmitted signals and the biasing current. In this way the rectified current and the biasing current will vary in a corresponding manner with changing line conditions, thus tending to eliminate bias in the received signals.

According to a modification of the invention, a marking signal is transmitted by means of a carrier current of a particular frequency, and a spacing signal is transmitted by means of a carrier current of another frequency. According to this method, each receiving relay at a terminal is thrown to its marking position, in the usual manner, by means of rectified incoming carrier current, and is restored to its spacing position by passing another rectified incoming carrier current through the biasing winding of the relay, any change in the transmission condition of the line affecting both currents in substantially the same manner.

The various features of the invention will be described in connection with the accompanying drawing in which:

Fig. 1 is a diagrammatic illustration of a terminal of a multiplex carrier current telegraph system embodying the invention;

Figs. 2 and 3 show curves used in describing the operation of the system of Fig. 1; and

Fig. 4 is a diagrammatic illustration of a modified system.

In Fig. 1 there is shown the east terminal of a multiplex carrier current telegraph system, the usual west terminal, which is identical to the east terminal, being omitted for the sake of simplifying the showing. The drawing shows only so much of the Morse telegraph equipment as is necessary for a complete understanding of the invention, this equipment being similar to that shown in Fig. 55 of the Colpitts and Blackwell article, supra.

The terminal circuits include a plurality of transmitting channels TC_1, TC_2, connected to a common transmitting circuit TL, and a plurality of receiving channels RC_1, RC_2, connected to a common receiving circuit RL. The common transmitting circuit TL and the common receiving circuit

RL are coupled to the multiplex transmission line ML by means of a three-winding transformer T.

Carrier currents are utilized for transmission over the line ML and are grouped as to their frequencies, and according to common practice the lower frequencies as a group are used for transmission from west to east, and the higher frequencies as a group are used for transmission from east to west.

Each transmitting channel includes a source of carrier current, a circuit for modulating the carrier current in accordance with signal impulses, and a selective circuit. These channels are identical in construction and hence detailed reference will be made only to the apparatus of channel TC_1.

The outgoing channel TC_1 comprises an oscillator O_1, a sending key 5, a sending relay 6 and a transmitting selective circuit TSC_1. These elements are shown in detail in Fig. 55 of the Colpitts and Blackwell article, supra. The selective circuits employed in the system may be either resonant circuits, or may be band filters of the type disclosed in Patent No. 1,227,113 to G. A. Campbell, issued May 22, 1917. The oscillators O_1, O_2, are adapted to generate carrier currents of the different frequencies which are assigned to the respective transmitting channels.

Carrier currents of the frequency assigned to the channel TC_1 are normally transmitted from oscillator O_1 through selective circuit TSC_1, common transmitting circuit TL, and transformer T to the multiplex transmission line ML. When the sending key 5 is opened the sending relay 6 is deenergized and the oscillator O_1 is short-circuited at the contact of the sending relay. The manipulation of the sending key 5 thus controls the sending relay 6, which in turn impresses the signals on the outgoing carrier current. Carrier currents of the frequencies assigned to other transmitting channels are similarly impressed upon the line ML.

Each receiving channel includes a receiving selective circuit, an amplifier, a detector and a receiving relay. These channels are all identical except, of course, that the constants of the selective circuits differ to the extent necessary to accommodate the different frequency carrier currents employed. The receiving channel RC_1, for example, comprises a receiving selective circuit RSC_1 which may be a resonant circuit or a band filter, an amplifier A_1, a detector D_1 and a receiving relay R_1. Carrier currents incoming over the line ML are transmitted through transformer T to the common receiving circuit RL where they are picked up by the respective selective circuits for transmission to the proper channels. Currents of the frequency assigned to channel RC_1, for example, are transmitted through selective circuit RSC_1, are amplified and detected in the amplifier A_1 and detector D_1 and caused to actuate receiving relay R_1.

In addition to the signaling channels indicated, a control channel is also connected to the line ML, employing a frequency different from that of any of the signaling channels, for the purpose of supplying biasing current to the relays in all the receiving circuits. The channel TC for transmitting the biasing current includes an oscillator BO and a selective circuit TSC. The channel RC for receiving the incoming biasing current includes a receiving selective circuit RSC, an amplifier A and a detector D. The output circuit of the detector D includes a source of space current 7, a choke coil 8 and the lower biasing windings of the several receiving relays R_1 and R_2.

The biasing current is continuously transmitted over the line from the distant terminal and the space current flowing in the output circuit of the detector D causes the armatures of the relays R_1, R_2, to be maintained in the spacing position during the intervals when no carrier currents are received over the signaling channels. Under such conditions, the armature of relay R_1, for example, is moved to its spacing position and the associated sounder 9 is deenergized. When carrier currents of the frequency assigned to channel RC_1 are received, which is the condition shown in the drawing, space current is caused to flow in the output circuit of the detector D_1 from grounded battery 10, through the primary winding of transformer 11, upper windings of relay R_1, to the plate of detector tube D_1, and thence through the space discharge path to the grounded filament. The upper windings of relay R_1 carry a greater current than the lower biasing windings and are so poled that the magnetic effect of the rectified current flowing therein overpowers the magnetic effect produced by the biasing current and causes the armature of the relay to be moved to the marking position shown in the drawing. When the armature of relay R_1 is in this position, the sounder 9 is actuated by current flowing over a circuit extending from ground, through battery 12, armature of relay R_1, winding of sounder 9, battery 13, to ground.

During a spacing interval when no carrier current is received in the channel RC_1, the armature of relay R_1 is moved to its spacing position by the action of the rectified current flowing continuously in the circuit including the space current path of detector D and the lower windings of all the receiving relays. The choke coil 8 serves to prevent signal currents in any receiving relay R_1 or R_2 from building up currents in the common biasing circuit which might affect other receiving relays to which the biasing circuit is connected. The secondary winding of the transformer 11 is connected to the central auxiliary windings of the relay R_1 and a change of current in this circuit causes a building up of flux which accelerates the operation of the relay, as is common practice in carrier telegraphy.

It will be seen that the signaling currents and the biasing current are affected by the same transmission conditions on the line ML and hence that the rectified signaling currents and biasing current are caused to rise and fall together whenever the attenuating properties of the line ML vary due to changing weather conditions, etc., thus tending to eliminate bias in the received signals. The operation of the system under changing line conditions is illustrated by the curves of Figs. 2 and 3. In Fig. 2, a signal originally impressed upon the line ML at a transmitting terminal is represented by the curve a, but as a result of passing over the line and through the terminal selective circuits this signal, at the receiving terminal, assumes the form represented by the curve b. The enlarged curve b of Fig. 3 represents a single dot signal such as is received, for example, in the receiving channel RC_1. The value of the rectified current produced by this incoming signal is c, and the equivalent value of the biasing current is d. When the rectified signal current rises to the value d, the armature of the receiving relay is thrown over to its marking position, and when it falls again below this value the armature of the relay is restored to its spacing position by the action of the biasing current. A change in the attenuation of the line ML causes a change in the form of the signal b, a decrease in the line attenuation, for example, causing the signal to take the form indicated by the curve g. If the biasing current remains unchanged, the receiving relay will be actuated for the same current as before, and in such case the signal will be distorted by the amount $wx+yz$. However, if the biasing current is also caused to rise, for example to the value h, due to the same conditions which cause the signaling current to rise, the length of the signal will then be mn, which is close to the original length xy. The invention, therefore, by maintaining the signaling currents and the biasing current always in the proper relation to each other, tends to eliminate the distortion heretofore caused by changes in the line attenuation.

In carrying out the invention it is not necessary to decrease the number of communication channels available within a given frequency range in order to add the two additional channels required for the purpose of transmitting biasing current in both directions over the line. Since no signals are transmitted over these channels, only a very narrow band of frequencies is required, and these frequencies may be placed in the usual dead space between the two oppositely directed groups of signaling frequencies. For example, in a multiplex system employing ten channels in one direction utilizing frequencies lying between 3300 and 5500 cycles, and ten channels in the opposite direction employing frequencies lying between 6500 and 10000 cycles, the biasing frequencies may lie in the frequency space between 5500 and 6500 cycles.

In the modified system illustrated in Fig. 4, a marking signal is transmitted by means of a carrier current of one frequency and a spacing signal is transmitted by means of a carrier current of another frequency. The marking and spacing currents preferably lie close together in the frequency scale so that any change in line attenuation will affect both currents in substantially the same manner. This system requires two transmitting and two receiving channels at each terminal for each complete two-way transmission. Furthermore, since it is necessary to employ two frequencies for the transmission of signals in each direction instead of one frequency as in the system described above, only half as many channels may be included in a given frequency range as in the above system. This system, however, provides a highly satisfactory method of transmission, since the quality of the signals is substantially independent of variations in line attenuation, and may be employed to advantage when only a relatively small number of communication channels and high quality transmission are required.

In the system of Fig. 4, when the transmitting key 14 is closed, as shown in the drawing, the upper winding of transmitting relay 15 is energized over a circuit extending from ground, through battery 16, upper winding of relay 15, key 14, battery 17 to ground. Under such conditions, the lower contact of relay 15 is closed, thus short-circuiting the output of oscillator O_2, and the upper contact is open, thus permitting carrier current to be transmitted from oscillator O_1, through amplifier A_1, transmitting selective circuit TSC_1, transformer T to the line ML. Although current is at all times supplied to the lower winding of relay 15 from battery 16, the upper winding of this relay carries a greater current than the lower winding when the key 14 is closed, since the energizing circuit of the upper winding includes batteries 16 and 17 in series aiding, producing a magnetic effect sufficient to overcome that of the lower winding. The oscillator O_1 furnishes the current for actuating the receiving relay at the distant terminal to its marking position, and is transmitting at all times when the key 14 is closed. When the key 14 is open, the upper winding of transmitting relay 15 is deenergized and the lower winding of this relay is energized over a circuit extending from ground through battery 16, lower winding of relay 15 to ground. The armature of relay 15 is actuated, opening its lower contact and thus removing a short circuit from the output of the oscillator O_2 and closing its upper contact and thus short-circuiting the output of the oscillator O_1. The oscillator O_2 transmits spacing current through amplifier A_2, selective circuit TSC_2, transformer T to the line ML.

The marking current incoming over the line ML is selectively transmitted by the selective circuit RSC_1, and is amplified and rectified in the detector-amplifier DA_1, the rectified current energizing the upper winding of receiving relay 18 and thus attracting the armature of this relay to its marking position. The spacing current, of a different frequency, incoming over the line ML, is selectively transmitted through the selective circuit RSC_2 and is amplified and rectified in the detector-amplifier DA_2, the rectified current energizing the lower winding of the relay 18 to move the armature of this relay to its spacing position.

Although the invention has been described in connection with certain specific embodiments, it is also susceptible of numerous other applications without departing from the scope and spirit of the invention as defined by the appended claims.

What is claimed is:

1. In a signaling system having a translating device associated with a variable transmission medium over which currents of different frequencies are transmitted, the method of reducing distortion which comprises operating said device in one direction in response to current of a particular frequency, and continuously biasing said device in another direction in response to current of another frequency.

2. In a signaling system in which a receiving relay is operated in one direction in response to a signaling current traversing a conducting path having variable attenuating properties, and is operated in another direction in response to a biasing current, the method of reducing distortion which comprises subjecting said biasing current to substantially the same conditions causing attenuation as those affecting the signaling current, whereby changes in the attenuation of said path will affect equally the signaling current and the biasing current.

3. In a signaling system having a plurality of receiving relays associated with a variable transmission medium over which signaling currents are transmitted, the method of reducing distortion which comprises operating said relays in one direction in response to signaling currents comprised within mutually exclusive bands of frequencies, transmitting over said medium a bias control current and utilizing said bias control current to operate said relays in common in another direction.

4. A telegraph system comprising a medium over which currents of different frequencies are transmitted, a receiving relay, means for operating said relay from its spacing to its marking position in response to current of a particular frequency, and means for operating said relay from said marking position to said spacing position in response to current of another frequency.

5. A telegraph system comprising a medium over which currents of different frequencies are transmitted, a receiving relay having a main winding and a biasing winding, means for energizing said main winding in response to current of a particular frequency, and means for continuously energizing said biasing winding in response to current of another frequency.

6. A telegraph system comprising a medium over which currents of different frequencies are transmitted, a receiving relay including a main winding and a biasing winding having a smaller number of ampere turns than said main winding, means for energizing said main winding in response to current of a particular frequency, and means for continuously energizing said biasing winding in response to current of another frequency.

7. A multiplex carrier current telegraph system comprising a medium over which carrier currents of different frequencies are transmitted, a plurality of receiving relays, means for operating said relays from their spacing to their marking positions in response to currents comprised within mutually exclusive frequency bands, and means for operating said relays from said marking to said spacing positions in response to a common current of another frequency.

8. A multiplex carrier current signaling system comprising a circuit for receiving carrier currents of different frequencies, a plurality of receiving channels associated therewith, a translating device in each of said channels operated in response to currents of a particular frequency, a control channel associated with said receiving circuit for continuously receiving current of a frequency different from the signaling currents, and means for operating said devices in response to said control current when no signaling current is received by the associated channel.

9. A multiplex carrier current telegraph system comprising a circuit for receiving

currents of different frequencies, a plurality of receiving channels associated therewith, selective circuits for transmitting mutually exclusive bands of signaling frequencies to said channels, a detector in each of said channels, a receiving relay in each of said channels having a winding in the output of the detector therein to actuate said relay to its marking position, a control channel associated with said receiving circuit for continuously receiving current of a frequency different from the signaling frequencies, a detector in said control channel, and an auxiliary winding on each of said receiving relays connected to the output of said last mentioned detector, said auxiliary windings being so proportioned and so poled as to cause said relays to be returned to the spacing position when no signaling current is received in the associated receiving channel.

10. In a telegraph system employing a two-position relay, means to transmit current of one frequency controlled in accordance with signals, means to transmit current of another frequency to indicate spaces, and means for actuating said relay under the sole control of said currents of the two frequencies, the current of one of said frequencies actuating the relay to one of its two positions and the current of the other mentioned frequency causing the relay to move out of such position into its other position.

In witness whereof I hereunto subscribe my name this 30th day of July A. D., 1926.

WALTER A. PHELPS.