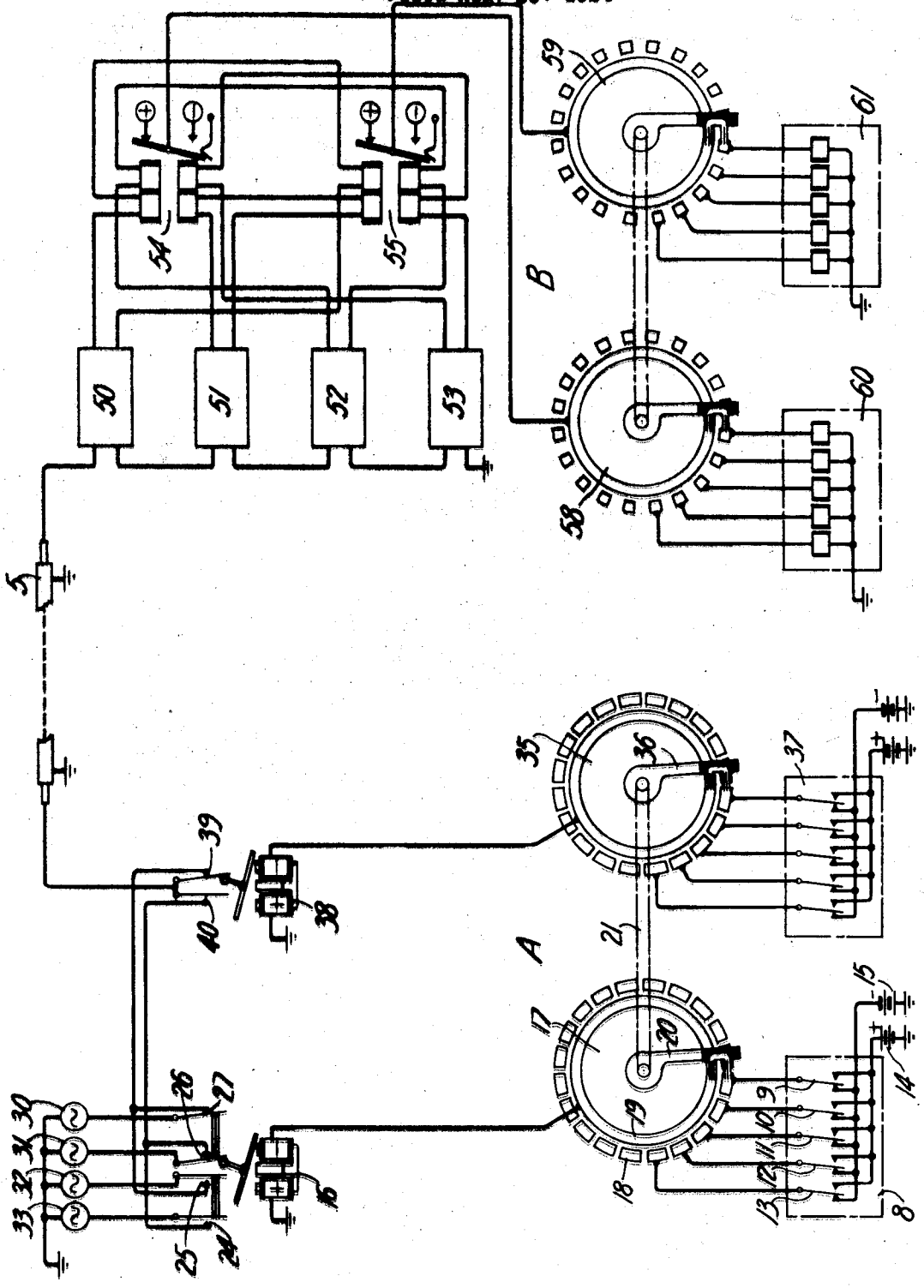
June 14, 1927. 1,631,976

R. C. MATHES

SIGNALING

Filed Aug. 26. 1924



Inventor:
Robert C. Mathes
by E. W. Adams Att'y.

Patented June 14, 1927. 1,631,976

UNITED STATES PATENT OFFICE.

ROBERT C. MATHES, OF WYOMING, NEW JERSEY, ASSIGNOR TO WESTERN ELECTRIC COMPANY, INCORPORATED, OF NEW YORK, N. Y., A CORPORATION OF NEW YORK.

SIGNALING.

Application filed August 26, 1924. Serial No. 734,150.

This invention relates to alternating current signaling, but more especially has to do with the adaptation of carrier multiplex telegraphy to loaded submarine cables.

In the present type of carrier multiplex telegraph system, such as that employed on land lines, current values of different frequencies are allotted to the respective signaling channels and transmission may be effected by the simultaneous application of several current frequencies to the line. Owing to the very character of the line, the impedance of which remains substantially constant irrespective of current changes, and the apparatus employed, which comprises vacuum tubes operated on the linear portion of the characteristic curve, no appreciable intermodulation or interference between the several current frequencies results. However, in the case of loaded cables, which preferably are continuously loaded with a magnetic material characterized by extremely high permeability at low magnetizing forces, any considerable variation in the current produces a relatively large change in the permeability and, consequently, in the impedance of the cable, so that crossfire or intermodulation of the several channels results when the current frequencies are applied simultaneously. These factors render the present type of carrier multiplex telegraph system unsuitable for operation with continuously loaded cables of considerable length which require relatively large sending energies.

It is an object of the present invention to overcome the difficulty described in the previous paragraph and thereby increase the signaling capacity of inductively loaded cables.

Another object of the invention is to employ a plurality of alternating currents of different frequencies to signal in a novel manner.

In the embodiment of the invention chosen for illustration, a plurality of transmitters, each capable of selectively providing combinations of signaling impulses in accordance with selective operations, are simultaneously brought into operative relation with electro-responsive devices which control the application of a predetermined current frequency to the cable to impart thereto, in succession, the current frequencies representing the various code combinations of direct current signaling impulses. An equal number of receiving printers are associated with the opposite end of the cable, which are likewise simultaneously connected to the cable through a suitable electro-filtering device responsive to currents of particular frequencies for recording the action of the received currents. The invention is adapted primarily to the Baudot or five-unit code and accordingly has been shown applied to such a system, but it is not limited to use in this particular type of system.

A better understanding of the invention may be had from the following description when taken in conjunction with the accompanying drawing which, for the sake of clearness, shows only so much of the system as is necessary for an accurate understanding of the invention.

Referring now to the drawing, stations A and B constituting transmitting and receiving stations, respectively, are connected by a continuously loaded cable 5. This continuously loaded cable 5 is constructed in accordance with the preferred form of the invention in a manner similar to that described in patent to O. E. Buckley 1,586,874, June 1, 1926. For more detailed information as to the construction and characteristics of the cable, reference should be had to the noted patent which describes in detail the features of the continuously loaded cable.

The transmitting and receiving mechanisms shown at stations A and B are shown diagrammatically, as the specific details of these mechanisms are well known and especially since the invention is not directed to these mechanisms per se.

Each of the transmitters, which is adapted to selectively and simultaneously impart various code combinations of message impulses comprises a plurality of circuit controlling elements 9, 10, 11, 12 and 13, each consisting

of a movable element which cooperates with a pair of fixed contacts. Normally, the movable elements are in engagement with the left hand fixed contact which is connected to the negative terminal of battery 15. Each of the selectable elements 9 to 13, inclusive, is adapted to engage either of its cooperating contacts for applying either positive or negative current impulses to an electroresponsive device, as will be later described.

There may be as many transmitters, each composed of selectable elements 9 to 13, as desired, each transmitter being allotted to a particular section or quadrant of the associated synchronous multiplex distributor. The system illustrated in the drawing is arranged for four transmitters to each distributor. The transmitters associated with the different quadrants of the various distributors are successively brought into operative relation with the associated electroresponsive device and thence to the cable 5 by suitable rotating brushes.

The selectable elements 9 to 13, inclusive, of the several transmitters may be selectively operated in a number of different ways. In the preferred form of the invention these selectable elements are operated automatically in accordance with the perforations appearing in a previously perforated tape, which is brought into operative relation with the selectable elements 9 to 13.

The synchronous multiplex distributor 17, which is adapted to successively connect the transmitters associated with that distributor with the associated electroresponsive device and thence to the cable 5 comprises a segmented ring 18, a continuous ring 19 and a brush arm 20, which carries a brush for bridging the smaller segments with the continuous ring 19 and which is fixed to a shaft 21. The shaft 21 is adapted to be rotated by power communicated thereto from a continuous rotating motor and is arranged to be maintained in synchronism with similar distributors at the receiving station. It is noted that the apparatus for maintaining synchronism has not been shown as this particular mechanism does not form a part of the present invention and also since such mechanisms are well known to those skilled in the art. The continuous ring 19 of the distributor 17 is connected to polarized relay 16, controlling a plurality of contacts 24, 25, 26 and 27. Each of these contacts is individual to a source of alternating current, such as 30, 31, 32 and 33 and upon each operation of the relay 16, two of these sources of alternating current are connected to the associated circuits, but as will be described later but one of these sources is connected to the continuous loaded cable 5, extending to station B.

In order to provide a plurality of channels of communication other distributors similar to distributor 17, such as 35 are provided, which successively associate transmitters designated by the numeral 37 with a similar electroresponsive device 38. The various distributors bear the same phase relation with respect to each other by mounting the brush arms, such as 36, on the same shaft as brush arm 20. The selectable elements of the transmitter 37 are successively connected to the windings of polarized relay 38, which controls the operation of contacts 39 and 40 and it is through these contacts that one of the two sources of alternating current connected to the associated circuits upon each operation of the relay 16 is selectively connected to the cable 5.

At the receiving station B, the currents impressed on the continuously loaded cable 5 by the operation of the relays 16 and 38 pass through a plurality of electro-filters 50, 51, 52 and 53. Each filter 50, 51, 52 and 53 comprises inductance and capacitance, which are so proportioned in accordance with well-known laws of alternating current phenomena, that each filter is responsive to currents of only a particular frequency, being practically unresponsive to currents of all other frequencies. In the system disclosed the filter 50 is responsive only to currents of the frequency supplied by the alternating current source 30, filter 51 to currents of the frequency supplied by the alternating current source 32, filter 52 by the currents from the alternating current source 31 and filter 53 from the currents of the alternating current source 33. Each of the filters 50, 51, 52 and 53 has its output circuit operatively connected to a winding of each of multiple contact relays 54 and 55. Each of these relays will thus be selectively operated in accordance with the particular frequency impressed on the filters and will in turn control circuits extending to distributors 58 and 59. Each of these distributors 58 and 59 simultaneously connects printing telegraph receiving printers 60 and 61 with the contacts of the relays 54 and 55. Inasmuch as the distributor brushes of each of the distributors 58 and 59 bear substantially the same phase relation as the distributor brush arms 20 and 36 of the transmitting distributors 17 and 35, respectively, they will traverse corresponding quadrants of associated distributors simultaneously.

The operation of the system will now be described. Assume for the sake of illustration that tapes previously perforated in accordance with the various code combinations of impulses representing the message pass through the tape transmitters 8 and 37 simultaneously. The tapes passing through the transmitters 8 and 37 will in all probability contain different perforations and, consequently, the selecting elements 9 to 13 of each of the transmitters will be oper-

ated in different combinations. Also assume that the selectable elements 13 of each of the transmitters has been moved so that they engage the right hand contact. Then too, that the selectable element 12 of transmitter 8 remains in the position shown while the corresponding selecting element of transmitter 37 has been moved to engage its right hand contact. On the passage of the brush carried by brush arm 20 on to the segment individual to the selectable element 13 positive current is supplied through the continuous ring 19 to the windings of relay 16. Simultaneously with this operation the brush carried by the distributor brush arm 36 engages the segment individual to the corresponding selectable element of the transmitter 37 and applies through its continuous ring positive current impulse to the windings of relay 38. Each of the relays 16 and 38 thus reverses the position of its armature, relay 16 closing contacts 24 and 25 and opening contacts 26 and 27 while relay 38 opens contact 39 and closes contact 40. The closure of contacts 24 and 25 of relay 16 connects the alternating current sources 32 and 33 with the contacts of relay 38, but inasmuch as but one of these contacts is closed, but one of the alternating current sources will be connected to the cable 5; in this particular case alternating current source 33 is connected through the contact 24 of relay 16 and contact 40 of relay 38 with the cable 5.

The impulse from the alternating current source 33 upon being received at the receiving station B traverses the input circuits of each of the filters 50, 51, 52 and 53. As previously stated, these filters are made responsive to a particular alternating current frequency and in the particular case selected the filter 53 responds to current from the alternating current source 33. A current in accordance with the impressed alternating current is applied to the output circuit of the filter 53 which passes through the lower right hand winding of relay 54 and the lower left hand winding of relay 55. In the case of relay 54, its armature will be positioned to connect the positive terminal of battery with the continuous ring of the distributor 58. Likewise relay 55 moves its armature to also connect the positive terminal of the battery to the continuous ring of the distributor 59. Inasmuch as the distributors 58 and 59 operate in synchronism with the distributors 17 and 35 at the transmitting station A, the segments corresponding to the segments individual to the selectable elements 13 of each of the transmitters 8 and 37 will be connected with the continuous ring through a suitable brush at the instant the relays 54 and 55 respond to the transmitted impulse for effecting the operation of the associated electromagnets of the receiving printers 60 and 61. It should be noted that both of the transmitters 8 and 37 were operated to transmit a positive impulse; accordingly relays 54 and 55 at the receiving station B were operated for applying through the distributors 58 and 59 to the receiving printers 60 and 61 simultaneously a corresponding impulse. Now with the selectable elements 12 of each of the transmitters 8 and 37, one in the position shown in the drawing and the other in its opposite position, the relays 16 and 38 will be operated upon the engagement of the brush of the associated distributor with the segment individual to the particular selectable element of the transmitter. In the case of the relay 16 its armature is caused to reverse its position, disconnecting the alternating current sources 32 and 33 and connecting the alternating current sources 30 and 31 through the contacts 26 and 27. Simultaneously with the operation of relay 16, relay 38 is operated for again closing contact 40. The operation of the relays 16 and 38 in this manner now connects the alternating current source 31 with the cable 5.

The impulse from the alternating current source 31 upon being received at the station B passes through each of the filters 50, 51, 52 and 53, but imparts current to only one of the output circuits of these filters. In this particular case current flows in the output circuit of the filter 52 through the upper right hand winding of relay 54 and lower right hand winding of relay 55. The armature of relay 54 is caused to reverse its position and connect the negative terminal of the battery with the distributor 58, while the relay 55 connects the positive terminal of battery with the distributor 59. The operation of the selecting magnet of the receiving printers 60 and 61 is effected in a manner similar to that previously described.

The invention has been illustrated for two channels of communication but obviously the system may be extended for providing additional channels of communication. Should more channels of communication be desired, it is only necessary that additional distributors be provided and additional contacts on each of the relays whereby the number of selective combinations may be effected for the transmission of a single alternating current frequency designating the combinations of plus and minus impulses. At the receiving station additional equipment must also be provided for accommodating the added channels of communication. In general it will be seen that for n channels, 2^n distinct frequencies will be needed for using this method of operation.

The invention has been disclosed and described with reference to a particular type of system but it is not intended that the

invention should be limited to this particular type of system as obviously various modifications may be made without departing from the spirit and scope of the present invention.

What is claimed is:

1. The method of transmitting intelligence which comprises generating alternating currents of a plurality of different single frequencies, selecting each of said currents respectively to represent portions of a plurality of messages and transmitting said currents only in succession.

2. The method of transmitting intelligence which comprises transmitting an alternating current of constant single frequency that represents portions of a plurality of separate messages and utilizing said current to cause simultaneously a plurality of separate indications respectively corresponding to said message portions.

3. The method of transmitting intelligence which consists in generating a plurality of alternating currents of different, pure, frequencies, applying the currents of different frequencies to a signaling path in succession and utilizing each current to designate various combinations of impulses of equal duration, each impulse in part representing a code character.

4. The method of transmitting intelligence from a plurality of channels simultaneously over an inductively loaded conductor which comprises applying portions of separate messages simultaneously to said conductor by means of one of a plurality of alternating currents of different, single frequencies, and similarly utilizing the other currents of different frequencies, and utilizing the selected single frequency current to represent a combination of impulses of equal duration, each combination consisting of portions of separate messages.

5. The method of receiving intelligence transmitted electrically through the successive application of alternating currents of different frequencies, each representing a combination of impulses for portions of separate messages, which method comprises filtering the several currents of different frequencies, and utilizing the filtered current of each frequency to control the simultaneous recordation of the portions of the plurality of messages represented by the current of that frequency.

6. In a telegraph system, a line connecting two stations, a plurality of transmitters arranged to be selectively and simultaneously operated in various combinations, a plurality of sources of current of different frequencies, and means operable for connecting any one of the said different sources of current to said line in accordance with one of the combinations set up by the simultaneous operation of said transmitters.

7. In a telegraph system, a line connecting two stations, a plurality of transmitters each arranged to be selectively operated in various combinations, a plurality of sources of alternating current of different, single frequencies, and electro-responsive means controlled by said transmitters for successively imparting, to said line, current impulses of different, single frequencies each representing a combination of separate message impulses.

8. In a telegraph system, a line connecting two stations, a plurality of transmitters each arranged to be selectively operated in various combinations, a plurality of sources of alternating current of different, single frequencies, and electroresponsive means individual to each of said transmitters and controlled thereby for successively imparting to said line current impulses of different, single frequencies each representing a combination of separate message impulses.

9. In a telegraph system, a line connecting two stations, a plurality of transmitters each arranged to be selectively operated in various combinations, a plurality of sources of alternating current of different, single frequencies, and multiple contact relays energized in accordance with the operation of said transmitters for selecting the particular current frequency designating the combination determined by said transmitters and imparting corresponding current to said line.

10. In a telegraph system, a line connecting two stations, a plurality of transmitters each arranged to be selectively operated in various combinations, a plurality of sources of current of different, single frequencies, means operated in accordance with the operation of said transmitters for selecting and connecting the different sources of current successively to said line, and distributing means for simultaneously associating said transmitters with said means.

11. In a telegraph system, a line connecting two stations, a plurality of transmitters at one of said stations, means for rendering said transmitters effective simultaneously during each impulse period, electro-responsive means controlled by said transmitters for imparting to said line during each period an alternating current impulse of a frequency dependent on the combination set up on said transmitters, receiving means associated at the other end of said line comprising a plurality of recording instruments, and selectively operated means controlled by the incoming combination for causing the simultaneous operation of said instruments in accordance with the code combination transmitted by said transmitters.

12. In a telegraph system, a line connecting two stations, a plurality of transmitters at one of said stations, means for rendering

said transmitters effective simultaneously during each impulse period to transmit portions of separate messages, electro-responsive means controlled by said transmitters for imparting to said line alternating current impulses of a frequency dependent on the combination set up on said transmitters, receiving means associated at the other end of said line comprising a plurality of recording instruments, a plurality of electro-filters each responsive to a particular current frequency, means associated with said filters and operated to reproduce the current combination similar to that set up by said transmitters during each impulse period, and means controlled by said last mentioned means for simultaneously registering the impulses of a combination on separate recording instruments.

13. In a telegraph system, a line connecting two stations, a plurality of transmitters at one of said stations, means for rendering said transmitters effective simultaneously, electroresponsive means controlled by said transmitters for imparting to said line alternating current impulses of a frequency dependent on the combination set up on said transmitters, receiving means associated at the other end of said line comprising a plurality of electro-filters each responsive to a particular current frequency, a number of relays associated with said filters, and operated to reproduce current conditions similar to those set up by said transmitters, and means controlled by said relays for recording the effect of the impulses.

14. In a telegraph system, a loaded submarine cable connecting two distant stations, a plurality of transmitters at one of said stations, means for rendering said transmitters effective simultaneously, electroresponsive means controlled by said transmitters for imparting to said cable alternating current impulses, each of a single frequency dependent on the combination set up on said transmitters, receiving means associated at the other end of the cable comprising a plurality of recording instruments and selectively operated means controlled by the incoming impulses for causing the operation of said instruments in accordance with the code combination of impulses transmitted by said transmitters.

15. In a telegraph system, a continuously loaded submarine cable of variable permeability extending between two distant stations, a plurality of transmitters at one of said stations, means for rendering said transmitters effective simultaneously, electroresponsive means controlled by said transmitters for imparting to said cable alternating current impulses, each of a single frequency dependent on the combination set up on said transmitters, and means controlled by said relays for recording the effect of the impulses.

16. In a telegraph system, a continuously loaded submarine cable extending between two distant stations, a plurality of transmitters at one of said stations, means for rendering said transmitters effective simultaneously, electro-responsive means controlled by said transmitters for imparting to said cable alternating current impulses, each of a single frequency dependent on the combination set up on said transmitters, receiving means associated at the other end of said cable comprising a plurality of electro-filters each responsive to a particular current frequency, a pair of relays associated with said filters, and operated to reproduce current conditions similar to the setting by said transmitters, and means controlled by said relays for recording the effect of the impulses.

17. In a telegraph system, a line connecting two stations, a plurality of transmitters at one of said stations, means for rendering said transmitters effective simultaneously, electroresponsive means controlled by said transmitters for imparting to said line alternating current impulses, each of a single frequency dependent on the combination set up on said transmitters, receiving means associated at the other end of said line comprising a plurality of frequency selecting systems, electromagnetic relay means controlled by said frequency selecting systems, a plurality of receiving printers for each transmitter, and distributing means for associating the receiving printers corresponding to said transmitters simultaneously with said electromagnetic relay means.

18. In a telegraph system, a line connecting two stations, a plurality of transmitters at one of said stations, means for rendering said transmitters effective simultaneously, electroresponsive means controlled by said transmitters for imparting to said line alternating current impulses of a frequency dependent on the combination set up on said transmitters, receiving means associated at the other end of said line comprising a plurality of frequency selecting systems, electromagnetic relay means controlled by said frequency selecting systems, a plurality of receiving printers for each transmitter and synchronous multiplex distributors for associating the receiving printers corresponding to said transmitters simultaneously with said electromagnetic relay means.

19. A signaling system comprising a plurality of message channels, means associated with each channel for producing a plurality of signal elements of different characteristics, for example, plus and minus impulses, in combination with a plurality of alternating current sources producing currents of

different frequencies, mechanism whereby each possible combination of signaling elements, selecting one element from each channel, selects and impresses upon a signaling conductor a distinctive alternating current from said plurality of sources, said current always containing fewer different essential frequency components than there are channels.

In witness whereof, I hereunto subscribe my name this 23rd day of August, A. D. 1924.

ROBERT C. MATHES.