April 26, 1932. W. WHITNEY 1,855,593

TELEPHONE SYSTEM

Filed April 28, 1931 4 Sheets-Sheet 1

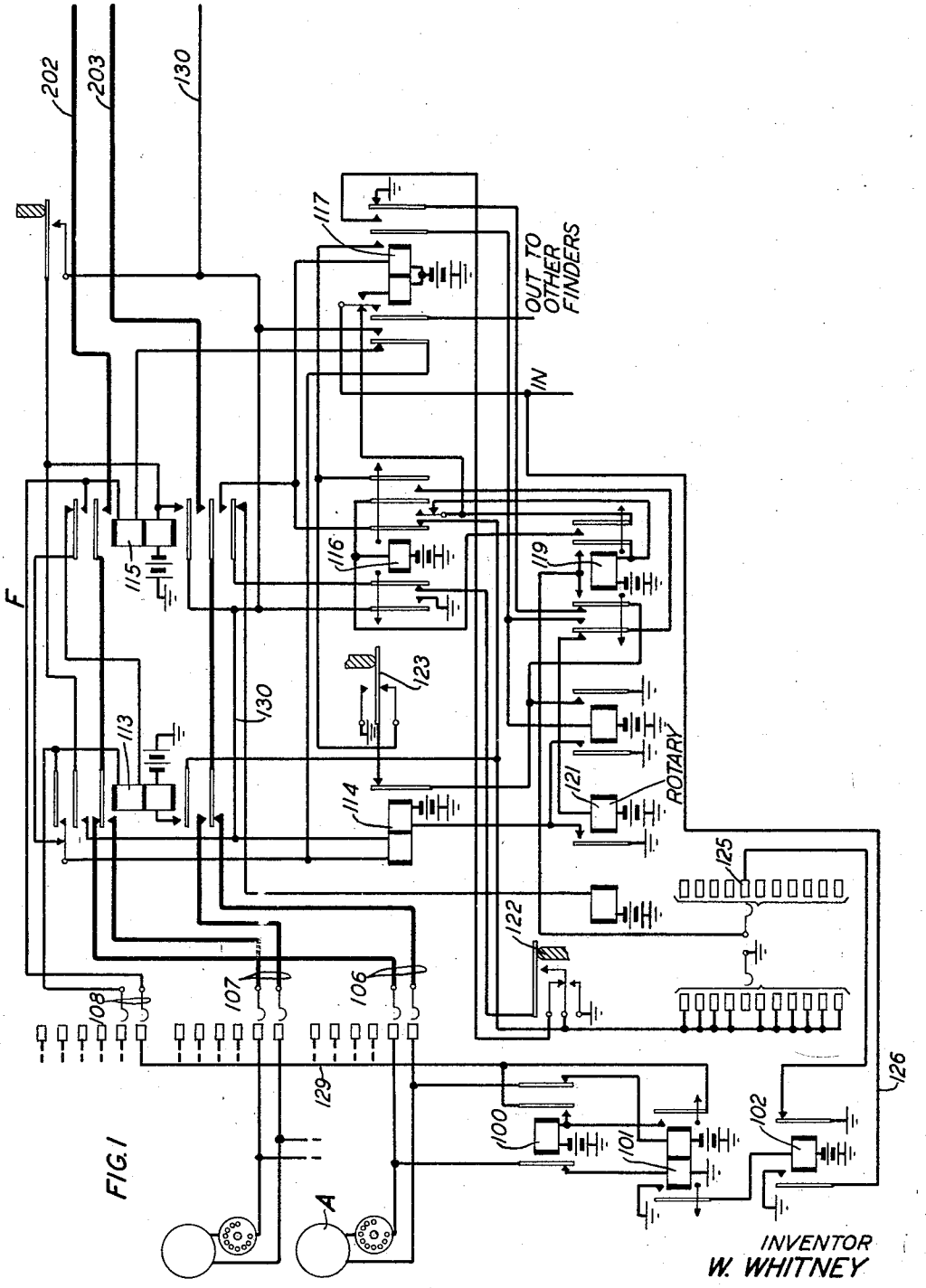

FIG. 1

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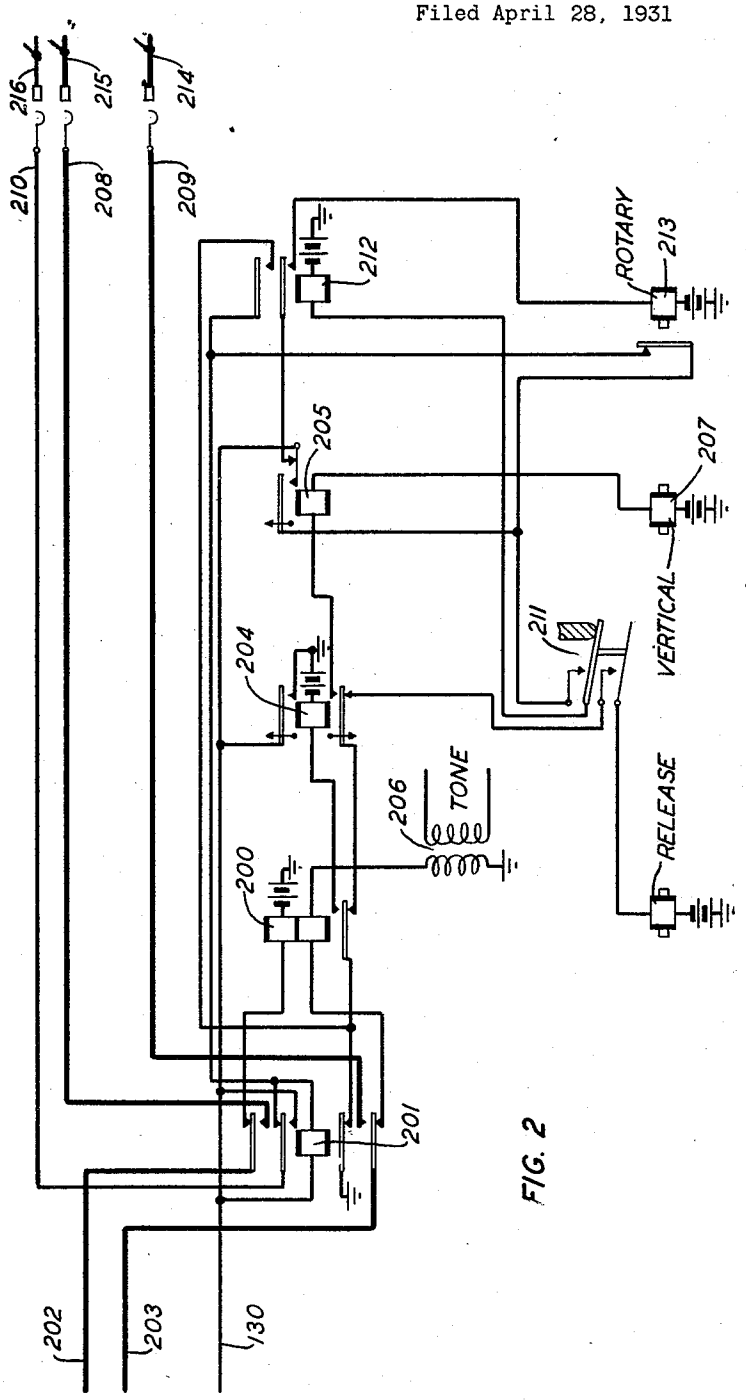

FIG. 2

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TELEPHONE SYSTEM

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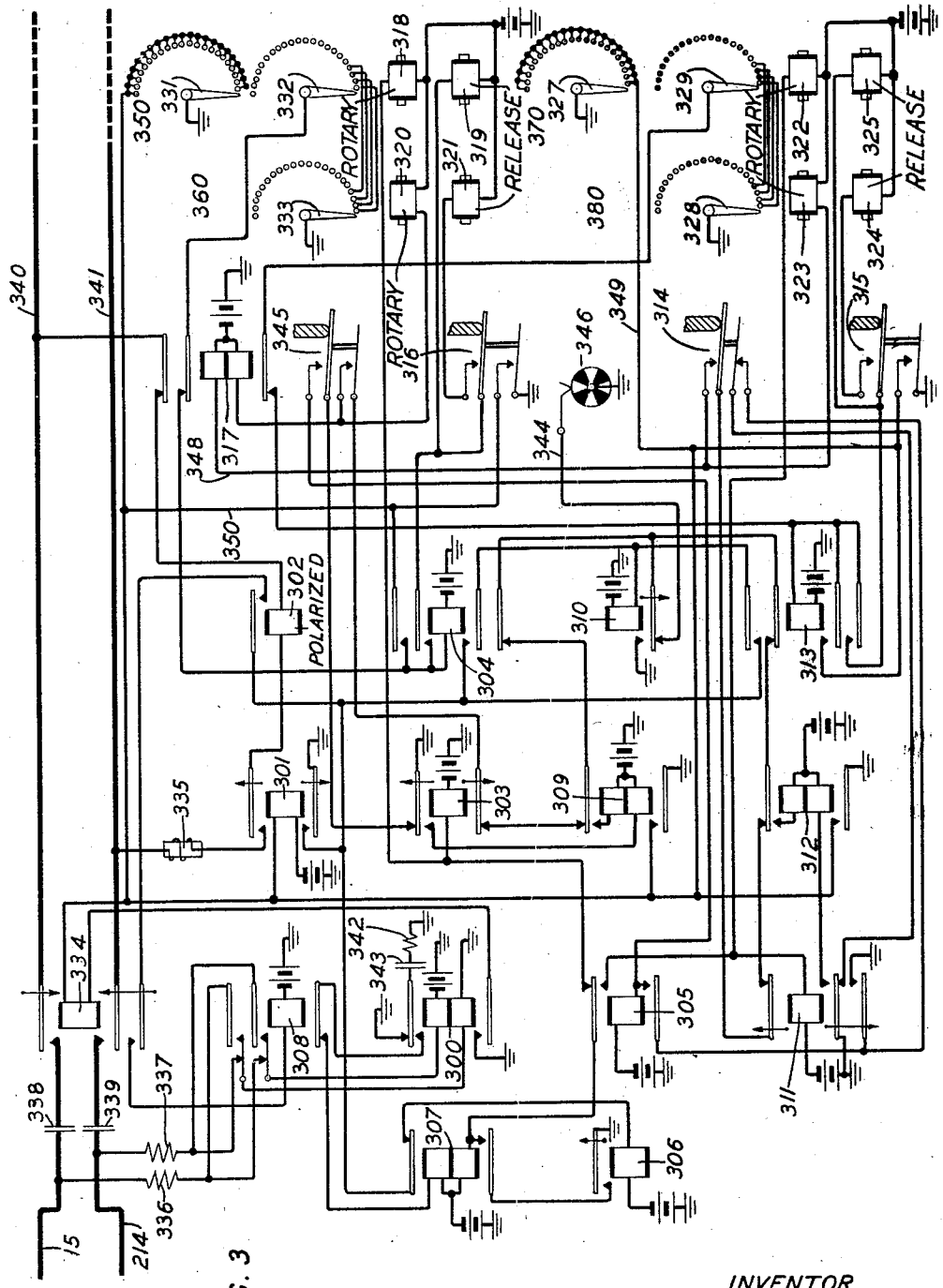

FIG. 3

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TELEPHONE SYSTEM

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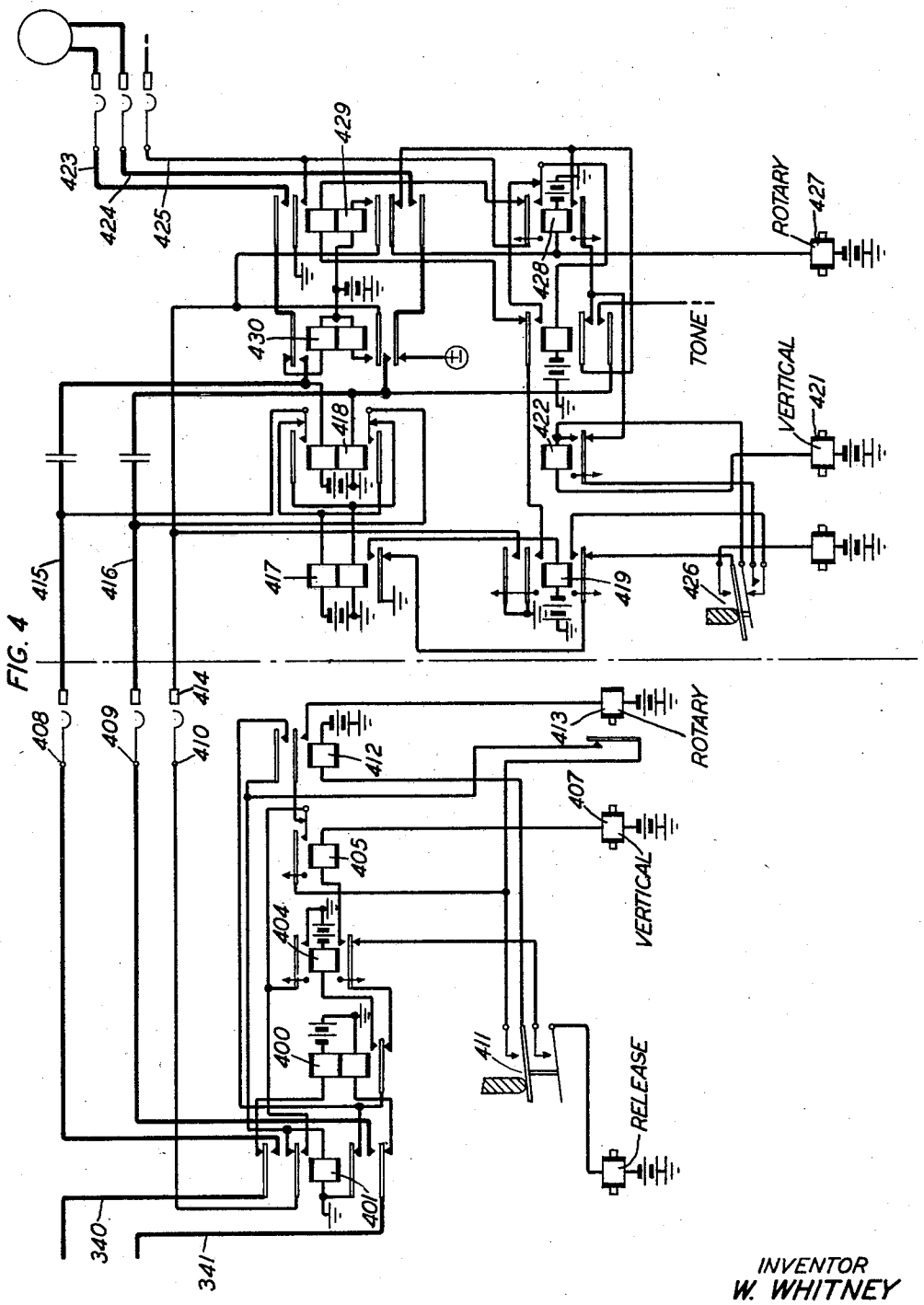

FIG. 4

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UNITED STATES PATENT OFFICE

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TELEPHONE SYSTEM

Application filed April 28, 1931. Serial No. 533,394.

This invention relates to automatic or semi-automatic telephone systems and more specifically to repeaters for use therein.

The object of this invention is to provide a simple yet efficient repeater which combines the double function of registration and transmission of impulses wherein the character of the impulses to be transmitted is altered to suit the requirements of the pulsing circuit of the distant selector, the said repeater being provided with a limited number of registers for the registration of the impulses of a plurality of digits wherein the number of digits is greater than the number of registers.

Repeaters which alter or modify the character of impulses prior to their transmission to a distant selector are not new but no repeater is available, so far as the applicant is aware, which provides means for the registration of a series of impulses in combination with transmitting facilities which send out other and modified impulses under the control of the receiving registers. By using separate impulse storing facilities for the registration of incoming impulses, the transmission of outgoing impulses exclusively under the control of modifying circuits within the repeater itself provides greater flexibility for altering the character of outgoing impulses to suit the pulsing requirements of the distant selector. In accordance with the invention, therefore, one specific embodiment of which is disclosed herein by way of illustration, this is accomplished in the following improved manner.

The repeater comprises two register switches and two corresponding transmitting switches, both of a known type, with an associated cooperating circuit. Normally the impulsing circuit is connected to the first register switch wherein are registered the impulses of the first digit. The impulsing circuit is thereafter transferred to the next register switch for the registration therein of the impulses of the second digit and while this operation is taking place the first transmitting switch is operated under the control of an interrupter to transmit impulses to the distinct incoming selector. The transmitting switch controls the closure of the trunk loop through the contacts of a relay which operates in parallel with the magnet of the transmitting switch. When the brushes of the transmitting switch have reached terminals corresponding to those to which the brushes of the first register switch were advanced, no further impulses are transmitted to the incoming selector and both switches, that is, the first register and transmitting switches are immediately restored to normal.

The registration and the consequent transmission of the impulses of the second digit now take place on the second register and second transmitting switch, respectively, in a manner identical with the reception and transmission of the first digit as already described.

By the time the impulses of the third digit are to be received and registered the first register and transmitting switches have restored to normal since the total time taken to transmit the impulses corresponding to the first digit to the distant office and to restore the first register and transmitting switches, is small compared with the time required to register the second digit and rotate the calling dial to a position corresponding to the number of impulses in the third digit. The impulsing circuit, therefore, is switched back to the first register switch and the impulses of the third digit are then registered on the first register switch and the corresponding impulses transmitted by the first transmitting switch. In a like manner the fourth digit is registered in the second register switch and transmitted by the second transmitting switch.

It is evident that there is no limit to the number of digits that can be registered on two switches in the manner described and the repeater, accordingly, may be easily modified by anyone skilled in the art to register and transmit any number of groups of impulses prior to the closure of the talking circuit over the repeater.

A clearer conception of the scope and purpose of the invention can be obtained from a consideration of the following description taken in connection with the attached drawings in which,

Fig. 1 is a 200 point line finder of a type

described in Patent No. 1,711,682 to H. Hovland, granted May 7, 1929;

Fig. 2 is a first selector;

Fig. 3 is the repeater circuit which is the subject of this invention; and

Fig. 4 is a second selector and connector.

The various figures of the drawings are to be placed next to each other in their numerical order for a complete disclosure of the invention.

A detailed description of the operation of the repeater in connection with the cooperating line finder, selectors and connector circuits will now be given, assuming the subscriber of line A to initiate the call. The initiation of the call results in the operation of the line relay 101 in an obvious circuit. Relay 101 operates the group relay 102. The group relay 102 removes ground from the commutator segment 125. Relay 102 also closes ground to the start circuit conductor 126 to initiate the movement of the line finder F. The start circuit may be traced from ground, left contacts of relay 102, conductor 126, left inner normal contacts of relay 117, right middle normal contacts of relay 116, winding of slow-to-release relay 119 to battery. Relay 119 operates and closes a circuit for slow-to-release relay 116 from the same ground through the right outer contacts of relay 119. Relay 116 locks in a circuit from battery through its winding and right middle front contacts to the ground on the start conductor 126 as traced. Relay 116 opens the circuit of relay 119 and the latter relay releases.

The rotary stepping magnet 121 is now operated to step the brushes over the terminals of the normal level to search for the calling line A. The operating circuit of the magnet 121 may be traced from battery through its winding, left outer back contacts of relay 119, right outer front contacts of relay 116, lower contacts of the off-normal springs 123, contacts of relay 114, left inner back contacts of relay 119, to ground at the right outer back contacts of relay 117. The magnet 121 steps the brushes 106, 107 and 108 to the first set of terminals. Magnet 121, in operating, closes an obvious circuit for relay 114. Relay 114 operates and releases the magnet 121. Magnet 121 in turn releases relay 114 which recloses the operating circuit of the magnet. The switch operates in this manner until the calling line is reached.

When the lower test brush 108 engages the test terminal of the calling line, a circuit is closed from battery through the winding of the cutoff relay 100, right contacts of relay 101, conductor 129, lower brush 108, upper winding of relay 115, left outer back contacts of relay 117, left winding of relay 114, conductor 130, outer left contacts of relay 116 to ground. Relay 115, which is arranged to close its inner lower contact before any of its other contacts are operated, locks in a circuit from battery through its lower winding and contact to ground at the contact of relay 116. Relay 115 extends the calling line A over the tip and ring conductors 202 and 203, respectively, of the trunk to the line relay 200 associated with the first selector switch. Relay 200 operates over the loop from battery through the top winding of relay 200, top outer back contacts of relay 201, conductor 202, top inner contacts of relay 115, top inner back contacts of relay 113, top brush 106 and connecting terminal, over the subscriber's loop, lower brush 106 and connecting terminal, bottom outer back contacts of relay 113, bottom middle front contacts of relay 115, conductor 203, bottom outer back contacts of relay 201, bottom winding of relay 200, left winding of tone coil 206 to ground. Relay 200 closes a circuit to operate relay 204 from ground through the bottom inner back contacts of relay 201, front contacts of relay 200, winding of relay 204 to battery. Relay 204 at its top contacts grounds conductor 130 to hold the line finder switch after relay 116 releases, which it will do presently.

The test circuit above traced, leading through the left winding of relay 114, maintains this relay operated to prevent further stepping of the switch by the rotary magnet 121. After relay 115 operates the test circuit is shifted and may now be traced from battery through the winding of cutoff relay 100 thence through the lower brush 108, top outer front contacts of relay 115, top outer normal contacts of relay 113, left winding of relay 114 to the grounded sleeve conductor 130. The cutoff relay 100 operates, releasing the relays 101 and 102. Relay 102 releases relay 116. Relay 116 closes a circuit for the relay 117 traceable from battery through the right winding of relay 117, bottom outer front contacts of relay 115, left inner contacts of relay 116, off normal contacts 122 to ground. Relay 100 is now held in a circuit from battery through its winding and its contact over the lower brush 108, upper front contacts of relay 115, top normal contacts of relay 113, outer left front contact of relay 117, to the sleeve conductor 130. Relay 114 is shunted and releases.

The subscriber is now ready to dial, having received notice of the readiness of the central office apparatus to receive impulses by the reception of dial tone which is induced in the line through the secondary winding of coil 206. At the first break of the impulse springs of the dial, relay 200 is released but relay 204, being slow releasing remains operated so that, for an instant, a path is completed from ground on the bottom inner back contacts of relay 201, back contacts of relay 200, bottom front contacts of relay 204, winding of relay 205, winding of vertical magnet 207 to battery. Magnet 207 operates, moving the selector shaft and brushes 208, 209 and

210 one step, at which time the off-normal springs 211 are closed. Relay 205 is also energized at the time that the magnet operates and closes a path from battery through the winding of relay 212, top contacts of off-normal springs 211, make contacts of relay 205, to ground on the top contacts of relay 204. Relay 212 operates and locks itself over a path through its winding, top contacts of off normal springs 211, contacts of rotary magnet 213, outer contacts of relay 212, bottom inner contacts of relay 201 to ground. At the termination of the impulse, relay 200 reoperates, and, at its back contacts, breaks the circuit of relay 205 and vertical magnet 207, allowing the magnet to release preparatory to moving the brush shaft another step. Relay 205, however, is slow to release and will not release during the interval between impulses. At the next impulse relay 200 will again release and magnet 207 will take another step. This action is continued during the return movement of the dial, relay 200 intermittently operating and releasing, in turn causing the brush shaft controlled by the armature of the vertical magnet to move the said shaft upwards a corresponding number of steps.

At the end of the first series of impulses, relay 205 releases and a circuit is completed from battery through the winding of rotary magnet 213, inner contacts of relay 212, normal contacts of relay 205, to ground on the top contacts of relay 204. Rotary magnet 213 operates and rotates the brush shaft to the first set of terminals in the level to which the brushes were raised. The operation of the rotary magnet also causes its contacts to be broken and thereby opening the locking circuit of relay 212 which releases. Relay 212, in releasing, breaks the circuit of magnet 213 at its inner contacts causing it to release also. If, now, the trunk or repeater to the terminals of which the brushes of the first selector have been connected on the first rotary step is idle, there will be no ground on sleeve conductor 216 and multipled terminal. Under such circumstances a circuit is closed from battery through the winding of relay 212, top contacts of off normal springs 211, contacts of rotary magnet 213, winding of relay 201 to ground on the top contacts of relay 204. Relay 201 operates in this circuit, but due to the high resistance of its winding, relay 212 does not operate. Relay 201 closes its contacts and extends conductors 202 and 203 to conductors 208 and 209, respectively, through its top and bottom outer front contacts. It also breaks the circuit for the impulsing relay 200 which, on releasing, releases relay 204. Relay 204, by virtue of its slow release feature keeps conductor 130 grounded until the release relay in the repeater circuit is operated and connects ground to conductor 210, as explained hereafter.

If, on the other hand, the first set of terminals to which the brushes have been connected are the terminals of a repeater which has been made busy, then conductor 216 is grounded. In such a case, the busy ground is extended to conductor 210 and thence over the top inner back contacts of relay 201 to one side of the winding thereof and the path previously traced through the winding of relay 212 to the said side of the winding of relay 201 will be effective in operating relay 212 while relay 201 remains shunted. Relay 212 recloses a previously traced circuit for magnet 213 which now rotates the brush shaft to the next set of terminals, and also releases relay 212 which, in restoring, deenergizes rotary magnet 213 as previously described. This cycle of operations is repeated until an idle or ungrounded sleeve terminal is reached, at which time relay 212 will remain released, stopping the further rotation of the brushes and energizing relay 201 as previously described.

When the first selector has established a connection with an idle repeater, a circuit is closed for relay 300 in the repeater from ground through the bottom winding of relay 300, top outer normally made contacts of relay 308, resistance 337, conductor 214 and associated terminal, conductor 209 and associated brush, bottom outer front contacts of relay 201, conductor 203, over the previously described loop in the line finder and subscriber's circuit, conductor 202, top outer front contacts of relay 201, conductor 208 and associated brush, conductor 215 and associated terminal, resistance 336, top inner normally made contacts of relay 308, top winding of relay 300 to battery. Relay 300 operates and, over its top front contacts, closes a charging circuit for condenser 343 in a circuit traceable from ground through resistance 342, condenser 343, top front contacts of relay 300, bottom contacts of relay 308, top winding of relay 307 to battery. During the time when relay 300 is normal, condenser 343 is normally discharged through the top back contacts of relay 300. Due to the charging current through the condenser 343 and the top winding of relay 307, relay 307 operates. When the condenser is fully charged and the charging current decays to zero, relay 307 releases, since at this time the locking circuit over its bottom winding and contacts to the contacts of relay 306 is not yet closed. Over its bottom contacts, relay 300 operates relay 301 in series with the winding of relay 334 over an obvious circuit. Relay 334 operates at this time but performs no function for reasons stated below. Over its top contacts, relay 301 closes the pulsing loop to the next switching stage or second selector which loop is traceable as follows: battery through the top winding of impulsing relay 400, top outer back contacts of re-

lay 401, conductor 340, top outer contacts of relay 317, winding of polarized relay 302, top contacts of relay 301, retard coil 335, conductor 341, bottom outer back contacts of relay 401, bottom winding of relay 400 to ground. Relay 400 operates in this circuit but the current is not in the proper direction to operate relay 302. Relay 400 closes a circuit for relay 404 from ground on the bottom inner back contacts of relay 401, front contacts of relay 400, winding of relay 404 to battery. Relay 404 operates and the second selector is then ready to receive impulses from the repeater.

When relay 307 releases after the decay of the charging current, a circuit is closed for relay 306 from battery through the winding of relay 306, back contacts of relay 307 to ground on the bottom contacts of relay 301. Relay 306 operates and closes a future locking circuit for relay 307. With relays 300 and 306 operated and relay 307 released, the repeater circuit is ready to receive the impulses of the second digit of the called subscriber's number. During the open interval of the first impulse relay 300 releases, opening the charging circuit of condenser 343 and discharging it to ground through its top back contacts. Relay 301 is slow to release, however, and is not affected by the momentary opening of its circuit by the release of relay 300. When the open interval of the impulse is over and relay 300 is operated again, the previously traced charging circuit for condenser 343 through the top winding of relay 307 is closed and, as before, relay 307 operates. Relay 306 is slow to release and does not release at this time but maintains the locking circuit for relay 307 which, instead of releasing when the charging current decays, now holds through its lower winding and contact to ground on the contacts of relay 306 for the length of time that relay 306 remains in an operated position. With relays 306 and 307 operated, a circuit is closed for relay 303 in parallel with the rotary magnet 318 traceable from ground on the contacts of relay 306, locking contacts of relay 307, top back contacts of relay 305, winding of relay 303 to battery and in parallel, winding of rotary magnet 318 to battery. Both relay 303 and magnet 318 operate, the said magnet advancing the associated brushes 331 and 332 to the first terminals of their respective arcs, thereby registering the receipt of the first impulse. Relay 303 operates relay 309. Relay 309 closes its bottom contacts and supplies holding ground for relay 301 and short circuits relay 334 which releases. The released condition of relay 334 keeps the subscriber's loop from being closed through the repeater during the period when impulsing operations are taking place in the repeater and subsequent switching stages. Finally, relay 306 releases and unlocks relay 307 which also releases. When this comes to pass the previously traced circuit for relay 306 is again closed and relay 306 again operates thus reestablishing the pulsing circuit as it was before the reception of the first impulse.

During the open interval of the next or second impulse, relay 300 releases and condenser 343 is short circuited as before. With the reclosure of the trunk loop during the closed interval of the impulse and the consequent operation of relay 300 the circuit for relay 307 is again established through the above described condenser charging circuit. The operation of relay 307 again results in the operation of rotary magnet 318 and the consequent advance of its corresponding brushes 331 and 332 of switch 350 to the next successive terminals to register the impulse. This operation continues during the reception of the impulses of the second digit during which time relay 303 remains operated while magnet 318 operates and advances the brushes 331 and 332 one terminal for each impulse received, thereby causing a registration of the digit impulses on the arcs of the switch 350.

It will be recalled that the operation of relay 303 resulted in the operation of relay 309. Relay 309, on closing its top front contacts, connects its top winding through the bottom back contacts of relay 304, back contacts of relay 310, conductor 344 to the brush of impulsing interrupter 346. So long as relay 303 remains operated, that is, so long as a train of impulses is being received, relay 309 is maintained in its operated condition over the circuit through its lower winding and the fact that its top winding has been connected to the impulsing interrupter 346 is of no consequence at this time.

When all the impulses of the digit have been received, relay 300 operates and remains operated, in turn, operating relay 307 over the condenser charging circuit. Relay 307 releases and, due to the fact that it does not reoperate immediately by the reception of another impulse, releases relay 303. The release of relay 303, however, does not necessarily cause the release of relay 309 for although the circuit through the bottom winding of relay 309 is now opened, relay 309 has a holding circuit through its top winding to the impulsing interrupter 346. If, at the instant relay 303 releases, the brush of the interrupter is in contact with a grounded segment of the interrupter drum, relay 309 will hold during such a contacting period; otherwise, it will release, which event also takes place when the brush eventually makes with an insulating segment.

The release of relay 303 causes the operation of relay 305 over a circuit traceable from battery through the winding of relay 305, top contacts of off-normal contacts 345 of switch 350, to ground on the top back contacts of relay 303. Relay 305 operates and switches the circuit of the locking contact

of relay 307 from the winding of relay 303 and magnet 318 to the winding of relay 311, and in parallel therewith to the winding of rotary switch magnet 322. Relay 305 also locks through its bottom contacts to ground on the bottom outer contacts of relay 311 when this relay operates. The function of relay 311 in respect to the registration of the impulses of the third digit is similar to that of relay 303 for the registration of the impulses of the second digit so that, as the impulses of the second digit are received, relay 311 remains operated while magnet 322, which operates in parallel with it, advances its corresponding brushes 327 and 329 over as many terminals as there are impulses received. The impulses of the second digit are received and registered on the arcs of switch 370 in the same manner as the impulses of the first digit were received and registered on the arcs of switch 350.

Simultaneously with the reception of impulses of the third digit and immediately after the release of relay 309 a path is closed for magnet 320, from battery through the winding of magnet 320, lower contacts of off-normal springs 345, bottom contacts of relay 303, top back contacts of relay 309, bottom contacts of relay 304, bottom contacts of relay 310, conductor 344, impulse interrupter 346 to ground. In parallel to this circuit at the lower contacts of off-normal springs 345 a path is also closed through the lower winding of relay 317. When the interrupter 346 again engages a commutator segment following the insulating segment which causes the release of relay 309, a ground is connected to the above path and both magnet 320 and relay 317 operate. Magnet 320 operates and advances brush 333 one terminal while relay 317 operates and opens the path previously established and described over the trunk conductors 340 and 341 to the impulse relay 400 of the said distant selector. The opening of the trunk loop causes the release of relay 400 which thereupon establishes a path for the vertical magnet 407 from ground on the bottom inner contacts of relay 401, back contacts of relay 400, bottom front contacts of relay 404, winding of relay 405, winding of vertical magnet 407 to battery. Magnet 407 operates, moving the selector shaft and brushes 408, 409 and 410 one step, at which time off normal springs 411 are closed. Relay 405 is also energized at the time that the magnet operates and closes a path from battery through the winding of relay 412, top contacts of off-normal springs 411, make contacts of relay 405, to ground on the top contacts of relay 404. Relay 412 operates and locks itself over a path through its winding, top contacts of off-normal springs 411, contacts of rotary magnet 413, outer contacts of relay 412, bottom inner contacts of relay 401 to ground. When the impulse interrupter 346 at the repeater engages an insulating segment, ground is removed from the above traced path including relays 317 and switch magnet 320 causing the former to release and reclose the loop to relay 400 of the distant selector while magnet 320 causes brush 333 to remain on the contact to which it was advanced as a registration of the one impulse transmitted to the distant office. When relay 400 operates at the reclosure of the loop, the circuit of relay 405 and vertical magnet 407 is broken, allowing the magnet to release preparatory to moving the brush shaft another step. Relay 405, however, is slow to release and will not release during the interval between impulses.

At the next engagement of the impulse interrupter brush with a commutating segment of the impulse drum 346, relay 317 and magnet 320 are again operated, the former opening the trunk loop and thereby transmitting another impulse, the latter operating to advance brush 333 another step to register the transmission of the said impulse. When the interrupter brush next engages an insulating segment, relay 317 releases and recloses the trunk loop. In accordance with operations previously described, the switch shaft controlled by vertical magnet 407 in the distant selector is likewise raised one step in response to the second transmitted impulse. These operations are continued until brush 333 reaches a terminal corresponding to that to which brush 332 of switch 350 was advanced in response to the reception of the number of impulses of the first digit registered in the repeater. When brush 333 reaches the same corresponding terminal on its cooperating arc as that occupied by brush 332 on its own arc, a circuit is closed from ground on brush 333, connecting conductor between the two terminals, brush 332, top inner contacts of relay 317, winding of relay 304 to battery. Relay 304 operates, and at its bottom outer contacts, opens the impulsing conductor which controls the operating path of relay 317 and switch magnet 320 thereby stopping any further transmission of impulses. Circuits are now closed from ground on the bottom contacts of off-normal springs 316 of switch 360, top contacts of relay 304, winding of release magnet 321 of switch 360 to battery, and also in parallel, to the winding of release magnet 319 of switch 350 to battery through the bottom contacts of off-normal springs 316. Both magnets operate to restore their respective sets of brushes to normal. Relay 310 is also operated at this time over a path traceable from battery through winding of relay 310, bottom inner contacts of relay 304 to ground at the bottom contacts of relay 301. The operation of relay 310 at this time, under the control of relay 304, provides a holding

circuit for relay 312, whose function is similar to that of relay 309 in respect to the transmission of the impulses of the third digit, so as to prevent its release during the time that switches 350 and 360 are restoring to normal. With relay 312 held locked to the front contacts of relay 310 after its original operating circuit is opened at the contacts of relay 311 and its locking winding not controllable by the impulse interrupter 346, the transmission of the impulses of the third digit to the distant office is prevented should the impulses of the said digit have been received and registered at the time switches 350 and 360 have not yet returned to normal after the transmission of the impulses of the second digit.

Meanwhile, when brush 333 of switch 360 has been returned to normal, off-normal springs 316 are opened, but relay 304 does not release because it has a locking circuit over its top outer contacts to the commoned terminals of the arc cooperating with brush 331 of switch 350. If, at the time brush 333 of switch 360 has returned to normal, the brushes 331 and 332 of switch 350 are still off normal, then relay 304 will remain locked, relay 310 remains operated and relay 312 remains under the control of relay 310, thereby delaying the transmission of the impulses of the third digit until switch 350 has restored. Although the circuit of release magnet 321 is opened by the release of off-normal springs 316, yet the circuit of release magnet 319 of switch 350 is maintained directly under the control of relay 304 to ground on brush 331 until the brushes 331 and 332 have cleared their respective arcs, which, due to the direct coupling of both brushes to the same rotating shaft, takes place when brush 331 has returned to normal.

When both switches 350 and 360 are normal, relay 304 releases, in turn, releasing relay 310. Relay 310 opens the solid ground to the top winding of relay 312 and, by the closure of its back contacts, places the locking circuit of relay 312 directly under the control of impulse interrupter 346.

At the end of the first series of impulses transmitted by switch 360, the vertical shaft of the second selector has been raised a corresponding number of steps or levels, relay 405 releases and a circuit is completed from battery through the winding of rotary magnet 413, inner contacts of relay 412, normal contacts of relay 405 to ground on the top contacts of relay 404. Rotary magnet 413 operates and rotates the brush shaft to the first set of terminals in the level to which the brushes were raised. The operation of the rotary magnet also causes its contacts to be broken and thereby opening the locking circuit of relay 412 which releases. Relay 412, in releasing, breaks the circuit of magnet 413 at its inner contacts causing it to release also. If the selector of the next switching stage or connector, as the case may be, to the terminals of which the brushes of the second selector have been connected on the first rotary step is idle, there will be no ground on the sleeve terminal making with brush 410. Under such circumstances a circuit is closed from battery through the winding of relay 412, top contacts of off-normal springs 411, contacts of rotary magnet 413, winding of relay 401 to ground. Relay 401 operates in this circuit but due to the high resistance of its winding relay 412 does not operate. Relay 401 closes its contacts and extends conductors 340 and 341 to conductors 415 and 416, respectively, through its top and bottom outer front contacts. It also breaks the circuit of impulsing relay 400 which, on releasing, releases relay 404. Relay 404, by virtue of its slow-to-release feature keeps brush 410 grounded until the release relay in the next switching stage is operated to connect ground on the release conductor.

It is not thought necessary here to describe the hunting operation of the second selector in case the brushes are connected to a busy circuit as it is the same as the operation of the first selector in Fig. 2 and need not be repeated.

It is further assumed in this description that there are no further trunk switching stages subsequent to the second and that the second selector connects directly with the final connector circuit shown to the right of the vertical division line of Fig. 4. It will be apparent, however, from the further description contained hereunder of the operation of the repeater that there is no limit to the number of switching stages which can be responsive to the transmitted impulses and hence it is not thought necessary to describe any further impulsing operations at other selectors in order to disclose the impulse repeating capacities of the repeater of my invention.

When the second selector has established connection with an idle connector a circuit is closed for relay 417 in a circuit traceable from battery through the top winding of relay 417, top normally made contacts of relay 418, conductor 415 and cooperating terminal, brush 408, over the loop through the second selector and repeater, above described, to brush 409, conductor 416 and cooperating terminal, bottom inner normally made contacts of relay 418, lower winding of relay 417 to ground.

Now the impulses constituting the third digit of the called number have been registered on rotary switch 370 as already described. The operation of relay 305 as previously described caused the impulsing conductor connected to the locking contact of relay 307 to be transferred from the parallel circuit of relay 303 and rotary magnet 318 to the parallel circuit of relay 311 and rotary

magnet 322. As each impulse is received, magnet 322 advances brushes 327 and 329 one step for registering the impulse while relay 311, which is slow to release and does not release between impulses, closes an obvious circuit for relay 312. At the termination of the series of impulses, relay 311 releases, but relay 312 will remain locked to the front contacts of relay 310 if, at this time, the switches 350 and 360 of the register circuit are returning to normal as previously explained, or will be locked under the control impulse interrupter 346 and release when its cooperating brush engages an insulating segment. When the impulses of the third digit have been received, relay 305 will release following the release of relay 311. If, however, at this time switches 350 and 360 of the first registering circuit are still off-normal relay 305 will remain operated to ground on the top back contacts of relay 303 through the top contacts of off-normal springs 345 thereby preventing the transfer of the impulse conductor to the first register circuit until the switches are normal, at which time off-normal springs 345 will open and relay 305 release.

The next subsequent ground closure of the interrupter 346 closes a circuit from ground over conductor 344, back contacts of relay 310, top back contacts of relay 313, top back contacts of relay 312, top contacts of relay 311, top contacts of off-normal springs 314 of switch 370, winding of switch magnet 323 to battery and, in parallel therewith, conductor 348, top winding of relay 317 to battery. Relay 317 operates and opens the previously described holding loop to the impulsing relay 417 of the connector and at the closure of conductor 344 with an insulating segment of the impulse interrupter 346, relay 317 and switch magnet 323 are both released, the former reclosing the holding loop to the impulsing relay and thereby terminating the transmitted impulse while the latter advances brush 328 to the first terminal of its cooperating arc thereby registering the first impulse of the third digit of the called number transmitted to the distant office. This cycle of operations is repeated for every impulse so transmitted until the brush 328 is standing on a terminal corresponding to that occupied by brush 329 of the registering switch 370. At such a time the impulses transmitted to the distant office are equal in number to those which were registered on switch 370 and a path is closed from ground on brush 328, the conductor which connects the corresponding terminal on the arc cooperating with brush 329, brush 329, bottom contacts of relay 317, winding of relay 313 to battery. Relay 313 operates and closes circuits to release magnets 324 and 325 over the top contacts of off-normal springs 315 of switch 380, bottom contacts of relay 313 to ground on the bottom contacts of off-normal springs 315. Over its top outer contacts, relay 313 closes a circuit for relay 310 from battery through the winding of relay 310, top outer contacts of relay 313 to ground on the bottom contacts of relay 301. Relay 310 operates, disconnects the impulsing conductor from the back contacts of relay 313 and, over its front contacts, supplies a holding circuit to relay 309 if it is operated as a result of another and fourth digit having been registered on switch 318 of the first register circuit during the period when the impulses of the third digit were being transmitted. When brush 328 has cleared the terminal strapped to the arc cooperating with brush 329, the operating circuit for relay 313 is opened, but so long as switch 370 is off normal a holding circuit exists for relay 313 from ground on brush 327 through all the commoned contacts of the cooperating arc, to conductor 349, bottom inner contacts of relay 313, to winding of the said relay. Another holding circuit exists from the bottom contacts of off-normal springs 315 of switch 370. Relay 313, therefore, will remain operated so long as either switch is off normal, and when both are returned, conductor 349 will be cleared of ground and off-normal springs 315 will have opened. Relay 313 will then release and open the circuits of the release magnets 324 and 325.

Following the transmission of the complete number of impulses of the third digit, relays 311 and 305 are released and since by this time the first set of switches has returned to normal, the impulses of the next or fourth digit will be registered on switch 350. When all impulses have been received and retransmitted to the distant office and no more are forthcoming from the calling subscriber, both switches 350 and 370 will be normal and relays 309 and 312 will be released. Under such circumstances the shunt around relay 334 will be removed and this relay now operates in series with relay 301 and closes through the subscriber's talking loop through the repeater.

The operation of the connector in response to the transmission of the impulses of the third or tens digit which has been described and also of the following units digit registered on the first set of switches, which it is not thought necessary to describe, is standard in all respects, but may be briefly described as follows: Upon receipt of the first series of impulses relay 417 deenergizes a corresponding number of times, and on each deenergization completes a circuit for the vertical magnet in series with relay 422 so that the brushes 423, 424 and 425 are raised a corresponding number of steps. Owing to the shifting of the off-normal contacts 426 the next series of impulses is transmitted to the rotary magnet 427 in parallel with relay 428 and the brushes are rotated accordingly. When they come to rest and relay 428 de-

energizes, a busy test is made; and if the required line is found idle the brush switching relay 429 operates from a battery circuit in series with the cutoff relay in the subscriber's line circuit, not shown, through its upper winding to ground in the top inner contacts of relay 419. Ringing current is then sent out from the ringing generator, symbolically shown connected to the bottom outer back contacts of relay 430, and when the wanted line replies the ringing trip relay 430 is operated. The speaking conductors are thus switched through, whereupon the back bridge relay 418 reverses the direction of current flow over conductors 340 and 341. The flow of current is now in such a direction as to permit the operation of polarized relay 302 in the repeater, so that by a closure of its contacts a circuit is closed to operate relay 308 traceable from battery through the winding of relay 308, bottom outer contacts of relay 334, contacts of relay 302 to ground on the contacts of relay 301. The operation of relay 308 reverses the direction of current flow over conductors 215 and 214 and this reversal may be used for supervision, metering or like operation according to standard practice. When the calling party restores his receiver, relay 300 releases, in turn releasing relay 301 and the release of relay 301 releases relay 308 and polarized relay 302, thereby restoring the repeater to normal. The release of the various selectors and the connector and line finder takes place in the normal manner.

From the foregoing description, it will be observed that the same number of impulses are transmitted outwardly as have been registered on the separate registering switches of the repeater. It will also be seen that the character of the impulses transmitted to the distant office can be made entirely independent of the character of the incoming impulses since the transmitted impulses possess whatever impulsing characteristics are imparted to them by the impulse interrupter 346 which, in itself, can be made to suit any speed or arrangement of open and closed period consistent with the physical and electrical properties of the outward line and selector to which the repeater is connected.

It will also be evident that there is no limit to the number of impulse series which can be received and subsequently transmitted on the two pairs of switches and cooperating circuits. As already explained, during the time that the impulses of the third digit are being transmitted to the distant office the first impulse receiving circuit, that is, switch 350 and switch 360 have already been restored to normal and if further impulses are forthcoming the circuit path previously existing for relay 303 and switch 350 will again become responsive to the operation and release of relay 300 thereby causing the registration of the fourth digit on the same switch which registered the impulses of the second digit. When all of the impulses have been received switch 360 will again function to transmit the impulses of the fourth digit. Likewise, during the time that the impulses of the third digit are being transmitted the second impulse receiving circuit, that is, switches 370 and 380 are also restored to normal, as previously described, and if the impulses of a fifth digit are forthcoming switch 370 and relay 311 will again respond to this next set of impulses; registering and subsequently transmitting them to the distant office in the manner described. Any number of digits may therefore be received and retransmitted on the two impulse receiving circuits of the repeater.

It will also be evident from the present embodiment of the invention that the digit transmitted does not have to necessarily correspond to the digit received, for, by a simple change in cross connections between the checking and registering arcs 333 and 332, 328 and 329 the transmitting switch may be made to send out either a greater, equal or lesser number of impulses than those received, so that the repeater may function, if so desired, not only as a repeater proper but also as a translator.

What is claimed is:

1. In a telephone repeater, means for registering an unlimited number of groups of incoming impulses sequentially, and means responsive to the registration of each of said groups of incoming impulses for transmitting over said repeater a group of outgoing impulses.

2. In a telephone repeater, two register circuits for registering therein an unlimited number of groups of incoming impulses sequentially and cyclically, and means responsive to the registration of one of said groups of incoming impulses on one of said register circuits for transmitting over said repeater a group of outgoing impulses and for preparing said register circuit thereafter for registering another of said groups of incoming impulses in said cyclic order.

3. In a telephone repeater, two register circuits for registering therein an unlimited number of groups of incoming impulses sequentially and cyclically, means responsive to the registration of one of said groups of incoming impulses in one of said register circuits for transmitting over said repeater a group of outgoing impulses, and means responsive during the transmission of said group of outgoing impulses registered on one of said register circuits for registering another group of incoming impulses in the other of said register circuits.

4. In a telephone system, a repeater, means in said repeater for registering a series of incoming impulses, an impulse transmitter in said repeater, and means responsive to the registration of said series of impulses for

operating said impulse transmitter for transmitting over said repeater a series of outgoing impulses.

5. In a telephone system, a repeater, a register in said repeater for registering therein a series of incoming impulses, an impulse transmitter in said repeater, and means responsive to the registration of the said series of impulses for operating said impulse transmitter to transmit over said repeater a number of impulses in accordance with the number of impulses contained in the said registered series.

6. In a telephone system, a repeater comprising a first register switch for registering a series of incoming impulses, an impulse transmitter, a second register switch, and means responsive to the registration of said series of impulses on said first register switch for operating said impulse transmitter for transmitting over said repeater a series of outgoing impulses and to operate said second register switch for registering thereon said series of outgoing impulses.

7. In a telephone system, a repeater comprising a first register switch for registering a series of incoming impulses, an impulse transmitter, a second register switch, and means responsive to the registration of said series of impulses on said first register switch for operating said impulse transmitter for transmitting over said repeater a series of outgoing impulses in accordance with the number of impulses registered in said first register switch and to operate said second register switch for registering thereon said series of outgoing impulses.

8. In a telephone system, a repeater comprising means for registering a series of incoming impulses, an impulse transmitter, and means responsive to the registration of said series of impulses for operating said impulse transmitter for transmitting over said repeater a series of outgoing impulses differing in number from said incoming series.

9. In a telephone system, a repeater comprising means for registering a plurality of groups of incoming impulses, and means responsive to the registration of each of said plurality of groups of impulses for transmitting over said repeater a series of outgoing impulses.

10. In a telephone system, a repeater comprising means for registering a plurality of groups of incoming impulses, and means responsive to the registration of each of said plurality of groups of impulses for transmitting over said repeater a corresponding series of outgoing impulses.

11. In a telephone system, a repeater, a first and second register in said repeater for registering therein successive series of incoming impulses, an impulse transmitter in said repeater, means responsive to the registration of the first of said series of incoming impulses in said first register for operating said impulse transmitter to transmit over said repeater a series of outgoing impulses in accordance with the number of impulses registered in said first register, means responsive to the registration of the second series of said series of incoming impulses in said second register for operating said impulse transmitter to transmit over said repeater a series of outgoing impulses in accordance with the number of impulses registered in said second register, means responsive to the transmission of said first series of outgoing impulses for restoring said first register to normal, means responsive to the transmission of the said second series of outgoing impulses for restoring said second register to normal, means responsive to the restoration of each of said registers for registering the impulses of other successive series of incoming impulses in each of said registers respectively, and means responsive to the successive registration of each of said impulse series for operating the said impulse transmitter to transmit over said repeater after each registration a series of outgoing impulses in accordance with the number of impulses in the series registered in the register which operated prior to the operation of said impulse transmitter.

12. In a telephone system, a calling line, a dial for said calling line, a plurality of selector switches, a register sender operatively associated with one of said selector switches, the said register sender comprising a first and second register, means for extending said calling line to said register sender, means for registering in said first and second registers successive series of impulses from said dial, an impulse transmitter in said register sender, means responsive to the registration of impulses of the first digit in said first register for operating said impulse transmitter to transmit a series of outgoing impulses to the first of said selector switches in accordance with the number of impulses registered in said first register, means responsive to the registration of the impulses of the second digit from said dial in said second register for operating said impulse transmitter to transmit to a second of said selector switches a series of outgoing impulses in accordance with the number of impulses registered in said second register, means responsive to the transmission of the first series of outgoing impulses for restoring said first register to normal, means responsive to the transmission of the second series of outgoing impulses for restoring said second register to normal, means responsive to the restoration of each of said registers to normal for registering the impulses of other successive digits from said dial in each of said registers respectively, and means re-

sponsive to the successive registration of each of said impulse series for operating the said impulse transmitter to transmit to other of said selector switches after each registration a series of outgoing impulses in accordance with the number of impulses in the series registered in one of the said registers which operated prior to the operation of said impulse transmitter.

13. In a telephone system, a repeater, a first and second register switch in said repeater for registering therein a successive series of incoming impulses, a first and second impulse counting switch each associated, respectively, with the said first and second register switches, an impulser in said repeater, means responsive to the registration of the first series of said series of incoming impulses in said first register for operating said impulser to operate the said first counting switch once for each impulse for transmitting over said repeater an impulse for each operation of said first impulse counting switch, means for stopping the operating of said first transmitting switch when the number of operations corresponds to the number of impulses registered in said first register, means responsive to the registration of the second series of said series of incoming impulses in said second register for operating said impulser to operate said second impulse counting switch once for each impulse and for transmitting over said repeater an impulse for each operation of said second impulse counting switch, means for stopping the operating of said second impulse counting switch when the number of steps taken corresponds to the number of impulses registered in said second register switch, means responsive to the transmission of the first series of outgoing impulses for restoring said first register and said first impulse counting switches to normal, means responsive to the transmission of the second series of outgoing impulses for restoring said second register and said second impulse counting switches to normal, means responsive to the restoration of each of said register switches and each of said impulse counting switches for registering the impulses of other successive series of incoming impulses in each of said register switches respectively, means responsive to the successive registration of each of said impulse series for operating the said impulser to operate the corresponding one of said impulse counting switches and for transmitting over said repeater after each registration a number of outgoing impulses in accordance with the number of impulses in the series registered in the said register switch which operated prior to the operation of said impulser.

In witness whereof, I hereunto subscribe my name, this 24th day of April, 1931.

WILEY WHITNEY.