March 23, 1926. 1,577,515

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SELECTIVE SIGNALING CIRCUITS FOR CARRIER SYSTEMS

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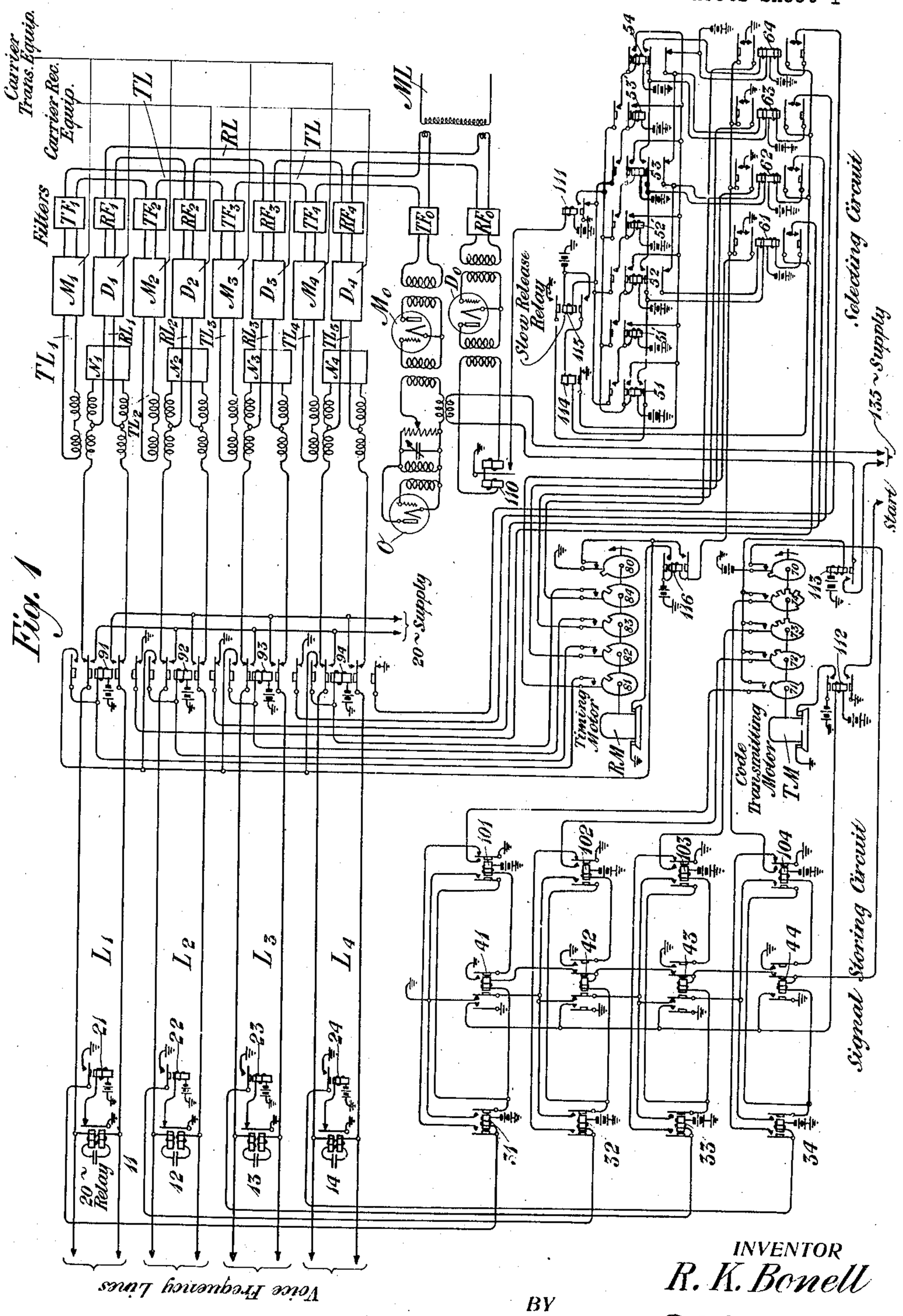

Fig. 1

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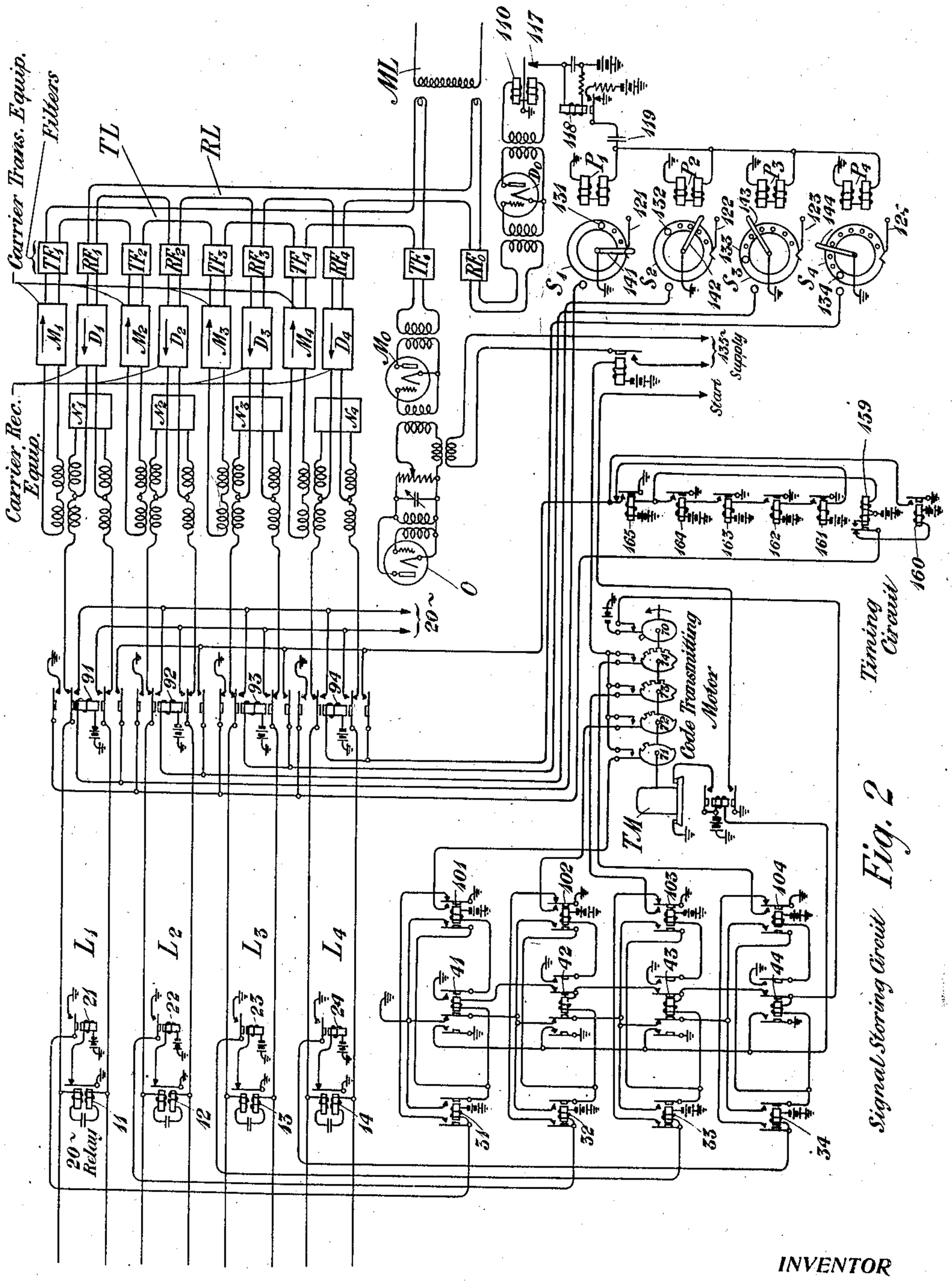

Fig. 2

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Patented Mar. 23, 1926. 1,577,515

UNITED STATES PATENT OFFICE.

RALPH K. BONELL, OF EAST ORANGE, NEW JERSEY, ASSIGNOR TO AMERICAN TELEPHONE AND TELEGRAPH COMPANY, A CORPORATION OF NEW YORK.

SELECTIVE SIGNALING CIRCUITS FOR CARRIER SYSTEMS.

Application filed May 15, 1924. Serial No. 713,583.

To all whom it may concern:

Be it known that I, RALPH K. BONELL, a citizen of the United States, residing at East Orange, in the county of Essex and State of New Jersey, have invented certain Improvements in Selective Signaling Circuits for Carrier Systems, of which the following is a specification.

This invention relates to transmission circuits and more particularly to arrangements for transmitting ringing or other supervisory signals in connection with transmission circuits.

One of the objects of the invention is to provide a signaling arrangement whereby a group of transmission channels may have associated therewith a signaling apparatus common to the group for transmitting ringing or other supervisory signals. The several transmission channels may comprise a plurality of separate wire lines or other transmission paths or they may comprise the multiplex channels of a multiplex system in which a plurality of signaling paths are superposed on the same circuit.

Another object of the invention is to provide a common signaling arrangement of the type above referred to, in which the signals originating with a plurality of channels will be stored up and transmitted successively over a common signaling path. The common signaling path may be either a separate wire circuit or it may be a channel of the multiplex system set aside for this purpose.

Another object of the invention is to provide a system of the type above described, in which the receiving mechanism of the signaling apparatus will be so arranged as to identify supervisory or other signals originating with different channels and will properly allocate the received signals to the proper terminal conductors.

Other and further objects of the invention will be clear from the following description when read in connection with the accompanying drawing, Figures 1 and 2 of which illustrate circuit diagrams embodying two forms of the invention.

Referring to Fig. 1 ML designates a transmission line, such as a telephone line, which is multiplexed in a well known manner so that it may be associated with a plurality of terminal lines, such as L_1, L_2, L_3, and L_4 for the simultaneous transmission of telephone conversations. In order to interconnect the main transmission line ML with the terminal lines, each terminal line is associated through the hybrid coils and balancing networks such as N_1, N_2, N_3 and N_4 with a transmitting carrier channel and a receiving carrier channel. For example, the line L_1 is associated with the transmitting carrier channel TL_1, including suitable carrier transmitting apparatus M_1. Likewise, the line L_1 is associated with the carrier receiving channel RL_1, including the carrier receiving apparatus schematically indicated at D_1. The carrier apparatus is of a type well known in the art and is not shown in detail. The various transmitting channels are connected through filters, such as TF_1 to TF_4 inclusive, to a common circuit TL, which is associated with the main line ML. Similarly, the various receiving carrier channels are connected through filters RF_1 to RF_4 inclusive with a common circuit RL associated with the main line ML.

The signaling apparatus associated with the group of lines L_1 to L_4 inclusive comprises a set of ringing responsive relays 11, 12, 13 and 14, individual to the line. A signal storing circuit is also provided which is common to the four lines shown, the signal storing circuit including storing relays 31 to 34 inclusive, controlled by the ringing responsive relays 11 to 14 inclusive. Also four additional relays 41 to 44 inclusive are provided in connection with the storing circuit, these relays being so arranged that when one is operated it controls the transmission of a signal originated by one of the corresponding terminal lines and at the same time prevents the other corresponding relays from being operated until the signal of the line having control is transmitted.

A code transmitting apparatus is associated with the signal storing circuit, said transmittig apparatus comprising a transmitting motor TM, driving a shaft upon which a plurality of cams 71 to 74 inclusive are provided, the cams being arranged to transmit code signals characteristic of the several lines L_1 to L_4 inclusive. A fifth cam 70 is also provided for performing certain translating operations in connection with the storing circuit. Switches are controlled by the various cams, which operate—

to transmit code groups of alternating waves to a suitable modulator M_0. An oscillating tube O is also associated with the modulator to impress thereon a carrier frequency to be used in the transmission of signals from the several terminal lines. The modulator operates to modulate the carrier frequency thus supplied, in accordance with code groups of alternating waves of some suitable ringing frequency such as, for example, 135 cycles, and the modulated carrier is then transmitted through a suitable filter TF_0 to the line ML.

The receiving apparatus of the signaling arrangement comprises a receiving filter RF_0 for selecting out the modulated carrier frequency upon which the signals transmitted from the distant station are superposed, and a suitable detector D_0 for detecting from the carrier the groups of 135 cycle waves making up the code signals. The detected low frequency waves operate a suitable alternating current relay 110. This relay operates to close a circuit each time a group of 135 cycle waves is transmitted by the detector. In this manner, direct current code pulses are transmitted to a relay 111, which controls a suitable selecting arrangement, whose operation is determined by the code received.

This selecting arrangement comprises a series of escapement relays arranged in pairs, the first pair being designated 51 and 51′ respectively, the second pair being designated 52 and 52′ respectively, etc. Only one relay of the last pair of escapement relays is provided, this relay being designated 54. The pairs of escapement relays are so arranged that one relay of a pair is operated when the relay 111 is energized and the other relay of the pair is operated when the relay 111 is deenergized, and each succeeding relay in the series of escapement relays is so arranged that it can not be operated until the preceding relay in the series has been energized.

A series of four selecting relays 61 to 64 inclusive are associated with the escapement relays, the selecting relays being individually responsive to a different code under the control of the escapement relays. The selecting relays are individual to the four terminal lines L_1 to L_4 inclusive and operate to transmit ringing signals to the terminal line selected under the control of a suitable timing apparatus.

The timing apparatus comprises a timing motor RM, driving a shaft having thereupon a series of cams 81 to 84 inclusive, one individual to each terminal line, and a fifth cam 80. The cam of the group 81 to 84 inclusive individual to a particular line initiates the ringing signal for that line, while the cam 80 operates to terminate the ringing signal initiated upon any line.

Further details of the invention will be clear from a detailed description of the operation which is as follows: Let us assume that a ringing signal comes in from the terminal line L_2 and that a moment thereafter another signal comes in from the terminal line L_4, the later signal arriving before the signal coming in from the line L_2 has had an opportunity to be transmitted. The ringing signal coming in from the line L_2 will operate the ringing responsive relay 12, which in turn opens the circuit of the normally operated relay 22 to close the circuit of the storing relay 32. The ringing signal incoming from the line L_4, which arrives a moment later, in turn operates the ringing responsive relay 14, which opens the normally closed circuit of the relay 24, thereby completing a circuit from ground, through the winding of the storing relay 34. The storing relay 32, upon being operated, is locked up over its left-hand front contact and the right-hand back contact of relay 102. Similarly, relay 34 is locked up over its left-hand front contact and the right-hand back contact of relay 104.

At its right-hand front contact relay 32 closes a circuit for the relay 42, from battery, over the normally closed contact controlled by cam 70, over the inner right-hand contact of relay 44, over the inner right-hand contact of relay 43, through the winding of relay 42, over the right-hand front contact of relay 32 and over the inner left-hand contact of relay 41 to ground. Relay 42, upon being energized, at its inner left-hand contact opens the ground connections to the windings of the relays 43 and 44, thereby preventing the circuit of the relay 44 from being closed by the relay 34. At its inner right-hand contact, relay 42 opens the battery connection from the relay 41 to the cam switch controlled by cam 70. Consequently, it will be apparent that when one of the relays 41 to 44 inclusive is operated all of the other relays of the group are prevented from being actuated.

At its outer left-hand contact, relay 42 completes a circuit from ground, through the winding of relay 112. Relay 112 in turn closes a circuit of the motor TM and starts the cams 70 to 74 inclusive revolving. Relay 42 at its right-hand outer contact closes a circuit of relay 102. The latter relay, at its left-hand front contact, completes a locking circuit for the relay 42, independently of the storing relay 32. At its right-hand back contact relay 102 opens the locking circuit of the storing relay 32 and releases the storing relay, while at its right-hand front contact said relay 102 completes a circuit to the switches controlled by cam 72. While the operations above described and the operations about to be described take place, the

storing relay 34 remains locked up because the relay 104 can not be actuated to release the relay 34 until the relay 44 is operated.

As the motor TM revolves the cam shaft, the cam 72 successively closes and opens the switch controlled thereby, to transmit a series of closed and open circuit pulses to the relay 113. This particular cam is arranged to transmit one short closed circuit pulse and one long closed circuit pulse. Each time the relay 113 is energized by a long or short closed circuit pulse a group of carrier waves, having a frequency of 135 cycles, is transmitted to the modulator M_0 and modulates the carrier frequency from the oscillator O to transmit a modulated code signal over the line ML.

As the shaft of the motor TM completes one revolution, the fifth cam 70 operates to open the normally closed switch controlled thereby to remove battery from the circuit of relay 42, thereby releasing said relay. Relay 42, upon being deenergized, opens the circuit of relay 102, which in turn opens the locking circuit of relay 42 and also opens the circuit controlled by the cam 72. Relay 42, upon being deenergized, also opens the circuit of the relay 112 so that the motor TM will come to rest.

At its inner right-hand back contact relay 42 completes a circuit for the relay 44 under the control of the storing relay 34 as follows: from battery, over the switch controlled by cam 70, through the winding of the relay 44, right-hand front contact of relay 34, and over the left-hand inner back contacts of relays 43, 42 and 41 in series, to ground. Relay 44, at its left-hand front contact, closes a circuit for the relay 112 to again set the motor TM into operation, and at its inner right hand contact disables relays 43, 42 and 41. At its outer right-hand contact relay 44 close a circuit of relay 104. The latter relay operates to lock up relay 44 and unlock the storing relay 34, so that the latter is restored to normal. Relay 104, at its right-hand front contact, closes a circuit for the switch operated by the cam 74. The cam 74 now proceeds to transmit a code combination consisting of three short closed circuit pulses and one long closed circuit pulse. This causes a corresponding group modulation of the carrier supplied by the oscillator O to transmit the signal corresponding to the line L_4 over the main line ML.

In order to understand the operation of the receiving apparatus at the distant end of the main line, the operation of the receiving apparatus illustrated, in response to similar signals transmitted over the main line from the distant station, will be described. Let us suppose that a carrier current is being received which is modulated by 135 cycle current, broken up into groups corresponding to one short closed circuit pulse followed by one long closed circuit pulse. This carrier current will be selected from other carrier frequencies by the filter RF_0 and impressed upon the detector D_0 so that the detector D_0 will operate to detect alternating current of 135 cycle frequency broken up to correspond to one short closed circuit pulse followed by one long closed circuit pulse. The alternating relay 110 will be energized to attract its armature once for each group.

In response to the first group, relay 110 will close the circuit of relay 111, which in turn attracts its armature and completes the circuit of escapement relay 51. Relay 51, at its inner upper contact, completes a locking circuit for its own winding, over the back contact of relay 114 and at its upper outer contact prepares the circuit of the second escapement relay 51′. It will be observed that relay 115 is normally energized and that a circuit is completed over the lower back contact of relay 111. The opening of this contact in response to short pulses of current through relay 111 does not permit the relay 115 to release its armatures, as it is a slow-release relay, and this relay will not be released until a long pulse is received, as will be described later. Consequently, the circuit, which will be closed through the upper winding of selecting relay 61 over the lower front contact of relay 51, is held open at the upper contact of the slow-release relay 115, and the relay 61 is not actuated at this time. At the end of the first short pulse, relay 111 is released by the armature of relay 110 and the circuit is closed over the lower back contact of relay 111 and over the outer upper contact of relay 51, through the winding of escapement relay 51′. The latter relay is energized and locked up over its upper inner contact to ground, over the back contact of relay 114. Relay 51′ at its outer upper contact, prepares the circuit of escapement relay 52.

When the following long group is detected by the detector D_0 relay 110 transmits a long pulse to relay 111, which is energized and completes a circuit from ground, over its front contact, and over the outer upper contact of escapement relay 51′, to escapement relay 52. The latter relay is locked up over its inner upper contact and at its outer upper contact prepares a circuit for escapement relay 52′. At its outer lower contact, relay 52 holds open the circuit of selecting relay 61 so that this relay cannot now be energized. At its inner lower contact relay 52 prepares a circuit through the upper winding of selecting relay 62.

The long pulse which energized relay 111, as just described, held open the circuit of the slow-release relay 115 for a sufficient length of time to permit it to release. As soon as this relay releases a circuit is closed

over its upper back contact, over the lower front contact of escapement relay 51, and over the inner lower front contact of escapement relay 52, through the upper winding of selecting relay 62, and over the outer lower contacts of escapement relays 53 and 54 in series, to battery. The upper and lower armatures of relay 62 are so arranged that when attracted they press the upper and lower middle contacts of said relay into contact with the upper and lower inner contacts of said relay. A locking circuit is accordingly established for the relay 62, from battery, through its lower winding, over its lower armature and lower middle contact, and over the outer lower contact of relay 92, to ground. At the same time a circuit is completed from battery, over the lower contact of deenergized relay 115, through the winding of relay 114, over the inner lower and lower middle contacts of relay 62, and over the outer lower back contact of relay 92 to ground. Relay 114, upon being energized, at its lower contact disconnects ground from the locking circuits of the several escapement relays which have been energized, thus restoring them to normal.

Relay 62 completes a circuit over its upper middle contact and upper armature through the winding of relay 116 to battery. Relay 116 is at once locked up over its lower contact and over the contacts controlled by cam 80. At its upper contact relay 116 completes a circuit for the timing motor RM, which begins to rotate the cams 80 to 84 inclusive. A circuit is also completed by the relay 62, over its upper middle and upper inner contacts to the switches controlled by the cam 82. Shortly after the beginning of the rotation of the cam shaft, the cam 82 permits one of the switch elements controlled thereby to drop into the notch in the cam, thereby closing the switches and completing the circuit previously traced from the contacts of relay 62 to said switches, and thence through the winding of relay 92. The relay 92 is at once energized and locked up over its outer upper contact and thence to ground, over the switches controlled by the cam 80. At its inner upper and lower contacts relay 92 connects ringing current to the terminal line L_2. At its lower outer contact relay 92 disconnects ground from the lower middle contact of relay 62, thereby opening the circuit of relay 114, and the locking circuit of relay 62, restoring these relays to normal. All of the circuits of the various escapement relays and the circuits of the selecting relays 61 to 64 inclusive are now in normal condition so that the selection in response to the next code combination may take place while the ringing signal is being transmitted to the line L_2 under the control of the timing motor RM.

As the shaft controlled by the timing motor RM continues to rotate, ringing current is continuously transmitted to the line L_2 by locked up relay 92 until just before the cam shaft has completed one revolution, at which time the tooth upon cam 80 engages the switches controlled by the cam to disconnect ground from the locking circuit of relay 92 and from the locking circuit of 116. Relays 92 and 116 are accordingly deenergized, the former disconnecting ringing current from the line L_2 and the latter opening the circuit of the timing motor RM to stop the rotation of the cam shaft.

While the ringing signal is being transmitted to the line L_2 another code combination may be received from the main line ML. Let us suppose that a carrier current is now being received, which is modulated by 135 cycle waves broken up into groups corresponding to three short pulses and one long pulse. The groups of 135 cycle waves will be detected by the detector D_0 and the alternating current relay 110 will transmit three short pulses and one long pulse to the relay 111. The latter relay, in response to the first pulse, energizes and locks up escapement relay 51. At the end of the pulse, escapement relay 51′ is energized. In response to the second pulse, relay 111 energizes and locks up escapement relay 52, and at the end of this pulse relay 52′ is energized and locked up. Similarly, escapement relays 53 and 53′ are energized and locked up at the beginning and ending respectively of the third pulse. At the beginning of the final long pulse through the relay 111, the last escapement relay 54 is energized and locked up.

It will be observed that each escapement relay, such as 51, 52, 53 and 54, prepares a circuit for the corresponding selecting relay of the group 61 to 64 inclusive. As the first escapement relay of each succeeding pair is energized, however, it locks up and holds open the circuit of the selecting relay prepared by the first escapement relay of the preceding pair. For example, escapement relay 51 prepares the circuit of selecting relay 61. Relay 52, however, holds open the circuit of relay 61 and prepares the circuit of selecting relay 62. Relay 53 in turn, however, holds open the circuit of relay 62 at its outer lower contact and prepares the circuit of escapement relay 63 at its lower inner contact. Finally, escapement relay 54 holds open the circuit of selecting relay 63 at its outer lower contact and at its inner lower contact prepares the circuit through the upper winding of escapement relay 64. Consequently, in response to the code group just received, selecting relays 61, 62 and 63 are disabled.

During the continuance of the long pulse received by the relay 111, the circuit of slow-release relay 115 is held open so that this

relay releases its armatures and completes a circuit from ground, over its upper back contact, and over the inner lower contacts of escapement relays 51, 52 and 53 in series, and thence over the inner lower contact of escapement relay 54 through the upper winding of selecting relay 64 to battery. Relay 64 is energized and attracts its armatures to control its contact in a manner similar to that described in connection with the relay 62.

Relay 64, upon being energized, is locked up through its lower winding and over its lower armature and lower middle contact to ground, over the outer lower back contact of relay 94. At the same time, relay 114 is energized by a circuit completed from battery, over the lower back contact of relay 115, through the winding of relay 114, over the inner and middle lower contacts of relay 64, and over the lower outer back contact of relay 94 to ground. Relay 114 operates to release all of the escapement relays and restore them to normal.

Relay 64, which is now locked up, completes a circuit from ground, over its upper armature, and through the winding of relay 116 to energize and lock up the latter relay, thereby setting the timing motor RM into operation. Shortly after the shaft begins to rotate the cam 84 permits the switch contacts controlled thereby to close and establish a momentary circuit for the relay 94, which circuit may be traced from ground, over the middle and inner upper contacts of relay 64, over the switches controlled by the cam 84, and through the winding of relay 94 to battery. Relay 94 is at once energized and locked up over its outer upper contact and over the switch controlled by cam 80. Ringing current is applied to the terminal line L_4 over the inner contacts of the relay 94. At the same time, relay 94, at its outer lower contact, disconnects ground from the lower middle contact of relay 64, thereby opening the locking circuit of the latter relay and also opening the circuit of relay 114. Relays 64 and 114 are restored to normal and relay 111 having been released at the end of the long impulse, with the consequent energization of slow-release relay 115, all of the escapement and selecting relays are in their normal condition ready to respond to the next received code group.

In the meantime, as the shaft of the timing motor RM revolves, the cam 80 opens the switches controlled thereby just before the end of one complete revolution of the cam shaft, thus disconnecting ground from the locking circuits of relays 116 and 94. The latter relay is released and disconnects ringing current from the line L_4, while relay 116 opens the circuit of the timing motor RM and stops the cam shaft.

A modified arrangement is shown in Fig. 2, this particular arrangement differing from that already described principally in the fact that instead of relay selective apparatus for receiving the signals step-by-step selectors are employed, these selectors being of the general type disclosed in U. S. patent to Field, 1,343,256, of June 15, 1920. The circuit of Fig. 2 also differs from that of Fig. 1 in that the timing arrangement for controlling the transmission of the ringing signal to the terminal lines comprises a chain of relays instead of a motor-driven cam control.

The details of the apparatus shown in Fig. 2 may be fully understood from the description of the operation. In describing the operation it will be unnecessary to refer to the transmitting apparatus or the operation thereof since the transmitting apparatus is identical with that shown in Fig. 1 and operates in the same manner. It should be noted, however, that because of the particular setting of the step-by-step selectors employed, each of the transmitting cams 71 to 74 inclusive is arranged to transmit one additional short pulse. For example, the cam 71 transmits one short pulse and one long pulse, whereas the corresponding cam of Fig. 1 transmits only the long pulse. Likewise, cam 74 in Fig. 2 transmits four short pulses and a long pulse, whereas the same cam in Fig. 1 transmits three short pulses and one long pulse. The extra pulse is not essential to the arrangement shown in Fig. 2, however, as this pulse may be omitted by changing the normal setting of the selectors. For example, the selector wheel S_1 is so set that it is advanced three steps to effect selection, one step being taken at the beginning of a short pulse, a second step being taken at the end of the pulse, and a third step being taken at the beginning of the long pulse, and the selector being released at the end of the long pulse. If the selector were set to select at the end of the first step it would take this step at the beginning of one long pulse and would then be restored at the end of the long pulse, so that the extra tooth would not be necessary on the corresponding transmitting cam.

The receiving operation is as follows: Let us assume that a combination is being transmitted from the distant station for the purpose of sending a ringing signal over the channel L_2 and that this code combination will be followed by one for the purpose of transmitting a ringing signal over the terminal line L_4. The first code combination will, in accordance with the transmitting cams shown, comprise two short pulses and one long pulse. Consequently, the carrier frequency transmitted from the distant station will be modulated in accordance with 135 cycle waves broken up into groups con-

sisting of two short groups and one long group. The detector D_0 will detect the groups of 135 cycle alternating current and impress them upon the alternating current relay 110, which is arranged to close its contact 117 at the beginning of each group and hold it closed until the end of each group of waves, thus transmitting to the relay 118 direct current combinations consisting of a series of short pulses followed by a long pulse, depending upon the particular code combination received. Each time a current pulse is transmitted through the relay 118 it attracts its armature and charges a condenser 119 so that a brief surge of current flows through each of the magnets P_1 to P_4 inclusive of the selectors in one direction. When the relay 118 releases its armature at the end of a given pulse, the condenser 119 is connected to ground, and by the discharge of the condenser a surge of current flows in the opposite direction through each of the magnets P_1 to P_4 inclusive. Each of the polar magnets P_1 to P_4 inclusive thus receives alternate positive and negative impulses.

Each polar magnet controls apparatus (not disclosed but fully set forth in the patent to Field, already referred to) whereby the corresponding disc of the group of discs S_1 to S_4 inclusive is stepped forward one step for each positive impulse, and one step for each negative impulse, regardless of the length of the pulse actuating the relay 118. The armature of each polar magnet has a normal neutral position and when the armature is in the neutral position the disc will be free to return to its normal position under the influence of a spring (not shown) unless the disc is maintained in the position to which it has been stepped by the engagement of a latch, such as 121, with a pin, such as 131, located upon the periphery of the disc. The pin on each disc is arranged to engage the latch at a different point in its revolution and when the latch engages the pin a wiper, such as 141, closes a contact to actuate a signaling relay.

When the relay 118 attracts its armature at the beginning of the first short pulse, each of the polar magnets P_1 to P_4 inclusive advance each of the selector wheels S_1 to S_4 inclusive in a clockwise direction one step. Since the pulse is a short pulse the relay 118 releases its armature before the armatures of the polar magnets have had an opportunity to shift to their neutral positions and free the selector wheels. Consequently, the discharge of the condenser 119, which occurs when relay 118 is released, causes a surge of current in the opposite direction through each of the polar magnets, thus throwing the armature of each magnet in the opposite direction and advancing each of the selector wheels a second step. The succeeding short pulse through the relay 118 follows the preceding pulse so quickly that the armatures of the polar magnets are not permitted to shift to their neutral positions, and when the relay 118 attracts its armature the armatures of the polar magnets are shifted to advance each selector wheel a third step. At the end of the pulse, the relay 118 releases its armature and the polar magnets advance each selector wheel a fourth step. As the selector wheel S_1 passed through the fourth step its wiper 141 momentarily closed a circuit through the relay 91 but the momentary closing of said circuit was not sufficient to energize the relay 91.

Upon receiving the succeeding long pulse relay 118 again attracts its armature and charges the condenser 119 so that a surge of current flows through each of the polar magnets, thus advancing each of the selector wheels a fifth step and permitting the latch 122 to engage the pin 133 of the selector wheel S_2. As soon as the surge of current through each of the windings ceases the armatures of all of the polar magnets will swing to their neutral positions and release the escapements of the selector wheels. The selector wheels S_1, S_3 and S_4 will at once be restored to normal, but owing to the engagement of the latch 122 with the pin 132 of the selector wheel S_2 the latter will remain in its advanced position until relay 118 releases its armature at the end of the long pulse, thereby discharging condenser 119 and causing a surge of current through each of the polar magnets in the opposite direction, with the consequent advance of each of the selectors one step. Selector wheel S_2 will now be advanced to its sixth position and the other three selector wheels will be advanced but one step from normal. At the end of the surge of current through the polar magnets, each of their armatures will swing to neutral position, thus releasing the escapements and permitting each of the selector wheels to be restored to normal, the pins of none of the selector wheels being engaged with the corresponding latches in the positions to which the wheels were advanced at the end of the long pulse.

During the continuance of the long pulse, the latch 122, being engaged with the pin 132 of the selector S_2, the wiper 142 carried by said disc completed the circuit of the relay 92 for a sufficient length of time to enable said relay to become energized. Upon the energization of relay 92, a circuit is closed from ground, over its outer upper contact, over the back contact of relay 159, and through the winding of relay 160 to battery. Relay 160 attracts its armature and connects ground to a conductor leading to the lower outer contact of relay 92, whereby relay 92 is locked up independently of the circuit closed by the selector wheel S_2.

A circuit is also established by the relay

160 from ground, over its front contact, over the normal contact of chain relay 165, and through the winding of chain relay 161 to battery. Chain relay 161 is thus energized and the series of chain relays 161 to 165 are successively actuated. At the same time that the chain relay 164 closes the circuit of the chain relay 165, it also closes a circuit through the right-hand winding of relay 159. Relay 159, upon being energized, attracts its armature and shifts the ground connection previously maintained over the upper contact of relay 92 and through the winding of relay 160 to the left-hand locking winding of relay 159. Relay 160 is accordingly released and relay 159 also locked up by the relay 92. Relay 160, upon being released, opens the ground connection whereby relay 92 was locked up, but before relay 160 has had an opportunity to be released the chain relay 165 established a new locking ground for the relay 92 over the front contact of said chain relay 165.

The actuation of relay 165 opens the normal make contact controlled by said relay, thereby opening the circuit of the first chain relay 161, which is accordingly released. The remaining relays of the chain at once begin to release in successive order until the last relay 165 of the chain permits its armature to fall off. This finally removes ground from the locking circuit of the relay 92, which is accordingly released. The ringing current which was transmitted to the terminal line L_2 over the inner contacts of the relay 92 during the time that the latter was maintained locked up, now ceases. It will be observed that the duration of the ringing interval coincides with the time that it required for the five chain relays to be successively energized in regular order and then successively deenergized in regular order. The deenergization of the relay 92 disconnects ground over its upper outer contact, from the left-hand locking winding of relay 159 so that the latter is accordingly deenergized and the circuit is restored to normal.

A code combination transmitted from the distant station consisting of four short pulses and one long pulse will advance all of the selector wheels nine steps. The selector wheel S_4 will be latched in its advanced position to close the circuit of the relay 94, while the other selector wheels will all be released during the continuance of the long pulse. At the end of the long pulse, each of the selector wheels are again advanced one step and—no latching operation occurring in connection with any of the discs—each of the discs will be returned to normal. The relay 94, upon being energized, sets into operation the chain relays in a manner similar to that described in connection with relay 94, thereby causing ringing current to be transmitted over the line L_4 until the last chain relay of the series is released, whereupon the ringing current ceases.

It will of course be obvious that any carrier channel may be employed as the signaling channel. However, it is advantageous to use for the signaling channel the channel which is usually set aside as the so-called "pilot" channel, i. e., the channel which is used in a manner well known in the art, to indicate the variation of the transmission equivalent of the circuit. The same channel may obviously be used both as a "pilot" channel and as a signal channel without any interference.

It will be obvious that the general principles herein disclosed may be embodied in many other organizations widely different from those illustrated without departing from the spirit of the invention as defined in the following claims.

What is claimed is:

1. In a signaling system, a plurality of transmission circuits, a rotatable cam shaft having a cam for each transmission circuit, each cam being so formed as to transmit a signal characteristic of the corresponding transmission circuit, signal storing apparatus associated with said circuits, and controlling circuits interconnecting said cams, said signal storing apparatus and said transmission circuits, said controlling circuits being so arranged that in response to signals substantially simultaneously incoming from a plurality of said transmission circuits said signals will be stored by said storing apparatus and the storing apparatus will control the cams to successively transmit to a distant station signals characteristic of the several transmission circuits, and means at the distant station individually responsive to the different characteristic signals.

2. In a signaling system, a plurality of transmission circuits, signal storing apparatus associated therewith comprising relays, one corresponding to each circuit, means whereby said relays will be locked up in response to signals incoming from the corresponding transmission circuit, a rotatable cam shaft having cams corresponding to each transmission circuit, each cam being so formed as to transmit a signal characteristic of the corresponding transmission circuit, a second group of relays, one corresponding to each transmission circuit, means whereby each relay of the second group controls a corresponding cam to transmit the signal characteristic of the corresponding transmission circuit to a distant station, and circuits for said second group of relays whereby the relays of the second group may be controlled by the storing relays, said circuits being so arranged that

when one relay of the second group is actuated the other relays of the group will be prevented from actuation until the signal controlled by the actuated relay is transmitted by the corresponding cam, and signal responsive means at the distant station individually responsive to the signals transmitted by the several cams.

3. In a signaling system, a plurality of transmission circuits, signal storing apparatus associated therewith comprising relays, one corresponding to each circuit, means whereby said relays will be locked up in response to signals incoming from the corresponding transmission circuit, a rotatable cam shaft having cams corresponding to each transmission circuit, each cam being so formed as to transmit a signal characteristic of the corresponding transmission circuit, a second group of relays, one corresponding to each transmission circuit, means whereby each relay of the second group controls a corresponding cam to transmit a signal characteristic of the corresponding transmission circuit to a distant station, circuits for said second group of relays whereby the relays of the second group may be controlled by the storing relays, said circuits being so arranged that when one relay of the second group is actuated the other relays of the group will be prevented from actuation until the signal controlled by the actuated relay is transmitted by the corresponding cam, corresponding transmission circuits at the distant station, and selective apparatus associated with said transmission circuits at the distant station, said selective apparatus being responsive to the signals transmitted by the said cams for selectively transmitting signals to the corresponding transmission circuit.

4. In a signaling system, a carrier transmission line interconnecting two stations, a plurality of carrier channels at each terminal station arranged to intercommunicate over said carrier line at different carrier frequencies, a rotatable cam shaft having cam corresponding to each carrier channel at one of said stations, said cams being so formed as to transmit signals characteristic of the corresponding channel, means responsive to a signal incoming to a carrier channel to set the corresponding cam into operation to transmit its characteristic signal, a source of carrier current common to said carrier channels, means to superpose upon said carrier current the characteristic signals produced by said cams, means to transmit the signal superposed on said carrier current over said carrier line to the distant station, means at the distant station to detect the signals thus transmitted, and selective apparatus at the distant station responsive to the detected signals to impress a signal upon the carrier channel at the distant station corresponding to the channel upon which the signal originated at said first station.

5. In a signaling system, a carrier transmission line interconnecting two stations, a plurality of carrier channels at each terminal station arranged to intercommunicate over said carrier line at different carrier frequencies, a rotatable cam shaft having cams corresponding to each carrier channel at one of said stations, said cams being so formed as to transmit signals characteristic of the corresponding channel, means responsive to a signal incoming to a carrier channel to set the corresponding cam into operation to transmit its characteristic signal, a source of carrier current common to said carrier channels, a source of low frequency alternating current, means whereby said carrier current may be modulated by said low frequency current, means for impressing on said low frequency current the characteristic signals produced by said cams, means to transmit the modulated carrier current over said carrier circuit, means at said distant station to detect the low frequency current in accordance with which said carrier current is modulated, means to translate the detected current into characteristic signals, and selective apparatus at the distant station responsive to said characteristic signals for selecting and transmitting a signal to the channel at the distant station corresponding to the channel upon which the signal originated at said first station.

6. In a signaling system, a carrier transmission line interconnecting two stations, a plurality of carrier channels at each terminal station arranged to intercommunicate over said carrier line at different carrier frequencies, means for storing signals originating on said carrier channels, a rotatable cam shaft having cams thereon corresponding individually to said channels, said cams being so formed as to transmit signals characteristic of the corresponding channel, circuits interconnecting said storing means and said cams whereby in response to a plurality of stored signals said cams will operate to successively transmit signals characteristic of the corresponding channels, a source of carrier frequency common to said channels, means to superpose on the carrier current from said source the signals transmitted by said cams, means to transmit the carrier current with signals superposed thereon over said carrier transmission line, means at the distant station to detect the characteristic signals superposed upon the carrier, and selective apparatus at the distant station operating in response to the detected characteristic signals to select and apply a signal to the channel thereat corresponding to the channel upon which a

corresponding signal originated at said first station.

7. In a signaling system, a carrier transmission line interconnecting two stations, a plurality of carrier channels at each terminal station arranged to intercommunicate over said carrier line at different carrier frequencies, means for storing signals originating on said carrier channels, a rotatable cam shaft having cams thereon corresponding individually to said channels, said cams being so formed as to transmit signals characteristic of the corresponding channel, circuits interconnecting said storing means and said cams whereby in response to a plurality of stored signals said cams will operate to successively transmit signals characteristic of the corresponding channels, a source of low frequency alternating current, a source of carrier current, means to modulate said carrier current in accordance with said low frequency current, means to impress upon said low frequency current the characteristic signals transmitted by said cams, means at the distant station to detect said low frequency alternating current, means to translate the detected low frequency alternating current into characteristic signals corresponding to those transmitted by said cams, and selective apparatus at said distant station responsive to the translated characteristic signals to select and apply a signal to the channel at said distant station corresponding to the channel on which the corresponding signal originated at said first station.

8. In a signaling system, a transmitting station and a receiving station, a plurality of transmission circuits at each station, a transmission medium between said stations for interconnecting the transmission circuits at the two stations, means to transmit from the transmitting station to the receiving station characteristic signals corresponding to each of the transmission circuits of the transmitting station, selective apparatus at the receiving station selectively responsive to received characteristic signals, said selective apparatus responding to a particular characteristic signal to select the corresponding transmission circuit at the receiving station and apply a signal thereto, and a timing arrangement set into operation by said selective apparatus to determine the duration of the signal applied to the transmission circuit.

9. In a signaling system, a transmitting station and a receiving station, a plurality of transmission circuits at each station, a transmission medium between said stations for interconnecting the transmission circuits at the two stations, means to transmit from the transmitting station to the receiving station characteristic signals corresponding to each of the transmission circuits of the transmitting station, selective apparatus at the receiving station selectively responsive to received characteristic signals, said selective apparatus responding to a particular characteristic signal to select the corresponding transmission circuit at the receiving station and apply a signal thereto, a timing arrangement set into operation by said selective apparatus to determine the duration of the signal applied to the transmission circuit, and means whereby said selective apparatus may be restored to normal upon the application of the signal to the transmission circuit in order to selectively respond to a succeeding characteristic signal while the preceding signal is being transmitted to its circuit.

10. In a signaling system, a carrier transmission line interconnecting two stations, a plurality of carrier channels at each terminal station arranged to intercommunicate over said carrier line at different carrier frequencies, a source of carrier current common to said channels at one of said stations, means to impress upon the current from said source successive signals characteristic of the individual channel, means to transmit the carrier current with the signals impressed thereon to the distant station, means at the distant station to successively detect from the transmitted carrier current the successive characteristic signals originating at said first station, selective apparatus at said distant station responsive to the detected characteristic signals, said selective apparatus responding to a given detected characteristic signal to select and apply a signal to the channel corresponding to that upon which the signal originated at said first station, and a timing arrangement set into operation by said selective apparatus to determine the length of time during which the signal will be applied.

11. In a signaling system, a carrier transmission line interconnecting two stations, a plurality of carrier channels at each terminal station arranged to intercommunicate over said carrier line at different carrier frequencies, a source of carrier current common to said channels at one of said stations, means to impress upon the current from said source successive signals characteristic of the individual channels, means to transmit the carrier current with the signals impressed thereon to the distant station, means at the distant station to successively detect from the transmitted carrier current the successive characteristic signals originating at said first station, selective apparatus at said distant station responsive to the detected characteristic signals, said selective apparatus responding to a given detected characteristic signal to select and apply a signal to the channel corresponding to that upon which the signal originated at

said first station, a timing arrangement set into operation by said selective apparatus to determine the length of time during which the signal will be applied, and means to restore said selective apparatus to normal upon the application of a signal to a given channel so that it may respond to the succeeding characteristic signal during the continuance of the signal then being applied to one of the channels.

12. In a signaling system, a carrier transmission line interconnecting two stations, a plurality of carrier channels at each terminal station arranged to intercommunicate over said carrier line at different carrier frequencies, a source of carrier current common to said channels at one of said stations, a source of low frequency alternating current, means to modulate said carrier current in accordance with said low frequency current, means to impress upon said low frequency alternating current successive characteristic signals corresponding to the several carrier channels, means to transmit the modulated carrier current over said carrier transmission circuit to the distant station, means at the distant station to detect from the received carrier current the low frequency current in accordance with which it is modulated, means to translate the detected low frequency current into successive characteristic signals corresponding to the channels at said first station, selective apparatus at said distant station responsive to the translated characteristic signals, said selective apparatus responding to a given translated characteristic signal to select and apply a signal to a carrier transmission channel at said station corresponding to the carrier transmission channel at said first station upon which the signal originated, and timing apparatus set into operation by said selective apparatus to determine the length of time during which the signal is to be applied to the carrier transmission channel.

13. In a signaling system, a carrier transmission line interconnecting two stations, a plurality of carrier channels at each terminal station arranged to intercommunicate over said carrier line at different carrier frequencies, a source of carrier current common to said channels at one of said stations, a source of low frequency alternating current, means to modulate said carrier current in accordance with said low frequency current, means to impress upon said low frequency alternating current successive characteristic signals corresponding to the several carrier channels, means to transmit the modulated carrier current over said carrier transmission circuit to the distant station, means at the distant station to detect from the received carrier current the low frequency current in accordance with which it is modulated, means to translate the detected low frequency current into successive characteristic signals corresponding to the channels at said first station, selective apparatus at said distant station responsive to the translated characteristic signals, said selective apparatus responding to a given translated characteristic signal to select and apply a signal to a carrier transmission channel at said station corresponding to the carrier transmission channel at said first station upon which the signal originated, timing apparatus set into operation by said selective apparatus to determine the length of time during which the signal is to be applied to the carrier transmission channel, and means to restore said selective apparatus to normal so that it may respond to a succeeding characteristic channel during the continuance of the signal then being applied to one of the channels.

In testimony whereof, I have signed my name to this specification this 14th day of May 1924.

RALPH K. BONELL.