

Sept. 4, 1945.

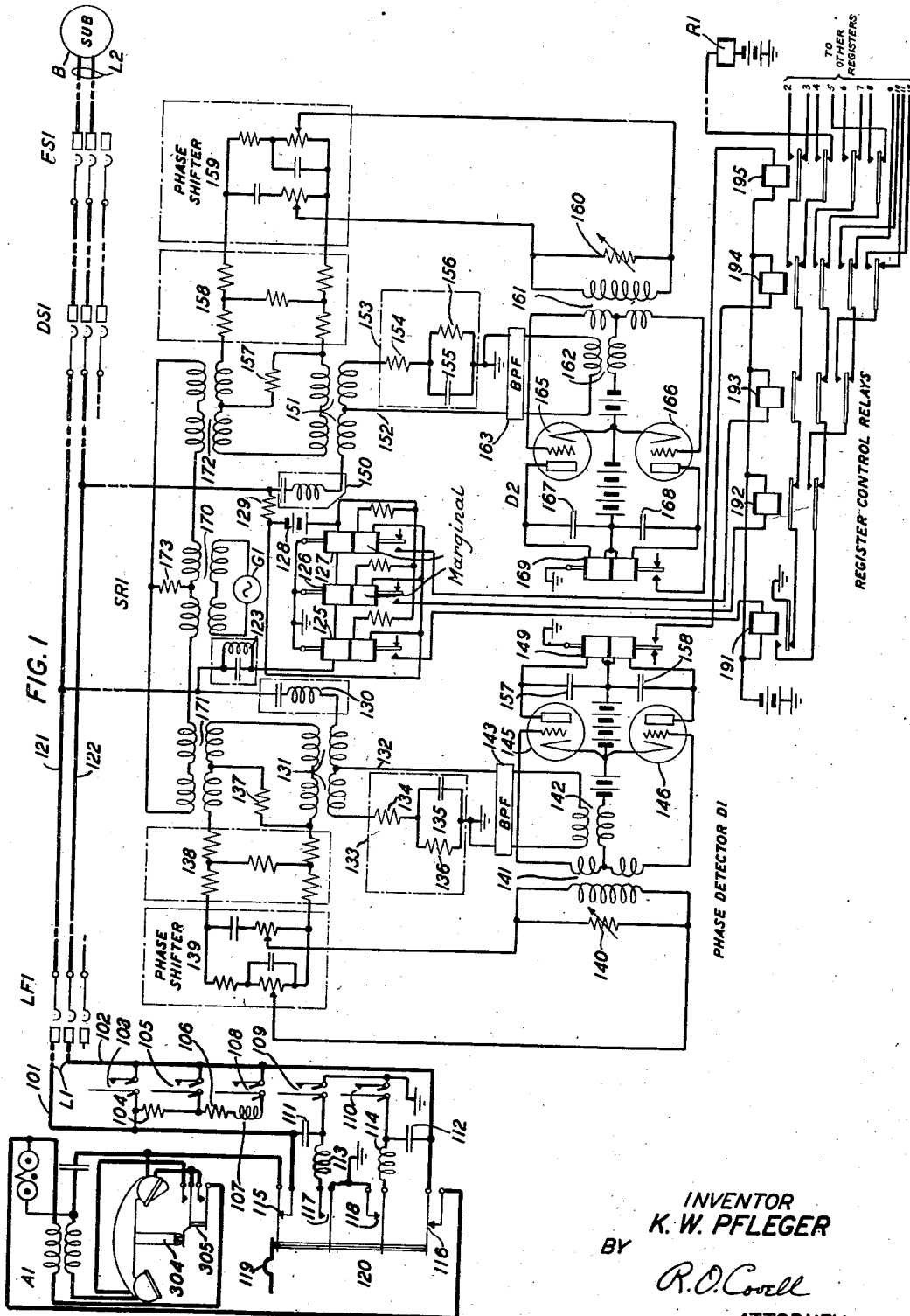
K. W. PFLEGER

2,384,336

SIGNALING SYSTEM

Filed June 4, 1943

3 Sheets-Sheet 1



Sept. 4, 1945.

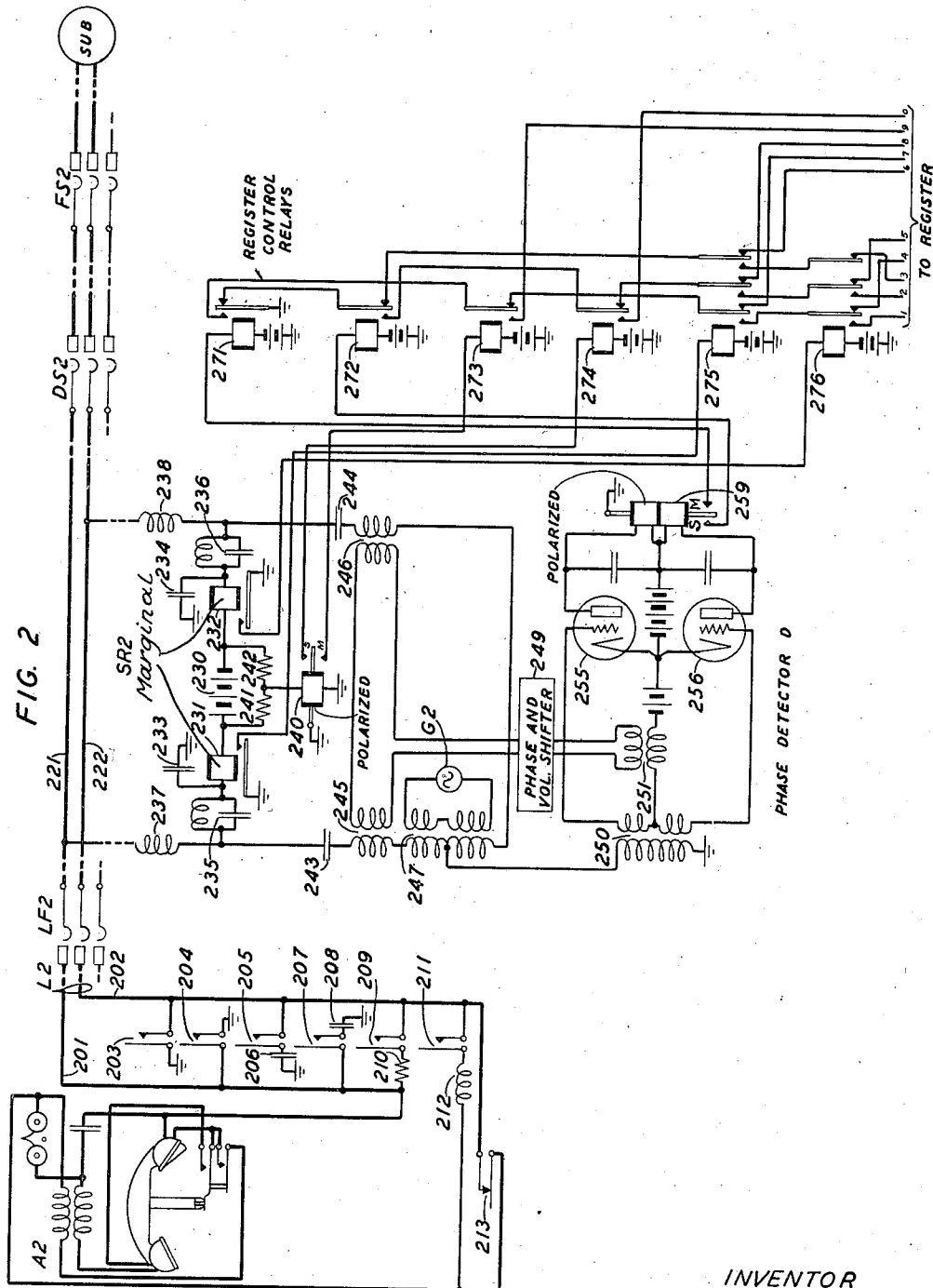
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SIGNALING SYSTEM

Filed June 4, 1943

3 Sheets-Sheet 2



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SIGNALING SYSTEM

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FIG. 3

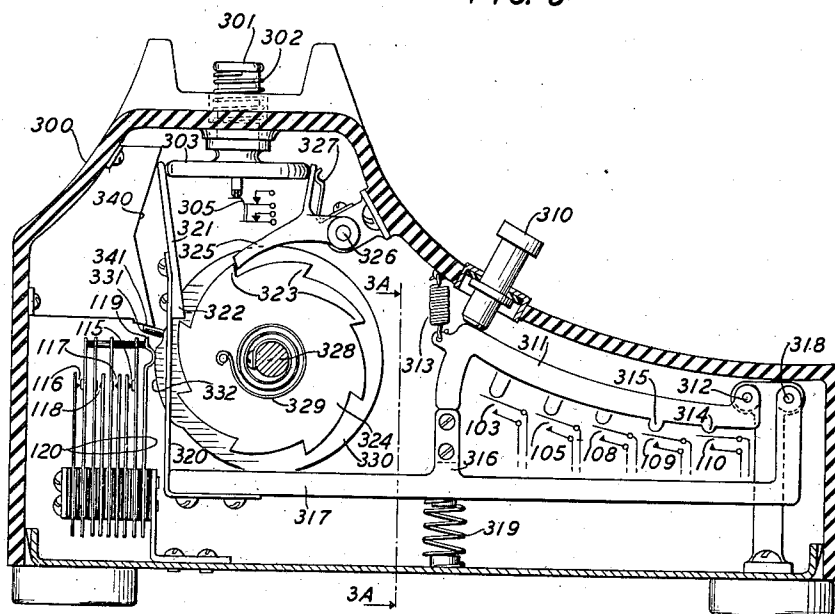
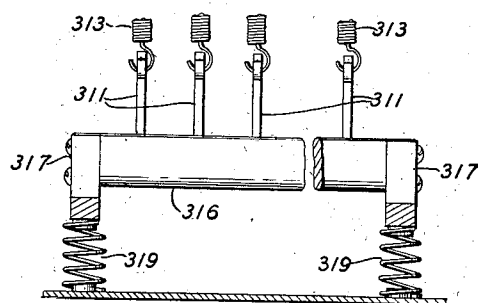


FIG. 3A



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2,384,336

SIGNALING SYSTEM

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Application June 4, 1943, Serial No. 489,612

7 Claims. (Cl. 177—353)

This invention relates to signaling systems and particularly to signaling in systems comprising selectively operated switching devices.

Objects of the invention are the extension of the range of selective signaling, minimization of interference from longitudinal line disturbances, and the elimination of adverse effects from differences in earth potential in grounded signaling circuits. Other objects are an increase in the rapidity with which selective signals are transmitted and the provision of simple and efficient selective signaling means.

A feature of the invention is a signaling system in which a plurality of selective signals are transmitted by combining a selective variation of the impedance angle in grounded signaling circuits with a selective variation of the magnitude of the current in loop signaling circuits, the number of signals thereby obtained being sufficient for the selective control of switching devices such as are commonly used in automatic telephone systems.

Another feature of the invention is a signaling system in which signal receiving means is selectively responsive to a variation in the impedance angle of one or more grounded signaling circuits and a variation in the magnitude of direct current in a loop signaling circuit.

A clear and complete understanding of the invention and its feature will be facilitated by considering specific embodiments of the invention represented schematically in the drawings which forms a part of this specification. The invention is not limited in its application to the systems shown in the drawings but is generally applicable to any system in which a plurality of selective signals are transmitted in grounded and loop circuits.

Referring now to the drawings:

Fig. 1 shows a telephone system comprising a subscriber's station A1 and line L1, a line finder switch LF1, district selector DS1, final selector FS1, and a called subscriber's station B. Fig. 1 further shows a selective signal receiver SR1 for receiving selective signals transmitted from the calling subscriber's station.

Fig. 2 shows a telephone system similar to that shown in Fig. 1 with modified signal transmitting and signal receiving arrangements; and

Figs. 3 and 3A show the structure of the signal transmitting means provided at the subscriber's station A in Fig. 1.

The line finder and selector switches shown in Figs. 1 and 2, may be of the well-known panel type, the selector switches being revertively controlled by a register sender. Reference may be had to the patent to Stearn et al. No. 1,395,977 of November 1, 1921, and the patent to Stearn et al. No. 1,505,171 of August 19, 1924, for a disclosure of systems comprising register sender controlled panel type switches. The subscribers'

stations are of the type usually provided in common battery systems. Station A1 is provided with a key-set mechanism for transmitting selective signals. This mechanism which is shown in detail in Figs. 3 and 3A consists of a set of twelve keys, any desired one of which may be operated to transmit a selective signal over the subscriber's line to the central office. To transmit the office code and number of a called subscriber's line, the required key is operated for each of these digits in succession. Upon operation of a key for the transmission of the first digit of the office code, the key-set contacts 115 and 116 are actuated to disconnect the telephone set from the line conductors 101 and 102; the contact 117 is actuated to connect ground through retard coil 113 and condenser 111 to conductor 101; and the contact 118 is actuated to connect ground through retard coil 114 and condenser 112 to conductor 102. The operation of each of the twelve keys causes the operation of a different combination of contacts 103, 105, 108, 109 and 110. The actuation of contact 103 is effective to close a short-circuit across the conductors 101 and 102; the actuation of contact 105 is effective to connect the resistor 104 across conductors 101 and 102; the actuation of contact 108 is effective to bridge the resistor 106 and inductance 107 in series across conductors 101 and 102; the actuation of contact 109 is effective to short-circuit the retard coil 113; and the actuation of contact 110 is effective to short-circuit the retard coil 114. The particular contacts 103, 105, 108, 109 and 110 which are operated by the depression of a digit key are restored to normal when the key is released; but contacts 115, 116, 117 and 118 remain in actuated position until all of the digits required for completion of the connection have been transmitted.

Referring to Fig. 3, the frame 300 forms a support for the keys 310 and mechanism actuated by operation of the keys, only one of which is shown. The upper portion of frame 300 forms a cradle to receive the telephone handset when not in use. When the handset is in the cradle, the pin 301 is depressed against the tension of spring 302 to actuate the contact springs 305 to disconnect the handset from the conductors of line L1 in the usual and well-known manner. Each of the twelve keys 310 has associated therewith a push-bar 311 which is pivoted on a rod 312, the opposite end of each push-bar being in engagement with a cross bar 316 extending between two end bars 317, as shown in Fig. 3A. Each push bar 311 and key 310 are normally held in non-operated position, as shown in the drawings, by a spring 313. The end bars are pivoted on the rod 318 and are held in normal position by springs 319. Each of eleven of the push-bars 311 has its under-surface formed to actuate one or more sets of contact springs which

are individual thereto, the springs being numbered 103, 105, 108, 109 and 110, depending upon the position of the projection on the push-bar by which it is actuated. For instance, the bar 311, shown in Fig. 3, has a projection 314 for actuating contact springs 110 and a projection 315 for actuating springs 109. Each of these eleven bars has a different combination of projections and contact springs actuated thereby, the contacts actuated by the similarly located projections of different push-bars being connected in parallel so that each of the contacts numbered 103, 105, 108, 109 and 110 in Fig. 1 represent all like-numbered sets of contact springs individual to the push-bars 311. The push-bar 311 associated with the twelfth key has no projections or sets of contacts associated therewith. Thus, the depression of any of eleven of the keys actuates the corresponding push-bar to close a particular combination of contacts 103, 105, 108, 109 and 110; and the depression of the twelfth key actuates the corresponding push-bar but does not actuate any of these contacts. The actuation of each of the twelve push-bars moves the cross bar 316 and end bars 317 on the pivot rod 318 and against the tension of springs 319. The free end of the end bar 317 shown in Fig. 3 carries a flat spring 320 on the upper end of which is mounted an actuating member 321. The lower end of the actuating member 321 forms a driving pawl 322 which engages the teeth 323 of a driving wheel 324. The upper end of the actuating member 321 engages a bearing surface 340 which is formed by or attached to the frame 300. The toothed wheel 324 and a cam wheel 330 are rotatably mounted on a fixed shaft 328. The cam wheel is attached to the toothed wheel and a clock spring 329 is effective to maintain both wheels in normal position with the projection 331 of cam wheel 330 in engagement with the stop 341 of the frame 300. With the wheels in normal position, the cam surface 332 engages the contact spring actuating bar 119 to close contacts 115 and 116 and open contacts 117 and 118 of the spring pile-up 120. Each actuation of the end bar 317 by the depression of a key 310 is effective to rotate the toothed wheel 324 and cam wheel 330 one step. When the key 310 which has been depressed is released, the end bars 317 resume their normal position, but the toothed wheel 324 and cam wheel 330 are held in their advanced position by the retaining pawl 325, the pawl 325 being pivoted at 326 and held in engagement with the wheel 324 by a spring 327. As soon as the cam wheel 330 is advanced out of normal position by the movement of the end bars 317 responsive to the depression of a key 310 corresponding to the first digit of a called office code, the cam controlled spring actuating bar 119 moves to the right thereby opening contacts 115 and 116 to disconnect the calling subscriber's telephone set from the conductors of line L1 and closes the contacts 117 and 118 to close a separate signal transmitting circuit over each of the line conductors 111 and 112. The actuation of a key 310 for each succeeding digit of the called office code and called subscriber's number effects an advance of the toothed wheel 324 and cam wheel 330 one step; and, at the same time, a combination of the contacts 103, 105, 108, 109 and 110 is actuated to selectively transmit the desired digit. When all of the digits of the office code and called subscriber's number have been transmitted by a corresponding number of key operations, the cam wheel 330 will have been ad-

vanced to a position in which the cam surface 332 has again engaged the contact actuating bar 119, thereby to open the selective signaling circuits over conductors 101 and 102 and connect the subscriber telephone set to these conductors for talking. The wheels 324 and 330 remain in this off-normal position during conversation. When the handset is replaced in the cradle at the end of the call, the actuating element 303, which is integral with or carried by the pin 301, bears against the actuating element 321 and also against a projection of the retaining pawl 325 whereby the driving pawl 322 and the retaining pawl 325 are disengaged from the wheel 324. The spring 329 thereupon drives the two wheels 324 and 330 back to their normal position, with the projection 331 resting against the stop 341 and with the cam surface 332 engaging the contact actuating element 119.

The signal receiver SR1 shown in Fig. 1 forms part of a register sender which registers the digits of a called subscriber's office code and number and controls the operation of the selector switches through which a talking connection is established between the calling and called lines. It is assumed that the register sender, of which the signal receiver SR1 forms a part, is connected to conductors 121 and 122 upon connection of the calling line to these conductors by the operation of the line finder switch LF1. Dial tone is thereupon transmitted to the calling station in the usual manner to indicate that the keys of the subscriber's key-set may be operated to selectively transmit the called office code and number. When the calling subscriber depresses the key corresponding to the first digit of the called office code, the cam controlled actuating element 119 effects the opening of contacts 115 and 116 whereby relay means in the register sender, which means is not shown in the drawings, is operated to disconnect the dial tone and to connect the signal receiver SR1 to conductors 121 and 122 for response to each of the digit signals transmitted by operation of the calling subscriber's key-set.

The signal receiver SR1 comprises polarized relays 125, 126 and 127 connected in series with an antiresonant network 123, a non-grounded battery 128 and a resistor 129 across conductors 121 and 122; and these relays are operatively responsive to the selective closing of direct current loop circuits over line L1. The signal receiver SR1 also comprises a source G1 of alternating current of suitable frequency, for instance 100 cycles, hybrid coils 170, 171, 172, 131 and 151, series resonant networks 130 and 150, comprise networks 133 and 153, attenuation pads 138 and 158, phase shifters 139 and 159, phase detectors D1 and D2 and differential relays 149 and 169 for responding to the selective closing of separate grounded alternating circuits over the conductors of line L1. The signal receiver SR1 further comprises register control relays 191, 192, 193, 194 and 195 operatively controlled by relays 125, 126, 127, 149 and 169, and a group of twelve registers for each digit to be registered, only one register R1 of one group being shown in the drawings. The transfer of the register control relays from one group of registers to the next may be effected in any desired known manner.

Each of the polarized relays 125, 126 and 127 has a normally energized biasing winding which tends to maintain the armature in normal position as shown in the drawings. The operation of key-controlled contact 108 connects resistor

104, resistor 106 and induction coil 107 across conductors 101 and 102 in series with the upper windings of relays 125, 126 and 127 and the battery 128. The impedance of elements 104, 106, and 107 is high enough to prevent the operation of marginal relays 126 and 127, but relay 125 is sensitive enough to be operated by the current in the circuit closed by contact 108. The operation of key-controlled contact 105 connects resistor 104 across conductors 101 and 102, the current through the operating windings of relays 125, 126 and 127 being sufficient to effect the operation of both of relays 125 and 126 but insufficient to effect the operation of relay 127. The operation of key-controlled contact 103 closes a short-circuit across conductors 101 and 102 thereby to effect the operation of all three of relays 125, 126 and 127. Thus, there are three direct current signaling conditions which may be selectively and independently established at the calling station and recognized by the signal receiver.

The resistors 173, 137 and 157 are selected to balance the impedance of the input circuits of the hybrid coils 170, 171 and 172, respectively. The attenuation pads 138 and 158 may be omitted if the hybrid coils 171 and 172 are well balanced. The network 123 is antiresonant at the frequency of source G1 to prevent the transmission of alternating current through the windings of relays 125, 126 and 127. The networks 130 and 150 are resonant at the frequency of source G1 to permit the transmission of signal current therethrough to the line conductors 101 and 102; and these networks do not pass direct current. They attenuate any interference currents such as power line hum, transients or modulation products. The networks 133 and 153 are designed for lines of average length, and the values of the elements 134, 135, 136 and 154, 155, 156 are such that the voltage across the upper windings of transformers 142 and 162 has a positive angle when the corresponding one of inductances 113 and 114 is short-circuited by the closure of key-controlled contact 109 or 110 at the calling station and has a negative angle when the corresponding one of these inductances is not short-circuited. Each of the phase detectors D1 and D2 comprises a first input transformer 141 or 161, a second input transformer 142 or 162, balanced push-pull vacuum tube rectifiers 145 and 146 or 165 and 166, and a differentially wound polarized relay 149 or 169. It is possible to replace the vacuum tubes with other types of rectifier, for instance copper oxide rectifiers. It is also possible to replace each of the phase detectors with a dynamometer type relay. The voltages in the right windings of the transformers 141 and 161 are adjusted in phase to have the desired phase angle with respect to an arbitrary standard voltage having zero angle. The phase shifters 139 and 159 are of known form and may provide for both fixed step and continuously varying adjustments; and, if necessary a switch may be provided in each of the phase shifters for interchanging the input leads to the phase detectors in which case a 360-degree phase adjustment is possible. The amplitude of the voltage applied to the input side of transformers 141 and 161 of the phase detectors is controlled by the setting of the variable resistor 140 or 160. With the phase shifter 139 properly adjusted, the voltage applied to the rectifiers of phase detector D1 will be effective to energize relay 149 to close its right contact when the phase angle of the volt-

age in the upper winding of transformer 142 is positive and to maintain closure of the left contact when the phase angle of the voltage in the upper winding of transformer 142 is negative. Thus, relay 149 closes its left contact when key-controlled contact 109 is normal and inductance coil 113 and condenser 111 are in series with conductor 101; and relay 149 closes its right contact when contact 109 is closed and coil 113 short-circuited. With the phase shifter 159 properly adjusted, the voltage applied to the rectifiers of phase detector D2 will be effective to energize relay 169 to close its right contact when the phase angle of the voltage in the upper winding of transformer 162 is negative and to maintain closure of the left contact when the phase angle of the voltage in the upper winding of transformer 162 is positive. Thus, relay 169 closes its right contact when key-controlled contact 110 is normal and inductance 114 and condenser 112 are in series with conductor 102; and relay 169 closes its left contact when contact 110 is closed and coil 114 is short-circuited. Thus, there are four alternating current signal conditions obtainable between the key-set at the calling station and the signal receiver SR1, as follows: (1) with both of key-controlled contacts 109 and 110 normal, in which case coil 113 and condenser 111 are in series with conductor 101 and relay 149 is normal; and coil 114 and condenser 112 are in series with conductor 102 and relay 169 is normal; (2) with both of contacts 109 and 110 closed, in which case coils 113 and 114 are short-circuited and both of relays 149 and 169 are operated; (3) with contact 109 closed and contact 110 normal, in which case coil 113 is short-circuited and relay 149 is operated and coil 114 and condenser 112 are in series with conductor 102 and relay 169 is normal; and (4) with contact 109 normal and contact 110 closed, in which case coil 113 and condenser 111 are in series with conductor 101 and relay 149 is normal and coil 114 is short-circuited and relay 169 is operated.

Interference currents in the conductors of line L1, although considerably attenuated by the series resonant networks 130 and 150, the compromise networks 133 and 153 and the hybrid coils 131 and 151, will pass in equal volume into the rectifiers 145 and 146 and in equal volume into the rectifiers 165 and 166, both windings of each of differential relays 149 and 169 being thereby energized in opposition without operative effect. Since current of the signaling frequency from source G1 appears in the input transformer 141 and also in the input transformer 142, there will be some modulation products at the rectifier outputs corresponding to the sum and difference frequencies between the interference frequency or frequencies and the signaling frequency; and these modulation products will produce beats. If the signaling frequency is 100 cycles per second and the interference current is 60 cycles per second, the beats may be in the order of 40 cycles per second in which case the differential relays 149 and 169 should be sensitive only to frequencies below 40 cycles per second, this result being obtainable by making these relays somewhat slow to respond although capable of satisfactory response to key closures at the rate of 10 cycles per second. To further protect against interference from beats produced by modulation products and the signaling frequency, band-pass filters 143 and 163 may be inserted in series with the input side of transformers 142 and 162, whereby current of only the signaling frequency

and its sidebands is applied through transformers 142 and 162. If the signaling frequency is 100 cycles per second, the band passed by these filters might be 85 to 115 cycles per second thereby clearing out all interference from 25 or 60-cycle per second current and from harmonics of these frequencies with the possible exception of the fourth harmonic of 25-cycle current.

Each of the alternating current signaling conditions may be established simultaneously with the above-described direct current signal conditions providing the coupling introduced between the two conductors of the line by closure of the direct current circuit is not sufficient to interfere with the selective response of relays 149 and 169. The coupling introduced by the operation of key-controlled contact 108 is not sufficient to effect the response of relays 149 and 169 since the impedance of elements 104, 106 and 107 is high; and therefore the direct current signaling condition produced by the closure of contact 108 may be combined with each of the aforementioned four alternating current signal conditions. The inductance coil 107 may be omitted if the line is not too long, thereby enabling faster direct current signaling. Whenever the coil 107 is provided, its direct current resistance is included in the value of resistor 106 in computing its effect. The alternating current resistance of coil 107 should be high so as to permit a small sized core. Since the operation of each of key-controlled contacts 103 and 105 produces a close coupling between the conductors of line L1, it is not possible to combine the direct current signal conditions selectively produced by the closure of each of these contacts with each of the four alternating current signal conditions. But each of these two direct current signal conditions may be combined with the alternating current signal condition which exists when neither of key-controlled contacts 109 and 110 is closed and also with the alternating current signal condition which exists when both of key-controlled contacts 109 and 110 are closed; because, in either of these cases, the alternating current potentials are balanced all along the conductors 101 and 102. Thus, there is a total of twelve non-interfering signal conditions which may be selectively established under the control of the key-set at the calling station to effect registration of any called subscriber's office code and number in the register sender which controls the operation of selector switches through which the desired connection is established. These twelve signal conditions are clearly indicated by the following table:

Digit key operated	Key-controlled contacts closed					A. C. signal relays operated		D. C. signal relays operated		
	103	105	108	109	110	149	169	125	126	127
1										
2				✓	✓	✓	✓			
3				✓		✓				
4					✓		✓			
5			✓					✓		
6			✓	✓	✓	✓	✓			
7			✓	✓		✓	✓	✓		
8			✓			✓	✓	✓		
9		✓				✓	✓	✓	✓	
10		✓		✓	✓	✓	✓	✓	✓	
11	✓					✓	✓	✓	✓	✓
12	✓			✓	✓	✓	✓	✓	✓	✓

The register control relays 191 to 195 are controlled by relays 125, 126, 127, 149 and 169 to operate the corresponding registers. A separate

relay or other electromagnetic device, such as R1, may be provided for each value of each digit; or a group of relays may be provided for each digit, the particular combination of relays being actuated which represents the value of the digit keyed. Since it may be desirable to use a decimal code and to provide for the operation of a supervisory relay to hold the connection between the calling line and the register sender while keying is taking place, the first signal condition of the table would not be used and another of the twelve possible signal conditions, for instance the eleventh, would be utilized as the condition existing between the depression of a key to transmit one digit and the depression of a key to transmit the next digit of the called office code and subscriber's number.

A modification of the arrangement shown in Fig. 1 consists of the omission of contact springs 103 and the omission of the ratchet and cam wheel mechanism. When the subscriber removes the handset, the line L1 is extended through a line finder switch LF and a link (not shown) to an idle register sender in the usual manner, all of contacts 105, 108, 109, 110, 117 and 118 being open and contacts 115 and 116 being closed to admit dial tone to the handset. The dial tone is of a high enough frequency, for instance 1,000 cycles, that it does not interfere with the direct or alternating current signaling conditions. All of the direct current controlled signal relays 125, 126 and 127 are operated while contacts 115 and 116 are closed under which condition no registration is effected in the register sender. The depression of any key effects the opening of contacts 115 and 116 and closes a particular combination of contacts 105, 108, 109, 110, 117 and 118. The opening of contacts 115 and 116 always effects the release of relay 127 thereby rendering the register control relays effective to register the digit being transmitted. Ten signal conditions are possible, these conditions being the same as the first ten of the above table.

A preferred embodiment of the invention, which requires only one phase detector, is shown in Fig. 2. The signal transmitting means at the subscriber's station comprises ten push-button keys, key-controlled contacts 203, 204, 205, 207, 209, 211 and 213, condensers 206 and 208, resistor 210 and inductance coil 212. The signal receiver SR2 comprises two marginal relays 231 and 232 and a polarized relay 240 for responding to direct current signal conditions established by operation of certain of the digit keys at a connected calling subscriber's station. The signal receiver SR2 also comprises a source G2 of alternating current of desired frequency, for instance 100 cycles per second, hybrid coil 247 for impressing the voltage of source G2 on both conductors of the calling line, a phase detector D, and phase and volume control means 249 and transformers 245 and 246 connecting the phase detector to the conductors of the calling line. The phase detector D comprises input transformers 250 and 251, vacuum tube rectifiers 255 and 256 and differential polarized relay 259. The signal receiver SR2 further comprises register control relays 271, 272, 273, 274, 275 and 276 for effecting the operation of the digit registers under the control of the signal relays 231, 232, 240 and 259. The antiresonant networks 235 and 236 prevent false operation of relays 231, 232 and 240 due to alternating current from source G2. When the line is balanced, there is no current through the left coil of input transformer

250. The windings of a supervisory relay may be connected in series with coils 237 and 238 to maintain the connection between the calling line and the register sender while the called office code and subscriber's number are being transmitted.

When the subscriber at station A2 removes the handset, means, including a line finder LF2, is operated to connect the line L2 to an idle register sender which includes a signal receiver SR2. The dial tone may consist of current from source G2 or a separate dial tone source of higher frequency may be provided. At this time, key-controlled contact 213 is closed but all of contacts 203, 204, 205, 207, 209 and 211 are open. The direct current through the windings of relays 231 and 232 and battery 230 effects the operation of these relays; but, the line being balanced, relay 240 remains normal with its armatures in mid-position, and so also does relay 259 since there is no alternating current from source G2 through the left winding of coil 250. Longitudinal noise currents which exist at this time produce substantially equal and opposite voltages in the secondary windings of transformers 245 and 246 so that there is no input applied to transformer 251. These longitudinal noise currents do not affect relay 240 since condensers 233 and 234 constitute a low impedance shunt for the windings of relays 231, 232 and 240 with respect to such currents. While insulation leakage between one conductor of line L2 and ground will unbalance the line, the unbalance introduced by the normal allowable leakage will not be sufficient to cause operation of either one of relays 240 and 259.

The closure of key-controlled contact 203 connects ground to conductor 202; and, with contact 213 open, relay 231 releases, relay 232 is held operated, and the line is unbalanced to effect the energization of relay 240 in a direction which closes its upper contact and to effect the energization of relay 259 in a direction which closes its left contact. The closure of contact 204 connects ground to conductor 201 and, with contact 213 open, relay 231 is held operated, relay 232 releases, and the line is unbalanced to effect the energization of relay 240 in a direction which closes its lower contact and to effect the energization of relay 259 in a direction which closes its right contact. The closure of contact 205 connects conductor 202 to ground through condenser 206; and, with contact 213 open, relays 231 and 232 release, relay 240 remains normal, and relay 259 is energized in the direction which closes its left contact. The closure of contact 207 connects conductor 201 to ground through condenser 208; and, with contact 213 open, relays 231 and 232 release, relay 240 remains normal and relay 259 is energized in the direction which closes its right contact. The closure of contact 209 bridges resistor 210 across conductors 201 and 202; and, with contact 213 open, relay 231 remains operated, relay 232 releases, and relays 240 and 259 remain normal. The closure of contact 211 bridges inductance coil 212 across conductors 201 and 202; and, with contact 213 open, relays 231 and 232 both remain operated, and relays 240 and 259 remain normal. The opening of contact 213 without closing any of contacts 203, 204, 205, 207, 209 and 211 causes the release of relays 231 and 232 and does not affect relays 240 and 259. The selective operation of each of the ten digit keys effects the actuation of a different combination of the key-controlled contacts to

control relays 231, 232, 240 and 259; and relays 271 to 276, inclusive, are thereby controlled to operate the corresponding registers. The following table indicates the various signal conditions and relays operated responsive to the depression of each of the ten digit keys, the two operated positions of each of the polar relays 240 and 259 being indicated by the letters M and S. The adjustment of these polar relays is different from that commonly used in that the tongues remain off contact when the relays are not operated.

Digit key operated	Key-controlled contacts closed	Signal relays operated					
		231	232	259		240	
				M	S	M	S
None.....	213	✓	✓	✓	✓	✓	✓
1.....	207, 211	✓	✓	✓	✓	✓	✓
2.....	205, 211	✓	✓	✓	✓	✓	✓
3.....	209	✓	✓	✓	✓	✓	✓
4.....	207, 209	✓	✓	✓	✓	✓	✓
5.....	205, 209	✓	✓	✓	✓	✓	✓
6.....	None	✓	✓	✓	✓	✓	✓
7.....	207	✓	✓	✓	✓	✓	✓
8.....	205	✓	✓	✓	✓	✓	✓
9.....	204	✓	✓	✓	✓	✓	✓
0.....	203	✓	✓	✓	✓	✓	✓

What is claimed is:

1. In a signaling system, a two-conductor line, a source of direct current and a marginal signal relay at one end of said line, said source and relay connected in series across the conductors of said line, signal sending means at the other end of said line for completing a circuit for operating said relay, an alternating current generator at said one end of said line, a network connected to one of the conductors of said line at said one end, means coupling said generator to said one conductor and network, a phase detector comprising balanced rectifiers and a polarized relay, means coupling said generator to said detector, a transformer having a primary winding connected in parallel with said conductor and in parallel with said network and having its secondary winding connected in the input circuit of said rectifiers, means comprising an induction coil and a condenser connected in series with said conductor at said other end of the line, signal sending means for short-circuiting said induction coil, said polarized relay being energized in one direction when said inductance coil is included in the circuit through said conductor and energized in the other direction when said inductance is short-circuited, and signal register means selectively controlled by said marginal and polarized relays.

2. In a signaling system, a two-conductor line, a source of direct current and a marginal signal relay at one end of said line, said source and relay connected in series across the conductors of said line, signal sending means at the other end of said line for completing a circuit for operating said relay, an alternating current generator at said one end of said line, a network connected to one of the conductors of said line at said one end, means coupling said generator to said one conductor and network, a phase detector comprising balanced rectifiers and a polarized relay, means comprising phase control means coupling said generator to said detector, a transformer having its primary winding connected in parallel with said conductor and in parallel with said network and having its secondary winding connected in the input circuit of said rectifier, means comprising an inductance coil and a condenser con-

nected in series with said conductor at said other end of the line, signal sending means for short-circuiting said inductance coil, said network and phase control means being of such a character that said polarized relay is energized in one direction when said induction coil is included in the circuit through said conductor and energized in the other direction when said inductance is short-circuited, and signal register means selectively controlled by said marginal and polarized relays.

3. In a signaling system, a two-conductor line, a source of direct current, a plurality of signal relays including a marginal relay connected in series with said source across the conductors of said line, signaling means at the other end of said line for selectively completing circuits for selectively operating said relays, an alternating current generator at said one end of said line, a network connected to one of the conductors of said line at said one end, means coupling said generator to said one conductor and network, a phase detector comprising balanced rectifiers and a polarized relay, means coupling said generator to said detector, a transformer having its primary winding connected in parallel with said conductor and in parallel with said network and having its secondary winding connected in the input circuit of said rectifiers, means comprising an induction coil and a condenser connected in series with said conductor at said other end of the line, signal sending means for short-circuiting said induction coil, said polarized relay being energized in one direction when said induction coil is included in a circuit through said conductor and energized in the other direction when said inductance is short-circuited, and signal register means selectively controlled by said marginal and polarized relays.

4. In a signaling system, a line, signal receiving means connected to one end of said line, signal transmitting means connected to the other end of said line, said signal receiving means comprising a source of direct current and a plurality of signal relays connected in series across the conductors of said line, one of said relays being a marginal relay, said signal transmitting means comprising means for closing a direct current circuit over said line to operate one of said relays without operating said marginal relay and means for closing a direct current circuit over said line to operate said marginal relay, said signal receiving means further comprising an alternating current source, a first phase detector including a polarized relay, phase control means coupling said alternating current source to said first detector, and means coupling said source to one of the conductors of said line, said signal transmitting means further comprising means including impedance elements for varying the phase of the alternating current in said one conductor, means for impressing on the input circuit of said detector a voltage derived from the voltage impressed on said one conductor to operate the polarized relay of said first detector in one direction when the alternating current of said conductor is of one phase and to operate said polarized relay in the other direction when the alternating current in said conductor is of a different phase, said signal receiving means further comprising a second phase detector including a polarized relay, phase control means coupling said alternating current source to said second detector, means coupling said source to the other conductor of said line, said signal transmitting means further comprising means including im-

pedance elements for varying the phase of the alternating current in said other conductor, means for impressing on the input circuit of said second detector a voltage derived from the voltage impressed on said other conductor to operate the polarized relay of said second detector in one direction when the alternating current in said other conductor is of one phase and to operate the polarized relay of said second detector in the other direction when the alternating current in said other conductor is of a different phase, and signal register means selectively controlled by said signal and polarized relays.

5. In a signaling system, a two-conductor line, a source of direct current and a marginal signal relay at one end of said line, said source and relay connected in series across the conductors of said line, signal sending means at the other end of said line for completing a circuit for operating said relay, an alternating current generator at said one end of said line, a network connected to one of the conductors of said line at said one end, another network connected to the other of the conductors of said line at said one end, means coupling said generator to said conductors and networks, a first phase detector comprising balanced rectifiers and a polarized relay, means comprising phase control means coupling said generator to said first detector, a second phase detector comprising balanced rectifiers and a polarized relay, means comprising phase control means coupling said generator to said second detector, a transformer having its primary winding connected in parallel with said first conductor and in parallel with said first network and having its secondary winding connected in the input circuit of the rectifiers of said first detector, a second transformer having its primary winding connected in parallel with the other conductor of said line and in parallel with said second network and having its secondary winding connected in the input circuit of the rectifiers of said second detector, means comprising an induction coil and a condenser at the other end of the line connected in series with said one conductor, means comprising an inductance coil and a condenser at said other end of the line connected in series with said other conductor, signaling sending means for short-circuiting the induction coil connected to said first conductor, signal sending means for short-circuiting the induction coil connected to said other conductor, the network and phase control means associated with said one conductor being of such a character that the polarized relay of said first detector is energized in one direction when the associated induction coil is included in the circuit through said one conductor and energized in the other direction when the associated induction coil is short-circuited, and the network and phase control means associated with said other conductor being of such a character that the polarized relay of said second detector is energized in one direction when the induction coil associated with said other conductor is included in the circuit through said other conductor and energized in the other direction when the induction coil associated with said other conductor is short-circuited, and signal register means selectively controlled by said marginal and polarized relays.

6. In a signaling system, a line, signal receiving means connected to one end of said line, signal transmitting means connected to the other end of said line, said signal receiving means comprising a source of direct current and a plu-

rality of signal relays connected in series across the conductors of said line, one of said relays being a sensitive relay operated whenever a loop circuit is closed over said line and the others of said relays being marginal relays, said signal transmitting means comprising means for closing a direct current circuit over said line to selectively operate said relays, said signal receiving means further comprising an alternating current source, a first phase detector including a polarized relay, phase control means coupling said alternating current source to said first detector, and means coupling said source to one of the conductors of said line, said signal transmitting means further comprising means including impedance elements for varying the phase of the alternating current in said one conductor, means for impressing on the input circuit of said detector a voltage derived from the voltage impressed on said one conductor to operate the polarized relay of said first detector in one direction when the alternating current of said conductor is of one phase and to operate the polarized relay in the other direction when the alternating current in said conductor is of a different phase, said signal receiving means further comprising a second phase detector including a polarized relay, phase control means coupling said alternating current source to said second detector, means coupling said source to the other conductor of said line, said signal transmitting means further comprising means including impedance elements for varying the phase of the alternating current in said other conductor, means for impressing on the input circuit of said second detector a voltage derived from the voltage impressed on said other conductors to operate the polarized relay of said second detector in one direction when the alternating current in said other conductor is of one phase and to operate the polarized relay of said second detector in the other direction when the alternating current in said other conductor is of a different phase, and signal register means selectively controlled by said signal and polarized relays.

- 5 In a signaling system, a two-conductor line, signal receiving means connected to one end of said line and comprising an alternating current source, a first phase detector including a first
- 10 signal relay, means coupling said alternating current source and first detector and one of the conductors of said line to effect the operation of said first signal relay when the alternating current in said one conductor is of one phase but
- 15 not when the alternating current in said one conductor is of the opposite phase, a second phase detector including a second signal relay, means coupling said alternating current source and said second detector and the other conduc-
- 20 tor of said line to effect the operation of said second signal relay when the alternating current in said other conductor is of one phase but not when the alternating current in said other conductor is of the opposite phase, a source of direct current and other signal relays including
- 25 a marginal relay connected in series with said source across the conductors of said line, signal transmitting means connected to the other end of said line and comprising selective means for
- 30 varying the magnitude of the direct current in said line, for varying the phase of the alternating current in one of the conductors of said line, for varying the phase of the alternating current in the other of the conductors of said line, for
- 35 varying the magnitude of the direct current and at the same time the phase of the alternating current in either one of the conductors of said line, for varying the phase of the alternating current in both of the conductors of said line at the same time or for varying the magnitude
- 40 of the direct current in said line and at the same time the phase of the alternating current in both of the conductors of said line, thereby to effect the selective operation of one or more of said signal relays, and signal register means controlled by said signal relays.

KENNETH W. PFLEGER.