H. D. MacPHERSON.

TELEPHONE SYSTEM.

APPLICATION FILED JULY 20, 1920.

1,386,719.

Patented Aug. 9, 1921.

3 SHEETS—SHEET 1.

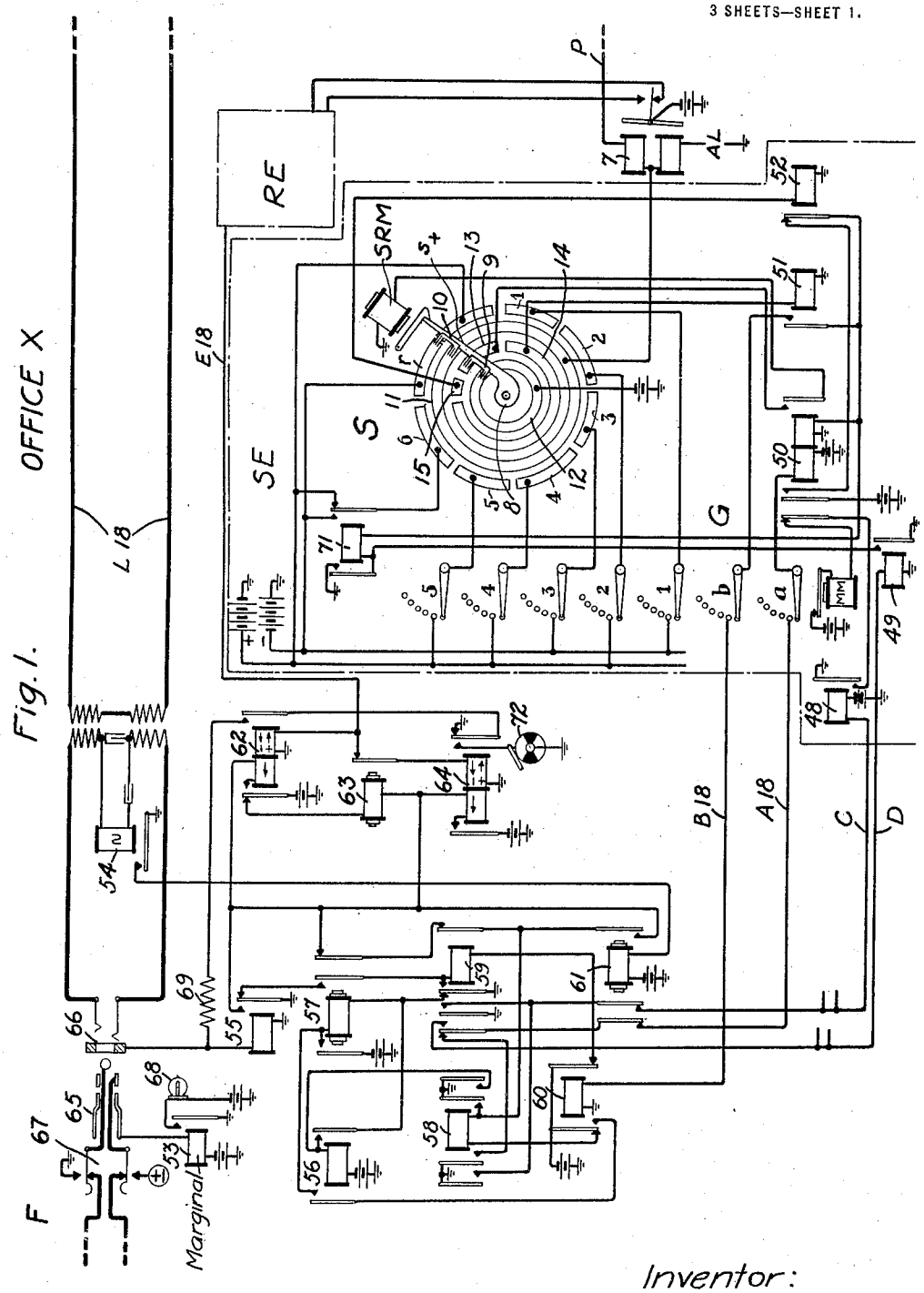


Fig. 1.

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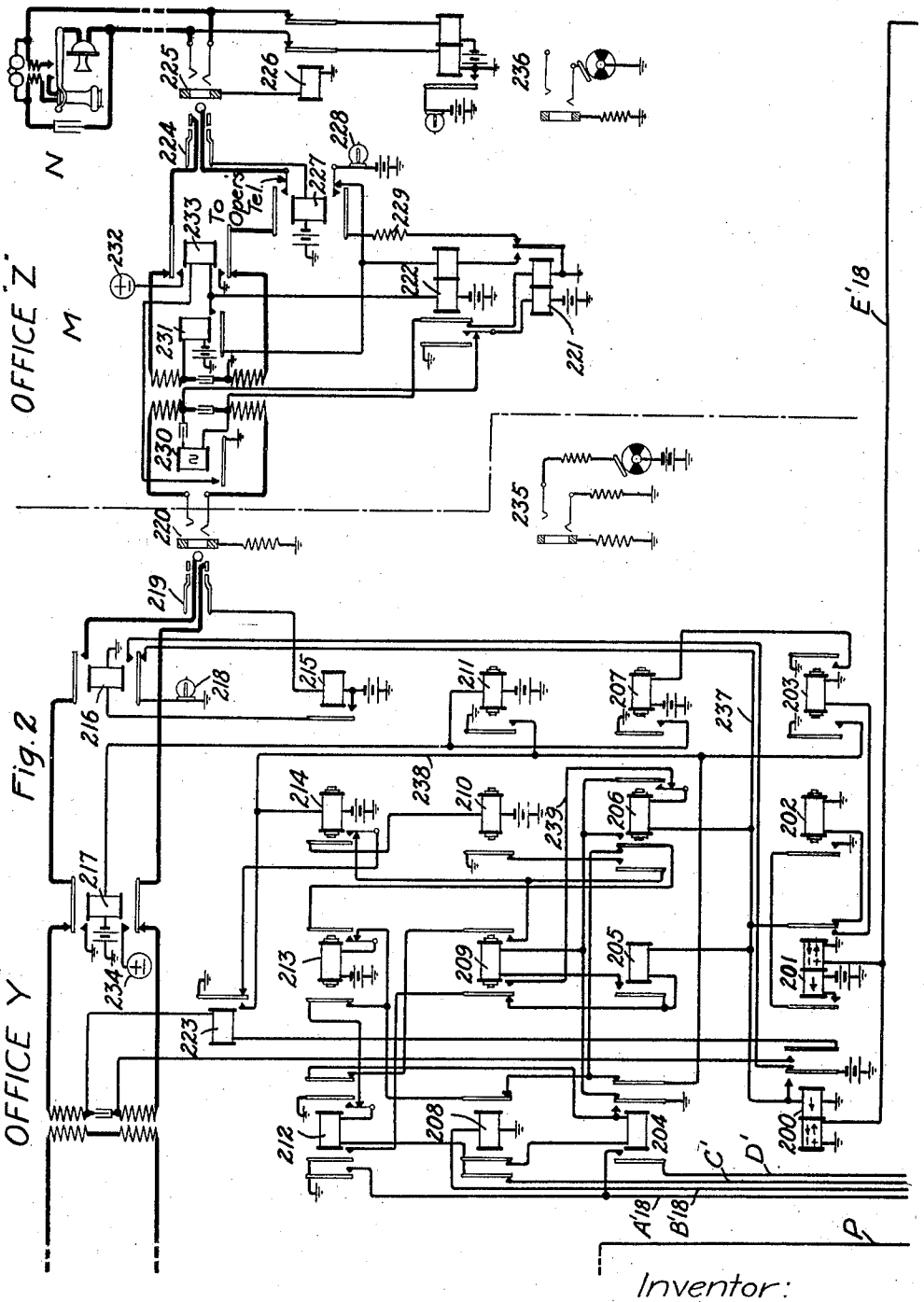


Fig. 2

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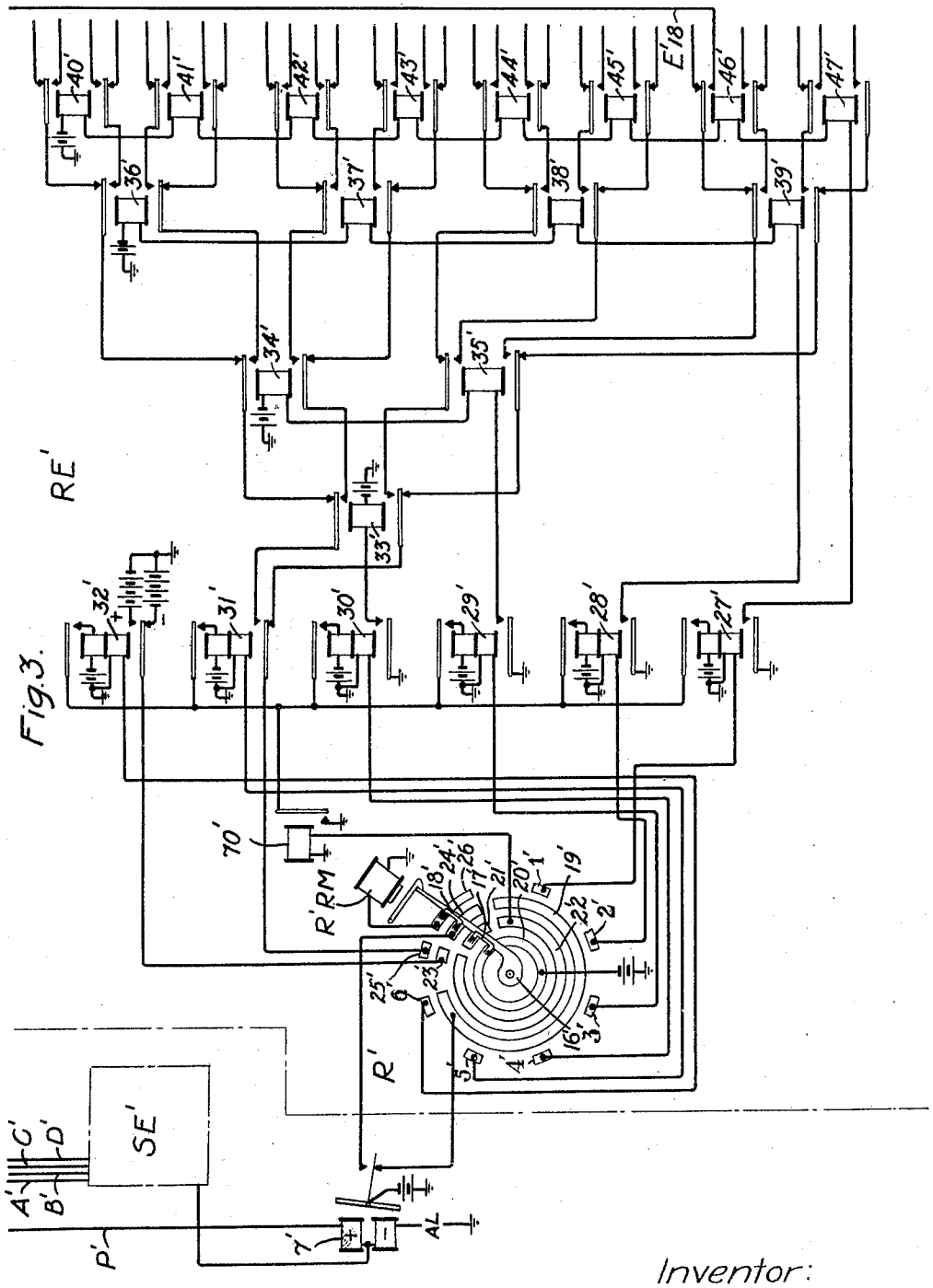


Fig. 3.

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UNITED STATES PATENT OFFICE.

HUGH D. MacPHERSON, OF SUMMIT, NEW JERSEY, ASSIGNOR TO WESTERN ELECTRIC COMPANY, INCORPORATED, OF NEW YORK, N. Y., A CORPORATION OF NEW YORK.

TELEPHONE SYSTEM.

1,386,719. Specification of Letters Patent. Patented Aug. 9, 1921.

Application filed July 20, 1920. Serial No. 397,641.

To all whom it may concern:

Be it known that I, HUGH D. MacPHERSON, a citizen of the United States, residing at Summit, in the county of Union and State of New Jersey, have invented certain new and useful Improvements in Telephone Systems, of which the following is a full, clear, concise, and exact description.

This invention relates to telephone systems, and more particularly to such systems in which the signals for a plurality of trunk lines extending between widely separated stations are controlled over a single signaling path common to such trunk lines.

In systems of this character heretofore employed there have been provided, at opposite ends of the signaling path, intermittently operated distributers, of the start-stop type generally employed in printing telegraph systems, for individually associating the trunk lines with the common signaling path, and for transmitting and receiving thereover code signals individual to the various trunk lines. For determining the code of the signals transmitted there have been provided intermittently operating selector switches comprising stationary contacts individual to the trunk lines and coöperating movable contacts individual to both those segments of the sending distributer which control the selection of the trunk lines at the receiving end, and those segments which control the character of the signal to be transmitted over the signal receiving conductor individual to the selected trunk line.

The principal object of this invention is the provision of improved means for determining the code of the signals to be transmitted over the common signaling path. Other objects will be apparent from a consideration of the following description and the appended claims.

In the present embodiment of the invention, there is provided at each end of the signaling path, a sending distributer and a receiving distributer common to the trunk lines for transmitting and receiving code signals individual to the various trunk lines. For determining the character of a portion of each code signal there is provided, in association with each sending distributer, an intermittently operating selector switch comprising stationary contacts individual to the various trunk lines and coöperating movable contacts individual to only those segments of the sending distributer which control the selection of the trunk line at the receiving end. For determining the character of that portion of each code signal which controls the character of the signal to be transmitted over the signal receiving conductor of the selected trunk line, there is provided means common to the trunk lines but independent of the selector switch. This means preferably takes the form of a relay to directly control the polarity of current connected to one of the segments of the sending distributer.

For a more complete understanding of this invention, reference should be had to the accompanying drawings in which Figs 1, 2 and 3 with Fig. 2 placed to the right of Fig. 1 and Fig. 3 below Fig. 2 illustrate certain portions of a telephone system embodying the invention. All apparatus shown in Fig. 1 is located at an office X; the apparatus to the left of the dotted line in Fig. 2 and that in Fig. 3 is located at an office Y, while that to the right of the dotted line in Fig. 2 is located at an office Z. For convenience where like apparatus is employed at offices X and Y, it is designated by the same reference character, that at office X without, and that at office Y with primes. In the drawings there is shown a toll trunk line L 18 comprising two talking conductors extending from a jack 66 at central office X to a plug 219 at central office Y. At central office X there is located a toll cord circuit F for extending connections from a calling line, (not shown) to the trunk lines. The trunk line L 18 may be connected with a toll switching trunk circuit M extending from the central office Y to a central office Z at which terminates a called subscriber's telephone line N with which the toll switching trunk circuit may be connected. While only one toll cord circuit, one toll trunk line, one toll switching trunk and one subscriber's telephone line are shown, it is to be understood that this is for the purpose of simplicity only and that many such circuits may be and usually are provided in actual service.

The signals for a plurality of toll trunk lines may be controlled over a signaling path common to the trunk lines, consisting of a conductor P, extending from office X to office Y and provided with a grounded return as shown. In order that signals may be simultaneously transmitted in both direc-

tions over the conductor P, there is provided the usual duplex equipment comprising differential polarized relays 7 and 7′ at opposite ends of the conductor, and artificial balancing lines AL.

Within the dotted inclosure SE in Fig. 1, there is shown signal transmitting equipment located at office X, which is common to a plurality of trunk lines and comprises a sending distributer S, a selector switch G, and controlling relays therefor: As the transmitting equipment located at office Y is identical with that at office X, it has been represented diagrammatically by the dotted square SE′ in Fig. 3. To the right of the dotted line in Fig. 3 there is shown signal receiving equipment RE′ located at office Y, comprising a receiving distributer R′, locking relays 27′ to 32′, and pyramid selecting relays 33′ to 47′. Since the receiving equipment at office X is identical with that at office Y, it has been represented diagrammatically by the dotted square RE in Fig. 1. A description of the equipment SE and RE′ will, therefore, serve to describe the equipment SE′ and RE as well.

The sending distributer S and the receiving distributer R′ are of the start-stop type well known in the art of printing telegraphy and comprise a set of stationary rings, some of which are continuous and some segmented, brush arms 8, 16′, brushes 9, 10 and 17′, 18′, carried by and insulated from the brush arms, and release magnets SRM and R′RM respectively. The brush arms 8 and 16 of distributers S and R at office X are mounted on a continuously rotating shaft and separated therefrom by friction clutch mechanism (not shown) so that upon the energization of either release magnet SRM or RRM, the brush arm normally held against rotation by the armature of that magnet will make one revolution being stopped at the end of the revolution by engagement with the armature of the release magnet which has been retracted during the rotation of the brush arm. The brush arms 8′ and 16′ of the distributers S′ and R′ at office Y are likewise mounted on a continuously rotating common shaft and operate in the same manner. Any well-known means, (not shown) may be employed to maintain synchronism between the rotating shaft at office X and that at office Y. The face of sending distributer S is provided with a common sending ring 11 which is successively connected during a rotation of the brush 10 to a restoring segment *r*, a start segment *s* and individual sending segments 1 to 6 for controlling the signals transmitted over the conductor P. A ring 12 which is successively connected during a rotation of the brush 9 with segments 13, 14 and 15 is also provided to control local circuits at office X. The face of receiving distributer R′ comprises segments 24′ and 26′ which control the circuit of release magnet R′RM, a common receiving segment 19′ which is successively connected by brush 18′ to individual receiving segments 1′ to 6′ to control relays 27′ to 32′ in accordance with the signals received over the conductor P, and segments 23′ and 25′ which complete the selected signaling circuit at office Y. A ring 20′ is also provided to coöperate with a segment 22′ in controlling the circuit of relay 70′.

The common signaling conductor P is connected through one winding of polarized relay 7 to the common sending ring 11 of distributer S at office X. Negative battery is normally connected through segment *r* to the conductor P, causing polarized relay 7′ at office Y to maintain closed its lower contact. Upon the energization of release magnet SRM, the brush arm 8 starts its rotation in a clockwise direction and positive battery is immediately connected through start segment *s* of distributer S to conductor P to cause relay 7′ to close its upper contact, thereby completing a circuit for release magnet R′RM of receiving distributer R′ at office Y. The energization of release magnet R′RM releases brush arm 16′ so that arm 8 at office X and arm 16′ at office Y rotate in approximate synchronism. When negative battery is connected through any of the sending segments 1 to 6, through ring 11 to conductor P, it will cause the closure of the lower contact of duplex relay 7′ at office Y, thereby completing a circuit from grounded battery, lower contact of relay 7′, receiving segment 19′, one of the individual segments 1′ to 6′ in accordance with the position of the brush arms 8 and 16′, through the lower winding of one of the relays 27′ to 32′ corresponding to the segments 1′ to 6′ to ground. When, however, positive battery is connected through one of the sending segments 1 to 6 and ring 11 to conductor P during the travel of brush arms 8′ and 16′, relay 7′ maintains closed its upper contact and no effects are produced on the locking relays 27′ to 32′. It will, therefore, be apparent that by varying the code of the signals transmitted over the conductor P, any desired combination of the locking relays 27′ to 32′ may be energized. Each of the first four of these relays 27′ to 30′ controls the circuit for one row of the pyramid selecting relays 33′ to 47′, while the fifth locking relay 31′ selects either the upper or lower armature of relay 33′ so that the selection of the signal receiving conductor E′ to be associated with the distributer R′ depends upon the code of the signal transmitted through segments 1 to 5 of distributer S and received through segments 1′ to 5′ of distributer R′. The character of signal to be transmitted over the selected conductor E′ depends upon the energized or inert con-

dition of relay 32′, the sixth of the locking relays, for if this relay is deënergized at the time brush 18′ passes over segments 23′, 25′ negative battery will be connected over the lower armature and back contact of relay 32′, segments 23′, 25′, lower armature of relay 31′ and thence over the armatures of other of the pyramid selecting relays to the conductor E′ which conductor is individual to the selected trunk line. If, however, relay 32′ is energized at this time, positive battery will be connected over the front contact and lower armature of relay 32′ and over the path just traced to conductor E′.

The code of that portion of each signal which controls the selecting of the conductor E′ individual to a given trunk line is, therefore, determined by the polarity of current connected to segments 1 to 5 of distributer S while the distributer is sending out a signal.

A selector switch G determines, by the position of its brushes 1 to 5, the polarity of current connected at any time to segments 1 to 5 of distributer S. The switch G comprises seven movable contacts or brushes *a*, *b*, 1, 2, 3, 4 and 5 which are preferably mounted at different levels on a common shaft. Each brush coöperates with a set of stationary contacts, as shown, there being one stationary contact in each set for each trunk line which may be associated with the distributer S. The brushes of switch G may be rotated over their contacts either by a continuously driven source of power or by a stepping magnet. In the present embodiment of the invention a self-interrupting motor magnet MM is provided to move the brushes step-by-step over their contacts. The switch G will be started whenever relay 48, which is common to the trunk lines, is energized, and will be stopped by the energization of relay 50 when the brush *a*, encounters a stationary contact connected over one of the conductors A to ground. There is provided for each trunk line, one conductor A leading from a stationary contact of the switch G to a back contact of the relay 61 which is individual to said line. Relay 48 is controlled over a conductor C, common to the trunk lines, by certain relays individual to each trunk line. There is also provided for each trunk line, a conductor B leading from the winding of individual relay 60 to that stationary contact upon which the brush *b* rests when the switch G has been associated with the particular trunk line in signaling condition. The stationary contacts of levels 1 to 5 of the switch G are connected to sources of current of positive and negative polarity in various combinations such as to cause the selection of the proper conductor E′ at office Y whenever one of the trunk lines at office X is in signaling condition. While the invention is not limited to any specific combination of polarities, nor to any particular number of trunk lines which may be served by one selector switch and set of distributers, the combination shown in the following table have been found satisfactory for use with a switch G having thirty contacts in each level to be used with a distributer S employing five sending segments in selecting the proper signal receiving conductor E′ at the distant office.

Trunk line	*Level No.* 1 2 3 4 5	*Trunk line*	*Level No.* 1 2 3 4 5
1	+ + − + +	16	− + + + +
2	+ + + − +	17	− − + + +
3	+ + + + −	18	− + − + +
4	+ + − − +	19	− + + − +
5	+ + − + −	20	− + + + −
6	+ + + − −	21	− − − + +
7	+ + − − −	22	− − + − +
8	+ − + + +	23	− − + + −
9	+ − − + +	24	− + − − +
10	+ − + − +	25	− + − + −
11	+ − + + −	26	− + + − −
12	+ − − − +	27	− − − − +
13	+ − − + −	28	− − − + −
14	+ − + − −	29	− − + − −
15	+ − − − −	30	− + − − −

The code of that portion of each signal transmitted by distributer S which controls the character of signal to be transmitted over the selected signal receiving conductor E′ is determined by the polarity of current connected to segment 6 of distributer S during signaling. This polarity is controlled by a relay 71 common to the trunk lines, which normally connects positive current to segment 6 over its right-hand armature and back contact, but which when energized connects segment 6 to a source of current of negative polarity. Relay 71 is initially energized upon the energization of a relay 49 and is locked up under the control of a release relay 52 which will be actuated near the end of a revolution of brush arm 8 after a signal has been transmitted. Relay 49 is controlled over a conductor D common to the trunk lines, and will be energized at such times as the relays individual to any trunk line determine, as will more fully appear hereinafter.

Having in mind the foregoing description of the apparatus of the system shown in the drawings, it is believed that the invention will be readily understood from a consideration of the following description of the operation of setting up and taking down a connection from cord circuit F to the called station N.

Connection of cord circuit F with trunk line L 18.

The operator at office X desiring to establish connection with the telephone line N which terminates at office Z, connection

with which must be established through the office Y, communicates over an order wire circuit (not shown) with the operator at office Y. The operator at office Y noting that trunk line L 18 is idle, designates this trunk for the completion of the connection whereupon the operator at office X inserts plug 65 of cord circuit F in jack 66 of trunk line L 18. A circuit is thereby completed from grounded battery through the winding of marginal relay 53, sleeve contacts of plug 65 and jack 66, and the winding of relay 55 to ground. Relay 55 is energized in this circuit but relay 53 being marginal remains inert. Relay 55 in energizing completes a circuit from ground, its armature and front contact, back contact and outer right-hand armature of relay 57, back contact and right-hand armature of relay 59, through the winding of relay 58, and back contact and left-hand armature of relay 60 to grounded battery. An energizing circuit is also completed from grounded battery, left-hand armature and back contact of relay 62, through the winding of slow release relay 63, and front contact and armature of relay 55 to ground. Relay 58 is energized in this circuit and locked up through its front contact and inner right-hand armature. In attracting its outer left-hand armature, relay 58 places a ground on conductor C thereby causing the energization of start relay 48. Upon attracting its outer right-hand armature, relay 58 causes the operation of relay 56 over a circuit from ground, outer right-hand armature and front contact of relay 58, through the winding of relay 56 to grounded battery. Relay 56 is thereupon locked up to ground at the innermost left-hand armature of relay 59. Relay 48 in attracting its armature completes a circuit from grounded battery, back contact and armature of motor magnet MM through the winding of said magnet, back contact and outer left-hand armature of relay 50, and front contact and armature of relay 48 to ground. Magnet MM interrupts this circuit at its armature thereby stepping the brushes of the selector switch G in a clockwise direction until the terminals individual to the trunk line L 18 are encountered. When brush *a* reaches the stationary contact associated with conductor A 18, stop relay 50 is energized over a circuit which may be traced from grounded battery, left-hand winding of relay 50, brush *a*, conductor A 18, back contact and outer left-hand armature of relay 61, outermost left-hand armature and back contact of relay 59, front contact and inner left-hand armature of relay 58 to ground. Relay 50 in attracting its outer left-hand armature, interrupts the previously traced circuit for magnet MM thereby stopping the selector switch G. In attracting its outer right-hand armature, relay 50 completes a circuit for release magnet SRM of distributer S which may be traced from ground, winding of magnet SRM, outer right-hand armature and front contact of relay 50, segment 13, brush 9, and ring 12 to grounded battery. Relay 50 when energized, was locked up over a circuit extending from grounded battery, inner left-hand armature and front contact of said relay, back contact and armature of relay 52, through the right-hand winding of relay 50 to ground. The energization of magnet SRM releases brush arm 8 which starts its rotation in a clockwise direction. Considering first the results produced at office X by this operation, it will be seen that upon reaching segment 14, a circuit will be completed from grounded battery, ring 12, brush 9, segment 14, through the winding of relay 51 to ground. Relay 51 will be energized in this circuit and maintained energized until brush 9 passes over segment 14. Relay 51 in attracting its armature, completes a circuit from grounded battery, inner left-hand armature and front contact of relay 50, back contact and armature of relay 52, armature and front contact of relay 51, brush *b*, conductor B 18, through the winding of relay 60 to ground. Relay 60 is energized in this circuit and in attracting its left-hand armature, interrupts the circuit of relay 58, which relay in retracting its armatures removes the ground connected to conductors C and A 18 and opens the original circuit for relay 56. Relay 60 also completes a circuit from grounded battery, left-hand armature and front contact of said relay, left-hand armature and front contact of relay 56, through the winding of relay 57 which is made slow to release, and back contact and innermost left-hand armature of relay 59 to ground. Slow release relay 57 is energized in this circuit and locked up under the control of relay 59. Relay 57 in attracting its right-hand armatures, interrupts the original energizing circuit for relay 58 and prepares a circuit for relay 59.

When brush 9 of distributer leaves segment 14 relay 51 deënergizes and in retracting its armature causes the deënergization of relay 60. When brush 9 of distributer S reaches segment 15, a circuit is completed from grounded battery, ring 12, brush 9, segment 15, through the winding of relay 52 to ground. Relay 52 in attracting its armature opens the previously traced locking circuit of relay 50 to deënergize this relay, the original energizing circuit of which was interrupted by the retraction of the armatures of relay 58. Relay 50 in deenergizing opens the previously traced circuit for magnet SRM, which magnet retracts its armature to arrest the travel of the brush

arm 8 at the completion of its revolution and in retracting its outer lefthand armature, relay 50 again places the motor magnet MM under the control of common start relay 48. Brush 9 in passing from segment 15 opens the circuit of relay 52 and the relays common to the sending equipment SE are now all inert.

Considering now the effects produced at office Y by the rotation of brush arm 8, when brush 10 reached segment *s*, a circuit was completed from the positive pole of battery, segment *s*, brush 10, sending ring 11, through the upper winding of duplex relay 7, conductor P, through the upper winding of duplex relay 7′ to SE′. In response to this circuit, relay 7′ closed its upper contact, completing a circuit from grounded battery, upper contact of relay 7′, segment 24′, brush 18′, segment 26′, through the winding of magnet R′RM to ground. Magnet R′RM in attracting its armature released brush arm 16′ which started a revolution in a clockwise direction. Upon reaching individual sending segment 1 of distributer S, brush 10 completed a circuit from the negative pole of battery, brush 1 of selector switch G, individual sending segment 1, brush 10, sending ring 11, through duplex relay 7, conductor P and relay 7′ to ground thereby causing relay 7′ to close its lower contact. At this time, brush 18′ was in contact with receiving segment 1′ of distributer R′, and a circuit was completed from grounded battery, lower contact of relay 7′, receiving segment 19′, brush 18′, segment 1′ and through the lower winding of relay 27′ to ground. Relay 27′ is energized and locked up over a circuit extending from grounded battery, upper winding of relay 27′, front contact and upper armature of said relay and armature and front contact of relay 70′ to ground. Relay 70′ was energized when brush 17′ completed a circuit from grounded battery, ring 20′, brush 17′, segment 22′, through the winding of relay 70′ to ground. Since the polarity of battery connected through brush 2 of switch G to individual sending segment 2 is positive, relay 7′ will close its upper contact when brushes 10 and 18′ are passing over segments 2 and 2′ respectively, so that no circuit will be completed for relay 28′. When these brushes reach segment 3 and 3′, however, negative battery is again connected over the path P to cause relay 7′ to close its lower contact to complete an energizing circuit for relay 29′ in the same manner as the circuit was completed for relay 27′. Relay 29′ is locked up over an obvious circuit in parallel with the locking circuit traced for relay 27′. Since sending segments 4 and 5 are connected to the positive pole of battery, no effect will be produced on relays 30′ and 31′, as the brushes of distributer S and R′ pass over segments 4, 4′ and 5, 5′, and since relay 71 is inert when the brushes pass from segments 6 and 6′, no effect will be produced on relay 32′. Thus, as brush 18′ leaves segments 6′ and 19′ of distributer R′, only the first and third of the locking relays, namely 27′ and 29′ will be energized. Relay 27′ in energizing, completes a circuit which may be traced from grounded battery, through the windings in series, of pyramid relays 40′ to 47′ inclusive and the front contact and lower armature of relay 27′ to ground. Relay 29′ in energizing, completes a circuit from grounded battery, through the winding of pyramid relays 34′ and 35′ in series, and the front contact and lower armature of relay 29′ to ground. As brush 18′ engages segments 23′ and 25′ a circuit will be completed from the negative pole of battery, back contact and lower armature of relay 32′, segment 23′, brush 18′, segment 25′, lower armature and back contact of relay 31′, lower armature and back contact of relay 33′, lower armature and front contact of relay 35′, upper armature and back contact of relay 39′, upper armature and front contact of relay 46′, conductor E′ 18, through the left-hand winding of relay 200 to ground. Relay 200 is energized in this circuit and in attracting its inner armature completes an obvious locking circuit for itself. Relay 201 was also energized in parallel with relay 200 but as no locking circuit was completed for relay 201, it was immediately deënergized and performed no useful function. Brush 17′ of distributer R′ in passing from segment 22′ interrupted the circuit of relay 70′ to deënergize this relay. The retraction of the armature of relay 70′ opened the locking circuit for such of the locking relays 27′ to 32′ as have been energized. The deënergization of these locking relays opens the circuit of such pyramid relays as have been energized thereby restoring the receiving equipment RE′ to its normal condition of readiness to receive the next signal transmitted over the conductor P.

Relay 200 in attracting its inner armature completed a circuit from grounded battery, inner armature and front contact of relay 200, conductor 237, back contact and lower armature of relay 216, through the guard lamp 218 to ground. A circuit was also completed from ground, through the winding of slow release relay 202, back contact and right-hand armature of relay 201 and thence in parallel with the circuit just traced to grounded battery at the right-hand armature of relay 200. The lighting of guard lamp 218 informs the operator at office Y that the operator at office X has connected

her cord circuit F to the designated toll line L 18.

Connection of toll line L 18 with toll switching trunk circuit M.

After the operator at office Y designated the trunk line L 18 for use she communicated with the operator at office Z over an order wire (not shown) advising the operator at office Z the number of the called line. The operator at office Z noting the idle condition of toll switching trunk M assigns it for use by the operator at office Y. The operator at office Y, noting the lighting of guard lamp 218, inserts plug 219 into jack 220 of toll switching trunk M thereby completing a circuit from grounded battery, through the winding of sleeve relay 215, and sleeve contacts of plug 219 and jack 220 to ground. Relay 215 is energized in this circuit thereby completing an obvious circuit for relay 216. Relay 216 in attracting its lower armature opens the circuit previously traced for guard lamp 218 to extinguish such lamp. In attracting its upper armature, relay 216 completes a circuit which may be traced from grounded battery, through the left-hand winding of the supervisory relay 221 of trunk circuit M, back contact of relay 222, tip contacts of jack 220 and plug 219, front contact and upper armature of relay 216 upper armature and back contact of relay 217, through the winding of supervisory relay 223, outer armature and front contact of relay 200, back contact and lower armature of relay 217, ring contacts of plug 219 and jack 220, inner armature and back contact of relay 222 through the right-hand winding of relay 221 to ground. Relay 221 is energized in this circuit and in attracting its armature, completes a circuit extending from grounded battery through lamp 228, the lower normal contact of relay 227, the right-hand winding of relay 222 and the alternate contact of relay 221 to ground. Lamp 228 is lighted to inform the operator at office Z that the operator at office Y has made connection with trunk circuit M. Relay 222, in attracting its armatures opens the previously traced circuit for relays 221 and 223 so that although relay 223 may operate momentarily, it immediately releases and produces no material effect. The attraction of the left-hand armature of relay 222 completes a holding circuit to maintain relay 221 operated.

Connection of toll switching trunk circuit M with telephone line N.

The operator at office Z after testing the called line in the usual manner inserts plug 224 into jack 225. A circuit is thereupon completed from grounded battery, through the winding of sleeve relay 227, the sleeve contacts of plug 224 and jack 225 and the winding of cut-off relay 226 to ground. Relays 226 and 227 operate the former disconnecting the line relay from the line in the usual manner and the latter completing the continuity of the tip conductor of the trunk and interruping the circuit for lamp 228 and relay 222. Lamp 228 is extinguished and the retraction of the armatures of relay 222 reëstablishes the original energizing circuit for relay 221. However, due to open condition of the lower normal contact of relay 227, relay 222 does not reoperate although relay 221 remains operated. Relay 223 operates and in attracting its armatures completes a circuit in parallel for relays 212, 213 and 214, that for relay 214 being traceable from grounded battery through the winding of relay 214 and front contact and armature of relay 223 to ground. Relay 214, is slow to release and relay 213, while somewhat slow in releasing, is faster in operating than relay 214 and relay 212 is a fast relay. The circuit for relay 213 may be traced from grounded battery, winding and make-before-break contact of said relay right-hand armature and back contact of relay 208, outer right-hand armature and back contact of relay 204, conductor 238, front contact and armature of relay 223 to ground. Upon operating, relay 213 is locked up over a circuit from grounded battery, winding, front contact and right-hand armature of said relay, inner left-hand armature and back contact of relay 206, back contact and outer right-hand armature of relay 204, and conductor 238 to ground at the front contact of relay 223. Relay 213 being somewhat slower in operating, did not attract its left-hand armature until after a circuit had been completed from grounded battery, through the winding of relay 48′ of sending equipment SE′, conductor C′, (back contact and outer left-hand armature of relay 208) through the winding of relay 212, left-hand armature and back contact of relay 213, and thence in parallel with the circuit traced for relay 213 to ground at the front contact of supervisory relay 223. Relay 212 in attracting its inner right-hand armature completed a locking circuit for relays 48′ and 212 independent of relay 213. Relay 48′ in energizing, caused the selector switch G to seek with its brush, a grounded conductor A′ in the same manner as above described for the sending equipment SE at office X. Relay 212 in attracting its outer left-hand armature, grounded conductor A′ 18 to stop selector switch G′ in association with the terminals individual to trunk line L 18. From this point the operation of sending equipment SE′ is identical with that described for the sending equipment SE and results in the transmission of an impulse of negative current over the conductor E 18 through the right-hand winding of re-

lay 62 to ground at office X. Relay 62 in attracting its left-hand armature completes a locking circuit for itself from grounded battery, left-hand winding of relay 62 and front contact and armature of relay 55 to ground. In attracting its right-hand armature, relay 62 completes a circuit from ground, back contact and right-hand armature of relay 64, right-hand armature and front contact of relay 62, through the resistance 69, sleeve contacts of jack 66 and plug 65, through the winding of marginal relay 53 to grounded battery. The increased flow of current caused by the closure of this circuit a portion of which shunts the winding of relay 55 allows marginal relay 53 to attract its armature but does not affect the energized condition of relay 55. Relay 53 in energizing, completes an obvious circuit for lamp 68 to inform the operator at office X that the connection has now been set up to the terminals of the desired line and that the established circuit is in condition for signaling the subscriber at the wanted substation.

Upon the operation of relay 51′ of sending equipment SE′, a circuit was completed from grounded battery, front contact of relay 51′, brush b', and conductor B′ 18 through the winding of relay 208 to ground to energize this relay in the same manner that the energization of relay 60 was brought about during the transmission of a signal from office X to office Y. Relay 208 in attracting its outer left-hand armature, interrupted the locking circuit of relays 48′ and 212 to deënergize these relays. At the time relay 212 was originally energized, a circuit was completed from grounded battery, inner armature and front contact of relay 200 through the winding of relay 205, back contact and left-hand armature of relay 209, front contact and inner left-hand armature of relay 212 to ground to energize relay 205. Relay 205 in energizing completed a circuit in parallel with that just traced through the armature and front contact of relay 205, the winding of relay 209 over the back contact and inner right-hand armature of relay 204 to ground, but relay 209 was not energized at this time since this circuit was shunted by the connection of ground from the inner left-hand armature of relay 212 to the armature of relay 205. Upon the deënergizing of relay 212, however, and the removal of this shunt circuit, relay 209 is energized but is without effect at this time. The condition of the relays associated with the trunk line L 18 and office Y, after the sending of the ringing signal to office X, will therefore be as follows:— relays 200, 202, 205, 209, 213, 214, 215, 216 and 223 energized and all other relays inert.

Operator at office X actuates ringing key.

The operator at office X upon observing the lighted condition of supervisory lamp 68, depresses her ringing key 67 to complete a circuit from a source of alternating current, lower alternate contact of key 67, ring contacts of plug 65 and jack 66, through the winding of alternating current relay 54, tip contacts of jack 66 and plug 65, and upper alternate contact of key 67 to ground. Relay 54 is energized in this circuit and completes an obvious circuit for slow release relay 61. Relay 61 in attracting its right-hand armature completes a circuit from ground, armature and front contact of relay 55, front contact and right-hand armature of relay 61, through the winding of relay 58, back contact and left-hand armature of relay 60 to grounded battery. Relay 58 is energized in this circuit and applied ground to conductors C and A 18 in exactly the same manner as when relay 58 was energized upon the insertion of plug 65 into jack 66. Since, however, relay 61 has opened these conductors at its left-hand armatures, no effect is produced through the continued depression of the ringing key by the operator at office X. Upon the release of this key by the operator at office X, relay 54 is deënergized to open the circuit of relay 61 which, in retracting its right-hand armature opens the original energizing circuit of relay 58. This relay, however, is locked up as before, being under the control of relay 60 and since conductors C and A 18 are now grounded, the same sequence of operations is produced in sending equipment SE as was previously described upon the insertion of plug 65 into jack 66 and results in the sending of a code signal over conductor P to select the signal receiving conductor E′ 18 at office Y and to transmit an impulse of negative polarity over this conductor through the right-hand winding of relay 201 to ground. Relay 201, in energizing, completes a locking circuit for itself which may be traced from grounded battery, left-hand winding front contact and armature of relay 201, armature and front contact of slow release relay 202 to ground. After the transmission of the impulse of negative current over conductor E′ 18, sending equipment SE at office X and receiving equipment RE′ at office Y, are restored to normal condition in the manner previously described, and of the relays individual to the toll line L 18 at office X, relays 55, 56, 57 and 62 will be energized and the other relays individual to this toll line will be inert.

Relay 201, which was energized and locked up in response to the ringing signal received from office X, in attracting its right-hand armature, completed a circuit from grounded

battery, inner armature and front contact of relay 200, right-hand armature and front contact of relay 201 through the winding of slow release relay 203 to ground, and opened the circuit of slow release relay 202 so that after a short interval, relay 202 is deënergized to open the locking circuit of relay 201 which thereupon retracts its armatures. Relay 203 in attracting its left-hand armature, connects ground to conductor 238 to maintain relays 213 and 214 energized upon the deënergization of supervisory relay 223. In attracting its right-hand armature relay 203 completes an obvious circuit for slow release relay 207. Relay 207 in attracting its armature completes circuits for ringing relay 217 and slow release relay 211 which may be traced from grounded battery, through the windings of said relays, front contact and armature of slow release relay 207 to ground. Relay 211 connects ground to conductor 238 to replace the ground connected thereto on the left-hand armature of relay 203 which is removed upon the deënergization of relay 203 which takes place after a short interval, due to the retraction of the right-hand armature of relay 201. Relay 217 in opening its back contacts, interrupts the circuits of relays 223 and 221, but relay 221 does not deënergize owing to the completion of a substitute circuit as will appear later. Relay 217 in closing its front contacts completes a circuit from a source of alternating current 234, front contact and lower armature of relay 217, ring contacts of plug 219 and jack 220, through ringing response relay 230, tip contacts of jack 220 and plug 219, front contact and upper armature of relay 216, upper armature and front contact of relay 217 to ground. Relay 230 is energized in this circuit to complete a circuit from ground, armature and front contact of relay 230, through the winding of relay 233 and the left-hand winding of relay 222 to grounded battery. Relay 222 in energizing completes a holding circuit for relay 221 which may be traced from grounded battery, left-hand winding of relay 221, front contact and outer armature of relay 222 to ground. Relay 233, in attracting its armatures, completes a circuit from a source of alternating current 232, front contact and upper armature of relay 233, ring contacts of plug 224 and jack 225, through the ringer at the called substation N, tip contacts of jack 225 and plug 224, front contact and upper armature of relay 227, lower armature and front contact of relay 233 to ground, thereby causing the operation of the call bell at the called substation.

Until the called subscriber answers, the lamp 68 remains lighted before the operator at office X, and if after a reasonable interval this lamp is not extinguished, she will again actuate her key 67 to cause another ringing signal to be transmitted over the path P to again actuate the relays at offices Y and Z to ring the call bell at substation N. In case the called subscriber does not answer within a reasonable time, in response to repeated actuations of key 67 the operator at office X will report this fact and abandon the call. When, however, the subscriber at station N answers, a circuit is completed which may be traced from grounded battery, through the winding of called line supervisory relay 231, back contact and upper armature of relay 233, ring contacts of plug 224 and jack 225, apparatus at substation N, tip contacts of jack 225 and plug 224, front contact and upper armature of relay 227, lower armature and back contact of relay 233 to ground. Relay 231 is energized in this circuit and completes a circuit from grounded battery, through the left-hand winding of relay 222, front contact and armature of relay 231, right-hand winding of relay 222, front contact and armature of relay 221 to ground to hold relay 222 energized during such time as the subscriber at station N retains his receiver away from its switchhook. During the intervals between ringing, relay 223 was alternately energized upon the retraction of the armatures of relay 217 which caused the deënergization of ringing response relay 230 and of relay 222 so that relay 221 was connected in the supervisory circuit previously traced to maintain relays 221 and 223 energized, but upon the permanent energization of relay 222 due to the answering of the called subscriber, the supervisory circuit is permanently opened at the outer armature and make-before-break contact of relay 222 and no circuit will be completed for supervisory relay 223. When, therefore, relay 203 is deënergized, after a short interval, relay 207 will be deënergized to interrupt the circuits of relays 217 and 211 so that no ground will now be connected to conductor 238 to maintain relays 213 and 214 energized and these relays will retract their armatures. Relay 214 in retracting its armature completes a circuit from ground, armature and back contact of relay 223 back contact of relay 214, front contact and right-hand armature of relay 209, back contact and outer right-hand armature of relay 212, through the winding of relay 204, back contact and inner left-hand armature of relay 208 over conductor C′, through the winding of relay 48′ of sending equipment SE′ to grounded battery to cause the energization of relays 204 and 48′. Relay 204 in attracting its inner right-hand armature completes a locking circuit for relays 204 and 48′ which may be traced from ground, inner right-hand armature and front contact and winding of relay 204, left-hand armatures and back contacts of relay 208 and conductor C′, through the winding of relay 48′ to grounded bat-

tery. In opening its inner right-hand back contact, relay 204 interrupted the circuits of relays 205 and 209 to cause the deënergization of these relays. Relay 204 in attracting its left-hand armature connected conductor A′ 18 to conductor D′ so that upon the arrival of brush *a′* of switch G′ whose rotation was started in response to the energization of relay 48′ and conductor A′ 18, a circuit will be completed from grounded battery, through the left-hand winding of relay 50′, brush *a′*, conductor A′ 18, front contact and left-hand armature of relay 204, conductor D′, through the winding of relay 49′ to ground. Relays 49′ and 50′ are energized in this circuit, relay 50′ stopping the selector switch G′ and starting the sending distributer S′ in the same manner in which relay 50 started the operation of distributer S when signals were transmitted from office X to office Y. Relay 49′ completes a circuit from ground, armature and front contact of this relay, through the winding of relay 71′, armature and back contact of relay 52′, inner left-hand armature and upper contact of relay 50′ to grounded battery to energize relay 71′. Relay 71′ in attracting its left-hand armature completes a locking circuit for itself independent of relay 49′ and in attracting its right-hand armature disconnects positive battery and connects negative battery to individual segment 6′ of distributer S′. The distributer S′ and receiving distributer R at office X, now operate in the same manner previously described to send a code signal consisting of six current impulses of which the first, third and sixth are of negative polarity. In response to this signal, locking relays 27, 29 and 32 at office X are energized and locked up so that when brush 18 reaches segments 23 and 25 of distributer R an impulse of current of positive polarity will be transmitted from the positive pole of grounded battery, front contact and lower armature of relay 32 and thence over the circuit previously traced over conductor E 18 through the right-hand winding of relay 62 to ground. It will be remembered that the transmission of an impulse of negative polarity through the right-hand winding of relay 62 causes a negative flux of such a direction as to aid that caused by the current flowing through the left-hand locking winding of this relay to cause the energization of this relay. Now, however, an impulse of current of positive polarity is received over conductor E 18 and transmitted through the right-hand winding of relay 62. This current causes a magnetic flux, equal in amount and opposite in direction to that caused by the current flowing through the locking winding of relay 62, to differentialize this relay so that relay 62 is rendered inert. In retracting its left-hand armature, relay 62 again completes the previously traced circuit for slow release relay 63 while in retracting its right-hand armature, relay 62 interrupts the shunt circuit through resistance 69 and the winding of marginal relay 53 to decrease the current flowing through marginal relay 53 to a point at which this relay retracts its armature to extinguish supervisory lamp 68. The operator at office X is thereby informed that the called subscriber has answered the call and that the conversation is now in progress. It will be remembered that upon the engagement by brush 8′ of sending distributer S′, with segment 14′, a circuit was completed for relay 51′, which in turn completed a circuit from grounded battery, inner left-hand armature and front contact of relay 50′, back contact and armature of relay 52′, armature and front contact of relay 51′, brush 5′ conductor B 18′ through the winding of relay 208 to ground. Relay 208 was energized in this circuit and in attracting its left-hand armatures, interrupted the locking circuit previously traced for relays 204 and 48′ to deënergize these relays. Upon the engagement by brush 9′ of segment 15′ of distributer S′, a circuit was completed for relay 52′ which in attracting its armature opened the circuit just traced for relay 208 to deënergize this relay. It is, therefore, apparent that during the conversation, relays 200, 215 and 216 will be maintained energized and that all other relays individual to toll line L 18 and located at office Y will be inert.

Subscriber at called substation N replaces receiver on its switchhook.

Upon the completion of the conversation, the subscriber at substation N in replacing his receiver on its switchhook, interrupts the circuit previously traced for supervisory relay 231. Relay 231 in deënergizing, interrupts the previously traced circuit for relay 222, which, in deënergizing again completes the supervisory circuit traced from grounded battery, through the left-hand winding of relay 221, left-hand back contact of relay 222, tip contacts of jack 220 and plug 219, upper armature and front contact of relay 216, upper armature and back contact of relay 217, winding of relay 223, right-hand armature and front contact of relay 200, lower armature and back contact of relay 217, ring contacts of plug 219 and jack 220, right-hand back contact of relay 222, and the right-hand winding of relay 221 to ground. Relay 221 is maintained energized in this circuit and relay 223 is energized. The energization of relay 223 causes the energization of relays 48′, 212, 213, and 214 in the same manner as the energization of these relays was caused when the operator at office Y inserted plug 219 in the jack 220, and the energization of these relays causes the same signal to be transmitted by send-

ing equipment SE′ and to be received by receiving equipment RE. It will be remembered that the result of this signal was to send a negative impulse of current over conductor E 18 to cause the energization and locking up of relay 62, thereby completing a shunt circuit in parallel with that of relay 55 through the winding of marginal relay 53 to cause the lighting of the supervisory lamp 68. As in the previous case, relays 200, 205, 209, 213, 214, 215, 216 and 223 will be maintained in an energized condition at the conclusion of the transmission of the signal, all other relays individual to toll line L 18 at office Y being inert.

The operator at office X disconnects toll cord circuit F from toll line L 18.

The operator at office X noticing the illumination of the supervisory lamp 68 is informed that the conversation has been terminated and disconnects plug 65 from jack 66 thereby interrupting the circuits of relays 53 and 55. Relay 53 in deënergizing extinguishes lamp 68. Relay 55 in opening its front contact, interrupts the locking circuit of relay 62 to deënergize this relay. In closing its back contact, relay 55 completes a circuit from ground, armature and back contact of relay 55, front contact and inner right-hand armature of relay 57, through the winding of relay 59, back contact and right-hand armature of relay 60 to grounded battery. Relay 59 is energized in this circuit and locked up to ground at its innermost left-hand armature and front contact under the control of relay 60. In attracting its innermost left-hand armature, relay 59 interrupts the locking circuits of relays 56 and 57 to deënergize these relays. In attracting its middle left-hand armature, relay 59 connects ground to conductor C to cause the energization of start relay 48, while in attracting its outermost left-hand armature, relay 59 connects conductor A 18 to conductor D so that when brush *a* engages conductor A 18, a circuit will be completed from grounded battery, through the left-hand winding of relay 50, brush *a*, conductor A 18, back contact and outer left-hand armature of relay 61, outermost left-hand armature and front contact of relay 59, conductor D, through the winding of relay 49 to ground. Relays 49 and 50 will be energized in this circuit and the sending equipment SE and receiving equipment RE′ will be operated in exactly the same manner as was described for the operation of sending equipment SE′ and receiving equipment RE, in response to the answering of the called subscriber at substation N. It will be remembered that the result of this operation was to send an impulse of current of positive polarity over the selected signaling receiving conductor E 18. Relay 200 is exactly similar in its windings to relay 62 so that the receipt of this impulse of positive polarity over the similarly selected signaling receiving conductor E′ 18, will differentialize relay 200 and cause it to retract its armature. In retracting its outer armature, relay 200 will interrupt the circuit of relays 223 and 221. Relay 221 in retracting its armature will complete a circuit from grounded battery, through lamp 228, front contact and lower armature of relay 227, resistance 229, back contact and armature of relay 221 to ground, to light lamp 228. The operator at office Z noticing the lighted condition of lamp 228 is informed of the termination of the conversation and removes plug 224 from jack 225 thereby causing the deënergization of relays 227 and 226.

Relay 200 in retracting its inner right-hand armature completed a circuit from grounded battery, inner right-hand armature and back contact of relay 200, front contact and lower armature of relay 216 through the lamp 218 to ground, to light the lamp 218. In opening its inner front contact, relay 200 interrupted the circuits of relays 202, 205 and 209 to deënergize these relays. Relay 223 in deënergizing opened the circuits of relays 213 and 214. The operator at office Y observing the lighted condition of lamp 218 withdraws plug 219 from jack 220 thereby interrupting the circuit of relay 215. Relay 215, in deenergizing opens the circuit of relay 216 to extinguish lamp 218 and all apparatus employed at offices X, Y and Z in completing the connection is now completely restored.

Subscriber at substation N recalls operator at office X.

Should the subscriber at substation N, after answering a call when connection has been completed from office X by the way of toll line L 18 and toll switching trunk circuit M, wish to signal the operator, he may signal the operator at office X by rapidly opening and closing his switchboard contact. It will be remembered that after the answer of the called subscriber and thereafter during the conversation, all the relays connected with the incoming end of toll line L 18 at office Y are controlled by signals received over the conductor E′18 and the operation of the called line supervisory relay 223 until relays 200 and 202 are energized. When the subscriber, recalling the operator at office X, has opened his switchhook contacts by depressing the switchhook, the circuit for relay 231 is interrupted to deënergize this relay and consequently relay 222. Relay 222 in retracting its armatures energizes relay 221 in the previously traced circuit through the talking conductors of the toll switching trunk M and the incoming end of the line L 18 which circuit operates supervisory

relay 223. When the recalling subscriber closes his switchhook contacts by releasing the switchhook, the circuit for relay 231 and consequently relay 222 is again completed. Relay 222 in retracting its armatures closes the holding circuit through the left-hand winding of relay 221 to maintain this relay energized but opens the circuit including supervisory relay 223 to deënergize this relay. Thus relay 223 will be alternately energized and deënergized so long as the subscriber at station N actuates his switchhook. Relay 214 is made slow to release so that it will remain energized during the intervals when the armature of supervisory relay 223 is retracted. Relay 210 is also made slow to release so as to hold its armature attracted during the intervals when relay 223 is energized. Relays 206 and 209 are also made slow to release to aid in sending the recall signal to office X as will more fully appear hereinafter.

Upon the energization of relay 223 in response to the depression of the switchhook at substation N, the previously traced circuits for relays 48′, 212, 213 and 214 are completed and these relays are energized and locked up in the same manner as was described in the case when the operator at office Y inserted plug 219 into jack 220 upon the first illumination of the guard lamp 218. It will be remembered that these operated to send a code signal consisting of six impulses, namely −+−+++, which resulted in the transmission of an impulse of negative current over the conductor E 18 to energize signal receiving relay 62 at office X. As in the former case, the energization of relay 62 completed the circuit to shunt relay 55 thereby causing the operation of marginal relay 53 and consequently illuminating lamp 68 before the operator. Relay 62 in attracting its left-hand armature interrupted the circuit of slow release relay 63 so that a subsequent impulse of current received over conductor E 18 will find a parallel path to ground through the right-hand winding of signal receiving relay 64 as well as through the right-hand winding of relay 62.

During the operation of the sending equipment SE′ in transmitting the signal just described, it will be remembered that relay 208 was energized to interrupt the circuits of relays 48′ and 212 to deënergize these relays. Relay 212 in deënergizing opens, at its inner left-hand armature, the shunt circuit about the winding of relay 209 so that relays 205 and 209 are now energized over a circuit from grounded battery, inner armature and front of relay 200, winding of relay 205, armature and front contact of said relay through the winding of relay 209, the back contact and inner right-hand armature of relay 204 to ground. It will be remembered that the circuit for relay 208 is interrupted during the sending out of a signal so that after the signal has been sent only relays 200, 202, 205, 209, 213 and 214 will be in an energized condition.

In response to the first closing of the switch-hook contacts after their opening, relay 223 is deënergized opening its front contact which interrupts the previously traced locking circuit for relay 213. Relay 213 although somewhat slow in operating and releasing, is fast enough to deënergize during the interval that the front contact of relay 223 remains open. In closing its back contact, relay 223 completes an energizing circuit for slow release relay 210 which may be traced from grounded battery, winding of relay 210, armature and front contact of relay 214, and back contact and armature of relay 223 to ground. Relay 210 in attracting its armature prevents the connection of ground to conductor 239 for as long as the recalling subscriber continues to actuate his switchhook. Before the opening of the front contact of relay 223 has had time to cause the closure of the normal contacts of relay 214 which would have applied ground to conductor 239, the subscriber again opens his switchhook contacts to energize relay 223. Relay 223 in energizing again completes the circuit for relays 48′, 212, 213 and 214. The energization of relays 212 and 48′ again causes the sending equipment SE′ to send a signal resulting in the transmission of an impulse of current of negative polarity over signal receiving conductor E 18 at office X. This impulse is transmitted in parallel through the right-hand windings of relays 62 and 64. Since relay 62 is already energized and locked up, no effect is produced on this relay. Relay 64, however, is energized and a locking circuit is completed from grounded battery, left-hand armature and front contact and winding of relay 64, and front contact and armature of relay 55 to ground. Relay 64 in attracting its right-hand armature disconnects from the armature of relay 64, the steady ground which has caused the continuous illumination of lamp 68 and replaces this ground connection by an intermittent connection to ground through the interrupter 72. The circuit thus completed causes the intermittent operation of marginal relay 53 by intermittently shunting the winding of relay 55 and thereby causes the lamp 68 to flash. It will be remembered that the interval between the original energization of relay 62 and consequent illumination of lamp 68 and the energization of relay 64 which causes the flashing of lamp 68 will be measured by the time between the first and second openings of the switchhook contacts at substation N so that an operator observing the condition of lamp 68 would scarcely note

its illumination before it began to flash and therefore would not be in danger of mistaking the recall signal for the steady illumination of lamp 68 which would indicate to her the termination of the call.

When relay 212 at office Y was energized to cause the sending of the second signal, a circuit was completed for relay 206 which may be traced from grounded battery, inner armature and front contact of relay 200, through the winding of slow release relay 206, right-hand normal contact of said relay, front contact and left-hand armature of slow release relay 209, the front contact and inner left-hand armature of relay 212 to ground. Relay 206 in attracting its inner left-hand armature, opens the original locking circuit of relay 213, which relay is energized at this time and completes a new locking circuit for relay 213 which relay owing to its slow releasing character remains energized. This locking circuit may be traced from grounded battery, winding, front contact and right-hand armature of relay 213, inner left-hand armature and front contact of relay 206, back contact and inner right-hand armature of relay 204 to ground. When, therefore, the switchhook contact at substation N is next closed to cause the deënergization of the front contact of relay 223, the only effect produced is the continued operation of relay 210 over the circuit previously traced. Upon the next opening of the switchhook contacts at substation N and consequent energization of relay 223, the closure of the front contact of relay 223 will maintain slow release relay 214 energized but will not affect relay 212 since the circuit previously traced for this relay is interrupted at the left-hand armature of relay 213 which is now locked up under the control of relay 204. Thus, subsequent actuation of the switchhook at substation N maintains slow release relays 210 and 214 energized but is without effect on the sending equipment SE′ so that no further signals are transmitted over the path P to office X and lamp 68 continues to flash before the operator notifying her of the recall. From the foregoing description it will be apparent that in recalling the operator at office X, the subscriber at substation N opens and closes his switchhook contacts in a more or less irregular manner causing the sending of only two code signals over the path P which result in the flashing of the lamp 68 at a steady rate to notify the operator that her attention is desired.

If, after repeatedly opening and closing his switchhook contacts to recall the operator at office X, the subscriber at station N should retain his receiver off its switchhook thereby causing the continued closure of the contacts, supervisory relay 223 would remain deënergized. After a short interval relay 214 would retract its armature thereby completing a circuit from ground, armature and back contact of relay 223, normal contacts of relay 214, front contact and right-hand armature of relay 209, back contact and outer right-hand armature of relay 212, through the winding of relay 204, back contacts and left-hand armatures of relay 208, conductor C′, through the winding of relay 48′ to grounded battery. Relays 48′ and 204 are energized in this circuit and locked up through the front contact and inner right-hand armature of relay 204. Relay 204 in opening its inner right-hand back contact interrupts the previously traced locking circuits for relays 206 and 213 to deënergize these relays. In attracting its left-hand armature, relay 204 connects conductor A′18 to conductor D′ so that upon the stopping of the selector switch G′ with its brush *a* resting upon the contact individual to conductor A′18, the previously traced circuit for relays 49′ and 50′ will be completed. Relay 49′ will cause the energization of relay 71′ in the manner previously described so that the signal sent out by distributer S′ will consist of six impulses of current of the following polarities: — + — + + —, the receipt of this signal at office X will cause the transmission of an impulse of current of positive polarity over receiving conductor E 18. This positive impulse passing through the right-hand windings of relays 62 and 64 to ground will cause a magnetic flux of opposite direction and equal amount to that caused by the current flowing through the left-hand locking windings of these relays and will thereby cause the differentialization and retraction of the armatures of relays 62 and 64. Relay 62 in retracting its right-hand armature interrupts the shunt circuit about relay 55 which had previously caused the intermittent operation of marginal relay 53 to render this relay inert. Relay 53 in retracting its armature extinguishes lamp 68 so that the operator at office X is now notified that the call is still in progress.

It will be remembered that during the transmission of the signal which caused the cessation of the flashing of lamp 68, relay 208 at office Y was energized in response to the energization of relay 51′. Relay 208 in energizing interrupts, at its left-hand armatures, the circuit of relays 48′ and 204. Relay 214 in retracting its armatures opens the circuit of relay 210 to deënergize this relay so that only relays 200 and 202 of the relays under the control of the supervisory relay 223 and signal receiving conductor E′18 are now energized and the condition at office Y is the same as before the recalling of the operator at office X.

If, after repeatedly opening and closing the switchhook contacts to recall the opera-

tor at office X, the subscriber at station N should leave the switchook contacts permanently open as by replacing his receiver on its switchhook, the supervisory relay 223 would remain energized. After a short interval, the continued opening of the back contact of relay 223 would cause the deënergization of slow release relay 210. Relay 210 in retracting its armature, completes a circuit which may be traced from ground, armature and back contact of relay 210, outer left-hand armature and front contact of relay 206, front contact and right-hand armature of relay 209, back contact and outer right-hand armature of relay 212 through the winding of relay 204, back contacts and left-hand armatures of relay 208, conductor C′, through the winding of relay 48′ to grounded battery. Relays 48′ and 204 are energized in this circuit. Relay 48′ starts the selector switch G′ to seek its terminals individual to line L 18, and relay 204 in closing its inner right-hand front contact completes an obvious locking circuit for relays 48′ and 204. Relay 204 in opening its inner right-hand back contact interrupts the previously traced locking circuits for relays 205, 209, 206 and 213 to deënergize these relays. In attracting its left-hand armature, relay 204 connects conductors A′ 18 and D′ so that in the manner previously described, relays 49′ and 71′ will be energized when brush *a*, of selector switch G′ comes to rest on the terminal of conductor A′ 18. The energization of common relay 71′ will cause the signal sent over the conductor P in response to the energization of relay 48′ to consist of six impulses of current of the following polarities: — + — + + —. This signal will, in the manner previously described, cause an impulse of current of positive polarity to be transferred over conductor E 18 at office X, through the right-hand windings of relays 62 and 64 to ground, thereby differentializing these relays and extinguishing lamp 68. As in the previous cases, relay 208 will be energized during the transmission of the signal to interrupt the circuit for relays 48′ and 204 so that upon the deënergization of relay 208, in response to the attraction of the armature of relay 52′, only relays 200, 202, 214 and 223 of the relays individual to line L 18 at its incoming end and under the control of supervisory relay 223 and signaling conductor E′18 will be in an energized condition. Although relay 223 has been maintained energized throughout the cycle of operations just described, the energizing circuit for relay 213 was held interrupted at the outer right-hand armature of relay 204 while this armature was attracted and thereafter at the right-hand armature of relay 208 so that upon the deënergization of relay 204 and thereafter of relay 208, the original traced energizing circuits for relays 48′, 212 and 213, will be completed and a second signal will be transmitted over conductor P. Since, however, there is now no circuit completed for relay 204 and consequently none for relays 49′ or 71′, the sixth impulse of the code signal which controls the polarity of current to be transmitted over the selected signal receiving conductor will be of positive polarity and thereby causing the transmission of an impulse of negative polarity over conductor E 18 at office X. It will be remembered that upon the deënergization of relay 62 in response to the signal transmitted, just previously to this one, relay 63 was energized to interrupt the signaling circuit through the right-hand winding of relay 64 so that no impulse of negative current will pass through the winding of relay 62 to energize this relay. Relay 62 in attracting its right-hand armature again completes a circuit from ground, back contact and right-hand armature of relay 64, right-hand armature and front contact of relay 62, resistance 69, sleeve contacts of jack 66 and plug 65, through the winding of marginal relay 53 to grounded battery, thereby allowing sufficient current to flow through the winding of relay 53 to operate this relay and maintain lamp 68 steadily illuminated. The steady illumination of lamp 68 is an indication to the operator at office X that the call has been terminated by the replacement of the receiver at station N on its switch hook. As in the case described when the operator at office Y inserted plug 219 into jack 220, the transmission of the signal which lighted the lamp 68 at office X resulted in the energization of relay 208 to deënergize relays 48′ and 212 thereby leaving relays 200, 202, 205, 209, 213 and 214 energized.

The operator at office X upon noting the termination of the call removes plug 65 from jack 66, thereby causing the sequence of operations previously described in connection with the breaking down, which results in the sending of an impulse of positive polarity over signal receiving conductor E′ 18 to differentialize relay 200. Relay 200 in opening its inner front contact, interrupts the circuits of relays 202, 205 and 209, and in opening its outer right-hand contact interrupts the circuits of relays 223 and 221 in the manner previously described. Relay 223 in deënergizing interrupts the circuits of relays 213 and 214 and relay 214 after an interval, opens its front contact to deënergize relay 210 so that all the relays associated with the incoming end of the line L 18 are now in normal condition. The operators at office Y and office Z are notified of the termination of the connection in the manner previously described and re-

move plugs 219 and 224 from their respective jacks 220 and 225, whereupon all the apparatus employed in building up the connection is restored to normal condition.

Use of busy back jacks at offices Y and Z.

At the time when the operator at office X in inserting the plug of cord circuit F in the jack of the designated toll line L 18 caused the illumination of guard lamp 218 before the operator at office Y, it will be remembered that only relays 200 and 202 of those associated with the incoming end of toll line L 18 were energized. If the operator at office Y had, in the meanwhile, determined over the order wire circuit (not shown) that there were no idle trunks leading to office Z, she would, upon the illumination of lamp 218 have inserted plug 219 into the busy back jack 235. Relays 215 and 216 would have thereupon been energized over obvious circuits, and relay 223 would be intermittently energized and deënergized in exactly the same manner as was described in connection with the recalling of the operator at office X by the subscriber at station N. The first energization of relay 223 would have sent out a signal to cause the steady illumination of lamp 68 before the operator at office X, but before this operator could have interpreted this signal as a ringing signal, relay 223 would have been deënergized to send a second signal of exactly the same character as was described in connection with the recalling of the operator at office X which would have resulted in the energization of relay 64 to cause the intermittent operation of lamp 68. The flashing of lamp 68 following next in succession to the insertion of the plug of her cord circuit in the jack of the designated toll line is an indication to the operator at office X that she will be unable to complete the desired connection on account of the busy condition of either a link in the circuit or in the called line and she may so inform the calling subscriber, thereupon removing the plug of the cord circuit from its associated jack to cause the sending of a signal to office Y which will light lamp 218 to notify the operator at office Y that the connection has been abandoned.

In case the operator at office Z, after assigning toll switching trunk circuit for use in connection with office Y to office Z, should find the called line busy, she would insert plug 224 in busy back jack 236 before her position, thereby causing the operation of relays 226 and 227. Relay 227 in attracting its upper armature completes an obvious circuit to cause the intermittent operation of relay 231. Relay 231 in intermittently closing and opening its front contact would intermittently energize and deënergize relay 222 so as to alternately exclude and include the windings of relay 221 in the end of toll switching trunk circuit M leading to the tip and ring contacts of jack 220. Thus, when the operator at office Y inserts plug 219 into jack 220 upon the illumination of guard lamp 218, relay 223 will be intermittently energized and deënergized in the circuit including relay 221 and the two signals previously described will be transmitted to office X to cause the flashing of lamp 68 before the operator. As in the case when the operator at office Y employed busy back jack 235, the operator at office X is thereby notified of the busy condition of some part of the circuit desired for completing the connection and may thereupon abandon the call.

The operation described above with reference to building up a connection over the trunk line L 18 through toll switching trunk circuit M to station N and the breaking down of such a connection is typical of that taking place in building up and breaking down a connection over any one of the trunk lines to which the signaling path P is common. The only essential difference in operation, so far as the establishment of a connection over the different toll lines is concerned, it that different code signals are employed for the different trunk lines, and while this invention is not limited to any particular arrangement of code signals, the codes shown in the following tables have been found to be very satisfactory for a total of thirty lines served by the same common signaling path.

Signals from office X to office Y.				Signals from office Y to office X.		
Trunk line No.	Guard.	Ring.	Disconnect.	Receiver on hook.	Receiver off hook.	Flashing.
1	3	3	36	3	36	3
2	4	4	46	4	46	4
3	5	5	56	5	56	5
4	34	34	346	34	346	34
5	35	35	356	35	356	35
6	45	45	456	45	456	45
7	345	345	3456	345	3456	345
8	2	2	26	2	26	2
9	23	23	236	23	236	23
10	24	24	246	24	246	24
11	25	25	256	25	256	25
12	234	234	2346	234	2346	234
13	235	235	2356	235	2356	235
14	245	245	2456	245	2456	245
15	2345	2345	23456	2345	23456	2345
16	1	1	16	1	16	1
17	12	12	126	12	126	12
18	13	13	136	13	136	13
19	14	14	146	14	146	14
20	15	15	156	15	156	15
21	123	123	1236	123	1236	123
22	124	124	1246	124	1246	124
23	125	125	1256	125	1256	125
24	134	134	1346	134	1346	134
25	135	135	1356	135	1356	135
26	145	145	1456	145	1456	145
27	1234	1234	12346	1245	12346	1234
28	1235	1235	12356	1235	12356	1235
29	1245	1245	12456	1245	12456	1245
30	1345	1345	13456	1345	13456	1345

In this table, the numbers in the first column indicate the numbers assigned to the trunk lines, while the numbers in the remaining columns indicate the order of the

impulses of each group of six. The numbers 1, 3 appearing in the first, second, fourth, and sixth columns of the horizontal row associated with trunk line 18 indicate that the first and third impulses of the code signal transmitted in response to the guard, ring, receiver on hook, and flashing signals will be negative, while the numbers 1, 3, 6 appearing in the third and fifth columns opposite line 18 indicate that the first, third and sixth impulses of the code signals transmitted are negative. The various code signals represented in the table are determined by the polarities of current connected with the contacts of the levels one to five of the automatic selector switches G and G, and by the energized or inert condition of relays 71 and 71′ during signaling.

What is claimed is:

1. In a telephone system, in combination, a plurality of trunk lines and a signaling path common thereto extending between two stations, means at one station for transmitting over the signaling path code signals individual to the different trunk lines, each code signal comprising a plurality of current impulses, means common to the trunk lines for determining the character of certain of the impulses of each code signal, additional independent means common to the trunk lines for determining the character of other of the impulses of each code signal, and means individual to each trunk line for controlling the operation of said additional means.

2. In a telephone system, in combination, a plurality of trunk lines and a signaling path common thereto extending between two stations, means at one station for transmitting over the signaling path code signals individual to the different trunk lines, each code signal comprising a plurality of current impulses, a normally inactive switching device common to the trunk lines for determining the character of some of the impulses of each code signal, a relay common to the trunk lines for determining the character of other of the impulses of each code signal, and means individual to each trunk line for controlling the operation of said relay.

3. In a telephone system, in combination, a plurality of trunk lines and a signaling path common thereto extending between two stations, means at one station for transmitting over the signaling path code signals individual to the different trunk lines, each code signal comprising a plurality of current impulses, a normally inactive switching device common to the trunk lines for determining the character of some of the impulses of each code signal, a relay common to the trunk lines for determining the character of other of the impulses of each code signal, means individual to each trunk line responsive to certain changes in condition of said trunk line for associating said switching device with said truk line, and a relay individual to each trunk line responsive to other changes in condition of said trunk line for associating said switching device with said trunk line and causing the operation of said impulse character determining relay.

4. In a telephone system, in combination, a plurality of trunk lines and a signaling path common thereto extending between two stations, means at one station for transmitting over the signaling path code signals individual to the different trunk lines, each code signal comprising a plurality of current impulses, a normally inactive switching device common to the trunk lines for determining the character of certain of the impulses of each code signal, means for operating said switching device in response to any change in condition of any trunk line, a relay common to the trunk lines for determining the character of another impulse of each code signal, and means individual to each trunk line operated in response to certain changes of condition of its associated trunk line for operating said relay.

5. In a telephone system, in combination, a plurality of trunk lines and a signaling path common thereto extending between two stations, a signaling device at one station, means at the other station for transmitting over the signaling path code signals individual to the different trunk lines, each code signal comprising a plurality of current impulses, a normally inactive switching device common to the trunk lines for determining the character of some of the impulses of each code signal, a relay common to the trunk lines for determining the character of another of the impulses of each code signal, means at said other station responsive to two rapid changes in the condition of one of said trunk lines to successively actuate said switching device twice to send two code signals over said signaling path to cause the intermittent operation of said signaling device, said switching device being unaffected by additional rapid changes, and means responsive to the cessation of such rapid changes to actuate said switching device and said common relay to send a single code signal of different character over said signaling path to render said signaling device inert.

In witness whereof, I hereunto subscribe my name this 17th day of July A. D., 1920.

HUGH D. MacPHERSON.