

Oct. 10, 1944.

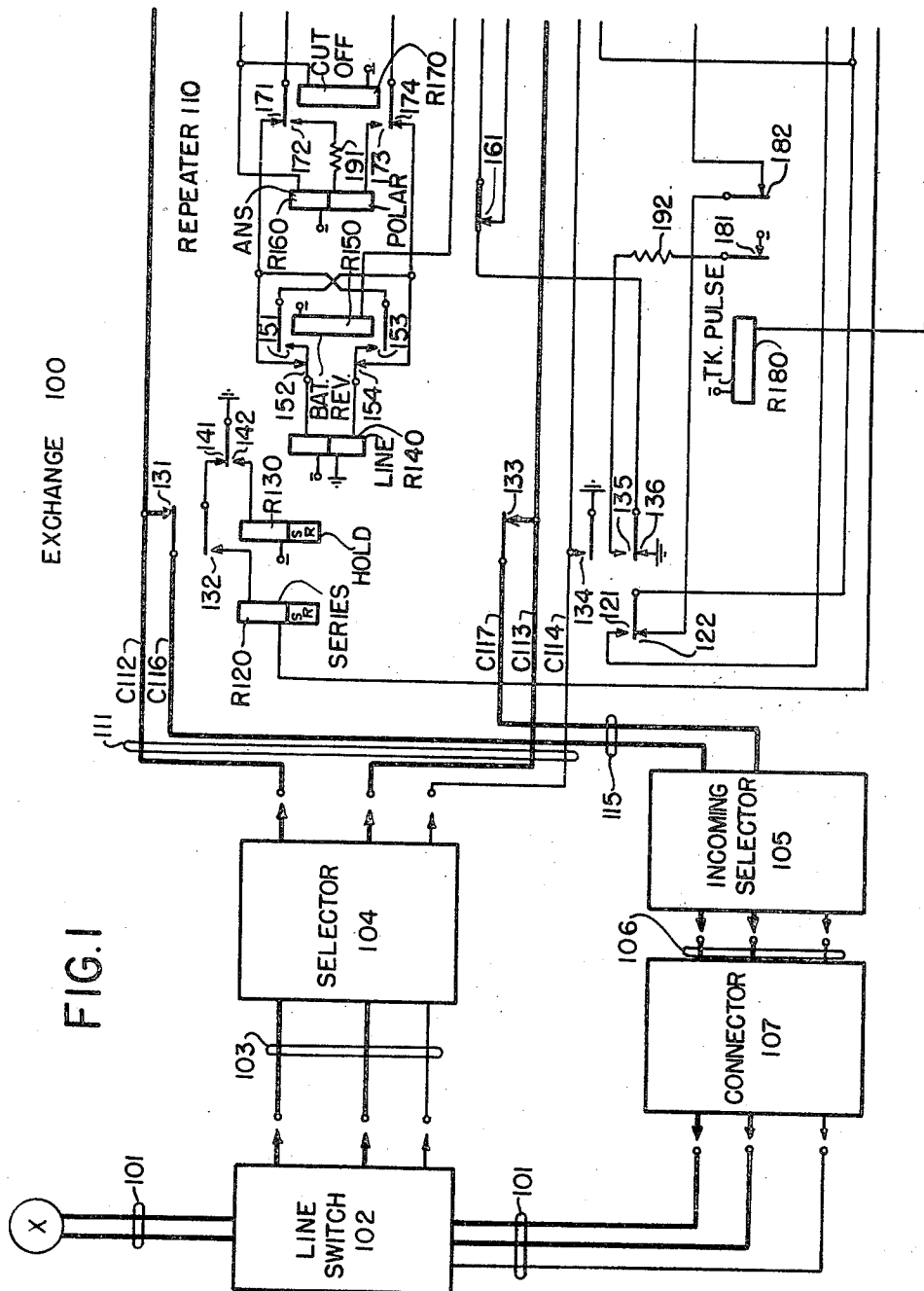
B. D. WILLIS

2,360,296

SIGNALING SYSTEM

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4 Sheets-Sheet 1



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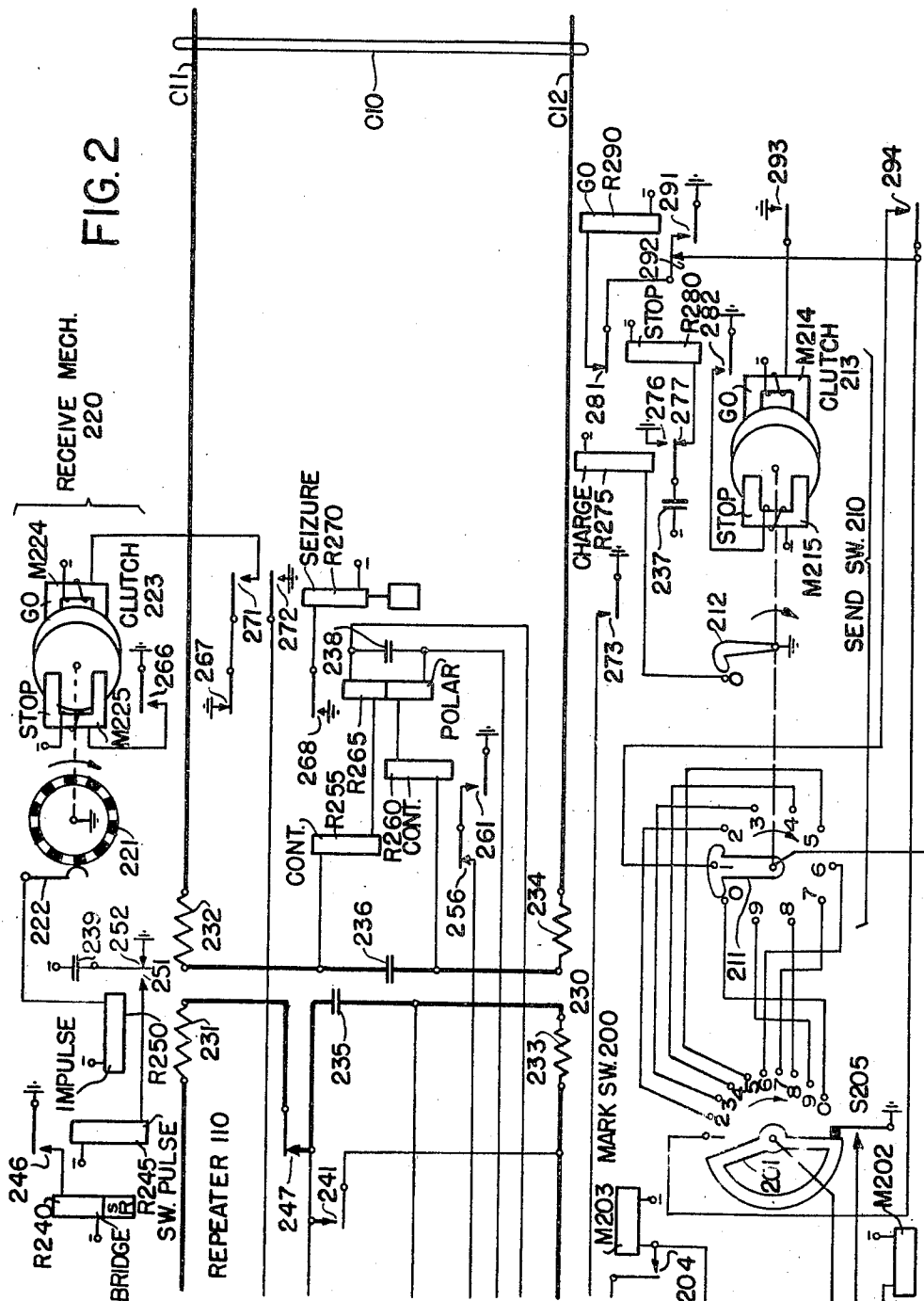
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SIGNALING SYSTEM

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4 Sheets-Sheet 2



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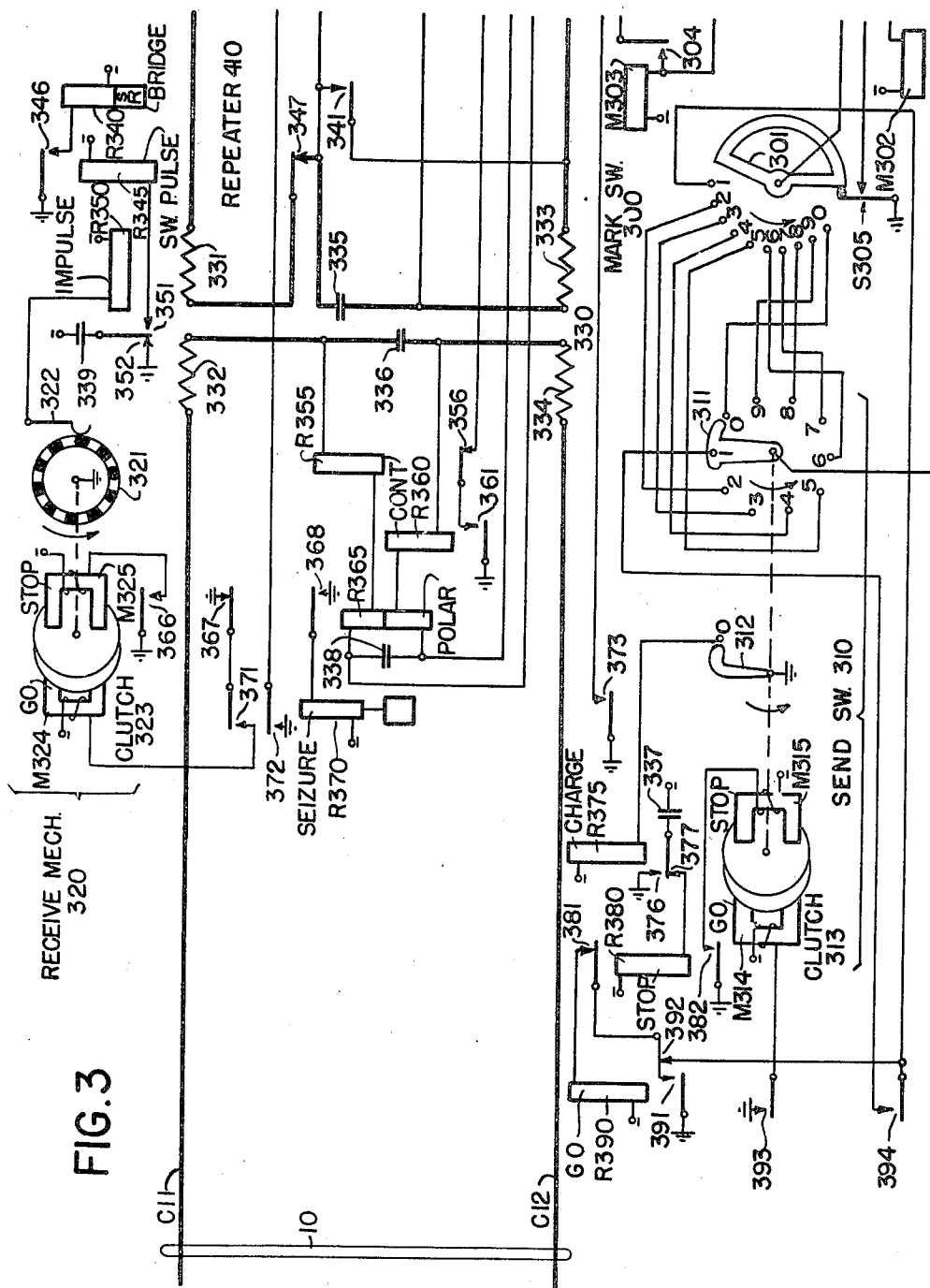
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SIGNALING SYSTEM

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4 Sheets-Sheet 3



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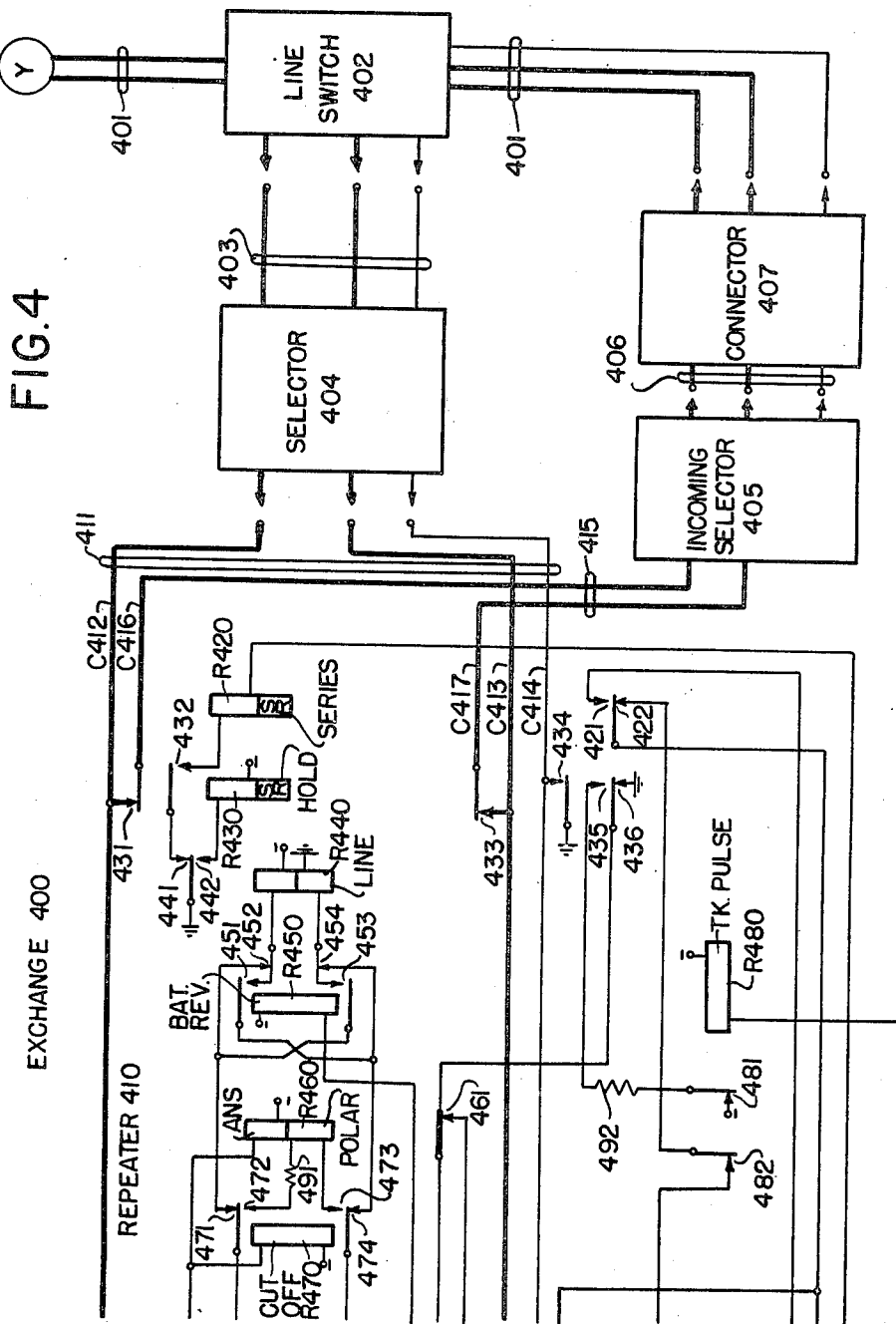
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SIGNALING SYSTEM

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4 Sheets-Sheet 4



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UNITED STATES PATENT OFFICE

2,360,296

SIGNALING SYSTEM

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Application September 11, 1942, Serial No. 457,930

17 Claims. (Cl. 179—16)

The present invention relates to signaling systems and more particularly to repeater circuits for automatic telephone systems.

In a conventional automatic telephone system including a plurality of exchanges, repeater circuits are frequently provided in the exchanges in order to terminate the trunks extending therebetween and to insure proper impulse transmission and supervisory control over the trunks. In setting up an interexchange connection in an automatic telephone system of the type noted, subscriber controlled automatic switching apparatus in the calling exchange is operated to seize the repeater circuit terminating one end of an idle trunk extending to the called exchange and to transmit a number of digits thereto. The last-mentioned repeater circuit responds to the digits transmitted thereto and repeats corresponding digits over the trunk to the repeater circuit in the called exchange terminating the other end of the trunk. The last-mentioned repeater circuit responds to the digits transmitted over the trunk and repeats corresponding digits to automatic switching apparatus in the called exchange, thereby selectively to control the operation of the last-mentioned switching apparatus. Each of the digits repeated by the repeater circuit in the calling exchange over the trunk to the repeater circuit in the called exchange is in the form of a series of impulses comprising a number of individual impulses corresponding to the numerical value of the particular digit.

While a repeater arrangement of the type described is entirely satisfactory in operation as long as the associated trunk is in good circuit condition, it fails entirely when the trunk is subjected to certain types of common faults. For example, the presence of a high resistive, capacitive or inductive fault on the trunk effectively blocks the transmission of impulses thereover or so distorts the wave form of the impulses transmitted thereover that the repeater circuit in the called exchange does not faithfully follow the impulses transmitted over the trunk.

Accordingly it is an object of the present invention to provide in a signaling system an improved repeater circuit arrangement, wherein a digit is transmitted from one repeater circuit over a trunk to another repeater circuit in such form that it is not appreciably affected by faulty electrical conditions of the trunk disposed within an extremely wide range.

Another object of the invention is to provide

an improved repeater circuit of the type noted, wherein the transmission of a variable digit over the associated trunk is based primarily upon a variable time control of a basic alteration in the electrical circuit condition of the trunk, rather than being based upon a variable number of rapid alterations in the electrical circuit condition of the trunk.

Another object of the invention is to provide an improved repeater circuit of the type noted, wherein a variable digit is transmitted over the associated trunk in the form of a single impulse of variable time duration.

A further object of the invention is to provide in a telephone system a repeater circuit of the type noted which embodies an improved supervisory control arrangement utilizing a simplified circuit network.

A further object of the invention is to provide in a telephone system a repeater circuit arrangement, including an improved repeater, which comprises means for receiving a variable series of impulses and means controlled by the receiving means for transmitting a single impulse of a corresponding variable time duration.

A further object of the invention is to provide in a telephone system a repeater circuit arrangement, including an improved repeater, which comprises means for receiving a single impulse of variable time duration and means controlled by the receiving means for transmitting a corresponding variable series of impulses.

A still further object of the invention is to provide in a telephone system a repeater circuit arrangement, including an improved two-way repeater, which comprises means for receiving a variable series of impulses and for transmitting a single impulse of a corresponding variable time duration and means for receiving a single impulse of variable time duration and for transmitting a corresponding variable series of impulses.

Further features of the invention pertain to the particular arrangement of the circuit elements of the telephone system, whereby the above-outlined and additional operating features are attained.

The invention, both as to its organization and method of operation, together with further objects and advantages thereof, will best be understood by reference to the following specification taken in connection with the accompanying drawings, in which Figs. 1 to 4, inclusive, taken together, illustrate diagrammatically one form of

a telephone system embodying the present invention; Figs. 1 to 4, inclusive, of the drawings being arranged horizontally end to end in numerical order.

Referring now more particularly to Figs. 1 to 4, inclusive, of the drawings there is illustrated a telephone system comprising two exchanges 100 and 400 of the automatic type and interconnected by a group of two-way trunks including the trunk 10. Each of the exchanges terminates a plurality of subscriber lines extending to subscriber substations; the exchanges 100 and 400 respectively terminating the subscriber lines 101 and 401 respectively extending to the subscriber substations X and Y. Also each exchange comprises subscriber controlled automatic switching apparatus for setting up the various local and trunk connections. In exchange 100 the switching apparatus comprises a plurality of line switches individual to the subscriber lines terminating thereat, the line switch 102 being individual to the subscriber line 101, a plurality of selectors including the selector 104, a plurality of connectors including the connector 107, and a group of incoming selectors including the incoming selector 105. Similarly, in exchange 400, the switching apparatus comprises a plurality of line switches individual to the subscriber lines terminating thereat, the line switch 402 being individual to the subscriber line 401, a plurality of selectors including the selector 404, a plurality of connectors including the connector 407, and a group of incoming selectors including the incoming selector 405.

The opposite ends of each trunk in the group extending between exchange 100 and exchange 400 terminate in repeaters respectively disposed in the exchanges mentioned. For example, one end of the trunk 10 terminates in the repeater 110 disposed in exchange 100 and the other end of the trunk 10 terminates in the repeater 410 disposed in exchange 400. In exchange 100 the incoming selectors in the group are individual to the repeaters in the group; for example, the incoming selector 105 is individual to the repeater 110 and is normally connected thereto by way of a trunk 115. Similarly, in exchange 400, the incoming selectors in the group are individual to the repeaters in the group; for example, the incoming selector 405 is individual to the repeater 410 and is normally connected thereto by way of a trunk 415.

In exchange 100 the line switch 102 has access to a trunk 103 extending to the selector 104; the selector 104 has access to a trunk 106 extending to the connector 107 and to a trunk 111 extending to the repeater 110; the incoming selector 105 has access to the trunk 106 extending to the connector 107; and the connector 107 has access to a group of subscriber lines including the subscriber line 101. Similarly, in exchange 400, the line switch 402 has access to a trunk 403 extending to the selector 404; the selector 404 has access to a trunk 406 extending to the connector 407 and to a trunk 411 extending to the repeater 410; the incoming selector 405 has access to the trunk 406 extending to the connector 407; and the connector 407 has access to a group of subscriber lines including the subscriber line 401.

Preferably, in exchanges 100 and 400, each subscriber substation X, Y etc. comprises conventional substation apparatus including a telephone instrument and a ringer and a calling device or impulse transmitter of the dial type; each of the line switches 102, 402 etc. is of conven-

tional connection and arrangement; each of the selectors 104, 404 etc. and each of the connectors 107, 407 etc. and each of the incoming selectors 105, 405 etc. are of the corresponding conventional Strowger types.

Preferably, in exchanges 100 and 400, the repeaters 110, 410 etc. are identical and are of the connection and arrangement illustrated. More particularly, the repeater 110 comprises a mark switch 200 of the minor type including a bridging wiper 201 provided with an individually associated contact bank, a rotary magnet M202 for driving the wiper 201 step by step in the clockwise direction away from its normal rotary position, a release magnet M203 for releasing the wiper 201 and for causing it to be returned to its normal rotary position, and a set of switch springs S205 which is actuated when the wiper 201 is driven away from its normal rotary position. Also the repeater 110 comprises a send switch 210 of the rotary type including two wipers 211 and 212 provided with individually associated contact banks, and a clutch mechanism 213 provided with a go magnet M214 and a stop magnet M215. Preferably, the clutch mechanism 213 is of the construction and arrangement of that disclosed in U. S. Patent No. 2,222,131, Bernard D. Willis, granted November 19, 1940; which clutch mechanism comprises a driving shaft, not shown, which is constantly rotated at a fixed predetermined speed, a driven shaft to which the wipers 211 and 212 are connected, and a pair of clutch plates carried by the shafts mentioned. Further the repeater 110 comprises a receive mechanism 220 including a commutator 221 associated with a wiper 222, and clutch mechanism 223 provided with a go magnet M224 and a stop magnet M225. Preferably, the clutch mechanism 223 is of the construction and arrangement of that disclosed in the Willis patent mentioned; which clutch mechanism comprises a driving shaft, not shown, which is constantly rotated at a fixed predetermined speed, a driven shaft to which the commutator 221 is connected, and a pair of clutch plates carried by the shafts mentioned. Finally the repeater 110 comprises a transformer 230 including the windings 231, 232, 233 and 234; a relay group including a series relay R120, a hold relay R130, a line relay R140, a battery reverse relay R150, an answer relay R160, a cutoff relay R170, a trunk pulse relay R180, a bridge relay R240, a switch pulse relay R245, an impulse relay R250, two control relays R255 and R260, a polar relay R265, a seizure relay R270, a charge relay R275, a stop relay R280, and a go relay R290; and a control network connected and arranged in a manner more fully described hereinafter.

Similarly, the repeater 410 comprises a mark switch 300 of the minor type, including a bridging wiper 301 provided with an individually associated contact bank, a rotary magnet M302 for driving the wiper 301 step by step in the counterclockwise direction away from its normal rotary position, a release magnet M303 for releasing the wiper 301 and for causing it to be returned to its normal rotary position, and a set of switch springs S305 which is actuated when the wiper 301 is driven away from its normal rotary position. Also the repeater 410 comprises a send switch 310 of the rotary type including two wipers 311 and 312 provided with individually associated contact banks, and clutch mechanism 313 provided with a go magnet M314 and a stop magnet M315. Preferably, the clutch

mechanism 313 is of the construction and arrangement of that disclosed in the Willis patent mentioned; which clutch mechanism comprises a driving shaft, not shown, which is constantly rotated at a fixed predetermined speed, a driven shaft to which the wipers 311 and 312 are connected, and a pair of clutch plates carried by the shafts mentioned. Further the repeater 410 comprises a receiver mechanism 320 including a commutator 321 associated with a wiper 322, and clutch mechanism 323 provided with a go magnet M324 and a stop magnet M325. Preferably, the clutch mechanism 323 is of the construction and arrangement of that disclosed in the Willis patent mentioned; which clutch mechanism comprises a driving shaft, not shown, which is constantly rotated at a fixed predetermined speed, a driven shaft to which the commutator 321 is connected, and a pair of clutch plates carried by the shafts mentioned. Finally the repeater 410 comprises a transformer 330 including the windings 331, 332, 333 and 334; a relay group including a series relay R420, a hold relay R430, a line relay R440, a battery reverse relay R450, an answer relay R460, a cutoff relay R470, a trunk pulse relay R480, a bridge relay R340, a switch pulse relay R345, an impulse relay R350, two control relays R355 and R360, a polar relay R365, a seizure relay R370, a charge relay R375, a stop relay R380, and a go relay R390; and a control network connected and arranged in a manner more fully described hereinafter.

In exchange 100, local calls are set up between the various subscriber substations in accordance with conventional practice; for example, a local call might be set up from the calling subscriber substation X by way of the line switch 102, the selector 104 and the connector 107 to the called subscriber substation; subsequently, this call might be released under the control of the subscriber at the calling subscriber substation X. Similarly, in exchange 400, local calls are set up between the various subscriber substations in accordance with conventional practice; for example, a local call might be set up from the calling subscriber substation Y by way of the line switch 402, the selector 404 and the connector 407 to the called subscriber substation; subsequently, this call might be released under the control of the subscriber at the calling subscriber substation Y.

Considering now the extension of a call in either direction between the exchanges 100 and 400, it is assumed that a call is to be extended from the calling subscriber substation X in exchange 100 to the called subscriber substation Y in exchange 400 via the trunk 10 extending between the exchanges mentioned. The call is first initiated at the calling subscriber substation X, whereupon the line switch 102 individual to the subscriber line 101 operates automatically in order to select an idle trunk in the associated group, such, for example, as the trunk 103, extending to the selector 104. When the line switch 102 seizes the trunk 103 an obvious loop circuit is completed between the selector 104 and the calling subscriber substation X. The subscriber at the calling subscriber substation X then proceeds to dial the first digit of the directory number of the called subscriber substation Y, whereupon the selector 104 operates in order to select the corresponding group of trunks and then operates automatically to select an idle trunk in this group, such, for exam-

ple, as the trunk 111, extending to the repeater 110, the repeater 110 terminating one end of the trunk 10 in exchange 100 as previously noted.

When the selector 104 seizes the trunk 111 extending to the repeater 110 a loop circuit is completed between the line relay R140 in the repeater 110 and the calling subscriber substation X; this circuit extending from ground by way of the lower winding of R140, the contacts 154 and 174, and the winding 233 of the transformer 230 to the line conductor C113 of the trunk 111, and from battery by way of the upper winding of R140, the contacts 152, 171 and 247 and the winding 231 of the transformer 230 to the line conductor C112 of the trunk 111, the line conductors C112 and C113 of the trunk 111 being connected by way of the selector 104, the trunk 103 and the line switch 102 to the line conductors of the subscriber line 101 extending to the calling subscriber substation X. When this loop circuit is completed the line relay R140 operates, thereby to complete, at the contacts 142, an obvious circuit for energizing the winding of the hold relay R130 in order to cause the latter relay to operate. Upon operating, the hold relay R130 interrupts, at the contacts 131 and 133, the normally completed connection, including the line conductors C116 and C117 of the trunk 115, between the repeater 110 and the individually associated incoming selector 105, whereby the incoming selector 105 is cut off of the repeater 110. Also the hold relay R130 completes, at the contacts 134, an obvious path for applying ground potential to the control conductor C114 of the trunk 111, thereby to mark the trunk 111 as busy to the other selectors having access thereto and to retain operated the selector 104 and the line switch 102.

Further the hold relay R130 interrupts, at the contacts 136, a normally completed path for applying ground potential by way of the lower winding of the polar relay R265, the winding of the control relay R260 and the winding 234 of the transformer 230 to the line conductor C12 of the trunk 10, and a normally completed multiple path for applying ground potential by way of the contacts 161, the upper winding of the polar relay R265, the winding of the control relay R255, and the winding 232 of the transformer 230 to the line conductor C11 of the trunk 10. Finally the hold relay R130 completes, at the contacts 135, multiple paths substantially identical to those traced above and including the resistor 192 and the contacts 181 for applying battery potential to the line conductors C11 and C12 of the trunk 10. More particularly, at this time, the hold relay R130 completes, at the contacts 135, a series circuit between the repeater 110 in exchange 100 and the repeater 410 in exchange 400; which series circuit comprises a simplex path including in parallel the line conductors C11 and C12 of the trunk 10, whereby the upper winding of the polar relay R265 and the winding of the control relay R255 in the repeater 110 are energized in series with the winding of the control relay R355 and the upper winding of the polar relay R365 in the repeater 410, and the lower winding of the polar relay R265 and the winding of the control relay R260 in the repeater 110 are energized in series with the winding of the control relay R360 and the lower winding of the polar relay R365 in the repeater 410. More particularly, the above-traced circuit extends from ground in the repeater 410 by way of the contacts 436 and 461, the upper winding of R365,

the winding of R355, the winding 332 of the transformer 330, the line conductor C11 of the trunk 10, the winding 232 of the transformer 230, the winding of R255, the upper winding of R265, the contacts 161 and 135, the resistor 192 and the contacts 181 to battery in the repeater 110; and from ground in the repeater 410 by way of the contacts 436, the lower winding of R365, the winding of R360, the winding 334 of the transformer 330, the line conductor C12 of the trunk 10, the winding 234 of the transformer 230, the winding of R260, the lower winding of R265, the contacts 135, the resistor 192 and the contacts 181 to battery in the repeater 110. When this simplex circuit is completed the control relays R255 and R260 in the repeater 110 and the control relays R355 and R360 in the repeater 410 operate; however, the polar relay R265 in the repeater 110 does not operate; whereas, the polar relay R365 in the repeater 410 does operate. The polar relay R265 in the repeater 110 does not operate due to the fact that the flow of current in the above-traced circuit is from the repeater 410 to the repeater 110; whereas, the polar relay R365 in the repeater 410 does operate due to the fact that the flow of current in the above-traced circuit is from the repeater 410 to the repeater 110, as noted above.

Upon operating, the polar relay R365 completes, at the contacts 366, an obvious circuit for energizing the stop magnet M325 of the clutch mechanism 323, whereupon the latter magnet operates in order positively to prevent rotation of the commutator 321 at this time. Also the polar relay R365 completes, at the contacts 368, an obvious circuit for energizing the winding of the seizure relay R370, thereby to cause the latter relay to operate. Upon operating, the seizure relay R370 completes, at the contacts 373, an obvious path for applying ground potential to the control conductor C414 of the trunk 411 extending to the repeater 410, thereby to mark the trunk 411 as busy to the selectors 404 etc. having access thereto. Also the seizure relay R370 completes, at the contacts 372, an obvious circuit for energizing the winding of the cutoff relay R470 in multiple with the upper winding of the answer relay R460, whereby the cutoff relay R470 operates. However, the answer relay R460 does not operate as it is of the polarized type. Upon operating, the cutoff relay R470 interrupts, at the contacts 471 and 474, an obvious normally completed path for connecting the upper and lower windings of the line relay R440 to the line conductors C412 and C413 of the trunk 411; and completes, at the contacts 472 and 473, a bridge connection including the lower winding of the answer relay R460 between the line conductors of the trunk 415 extending to the incoming selector 405. The above-mentioned bridge connection extends from the line conductor C416 of the trunk 415 by way of the contacts 431, the winding 331 of the transformer 330, the contacts 347 and 472, the resistor 491, the lower winding of R460, the contacts 473, the winding 333 of the transformer 330 and the contacts 433 to the line conductor C417 of the trunk 415. When this bridge path is completed between the line conductors of the trunk 415 the lower winding of the answer relay R460 is energized; however, the latter relay does not operate at this time as it is of the polarized type, as previously noted. Also when this bridge path is completed between the line conductors of the trunk 415 the incoming selector 405 is conditioned to be responsive to impulses transmitted thereto.

The subscriber at the calling subscriber substation X then proceeds to dial the second digit of the directory number of the called subscriber substation Y, whereby the line relay R140 in the repeater 110 follows the digit mentioned in an obvious manner. Each time the line relay R140 restores and then reoperates it completes and then interrupts, at the contacts 141, an obvious circuit, including the contacts 132, for energizing the winding of the series relay R120 in series with the rotary magnet M202; whereupon the series relay R120 operates and the rotary magnet M202 operates and restores, thereby to drive the wiper 201 of the mark switch 200 one step in the clockwise direction. Also each time the line relay R140 restores and then reoperates it interrupts and then completes, at the contacts 142, the previously mentioned circuit for energizing the winding of the hold relay R130. Accordingly the hold relay R130 and the series relay R120 remain operated during impulsing as both of the relays mentioned are of the slow-to-release type; and the wiper 201 of the mark switch 200 is driven a number of steps in the clockwise direction away from its normal rotary position corresponding to the second digit, in an obvious manner. When the wiper 201 of the mark switch 200 is driven one step in the clockwise direction away from its normal rotary position the set of switch springs S205 is operated, thereby to complete an obvious path, including the contacts 121, for applying ground potential to the wiper 201. The application of ground potential to the wiper 201 of the mark switch 200 completes an obvious circuit, including the contacts 292 and 281, for energizing the winding of the go relay R290 in view of the fact that the wiper 201 engages the first contact in the associated contact bank. When thus energized the go relay R290 operates to complete, at the contacts 291, an obvious holding circuit, including the contacts 281, for energizing the winding thereof; and to complete, at the contacts 294, a path for applying ground potential to the first contact in the contact bank associated with the wiper 211 of the send switch 210. The last-mentioned path extends from ground by way of the set of switch springs S205, the contacts 121, the wiper 201 of the mark switch 200 and the engaged first contact in the associated contact bank, and the contacts 294 to the first contact in the contact bank engaged by the wiper 211 of the send switch 210. This application of ground potential to the wiper 211 of the send switch 210 completes an obvious circuit for energizing the winding of the trunk pulse relay R180, thereby to cause the latter relay to operate.

Upon operating, the trunk pulse relay R180 interrupts, at the contacts 181, the previously traced simplex circuit for energizing in series the upper winding of the polar relay R265, the winding of the control relay R255, the winding of the control relay R355 and the upper winding of the polar relay R365, and for energizing in series the lower winding of the polar relay R265, the winding of the control relay R260, the winding of the control relay R360 and the lower winding of the polar relay R365. When this simplex circuit is thus interrupted the control relays R255 and R260, as well as the control relays R355 and R360, restore without effect at this time; the polar relay R265 remains restored; and the polar relay R365 restores, for a purpose more fully explained hereinafter.

Also when the go relay R290 operates it completes, at the contacts 293, an obvious circuit for

energizing the go magnet M214 of the clutch 213, whereupon the latter magnet operates in order to engage the pair of clutch plates; whereby the shaft of the send switch 210, carrying the wipers 211 and 212 thereof, is constantly rotated in the clockwise direction at the fixed predetermined speed.

As previously noted, the line relay R140 follows the second digit dialed at the calling subscriber substation X, whereby, at the conclusion of the second digit, the rotary magnet M202 has been energized a corresponding number of times and the wiper 201 of the mark switch 200 bridges a corresponding number of the contacts in the associated contact bank. For example, in the event the second digit is 5, the wiper 201 of the mark switch 200 bridges the first five contacts in the associated contact bank, whereby ground potential is applied to each of the first five contacts mentioned. As the wiper 211 of the send switch 210 is rotated in the clockwise direction it first engages the second contact and then disengages the first contact in the associated contact bank, thereby to complete an obvious alternative circuit substantially identical to that previously traced for energizing the winding of the trunk pulse relay R180. Hence, in the present example, the wiper 211 of the send switch 210, as it is rotated in the clockwise direction, successively makes and then interrupts five obvious alternative circuits for energizing the winding of the trunk pulse relay R180, whereby the last alternative circuit for energizing the winding of the trunk pulse relay R180 is interrupted only when the wiper 201 engages the sixth contact and disengages the fifth contact in the associated contact bank, thereby to cause the trunk pulse relay R180 to restore. Upon restoring, the trunk pulse relay R180 re completes, at the contacts 181, the previously traced simplex circuit for energizing the upper and lower windings of the polar relays R265 and R365 and for energizing the windings of the control relays R255, R260, R355 and R360, in the manner previously explained. When this simplex circuit is again re completed the polar relay R265 remains in its restored position; the polar relay R365 reoperates for a purpose more fully explained hereinafter; and the control relays R255, R260, R355 and R360 reoperate without effect at this time.

At the conclusion of the second digit dialed at the calling subscriber substation X the line relay R140 is retained in its operated position, thereby to retain interrupted, at the contacts 141, the previously traced series circuit for energizing the winding of the series relay R120 and the rotary magnet M202 of the mark switch 200. Shortly thereafter the series relay R120 restores, the latter relay being of the slow-to-release type as previously noted. Upon restoring, the series relay R120 interrupts, at the contacts 121, the previously traced path for applying ground potential to the wiper 201 of the mark switch 200, thereby to interrupt a further point in the previously traced circuit for energizing the winding of the trunk pulse relay R180. Also, upon restoring, the series relay R120 completes, at the contacts 122, a circuit, including the set of switch springs S205 and the contacts 182, for energizing the release magnet M203, thereby to cause the latter magnet to operate and release the wiper 201 of the mark switch 200; whereupon the wiper 201 is returned in the counterclockwise direction to its normal rotary position. Also, upon operating, the release magnet M203 completes, at the contacts

204, an obvious holding circuit, including the set of switch springs S205, for energizing the magnet M203. When the mark switch 200 is thus released the set of switch springs S205 is actuated, thereby to interrupt the above-traced holding circuit for energizing the release magnet M203 of the mark switch 200, whereby the latter magnet restores.

Further operation of the send switch 210 occurs at this time without effect until the wiper 212 thereof engages and then disengages the tenth contact in the associated contact bank. When the wiper 212 of the send switch 210 engages the tenth contact in the associated contact bank an obvious circuit for energizing the winding of the charge relay R275 is completed, thereby to cause the latter relay to operate. Upon operating, the charge relay R275 completes, at the contacts 276, an obvious circuit for charging the condenser 237. When the wiper 212 of the send switch 210 is driven to disengage the tenth contact in the associated contact bank and back into its normal rotary position, the above-traced circuit for energizing the winding of the charge relay R275 is interrupted, thereby to cause the latter relay to restore. Upon restoring, the charge relay R275 interrupts, at the contacts 276, the previously mentioned circuit for charging the condenser 237; and completes, at the contacts 277, an obvious circuit for discharging the condenser 237 in series through the winding of the stop relay R280. When the condenser 237 is thus discharged through the winding of the stop relay R280 the latter relay is momentarily energized. Hence the stop relay R280 operates and then restores. Upon operating, the stop relay R280 interrupts, at the contacts 281, the previously traced holding circuit for energizing the winding of the go relay R290, thereby to cause the latter relay to restore. Upon restoring, the go relay R290 interrupts, at the contacts 293, the previously mentioned circuit for energizing the go magnet M214 of the clutch 213. Also, upon operating, the stop relay R280 completes, at the contacts 282, an obvious circuit for energizing the stop magnet M215 of the clutch 213. When the go magnet M214 of the clutch 213 is deenergized and the stop magnet M215 thereof is energized the clutch plates thereof are disengaged, whereby further rotation of the shaft of the send switch 210 is arrested at a time when the wipers 211 and 212 thereof occupy their normal rotary positions. At this time the wiper 211 of the send switch 210 engages the first contact in the associated contact bank and the wiper 212 of the send switch 210 disengages the tenth contact in the associated contact bank. Upon restoring, the stop relay R280 interrupts, at the contacts 282, the previously mentioned circuit for energizing the stop magnet M215 of the clutch 213, thereby to cause the latter magnet to restore without effect at this time. Accordingly, at this time, the apparatus incorporated in the repeater 110 occupies the seized position thereof, this position being the same as that which it occupied prior to the reception of the second digit 5 dialed at the calling subscriber substation X.

In view of the foregoing explanation of the mode of operation of the repeater 110, it will be understood that the mark switch 200 is operative to register the digit dialed at the calling subscriber substation and to initiate operation of the send switch 210, whereupon the trunk pulse relay R180 operates. Operation of the send switch 210 is continued at a constant predetermined speed for

a time interval corresponding to the digit registered in the mark switch 200 in order to retain the trunk pulse relay R180 in its operated position during this time interval mentioned. At the conclusion of this time interval mentioned the wiper 211 of the send switch 210 disengages the last marked contact in the associated contact bank, thereby to effect the restoration of the trunk pulse relay R180. Also at this time the series relay R120 restores, which is shortly following the conclusion of the digit, in order to effect the release of the mark switch 200. The send switch 210 is then further operated back into its normal position, whereupon further operation thereof is arrested. It will be understood that operation of the send switch 210 is initiated immediately upon operation of the mark switch 200; that the effective operation of the send switch 210, to retain operated the trunk pulse relay R180, is completed very shortly following the conclusion of the digit received by the repeater 110; and that this effective operation of the send switch 210 is completed shortly prior to the restoration of the series relay R120, the latter relay restoring shortly following the reception of the digit mentioned. Hence it will be understood that the repeater 110 is operative to register any digit dialed at the calling subscriber substation X and to effect operation of the trunk pulse relay R180, in response to this digit received for a time interval corresponding to the digit mentioned. More particularly, the trunk pulse relay R180 is retained operated a variable time interval precisely corresponding to the variable number of impulses in the digit received by the repeater 110. Further it will be understood that the operation of the trunk pulse relay R180 for the variable time interval mentioned retains interrupted for this variable time interval the previously traced simplex circuit extending between the repeater 110 and the repeater 410; and then recompletes, at the conclusion of the time interval mentioned, the previously traced simplex circuit between the repeater 110 and the repeater 410. Accordingly, it will be understood that the repeater 110 is effective to register any variable digit and to transmit over the trunk 10 to the repeater 410 a single impulse of a corresponding variable time duration. For example, the repeater 110 is effective to register the digit 4, 5 or 6 and to transmit over the trunk 10 to the repeater 410 a single impulse of corresponding 4, 5 or 6 unit time intervals of duration.

Continue now with the operation of the repeater 410 in response to the restoration of the polar relay R365, at the beginning of the single impulse received thereby when the previously traced simplex circuit including the trunk 10 is interrupted. Upon restoring, the polar relay R365 interrupts, at the contacts 368, the previously mentioned circuit for energizing the winding of the seizure relay R370; however, the latter relay does not restore during the reception of any impulse as it is of the dashpot type. Also, upon restoring, the polar relay R365 interrupts, at the contacts 366, the previously mentioned circuit for energizing the stop magnet M325 of the clutch 323, and completes, at the contacts 367, an obvious circuit, including the contacts 371, for energizing the go magnet M324 of the clutch 323. When the stop magnet M325 is deenergized and the go magnet M324 is energized the clutch plates are engaged, whereby the shaft and the commutator 321 carried thereby are rotated in the counterclockwise direction continuously at the predetermined speed previously mentioned. As

the commutator 321 is rotated at the predetermined speed in the counterclockwise direction, the conductive and insulating segments thereof alternately engage the associated wiper 322, thereby to complete and then to interrupt repeatedly an obvious circuit for energizing the winding of the impulse relay R350; whereby the latter relay operates and restores at a fixed rate corresponding to the predetermined speed of rotation of the commutator 321 in the counterclockwise direction. Each time the impulse relay R350 operates it interrupts, at the contacts 352, an obvious circuit for charging the condenser 339; and completes, at the contacts 351, an obvious circuit for discharging the condenser 339 in series through the winding of the switch pulse relay R345, whereby the latter relay operates and then restores. Each time the impulse relay R350 restores it interrupts, at the contacts 351, the previously mentioned circuit for discharging the condenser 339 in series through the winding of the switch pulse relay R345; and recompletes, at the contacts 352, the previously mentioned circuit for charging the condenser 339. Accordingly the switch pulse relay R345 follows the impulse relay R350. Upon the first operation of the switch pulse relay R345 it completes, at the contacts 346, an obvious circuit for energizing the winding of the bridge relay R340, thereby to cause the latter relay to operate. Also upon the first operation of the switch pulse relay R345 it interrupts, at the contacts 347, the previously traced path for connecting the lower winding of the answer relay R460 across the line conductors of the trunk 415 extending to the incoming selector 405. Upon operating, the bridge relay R340 completes, at the contacts 341, an obvious path, including the contacts 472 and 473 and the resistor 491, for short-circuiting the winding 333 of the transformer 330 in series with the lower winding of the answer relay R460. Upon the first restoration of the switch pulse relay R345 it interrupts, at the contacts 346, the previously mentioned circuit for energizing the winding of the bridge relay R340; however, the latter relay does not restore during impulsing as it is of the slow-to-release type. Also upon the first restoration of the switch pulse relay R345 it completes, at the contacts 347, a bridge across the line conductors of the trunk 415 extending to the incoming selector 405. The above-mentioned bridge extends from the line conductor C417 of the trunk 415 by way of the contacts 433, C413, the contacts 341 and 347, the winding 331 of the transformer 330 and the contacts 431 to the line conductor C416 of the trunk 415. Accordingly the switch pulse relay R345 repeats impulses at the contacts 347 over the trunk 415 to the incoming selector 405, thereby to cause operation of the last-mentioned selector in accordance with conventional practice.

At the conclusion of the single impulse transmitted over the trunk 10 to the repeater 410, the previously traced simplex circuit between the repeater 110 and the repeater 410 is recompletes, thereby to cause reoperation of the polar relay R365, as previously noted. Upon reoperating, the polar relay R365 recompletes, at the contacts 368, the previously mentioned circuit for energizing the winding of the seizure relay R370, whereby the latter relay is retained in its operated position continuously, as previously explained. Also the polar relay R365 interrupts, at the contacts 367, the previously traced circuit for energizing the go magnet M324 of the clutch 323; and completes, at the contacts 366, the pre-

viously mentioned circuit for energizing the stop magnet M325 in the clutch 323. When the go magnet M324 is deenergized and the stop magnet M325 is energized the pair of clutch plates are disengaged, whereby further rotation of the commutator 321 in the counterclockwise direction is arrested, thereby to prevent further intermittent operation of the impulse relay R350. At this point it is noted that, when operation of the commutator 321 is arrested, the associated wiper 322 may engage either a conductive or an insulating segment thereof, whereby the impulse relay R350 may be retained either in its operated or its restored position. However, regardless of whether the impulse relay R350 is retained in its operated position or its restored position, the switch pulse relay R345 is restored in order to effect the restoration of the bridge relay R340 shortly thereafter, the bridge relay R340 being of the slow-to-release type. Upon restoring, the bridge relay R340 interrupts, at the contacts 341, the previously traced path for short-circuiting the winding 333 of the transformer 330 in series with the lower winding of the answer relay R460, whereupon the previously traced circuit for connecting the lower winding of the answer relay R460 across the line conductors of the trunk 415 extending to the incoming selector 405 is recompleted. Accordingly, at this time, the apparatus incorporated in the repeater 410 occupies the seized position thereof, this position being the same as that which it occupied prior to the reception of the single impulse over the trunk 10 which was transmitted by the repeater 110.

In view of the foregoing explanation of the mode of operation of the repeater 410, it will be understood that the polar relay R365 is restored for a variable time interval corresponding to the variable time duration of the single impulse received over the trunk 10; and then the polar relay R365 reoperates. During the time interval while the polar relay R365 occupies its restored position, the commutator 321 is continuously rotated at the fixed predetermined speed in the counterclockwise direction; whereby the impulse relay R350 is operated and restored a corresponding number of times in order to effect a corresponding number of operations and restorations of the switch pulse relay R345. Hence the number of intermittent operations of the switch pulse relay R345, to transmit impulses over the trunk 415 extending to the incoming selector 405, is proportional to the time interval during which the commutator 321 is continuously rotated in the counterclockwise direction, which time interval is proportional to the time duration of the single impulse received over the trunk 10. More particularly, the speed of rotation of the commutator 321 in the counterclockwise direction is so correlated with respect to the time duration of the single impulse received over the trunk 10 that the switch pulse relay R345 is operated to transmit a number of impulses over the trunk 415 extending to the incoming selector 405 corresponding to the number of unit time intervals of the duration of the single impulse received over the trunk 10. Accordingly the repeater 410 is operative to receive a single impulse of variable time duration over the trunk 10 and to repeat a number of impulses over the trunk 415 corresponding to the time duration of the single impulse mentioned. For example, the repeater 410 is operative to receive the single impulse of 4, 5 or 6

unit time intervals of duration and to transmit a series of impulses over the trunk 415, including the corresponding 4, 5 or 6 impulses.

The incoming selector 405 responds to the second digit dialed at the calling subscriber substation X to select a corresponding group of trunks and then operates automatically to seize an idle trunk in the selected group, such, for example, as the trunk 406, extending to the connector 407. When the trunk 406 extending to the connector 407 is seized by the incoming selector 405 the connector 407 is rendered responsive to impulses transmitted thereto in accordance with conventional practice.

The subscriber at the calling subscriber substation X then proceeds to dial the third digit of the directory number of the called subscriber substation Y. The repeater 110 first registers the third digit received over the trunk 111 and transmits a single impulse over the trunk 10 in the manner previously explained, the single impulse transmitted over the trunk 10 comprising a number of unit time intervals of duration corresponding to the number of impulses of the third digit received over the trunk 111. The repeater 410 receives the single impulse over the trunk 10 and transmits a series of impulses over the trunk 415, the number of impulses in the series transmitted over the trunk 415 corresponding to the number of unit time intervals of duration of the single impulse received over the trunk 10, and consequently to the third digit dialed at the calling subscriber substation X. The subscriber at the calling subscriber substation X then proceeds to dial the fourth digit of the directory number of the called subscriber substation Y, whereby the repeaters 110 and 410 operate in the manner described above. More particularly, the third and fourth digits of the directory number of the called subscriber substation Y are repeated by the repeater 410 over the trunk 415, the incoming selector 405 and the trunk 406 to the connector 407, whereby the connector 407 operates in order to select the subscriber line 401 extending to the called subscriber substation Y in accordance with conventional practice.

When the connector 407 seizes the subscriber line 401 extending to the called subscriber substation Y the idle or busy condition thereof is tested, whereby ringing current is projected thereover from the connector 407 and ring-back tone current is returned from the connector 407 over the trunk 415 to the repeater 410, all in the event the subscriber line 401 is idle. On the other hand, in the event the subscriber line 401 is busy, busy tone current is returned from the connector 407 over the trunk 415 to the repeater 410. The ring-back tone current or the busy tone current returned over the trunk 415 traverses the windings 331 and 333 of the transformer 330 included in the previously traced circuit, whereby a corresponding tone voltage is induced in the windings 332 and 334 of the transformer 330 in order to cause a corresponding tone current to be returned over the trunk 10. The tone current returned over the trunk 10 traverses the windings 232 and 234 of the transformer 230 in order to induce a corresponding tone voltage in the windings 231 and 233 of the transformer 230, whereby a corresponding tone current is returned over the subscriber line 101 to the calling subscriber substation X. In the event ring-back tone current is returned to the calling subscriber substation X, it indicates to the subscriber thereat

that the called subscriber substation Y is being rung and the subscriber at the calling subscriber substation X waits for the subscriber at the called subscriber substation Y to answer the call. On the other hand, in the event busy tone current is returned to the calling subscriber substation X, it indicates to the subscriber thereat that the desired connection may not be had immediately due to the busy condition of the called subscriber substation Y; whereupon the subscriber at the calling subscriber substation X replaces the receiver of the telephone instrument thereat upon its associated switchhook, thereby to effect the release of the switching apparatus involved in the incompleting connection, in a manner more fully explained hereinafter.

Assuming that the called subscriber substation Y is idle at this time, when the subscriber thereat answers the call the connector 407 operates in order to cause current to be reversed over the trunk 415 extending to the repeater 410, whereby the lower winding of the answer relay R460 is energized in the opposite direction. When the lower winding of the answer relay R460 is energized in the direction mentioned the latter relay operates as it is of the polarized type and the upper winding thereof is directly energized at this time. Upon operating, the answer relay R460 interrupts, at the contacts 461, a point in the previously traced simplex circuit for energizing in series the upper winding of the polar relay R365, the winding of the control relay R355, the winding of the control relay R255 and the upper winding of the polar relay R265; however, the previously traced circuit for energizing the lower winding of the polar relay R365, the winding of the control relay R360, the winding of the control relay R260 and the lower winding of the polar relay R265 is retained completed. Accordingly, at this time, the control relays R355 and R255 restore; the control relays R360 and R260 are retained in their operated positions; the polar relay R365 is retained in its operated position; and the polar relay R265 is retained in its restored position. Upon restoring, the control relay R355 completes, at the contacts 356, an obvious circuit for energizing the winding of the battery reverse relay R450, thereby to cause the latter relay to operate. The operation of the battery reverse relay R450 is without effect at this time in view of the operated position of the cutoff relay R470. Upon restoring, the control relay R255 completes, at the contacts 256, an obvious circuit for energizing the winding of the battery reverse relay R150, thereby to cause the latter relay to operate. Upon operating, the battery reverse relay R150 completes, at the contacts 151 and 153, a circuit substantially identical to that previously traced for energizing the upper and lower windings of the line relay R140; and interrupts, at the contacts 152 and 154, the previously traced original circuit for energizing in series the upper and lower windings of the line relay R140; whereby the direction of battery current feed over the trunk 111 to the selector 104 is reversed. This reversal of battery current feed over the trunk 111 to the selector 104 and consequently over the trunk 103, the line switch 102 and the subscriber line 101 extending to the calling subscriber substation X may be utilized for supervisory purposes, meter control in the line switch 102, etc., all in accordance with conventional practice.

At this time an established connection is completed between the calling subscriber substation

X in exchange 100 and the called subscriber substation Y in exchange 400. More particularly, the previously traced loop circuit is completed between the calling subscriber substation X and the line relay R140 in the repeater 110, which loop circuit includes the windings 231 and 233 of the transformer 230; the windings 232 and 234 of the transformer 230 are operatively connected by way of the trunk 10 to the windings 332 and 334 of the transformer 330 in the repeater 410; the windings 331 and 333 of the transformer 330 are included in the previously traced loop circuit extending between the lower winding of the answer relay R460 and the connector 407, the last-mentioned loop circuit including the trunk 415, the incoming selector 405 and the trunk 406; and an obvious loop circuit is completed between the connector 407 by way of the subscriber line 401 to the called subscriber substation Y. Accordingly the conversation between the calling subscriber substation X in exchange 100 and the called subscriber substation Y in exchange 400 proceeds.

The release of this established connection is assumed to be under the control of the subscriber at the calling subscriber substation X in exchange 100 and is effected when the subscriber thereat replaces the receiver of the telephone instrument at the calling subscriber substation X upon its associated switchhook in order to interrupt the previously traced loop circuit for energizing in series the upper and lower windings of the line relay R140 in the repeater 110. When the loop circuit mentioned is interrupted the line relay R140 restores, thereby to interrupt, at the contacts 142, the previously mentioned circuit for energizing the winding of the hold relay R130; whereupon the latter relay restores shortly thereafter, the hold relay R130 being of the slow-to-release type. Also, upon restoring, the line relay R140 completes, at the contacts 141, the previously traced circuit for energizing the winding of the series relay R120 in series with the rotary magnet M202 of the mark switch 200. The rotary magnet M202 operates, thereby to drive the wiper 201 of the mark switch 200 one step in the clockwise direction, in the manner previously explained; and the series relay R120 operates in order to complete, at the contacts 121, the previously traced path for applying ground potential to the wiper 201 of the mark switch 200, whereby the go relay R290 operates in order to effect operation of the send switch 210 in the manner previously explained. Also the go relay R290 completes, at the contacts 294, the previously traced circuit for energizing the winding of the trunk pulse relay R180, thereby to cause the latter relay to operate. Upon operating, the trunk pulse relay R180 interrupts, at the contacts 181, the previously traced series circuit for energizing the lower winding of the polar relay R265, the winding of the control relay R260, the winding of the control relay R360 and the lower winding of the polar relay R365; whereby the control relays R260 and R360 and the polar relay R365 restore. Upon restoring, the control relay R260 interrupts, at the contacts 261, the previously traced circuit for energizing the winding of the battery reverse relay R150, thereby to cause the latter relay to restore. Upon restoring, the control relay R360 interrupts, at the contacts 361, the previously traced circuit for energizing the winding of the battery reverse relay R450, thereby to cause the latter relay to restore.

Operation of the send switch 210 proceeds in

the manner previously explained and when the wiper 211 thereof disengages the first contact in the associated contact bank the previously traced circuit for energizing the winding of the trunk pulse relay R180 is interrupted, whereupon the latter relay restores. Upon restoring, the trunk pulse relay R180 re completes, at the contacts 181, the previously traced series circuit for energizing the lower winding of the polar relay R265, the winding of the control relay R260, the winding of the control relay R360, and the lower winding of the polar relay R365, whereby the control relays R260 and R360 and the polar relay R365 reoperate. Upon operating, the control relay R260 completes, at the contacts 261, the previously traced circuit for energizing the winding of the battery reverse relay R150, thereby to cause the latter relay to operate. Upon operating the control relay R360 completes, at the contacts 361, the previously traced circuit for energizing the winding of the battery reverse relay R450, thereby to cause the latter relay to operate.

When the hold relay R130 restores, as previously explained, shortly following the release operation performed at the calling subscriber substation X it interrupts, at the contacts 132, the previously traced circuit for energizing the winding of the series relay R120 in series with the rotary magnet M202, whereupon the series relay R120 restores shortly thereafter, the series relay R120 being of the slow-to-release type. Further the hold relay R130 re completes, at the contacts 131 and 133, the connection between the line conductors C112 and C113 of the trunk 111 and the line conductors C116 and C117 of the trunk 115, the trunk 115 extending to the incoming selector 105. Further the hold relay R130 interrupts, at the contacts 134, the previously traced path for applying ground potential to the control conductor of the trunk 111, thereby to effect the release of the selector 104 and the line switch 102. At this time the trunk 111 extending to the repeater 110 is marked as idle to the selectors having access thereto; the trunk 103 extending to the selector 104 is marked as idle to the line switches having access thereto; and the subscriber line 101 extending to the calling subscriber substation X is marked as idle to the connectors having access thereto.

Operation of the send switch 210 proceeds in the manner previously explained, whereby the wipers 211 and 212 thereof are returned to their normal rotary positions; the charge relay R275 operates and restores, thereby to effect operation and restoration of the stop relay R280, as previously explained. Upon operating, the stop relay R280 interrupts, at the contacts 281, the previously traced holding circuit for energizing the winding of the go relay R290, thereby to cause the latter relay to restore. Upon restoring, the go relay R290 interrupts, at the contacts 293, the previously mentioned circuit for energizing the go magnet M214 of the clutch 213; and, upon operating, the stop relay R280 completes, at the contacts 282, the previously mentioned circuit for energizing the stop magnet M215 of the clutch 213. Upon restoring, the stop relay R280 interrupts, at the contacts 282, the previously mentioned circuit for energizing the stop magnet M215 of the clutch 213, whereby the send switch 210 is completely released.

Further, upon restoring, the hold relay R130 interrupts, at the contacts 135, the previously traced circuit for energizing in series the lower winding of the polar relay R265, the winding

of the control relay R260, the winding of the control relay R360 and the lower winding of the polar relay R365, whereby the control relays R260 and R360 and the polar relay R365 restore. Upon restoring, the control relay R260 interrupts, at the contacts 261, the previously mentioned circuit for energizing the winding of the battery reverse relay R150, thereby to cause the latter relay to restore. At this time the repeater 110 is completely released and available for further use.

Considering now the release of the repeater 410, the first time the polar relay R365 restored it interrupted, at the contacts 366, the previously mentioned circuit for energizing the stop magnet M325 of the clutch 323 and completed, at the contacts 367, the previously traced circuit for energizing the go magnet M325 of the clutch 323, whereby the commutator 321 was rotated in the counterclockwise direction. Subsequently, when the polar relay R365 reoperated it re completed, at the contacts 366, the previously mentioned circuit for energizing the stop magnet M325 of the clutch 323 and interrupted, at the contacts 367, the previously traced circuit for energizing the go magnet M324 of the clutch 323, whereby further rotation of the commutator 321 was arrested. This rotation of the commutator 321 caused one operation and restoration of the impulse relay R350 and consequently one operation and restoration of the switch pulse relay R345, whereby the bridge relay R340 was operated. Also the operation and subsequent restoration of the switch pulse relay R345 caused one impulse to be transmitted over the trunk 415 to the connector 407 without effect at this time.

When the polar relay R365 again restored it again initiated rotation of the commutator 321, whereby the impulse relay R350 and the switch pulse relay R345 were again operated intermittently and the bridge relay R340 was operated. However, at this time, the polar relay R365 remains restored and after a predetermined time interval the seizure relay R370 restores, the latter relay being of the dash-pot type and having a slow-to-release characteristic. Upon restoring, the seizure relay R370 interrupts, at the contacts 371, the previously traced circuit for energizing the go magnet M324 of the clutch 323, whereby further rotation of the commutator 321 in the counterclockwise direction is arrested in order to effect restoration of the impulse relay R350 and the switch pulse relay R345 and restoration of the bridge relay R340 shortly thereafter, the bridge relay R340 being of the slow-to-release type. Also, upon restoring, the seizure relay R370 interrupts, at the contacts 372, the previously traced circuit for energizing in multiple the winding of the cutoff relay R470 and the upper winding of the answer relay R460, whereupon the cutoff relay R470 restores. Upon restoring, the cutoff relay R470 interrupts, at the contacts 472 and 473, the previously traced bridge connection, including the lower winding of the answer relay R460, between the line conductors of the trunk 415.

Finally the seizure relay R370 interrupts, at the contacts 373, the previously mentioned path for applying ground potential to the control conductor C414 of the trunk 411, thereby to mark the trunk 411 and consequently the repeater 410 as idle to the selectors having access thereto. Further, upon restoring, the cutoff relay R470 completes, at the contacts 471 and 474, obvious

paths respectively including the contacts 452 and 454 and the windings 331 and 333 of the transformer 330 and the contacts 431 and 433 for applying battery and ground potentials by way of the upper and lower windings of the line relay R440 to the respective line conductors C416 and C417 of the trunk 415 extending to the incoming selector 405; whereby the line relay included in the connector 407 is effectively short-circuited in order to cause the connector 407 and consequently the incoming selector 405 to be released. At this time the trunk 406 extending to the connector 407 is marked as idle to the incoming selectors having access thereto and the subscriber line 401 extending to the called subscriber substation is marked as idle to the connectors having access thereto, assuming that the subscriber at the called subscriber substation Y has replaced the receiver of the telephone instrument thereat upon its associated switchhook at this time. On the other hand, in the event the subscriber at the called subscriber substation Y has not replaced the receiver of the telephone instrument thereat upon its associated switchhook at this time, the line switch 402 operates incident to the release of the connector 407 to lock the subscriber line 401 extending to the called subscriber substation Y out of service and to mark the subscriber line 401 as busy to the connectors having access thereto, all in accordance with conventional practice. At this time the repeater 410 is completely released and available for further use.

Of course it will be understood that the release of the repeater 110 and the release of the repeater 410 take effect simultaneously, whereby these two repeaters will become completely released and respectively marked as idle by way of the trunks 111 and 411 respectively extending thereto substantially simultaneously. At this time ground potential in the repeater 110 is applied by way of the contacts 136 and the previously traced simplex connection to the line conductors C11 and C12 of the trunk 10; and ground potential in the repeater 410 is applied by way of the contacts 436 and the previously traced simplex connection to the line conductors C11 and C12 of the trunk 10. Accordingly, at this time, the trunk 111 may be seized by a selector to extend a call over the trunk 10 from exchange 100 to exchange 400; similarly, the trunk 411 may be seized by a selector to extend a call over the trunk 10 from exchange 400 to exchange 100.

In view of the foregoing explanation of the modes of operation of the repeater 110 as a sending repeater and the repeater 410 as a receiving repeater, it will be understood that the repeater 410 is operative in a similar manner as the repeater 110, when it is utilized as a sending repeater, and that the repeater 110 is operative in a similar manner as the repeater 410, when it is utilized as a receiving repeater.

While one embodiment of the invention has been disclosed it will be understood that various modifications may be made therein, which are within the true spirit and scope of the invention.

What is claimed is:

1. In a signaling system, a two-way translator comprising means for generating a variable first series of impulses, means for converting said variable first series of impulses into a directly proportional single impulse of a corresponding variable time duration, and means for reconverting

a single impulse of variable time duration into a corresponding variable second series of impulses.

2. In a signaling system, a two way translator comprising means for generating a first series of impulses including a variable number of individual impulses, means for converting said first series of impulses into a single impulse of variable time duration including a number of unit time intervals corresponding to the number of individual impulses in said first series, and means for reconverting a single impulse into a second series of impulses including a number of individual impulses corresponding to the number of unit time intervals of said single impulse.

3. In a signaling system, means for generating a first series of impulses including a variable number X of individual impulses, means for converting said first series of impulses into a single impulse of variable time duration including a corresponding variable number X of unit time intervals, and means for reconverting said single impulse into a second series of impulses including a corresponding number X of individual impulses.

4. In a signaling system, a pair of stations each having means for receiving a variable first series of impulses, means controlled by said receiving means for transmitting a single impulse of a corresponding variable time duration to the other station, and means at the other station controlled by said transmitting means for transmitting a corresponding variable second series of impulses.

5. In a signaling system, a plurality of stations interconnected by a trunk line and a simplex circuit, means at each station for registering a variable first series of impulses, means controlled by said registering means for transmitting over said simplex circuit a single impulse of a corresponding variable time duration, and means at the remote station controlled by said transmitting means for transmitting a corresponding variable second series of impulses.

6. In a signaling system including a first repeater, a second repeater, and a trunk interconnecting said repeaters; said first repeater including means for receiving a variable series of impulses; and means controlled by said receiving means for transmitting over said trunk for each said series of impulses a single impulse of a corresponding variable time duration; said second repeater including means for receiving over said trunk impulses of variable time duration, and means controlled by said receiving means for transmitting for each impulse received a corresponding variable series of impulses.

7. In a signaling system including a first repeater, a second repeater, and a trunk interconnecting said repeaters; said first repeater including means for receiving a variable series of impulses, and means controlled by said receiving means for transmitting over said trunk a single impulse of a corresponding variable time duration; said second repeater including a generator operative to transmit a variable series of impulses during a directly proportional corresponding variable time interval, means for receiving over said trunk a single impulse of variable time duration, and means governed by said receiving means for selectively controlling the time interval of operation of said generator, whereby said generator is controlled to transmit a variable series of impulses corresponding

to the variable time duration of a single impulse received by said receiving means.

8. In a signaling system including a first repeater having a first line extending thereto, a second repeater having a second line extending therefrom, and a trunk interconnecting said repeaters; said first repeater including means for receiving over said first line a variable series of impulses, and means controlled by said receiving means for transmitting over said trunk a single impulse of a directly proportional corresponding variable time duration; said second repeater including means for receiving over said trunk a single impulse of variable time duration, and means controlled by said receiving means for transmitting over said second line a corresponding variable series of impulses.

9. In a signaling system including a pair of two-way repeaters, and an interconnecting trunk; each of said repeaters including first means for receiving a variable series of impulses, means controlled by said first receiving means for transmitting over said trunk a single impulse of a corresponding variable time duration, second means for receiving over said trunk a single impulse of variable time duration, and means controlled by said second receiving means for transmitting a corresponding variable series of impulses.

10. In a signaling system including a pair of two-way repeaters each having an incoming line extending thereto and an outgoing line extending therefrom, and an interconnecting trunk; each of said repeaters including first means for receiving over the associated incoming line a variable series of impulses, means controlled by said first receiving means for transmitting over said trunk a single impulse of a corresponding variable time duration, second means for receiving over said trunk a single impulse of variable time duration, and means controlled by said second receiving means for transmitting over the associated outgoing line a corresponding variable series of impulses.

11. In a telephone system including a calling station, a called station, a first repeater, a second repeater, a trunk interconnecting said repeaters, first switching apparatus associated with said calling station and having access to said first repeater, and second switching apparatus associated with said second repeater and having access to said called station; means controllable from said calling station for operating said first switching apparatus to seize said first repeater and for transmitting one or more digits to said first repeater, said first repeater including means for receiving a variable digit transmitted thereto and means controlled by said receiving means for transmitting over said trunk a single impulse of a directly proportional corresponding variable time duration, said second repeater including means for receiving over said trunk a single impulse of variable time duration and means controlled by said receiving means for transmitting to said second switching apparatus a corresponding variable digit, and means responsive to one or more digits transmitted to said second switching apparatus for operating said second switching apparatus to seize said called station.

12. In a telephone system including a calling station, a called station, a first repeater, a second repeater, a trunk interconnecting said repeaters, first switching apparatus associated with said calling station and having access to said first repeater, and second switching apparatus asso-

ciated with said second repeater and having access to said called station; a calling device at said calling station operative to transmit one or more digits to said first switching apparatus in order to cause said first switching apparatus to seize said first repeater and then to transmit one or more digits to said first repeater, said first repeater including means for receiving a variable digit transmitted thereto and means controlled by said receiving means for transmitting over said trunk a single impulse of a corresponding variable time duration, said second repeater including means for receiving over said trunk a single impulse of variable time duration and means controlled by said receiving means for transmitting to said second switching apparatus a corresponding variable digit, said second switching apparatus being responsive to one or more digits transmitted thereto in order to cause said second switching apparatus to seize said called station.

13. In a telephone system including a pair of two-way repeaters, a pair of switches normally respectively connected to said repeaters, and a trunk interconnecting said repeaters; means for seizing one of said repeaters and for transmitting a variable digit thereto, and means responsive to the seizure of said one repeater for disconnecting the associated switch therefrom, said one repeater including means for receiving a variable digit transmitted thereto and means controlled by said receiving means for transmitting over said trunk a single impulse of a corresponding variable time duration, the other of said repeaters including means for receiving over said trunk a single impulse of variable time duration and means controlled by said receiving means for transmitting to the associated switch a corresponding variable digit, thereby selectively to operate the said-mentioned switch.

14. In a telephone system, including a calling station, a called station, a pair of repeaters, a trunk extending between said repeaters and including two line conductors, and means for setting up a connection from said calling station by way of said repeaters and said trunk to said called station; said connection including a circuit extending from one terminal of a source of current supply in a first of said repeaters by way of the two line conductors of said trunk in parallel to the other terminal of the source of current supply in a second of said repeaters, and means responsive to a control operation performed at one of said stations for causing apparatus in said second repeater to disconnect one of the line conductors of said trunk from said other terminal of the source of current supply in said second repeater, thereby to transmit a supervisory control to said first repeater.

15. In a telephone system, including a calling station, a called station, a pair of repeaters, a trunk extending between said repeaters and including two line conductors, and means for setting up a connection from said calling station by way of said repeaters and said trunk to said called station; said connection including a circuit extending from one terminal of a source of current supply in a first of said repeaters by way of the two line conductors of said trunk in parallel to the other terminal of the source of current supply in a second of said repeaters, and means responsive to the performance of an answer operation at said called station for causing apparatus in said second repeater to disconnect one of the line conductors of said trunk from

said other terminal of the source of current supply in said second repeater, thereby to transmit an answer supervision to said first repeater.

16. In a telephone system, including a calling station, a called station, a pair of repeaters, a trunk extending between said repeaters and including two line conductors, and means for setting up a connection from said calling station by way of said repeaters and said trunk to said called station; said connection including a circuit extending from one terminal of a source of current supply in a first of said repeaters by way of the two line conductors of said trunk in parallel to the other terminal of the source of current supply in a second of said repeaters, means responsive to the performance of an answer operation at said called station for causing apparatus in said second repeater to disconnect one of the line conductors of said trunk from said other terminal of the source of current supply in said second repeater, thereby to transmit an answer supervision to said first repeater, and means responsive to the transmission of an answer su-

pervision to said first repeater for effecting a reversal of the current supplied to said calling station.

17. In a signaling system, a translator comprising a register having a plurality of settings, means for receiving a variable series of impulses and for selectively operating said register to a corresponding one of its settings, a sender having a plurality of settings, timing means controlled by the operation of said register to any one of its settings for operating said sender to a corresponding one of its settings, whereby said sender is operated a variable time interval to the different ones of its settings, and means for transmitting a single impulse during the time interval said sender is being operated to a corresponding one of its settings, whereby the single impulse transmitted by said transmitting means is of variable time duration:

WM. WALTER OWEN,
Executor of the Estate of Bernard D. Willis, Deceased.

479-16
CERTIFICATE OF CORRECTION.

Patent No. 2,360,296.

October 10, 1944.

BERNARD D. WILLIS, DECEASED,
BY WM. WALTER OWEN, EXECUTOR.

It is hereby certified that error appears in the printed specification of the above numbered patent requiring correction as follows: Page 11, second column, line 40, claim 13, for "said-mentioned switch" read --said last-mentioned switch--; and that the said Letters Patent should be read with this correction therein that the same may conform to the record of the case in the Patent Office.

Signed and sealed this 16th day of January, A. D. 1945.

Leslie Frazer

(Seal)

Acting Commissioner of Patents.