

July 1, 1941.

C. R. DOTY

2,247,909

COMMUNICATION SYSTEM

Filed Dec. 5, 1939

3 Sheets-Sheet 1

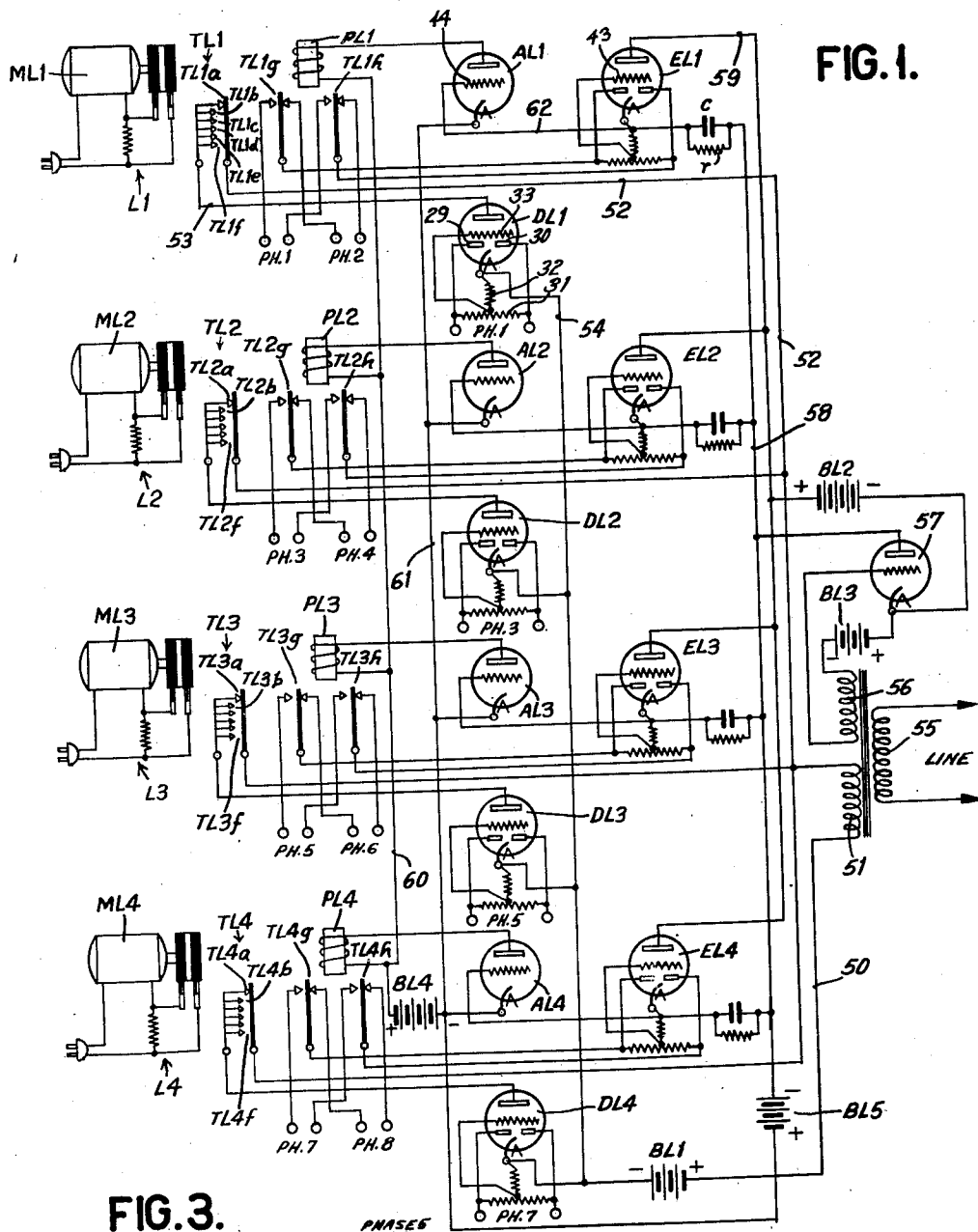


FIG. 1.

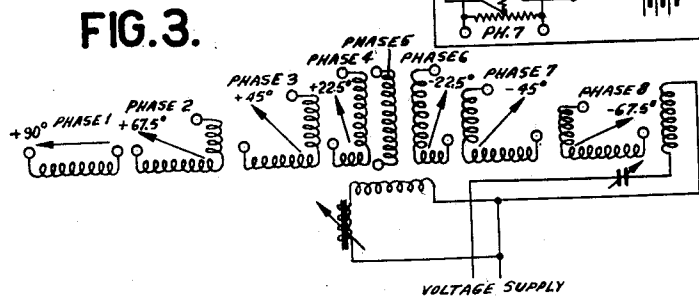


FIG. 3.

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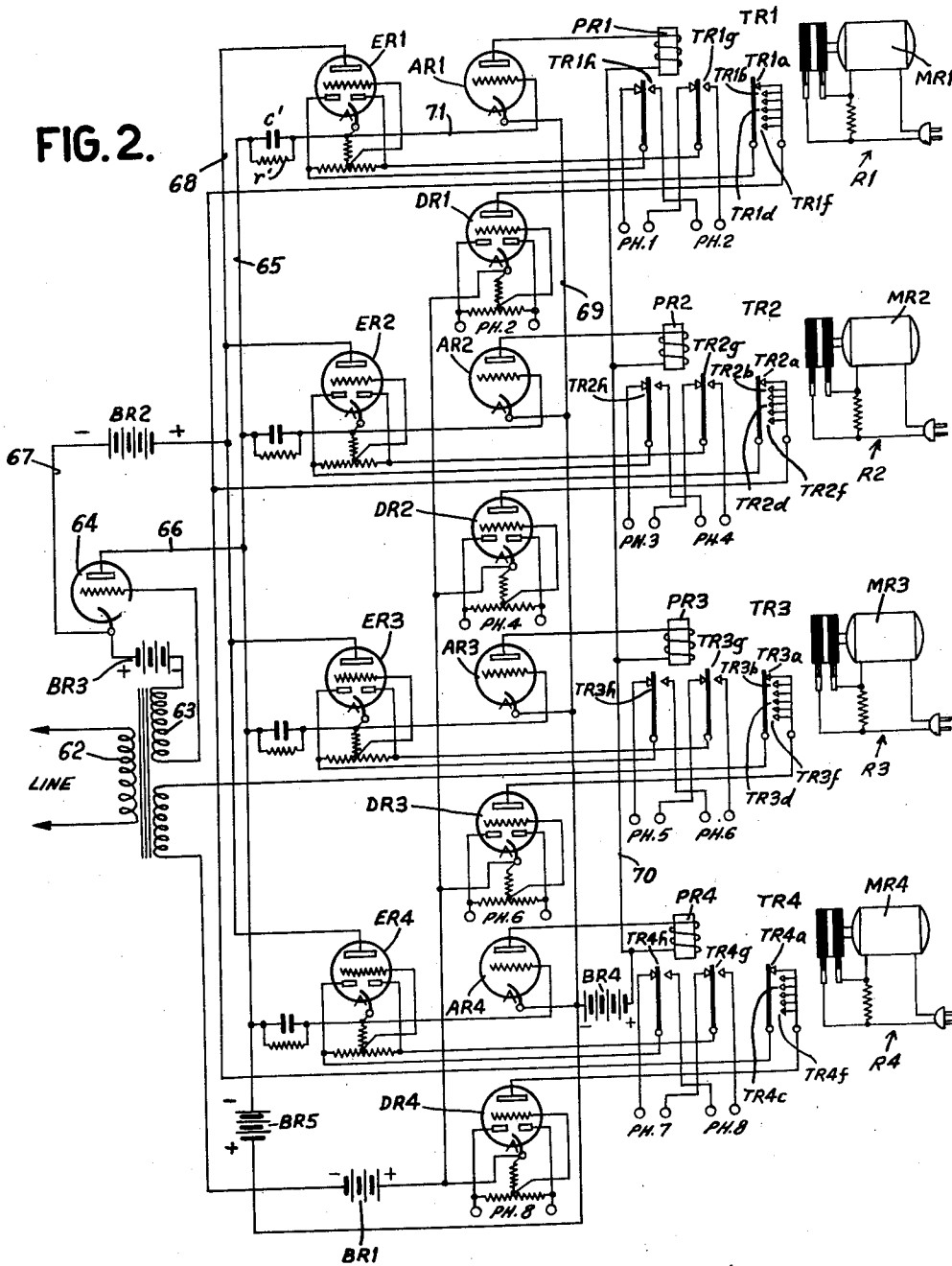
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FIG. 2.



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FIG. 4.

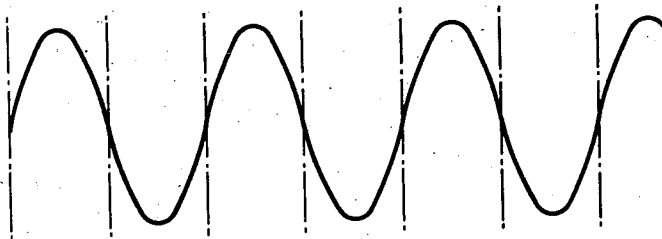


FIG. 4a.

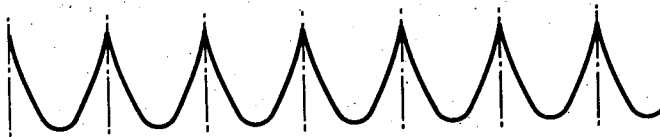


FIG. 4b.

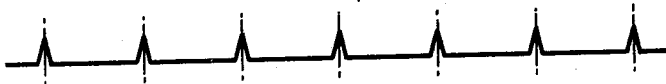
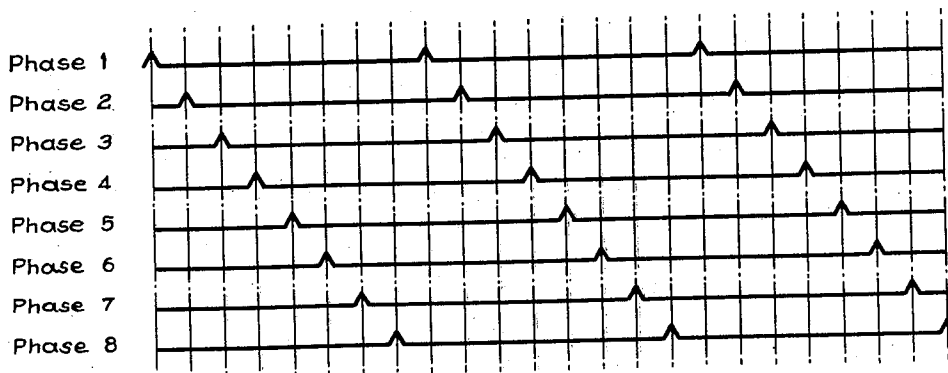


FIG. 5.



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COMMUNICATION SYSTEM

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Application December 5, 1939, Serial No. 307,568

3 Claims. (Cl. 178—50)

This invention relates to communication systems and, more particularly, to two-way transmission systems comprising a plurality of start-stop printers adapted for operation over a single working channel.

It is the general object of the instant invention to provide an improved system wherein the customary two wires connecting the transmitting and receiving portions of the system have their control properties and their transmission capacities greatly increased by means of phase-splitting, a factor which permits simultaneous operation of a plurality of start-stop printers at both stations with the same facility as though they were each connected by individual metallic circuits.

More specifically, it is proposed to send coded impulses of different phase relationship from each transmitter so as to permit receiving units to be selected for operation in accordance with the different phases of the impulses and thereby to provide for multiple unit control over a single working channel without signal interference.

According to the instant invention, a plurality of teletypewriter machines or the like are located at each end of a single transmission line and arranged for transmitting or receiving impulses corresponding to data. The circuit structure at each end of the line is similar and includes a phase transformer, a plurality of electronic tubes and, of course, the machines themselves. Some of the electronic tubes act as transmission valves and others as receiving valves, one transmission valve and two receiving valves being associated with the transmitting unit and receiving unit, respectively, of each machine. The transmission valves are each impressed with a different phase potential from the phase transformer. Each of these valves, however, remains inoperative insofar as the passage of impulses to the line is concerned until the transmitting unit of its associated machine is operated to initiate impulses corresponding to data. At such time, the tube passes current impulse waves of a particular phase which are then impressed on the transmission line. The receiving valves also have different phase potentials from the phase transformer impressed on them, the reception of impulses of a phase corresponding to the phase of the impressed potential causing the tube to pass current for operating the recording unit to record the data. By virtue of the fact that the impulses transmitted from each machine at one end of the line

to a corresponding machine at the other end of the line have different phase characteristics, there is no signal interference. Sending over the line in the opposite direction is effected in the same way, each wave impulse identifying by its phase the machine which effected its transmission. Thus, the proposed system presents, in effect, an improved method of multiplexing by multiphasing.

Other objects of the invention will be pointed out in the following description and claims and illustrated in the accompanying drawings, which disclose, by way of example, the principle of the invention and the best mode, which has been contemplated, of applying that principle.

In the drawings:

Figs. 1 and 2 are wiring diagrams of the primary and secondary stations, respectively.

Fig. 3 is a diagram of the phase connections of a phase transformer from which eight different phases may be taken.

Figs 4, 4a, and 4b taken together, show the effect of the rectifying action of the discharge tube connected to one of the phases of the transformer.

Fig. 5 illustrates the manner in which a plurality of signals may be impressed on a line at the same time without interference.

Referring now to the drawings, and particularly to Figs. 1 and 2, three main operating units of a standard start-stop teletypewriter are represented symbolically by the reference characters M, T, and P in a conventionally diagrammatic form. M refers to a motor which may be governor controlled or synchronous; T refers to a set of cam operated transmitting contacts which are arranged to close at differential times to initiate coded combinations of impulses corresponding to data characters, and P refers to a signal magnet which operates in response to signals from the transmission line and which controls any well-known mechanism (not shown) for effecting selective character printing. To the standard arrangement has been added two sets of transfer contacts bearing the reference characters Tg and Th at each machine station, and these contacts are caused to transfer simultaneously with the opening of the normally closed set of teletypewriter line current contacts Ta and to again assume the position shown when the latter contacts are again closed so as to transmit the "stop" signal to the line. In operation, this system closely follows standard "start-stop" printer operations which will now be reviewed briefly for the purpose of clarity.

Reference may be made to the Kinkhead Patent No. 1,795,652, dated March 10, 1931, for more detail as to the operation and structure of these systems.

In "start-stop" systems the receiving mechanisms are stopped at the end of each character cycle and are again started when the next letter is transmitted. All machines on the circuit must, therefore, operate at substantially the same speed in order that the sending and receiving mechanisms may always be in the same relative position. The motors which drive the units are equipped with governors which keep their speed within the required limits. When closely regulated alternating current is available, synchronous motors may be used. In this system current is on the line during the normal idle condition of the machines and the transmitting is done by opening the circuit so that no current will flow, or closing it to cause current to flow. These electrical impulses are referred to as a code. The most commonly used code is known as the Baudot code, in which the same number of elements (ordinarily five) are transmitted for each character to be printed or function to be performed. These two conditions of current or no current in the line are known as marking and spacing impulses respectively.

In transmission, the depression of a typewriter key sets up a mechanical condition corresponding to the code combination of the character to be printed or the function to be performed. The circuit condition of marking or spacing impulses at the time of transmission of the five selecting impulses, provides a total of 32 different combinations.

Preceding the transmission of the five selecting elements is a period of no line current which is called the "start" time. This signal is sent automatically as soon as the sending mechanism is put into operation and initiates the operation of the receiving mechanism on all the receiving machines connected to the circuit. Following the selecting signals, current is again put on the line and this is called the "stop" impulse. This impulse arrests the operation of the receiving mechanism of all the receiving instruments connected to the circuit. In keyboard sending the maximum length of the stop impulse depends upon the time the operator hesitates between the striking of the individual keys of the teletypewriter.

Four sets of standard start-stop printer stations, represented generally by reference characters L1 to L4, are shown in Fig. 1 and likewise four more designated R1 to R4 are set forth in Fig. 2. In order to facilitate describing the circuits in the explanation in the wiring diagram which is given hereinafter, the reference characters referred to in the preceding paragraph are provided with suffixes L or R, followed by a numeral 1 to 4, which allocate them to the particular machine stations L1 to L4 or R1 to R4 as the case may be. The mechanism at each machine station is similar and thus a description of the transmission of a signal from say machine ML1 and a reception of that signal on machine MR1 will explain the principle of operation of the system.

The signal system employs a multi-phase principle comprising a plurality of signals which may be impressed on the transmission line simultaneously without interference, the different phases being devised from phase transformers at the

primary and secondary stations in a manner which will now be described.

Referring to Fig. 3, it will be noted that the action of the phase transformer shown in that figure is to take single phase synchronous alternating current and sub-divide the same into as many equally spaced phases as may be required by the system. In the present embodiment eight such phases are arranged to be supplied by each transformer. Transformers of this type are provided at both primary and secondary stations and are adapted to be connected to various tube circuits at these stations for the purpose of supplying them with electrical energy of different phase relationships. The internal connections of the transformers are not shown but may be of the type explained in detail in U. S. Patent No. 2,153,178, to Clyde J. Fitch, dated April 4, 1939. The turns ratio of the windings are such that the voltage delivered across the free ends of the secondary circuits are equal. For purposes of illustration, eight such secondary circuits are provided and are designated PH1 to PH8. Different phase sine wave currents are taken off the various phase connection outlets of the secondary transformer for transmitting purposes, but it is obvious that a plurality of, let us say, sixty cycle sine waves cannot be transmitted simultaneously over the working channel of a single network to effect the various required operations of the system. In order to overcome this difficulty, the wave shapes similar to that of a sine wave are changed to the forms illustrated in Fig. 5, one method of which will now be described.

Referring now to Fig. 4, a sinusoidal wave form of alternating current is shown and is similar to the current wave forms developed by each of the plurality of secondary circuits of the phase transformer. These sinusoidal current waves may then be impressed upon any type of full wave rectifier to change the shape of the current waves to conform to that shown in Fig. 4a which is representative of a pulsating current wave form. In turn, the rectified current wave may then be applied as follows: If the voltage rectified wave form shown in Fig. 4a is impressed on the grid of a thermionic tube, for example, and the voltage is sufficient to drive the tube far below its plate current cut-off point, the shape of the current wave in the plate circuit will be altered to conform to the shape shown in Fig. 4b. The characteristics of the circuits may be selected and adjusted so that the length of the base of the short impulses shown in Fig. 4b is approximately $\frac{1}{8}$ of the distance between the impulses. Of course, it is obvious that the particular wave shapes may vary according to the characteristics of the circuits employed, and it is very evident by the method just described or by the conversions based upon the same principles that many different shapes of the resultant current may be obtained. Accordingly, a preferred method is given.

In further explanation of the principle of wave conversion just described, this entire action may take place automatically in a single thermionic tube of a type well known in the art comprising a combination of a full wave rectifier and triode in one envelope. The electrical connections for this type of tube may be as shown in the wiring diagrams for tubes DL1 to DL4, DR1 to DR4, EL1 to EL4 and ER1 to ER4. It will be noted that the alternating voltage of the sinusoidal wave is applied across a center tapped resistor 31 (see tube DL1 in Fig. 1). In each of the

tube circuits the wave shape of the current flowing through this resistor or the voltage across it assimilates a wave form similar to that shown in Fig. 4. A resistor 32 is connected between the cathode of the tube and the center tap of resistor 31, the terminals of which are connected to the two rectifier plates 29, 30 of the said tube. Therefore, the wave shape of the rectified current through resistor 32 and the voltage across this resistor become similar to that shown by the pulsating wave in Fig. 4a. The grid 33 of the tube may also be connected to the center tap of resistor 31, the grid being normally at zero bias due to the fact that no current is passing through resistor 32. Then, the voltage across resistor 32 may be applied between the grid and cathode of said tube.

If the said voltage is of sufficient value, the tube may be driven far below its plate current cut-off point to obtain a plate current having the wave shape similar to that shown in Fig. 4b. This is impressed accordingly on a connected output circuit of the tube which will be described later in connection with the general circuits of the system. Any suitable form of direct current supply may be employed for supplying electrical energy to the plate circuit of the signaling tubes. The negative terminal of the battery is connected directly to the cathode of the signaling tubes and current flows through the plate circuit upon operation of the various character sending key contacts in the circuit which will be described later. This current flow lasts for only a comparatively short time, however, because the bias on the grid is not a constant factor, but varies in timed relationship with the frequency of the A. C. supply coming from the secondary of the phase transformer. The said supply is impressed upon the full wave rectifying portion of the tube. The rectified voltage impressed across resistor 32 immediately drives the grid sufficiently negative to prevent further flow of plate current. Thus, the plate current is reduced to a substantially zero value. At such times when the rectified voltage passes through zero, a pulse is impressed upon the output circuit of the triode. This pulse is utilized as a signal and is sent from the transmitter to the receiver to effect operation of the punch mechanism at the receiver.

From the foregoing description, it will be understood that, if eight separate phases spaced $22\frac{1}{2}$ electrical degrees apart are taken off the secondary phase transformer and connected to eight electrical circuits each embodying a tube of the type just described, so that the terminals of the separate resistors 31 are joined with the terminals of the secondary windings of each phase, eight series of short impulses similar to those illustrated in Fig. 5 may be generated. It will be noted that no two impulses overlap or occur at the same time, and therefore it is possible that all eight of these phases may be transmitted over a single carrier simultaneously. For the sake of simplicity in the wiring diagrams the terminals of the various tubes are not shown fully connected to the phase connections of the phase transformer, but the terminals of the tube are given a designation PH1 to PH8 to indicate with which of the phases it is connected.

Referring now to the receiving tubes EL1 to EL4 and ER1 to ER4, it will be noted that the circuits for these tubes are similar to the ones described above. Taking tube EL1 as an example, it will be assumed that this tube is connected to phase PH2 of the transformer, and

that the grid 43 of this tube is connected in the cathode circuit of the tube and is arranged to be normally biased to cut-off. The negative battery BL5 is connected to one side of a resistance r and a condenser C, each of which leads to the cathode circuit of tube EL1 and also to the grid 44 of tube AL1. Positive battery potential of battery BL2 is applied to the anode of tube EL1. When a signal is received, it is impressed upon a high biased tube 57 and then sent through conductor 58 to the circuits embodying tube EL1. Condenser C becomes charged and thus controls the actuation of the grid 44 of an amplifying tube AL1 to which it is connected in such a manner that if the phase relationship of the signal is the same as PH2, the tube AL1 is triggered off and a virtually steady current flows through its plate circuit to effect energization of the print selector magnet PL1. It will be noted that tube AL1, normally inoperative, becomes operative only upon reception of a signal of a phase corresponding to PH2. The signal phase and the tube circuit phase must agree in order that the amplifier tube AL1 may be operated, since the bias placed on the grid of tube AL1 by each of these supply sources individually is insufficient to cause current flow through the windings of magnet PL1.

Considering now the operation of the system as a whole, it is noted that machine ML1 (Fig. 1) is sending continuous signals of phase PH1 to the line, and that machine MR1 (Fig. 2) is sending continuous signals of phase PH2 to the line. The sending of phases PH1 and PH2 corresponds to the sending of normal line current of the usual teletype system. Likewise, machine ML2 is sending impulses of phase PH3 continuously to a corresponding machine MR2 which, in turn, sends continuous impulses of phase PH4 over the line to machine ML2. Similarly, machines ML3 and MR3 send continuous impulses of phases PH5 and PH6, respectively, and machines ML4 and MR4 employ phases PH7 and PH8, respectively.

The transmission of a typical character from machine ML1 to machine MR1 will now be described, it being understood that the other machines, although working on different phases, employ the same operating principle.

If the operator at station L1 depresses a character key for the purpose of transmitting the character "A," for example, the TL1 contacts are operated selectively in such a manner as to produce a coded series of impulses to represent "A." The opening of contacts TL1a stops the continuous series of impulses on phase PH1 which releases the current from print selector magnet PR1 (Fig. 2) and initiates a receiving cycle at that station. At the time contacts TL1a open, contacts TL1g and TL1h transfer to shift the tubes EL1 and AL1 from phase PH2 to phase PH1, so that the magnet PL1 will be responsive to the same impulses (PH1) that are being transmitted to operate the magnet PR1 at the receiving station R1. Assume the letter "A" to be represented by impulses under control of contacts TL1b and TL1c. After contacts TL1a are open for a sufficient length of time to initiate the start signal, contacts TL1b and TL1c are closed successively to send marking impulses of phase PH1 to the line. Inasmuch as contacts TL1d, TL1e, and TL1f do not close, no signals are sent to the line on phase PH1 through these contacts. The transmission circuit for impulses representing the letter "A" under the assumed code may be

traced as follows: from plus battery BL1, conductor 50, transformer winding 51, conductor 52, contacts TL1b now closed, conductor 53, plate and cathode tube DL1, conductor 54, to negative battery BL1. The same circuit is completed through TL1c when these contacts make. The pulses impressed upon transformer winding 51 are simultaneously impressed on the line winding 55 and another winding 56. The impulses impressed on winding 56 overcome the high bias on the grid of tube 57 created by a battery BL3 in series with winding 56 and grid and cathode of the tube causing the latter to pass current through it. The anode of tube 57 is connected to the cathode of tube EL1 through conductor 58. Negative battery BL5 is normally applied through conductor 58 and condenser C and resistance r in parallel to the cathode of tube EL1 and the grid of tube AL1. The plate of tube EL1 is connected with positive battery BL2 through conductor 59. The cathode of tube AL1 is connected by means of conductor 61 with the positive battery BL5. The selection of tube EL1 for operation was by virtue of the fact that this tube alone of the group of tubes EL1 to EL4 was operating on phase PH1 and the incoming impulses combined with the normal phase current from source PH1 to provide a flow of current through tube EL1 but not through the others which were operating on other phases. The condenser C and resistance r in parallel provide a time lag for the impulses impressed on the grid of tube AL1, so that these impulses may remain effective to overcome the bias on the grid 44 for a much longer period than would otherwise be the case, thus giving a sufficiently long impulse to insure the actuation of print selector magnet PL1 connected in the plate circuit of tube AL1. The circuit for energizing magnet PL1 is from positive battery BL4, conductor 60, magnet PL1, plate and cathode of tube AL1, conductor 61, to negative battery BL4.

The impulses impressed on the line through the medium of transformer winding 55 in the manner described above are received by transformer winding 62 (Fig. 2) and then impressed upon winding 63. Impulses from winding 63 overcome the bias caused by battery BR3 on the tube 64 to initiate the flow of current through the tube 64 as follows: positive side of battery BR2, conductor 68, plate and cathode of tube ER1, condenser C' and resistance r' in parallel, conductors 65, 66, plate and cathode of tube 64, conductor 67, to negative battery BR2. Since there is no transmission from machine MR1 at station R1 at this time, transfer contacts TR1g and TR1h are in normal position and tube ER1 is working on phase PH1. Thus, the impulses from the line coincide in phase with the impulses from the phase transformer at the receiving station and reinforce them so as to cause operation of tube ER1. Amplifier tube AL1 is now caused to operate in view of the reduction of the bias on its grid as tube ER1 is operated. The circuit is traceable from positive side of battery BR4, conductor 70, print selector magnet PR1, plate and cathode of tube AL1, conductor 69, to negative battery BR4. As previously explained in connection with the circuits in Fig. 1, condenser C' and resistance r' provide the necessary time lag to insure the full energization of magnet PR1 upon operation of tube AR1. The input circuit to tube AR1 is from negative battery BR5, conductor 65, condenser C' and resistance r' in parallel, conductor 71, grid and cathode of tube AR1, conductor 69, to positive battery BR5.

At the end of each character cycle, contacts TL1a at transmitting station L1 again close to send continuous signals of phase PH1 which holds the magnet PR1 at the receiving station R1 in a normally energized condition.

It will be appreciated that it is possible for all eight machines to be operating at the same time over a two wire network in the manner above described. All of the operations of the normal teletypewriter are maintained and each of the machines, when transmitting, monitors its own signals through the energization of the print selector magnets to effect printing of characters represented by those signals.

Although the wiring diagram shows machine ML1 at one station connected for operation with machine MR1, ML2 with MR2 etc., it is to be understood that the wiring to the phase transformers could be so altered at any time that the machines could cooperate for both transmitting and receiving in widely different arrangements.

While there has been shown and described and pointed out the fundamental novel features of the invention as applied to a single modification, it will be understood that various omissions and substitutions and changes in the form and details of the device illustrated and in its operation may be made by those skilled in the art without departing from the spirit of the invention. It is the intention, therefore, to be limited only as indicated by the scope of the following claims.

What is claimed is:

1. In a communication system comprising a plurality of printing telegraph machines at each end of a common line, in combination, means at one end of said line comprising a plurality of primary sources of current of different phase characteristics, a wave modifying device for each of said sources, a plurality of sets of control contacts, one for each machine, individual means for differentially operating said contacts according to a preselected code, and circuit connections normally completed under control of said sets of contacts from predetermined ones of said sources of current through the related wave modifying means to the line to impress modified wave forms of carrier currents on said line of predetermined different phases to represent the different machines, and means at the other end of the common line comprising a plurality of secondary sources of current of different phase characteristics corresponding to the phases of the aforementioned primary sources of current, an electronic valve connected to each of the secondary sources, a plurality of printing control magnets, one for each machine, individual circuit connections from predetermined ones of the secondary sources of current through the medium of said electronic valves to said magnets and means responsive to the carrier currents for completing said circuit connections in accordance with agreement of the phases of the carrier currents with the phases of the currents of the connected secondary sources to energize the printing control magnets, whereby the different sets of control contacts of the machines at the first mentioned end of the line may be operated simultaneously by their individual operating means to effect control of the energization of printing control magnets of the machines at the other end of the line to effect printing according to the preselected code.

2. In a communication system comprising a plurality of printing telegraph machines at each end of a common line, in combination, means at one end of said line comprising a phase trans-

former having a plurality of sets of secondary taps for supplying currents at different phases, a wave form modifying device for each of said currents, a plurality of sets of control contacts, one set for each machine, including a series of normally open contacts and a normally closed contact, individual operating means for immediately opening the normally closed contact and for closing the normally open contacts at a differential time according to a preselected code, and circuit connections normally completed by the normally closed contacts and then completed under control of the normally open contacts as the latter contacts are operated, from predetermined ones of said sets of secondary taps through the related wave form modifying means to the line to impress modified wave forms of carrier currents on said line of predetermined different phases to represent the different machines; and means at the other end of the common line comprising a phase transformer having a plurality of sets of secondary taps for supplying current at different phases corresponding to the phases of the current from the first mentioned transformer, an electronic valve connected to each of the sets of taps of the second mentioned transformer, a plurality of printing control magnets, one for each machine, individual circuit connections from predetermined ones of the sets of taps of the second mentioned transformer through the medium of said electronic valves to said magnets, and means responsive to the carrier currents for completing said circuit connections in accordance with agreement of the phases of the carrier currents with the phases of the currents of the connected taps of the second mentioned transformer to energize the printing control magnets, whereby, upon operation the normally open control contacts of the machines at

the first mentioned end of the line by their individual operating means, energization of printing control magnets of the machines at the other end of the line is controlled to effect printing according to the preselected code.

3. A communication system comprising a plurality of units at one end of a line, a transmitting device for each unit including a plurality of control contacts for normally transmitting a carrier current of a predetermined phase different from the carrier current of the other units, individual means for operating the contacts of each transmitting device so as to interrupt said carrier current in accordance with a preselected code to establish impulse representing characters, a receiving device for each unit normally responsive to impulses of a predetermined phase different from the phase of the current normally transmitted by said units, a plurality of similar units at the other end of the line, each unit having a receiving device responsively matched in phase with a predetermined one of the first-named units and a transmitting device for sending out carrier current on the line to which a predetermined one of the receiving devices of the first-named units is responsively matched in phase, whereby the various units at either end of the line may transmit to or receive character impulses from the matched units at the other end of the line over the said line without interference, and switching means associated with each unit and controlled by the operating means for the transmitting control contacts of said unit upon operation thereof for switching the receiving means of said unit from current of the normal receiving phase to current of the normal sending phase.

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