Oct. 27, 1925. 1,559,251

R. W. HARPER

PRIVATE BRANCH EXCHANGE SENDER CIRCUIT

Filed June 13, 1924 3 Sheets-Sheet 1

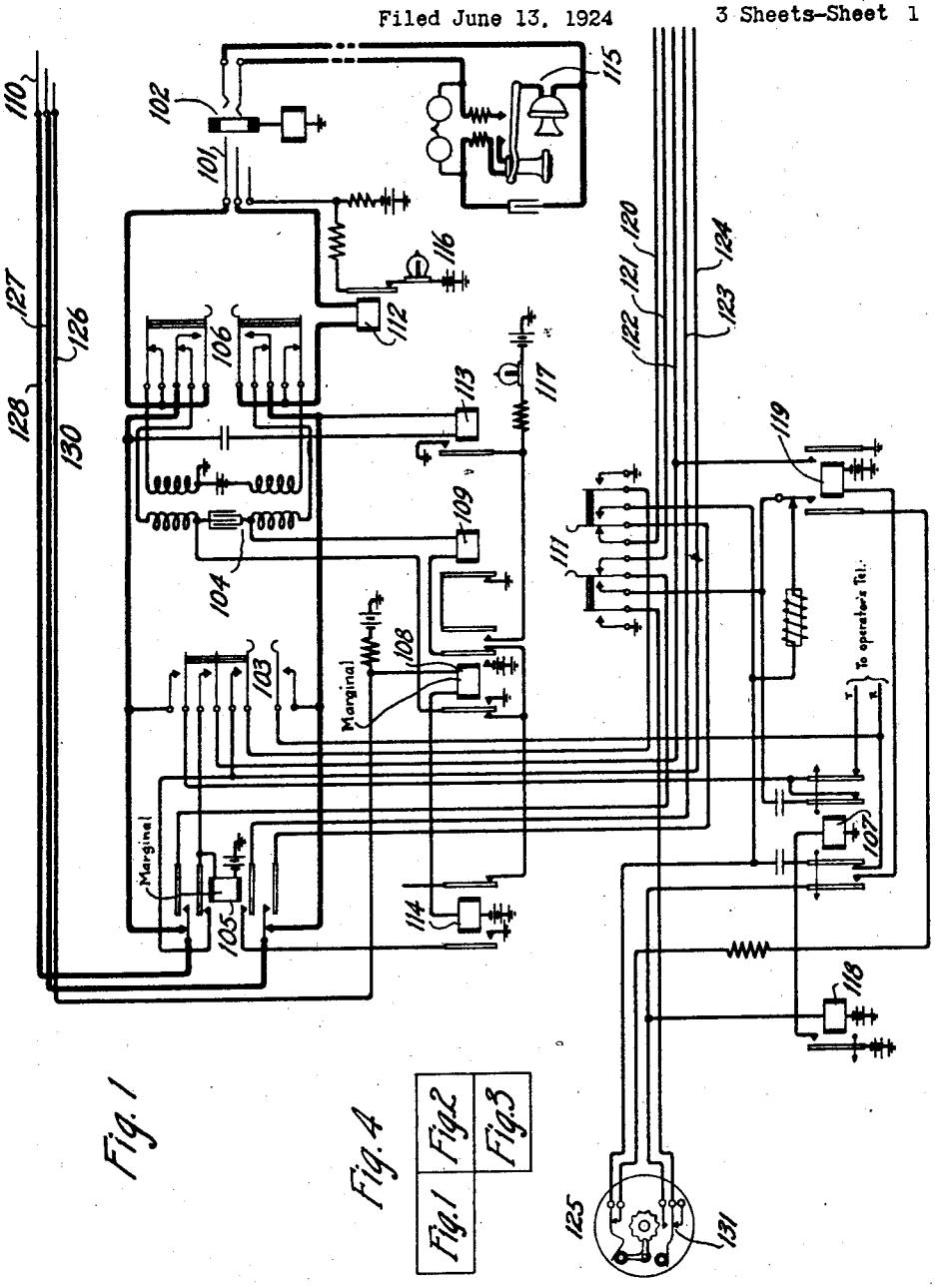


Fig. 1

Fig. 4

Fig. 2	Fig. 3
Fig. 1	

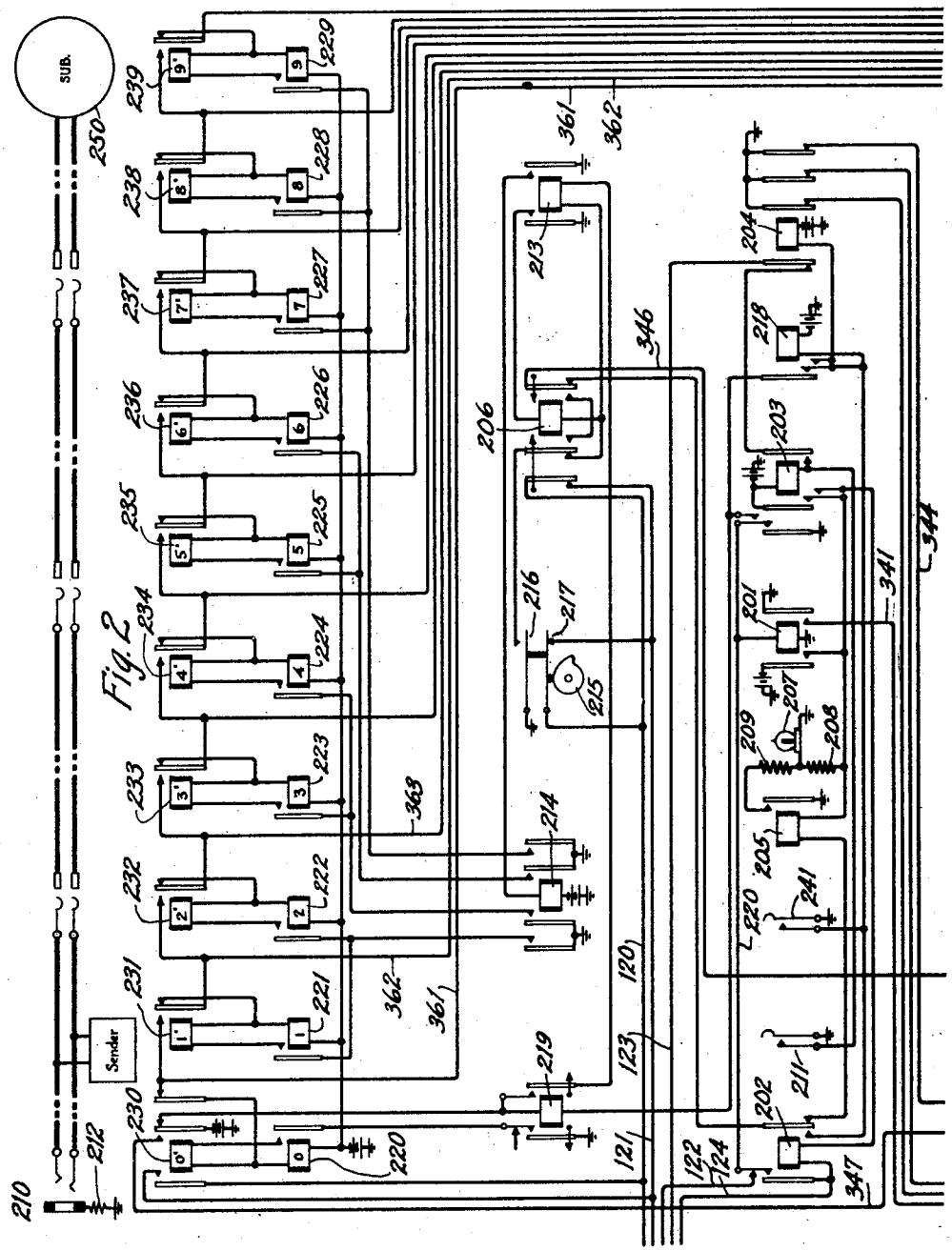
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PRIVATE BRANCH EXCHANGE SENDER CIRCUIT

Filed June 13, 1924 3 Sheets-Sheet 2



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PRIVATE BRANCH EXCHANGE SENDER CIRCUIT

Filed June 13, 1924 3 Sheets-Sheet 3

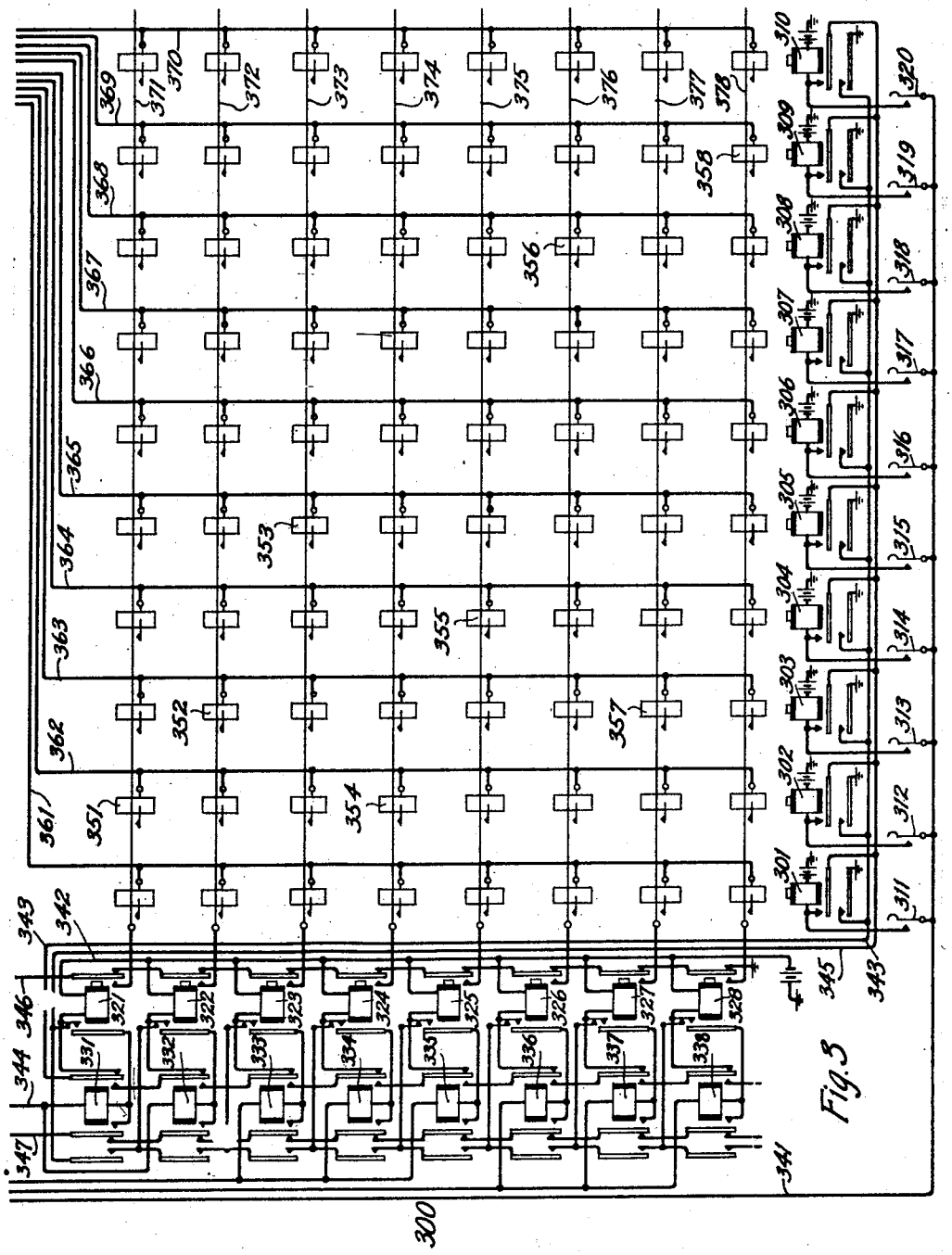


Fig. 5

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Patented Oct. 27, 1925. 1,559,251

UNITED STATES PATENT OFFICE.

ROBERT W. HARPER, OF EAST ORANGE, NEW JERSEY, ASSIGNOR TO WESTERN ELECTRIC COMPANY, INCORPORATED, OF NEW YORK, N. Y., A CORPORATION OF NEW YORK.

PRIVATE-BRANCH EXCHANGE SENDER CIRCUIT.

Application filed June 13, 1924. Serial No. 719,711.

To all whom it may concern:

Be it known that I, ROBERT W. HARPER, a citizen of the United States of America, residing at East Orange, in the county of Essex, State of New Jersey, have invented certain new and useful Improvements in Private-Branch Exchange Sender Circuit, of which the following is a full, clear, concise, and exact description.

This invention relates to telephone exchange systems and more particularly to automatic telephone exchange systems wherein series of pulses are transmitted over a calling line to control the operation of automatic switches employed in establishing a connection.

This invention relates more specifically to an improved type of impulse transmitter requiring a minimum amount of an operator's time for transmitting a series of pulses for use at an operator's position in a private branch exchange (PBX) associated with an automatic telephone exchange system preferably of the type employing power driven switches of the revertive impulse type, the selective operations of which are controlled by registering mechanisms responsive to series of impulses corresponding to the wanted line designation transmitted over a calling line.

It is to be understood that this invention is not limited to automatic telephone exchange systems of the foregoing character but may be employed in private branch exchanges associated with automatic telephone systems of other types such as the automatic exchange systems wherein series of impulses transmitted over a calling line are employed for directly controlling the operation of its selective switches.

Hitherto in P. B. X. systems associated with automatic telephone exchange systems of the foregoing character a dial impulse sender has been provided at the P. B. X. operator's position to enable the operator to transmit over the calling line, series of pulses corresponding to the designation of the wanted line communicated to the P. B. X. operator by the calling P. B. X. subscriber. Due to the nature of its structure the usual dial impulse sender requires a comparatively long period of time in which to send the series of pulses required for registering the wanted line designation in the sender register. When it is considered that the private branch exchange operator usually has various other duties besides attending the switchboard it is deemed advisable that the time spent by the P. B. X. operator in transmitting series of pulses of wanted line designations be reduced as much as possible.

For this reason there is provided at the private branch exchange operator's position a single set of digit keys on which the digits of a wanted line designation may be quickly and successfully written up and concurrently recorded in a unitary registering device of the coordinate switch type associated with the P. B. X. operator's single set of keys. Thereafter upon the operation of a start key by the operator, series of impulses corresponding to the wanted line designation are transmitted to the register sender in the automatic telephone exchange associated with the private branch exchange by means of an interrupter impulser, the number of pulses transmitted for each digit being determined by a set of counting relays under the control of the corresponding registration set up in the registering mechanism.

It is the object of this invention to provide in a system of the foregoing character an impulse sending device for transmitting series of pulses corresponding to dial impulses in accordance with the registration set up in a unitary registering device of the coordinate switch type by the manipulation of associated keys.

A feature of the invention consists in the provision of a single set of ten recording keys and a unitary registering device of the coordinate or cross-bar switch type capable under the repeated manipulation of the recording keys to record all the digits of a desired line designation.

A still further feature of the invention relates to the provision with the above-mentioned unitary registering device of the coordinate or cross-bar switch type of a single set of transfer relays for progressively associating the different register elements of the registering device with the recording keys and for progressively associating such register elements of the registering device with a set of counting relays employed for determining the number of pulses to be transmitted in any series of pulses.

These and other features of the invention

will be more clearly apparent from a consideration of the following description taken in connection with the accompanying drawings and appended claims.

Referring to the drawings, Fig. 1 shows the cord circuit at a P. B. X. operator's position having the plug 101 for answering calls incoming from a private branch exchange subscriber's station 115, plug 110 for connection with a trunk outgoing to an automatic telephone exchange, the emergency dial impulse sender 125 and talking and dialing keys.

Fig. 2 shows the impulse interrupter 215 and its circuit, and the counting relays for determining the number of pulses to be transmitted in any series of impulses. Fig. 2 also shows in a schematic form the various automatic switches and the register sender used in establishing a connection from the outgoing trunk jack 210 to the called subscriber's station 250.

Fig. 3 shows the single set of recording keys 311 to 320 having digit values of 1 to 0 respectively, the unitary registering device 300 comprising eight register elements corresponding to the eight digits of a wanted line designation and a single set of transfer relays 321 to 328 for progressively associating the register elements with the recording keys and the counting relays.

Fig. 4 shows the manner in which Figs. 1, 2 and 3 should be arranged.

The registering mechanism disclosed in Fig. 2 is of the coordinate or cross-bar switch type and more particularly of the general type shown and described in detail in the patent to C. L. Goodrum, No. 1,551,024, issued Aug. 25, 1925. This switch consists of ten vertically disposed bars, each of which is controlled by a vertical magnet actuated in response to the depression of a key associated with it, and eight horizontal bars. Each of the horizontal bars is operated by a horizontal magnet individual thereto and shown at the left end of each bar, respectively. The number of horizontal bars may, however, be increased to include additional horizontal bars when it is desired to record digits in addition to the digits normally required for a wanted line designation.

Associated with each of the vertical bars are a number of contacts, each of which is arranged to connect the conductor associated with the vertical bars to a conductor individual to an operated horizontal bar. These contacts extend through micarta cards which are arranged to lift them into contact with the horizontal bar upon the conjoint operation of a vertical bar and a horizontal bar.

The chain of transfer relays shown in Fig. 3 serves as a progression switch in conjunction with the horizontal magnets for successively associating the several different register elements of the registering mechanism with the recording keys during the recording of a desired line designation and thereafter for successively associating the several different register elements of the registering mechanism with the counting relays to determine the number of pulses to be included in each series of pulses transmitted for each digit of the desired line designation.

The automatic telephone line extending equipment shown in schematic form on Fig. 2 consists of a number of selector switches and a register sender for controlling the operation of the automatic switches, preferably of the well-known panel type such as disclosed in Patent 1,395,977, issued to F. A. Stearn and F. J. Scudder, November 1, 1921.

The relays and magnets of the registering mechanism and impulse circuit are operated by common battery potential.

It is believed that the invention will be best understood from a detailed description of the manner in which the apparatus functions.

In response to a signal (not shown) of a calling P. B. X. subscriber, the P. B. X. operator inserts the plug 101 of her cord into the answering jack 102 and operates her talking key 103, thereby establishing a talking connection between the calling subscriber and P. B. X. operator. This talking connection may be traced from the tip side of the operator's telephone set (not shown), outer right back contact of relay 107, outer upper contact of key 103, inner normal contact of key 106, upper left winding of repeating coil 104, left and inner right back contacts of relay 108, winding of relay 109, lower left winding of repeating coil 104, inner lower normal contact of key 106, lower contact of relay 103 to the ring side of the operator's telephone set. The circuit from the right windings of the repeating coil 104 to the calling subscriber's station may be traced from grounded battery lower right winding of repeating coil 104, lower contact of key 106, winding of relay 112, ring of answering plug 101 and answering jack 102 through the calling subscriber's station 115, tip of answering jack 102 and plug 101, outer upper normal contact of key 106 to ground through the upper right winding of repeating coil 104. In operating key 103 a circuit is completed for operating relays 105 and 201 from grounded battery, winding of relay 105, middle upper alternate contact of key 103, conductor 122, left back contacts of relay 202, conductor 220 to ground through the winding of relay 201. Relay 201 in operating provides ground at its right front contact for operating the vertical magnets upon the depression of the recording keys and at its left front contact

completes a circuit from grounded battery, winding of relay 205, right back contact of relay 202, right back contact of relay 206, conductor 346, and the right back contact of each horizontal magnet, Fig. 3, in series to ground. Relay 205 operates in the above circuit and at its front contact completes a circuit for shunting the "off-normal" lamp 207 which may be traced from grounded battery, left front contact of relay 201, resistances 208 and 209 in series to ground on the front contact of relay 205. The off-normal lamp 207 remains unlighted until the operation of the registering mechanism as described later herein.

Assuming the line wanted by the calling P. B. X. subscriber is designated BEL 2483–W, the P. B. X. operator successively depresses non-locking digit keys 312, 313 and 315 for setting the code registration in the registering mechanism, it having been assumed that the code is BEL, which have a digit value of 2, 3 and 5 respectively, and the keys 312, 314, 318 and 313 which have a digit value of 2, 4, 8 and 3 respectively for setting the numerical registration and the key 319 for setting the station's registration, since we have assumed the station's designation to be W which has a digit value of 9.

Upon the depression of key 312 for the first letter B of the code a circuit is completed for energizing vertical magnet 302 from grounded battery, winding of vertical magnet 302, spring contact of key 312, conductor 341 to ground on the right front contact of relay 201. Vertical magnet 302 attracts its armatures, rotates the associated vertical bar of the register associated therewith and establishes a circuit for operating horizontal magnet 321 from ground on the lower front contact of vertical magnet 302, conductor 343, right back contact of transfer relay 331, winding of horizontal magnet 321, conductor 342 to grounded battery. Vertical magnet 302, in operating, also completes a locking circuit for itself before the operation of horizontal magnet 321. This circuit extends from grounded battery through the winding and inner front contact of vertical magnet 302, conductor 345, left back contact of horizontal magnet 321, right back contact of transfer relay 331, conductor 343 to ground on the outer front contact of vertical magnet 302. Vertical magnet 302 in completing a locking circuit for itself assures the operation of horizontal magnet 321 in the event that the release of key 312 opens the initial energizing circuit of vertical magnet 302 before the operation of horizontal magnet 321. Horizontal magnet 321 operates and rotates the horizontal bar associated therewith which, in conjunction with the vertical bar, operates the card 351 located at the junction of the two operated bars in the well known manner, thereby setting the register for the first letter of the code.

Horizontal magnet 321, in operating, completes at its left front contact, a locking circuit for itself from grounded battery, conductor 342, winding and left front contact of horizontal magnet 321, winding of transfer relay 331, conductor 344 to ground on the outer right back contact of relay 204 but relay 331 does not operate in this circuit until ground is removed at the contact of magnet 302. Horizontal magnet 321, upon operating, also opens at its left back contact the locking circuit of vertical magnet 302 causing it to release and restore its associated vertical rod. Card 351 is held operated by its horizontal bar while horizontal magnet 321 remains operated. As soon as magnet 302 deenergizes, relay 331 energizes in the locking circuit of magnet 321, opening at its right back contact the initial energizing circuit of magnet 321 and at its right front contact prepares a circuit for operating horizontal magnet 322 associated with the register elements for registering the second letter of the code.

When horizontal magnet 321 is operated, the circuit through its right back contact for energizing relay 205 is opened. Relay 205 releases and in so doing opens the shunt circuit around lamp 207. Lamp 207 is lighted and continues so until the register mechanism is returned to normal.

Upon the depression of key 313 for letter E, the second letter of the code, a circuit is completed for energizing vertical magnet 303 from grounded battery, winding of vertical magnet 303, spring contact of key 313 to ground on conductor 341. Vertical magnet 303, in operating, completes a locking circuit for itself for assuring the operation of horizontal magnet 322 in a manner similar to that described for locking vertical magnet 302 to assure the operation of horizontal magnet 321. Vertical magnet 303 also rotates the vertical bar associated therewith and establishes a circuit for operating horizontal magnet 322 associated with the register elements of the registering mechanism for recording the second letter of the code. The circuit for horizontal magnet 322 may be traced from ground, lower front contact of vertical magnet 303, conductor 343, right front contact of transfer relay 331, right back contact of transfer relay 332, winding of horizontal magnet 322, conductor 342 to grounded battery. Horizontal magnet 332, in operating, rotates the horizontal bar associated therewith, which, in conjunction with the operated vertical bar, operates the register card 352 located at the junction of the two operated bars in the well known manner, thereby setting the register for the second letter of the code.

When horizontal magnet 322 operates, it

completes at its left front contact, a locking circuit for itself which may be traced from grounded battery, conductor 342, winding of and left front contact of horizontal magnet 322, winding of transfer relay 332, conductor 344 to ground through the outer left back contact of relay 204. Transfer relay 332 does not operate in this circuit until after the release of vertical magnet 303, since its winding is shunted through the contact of magnet 303. Horizontal magnet 322, in operating, opens the locking circuit for vertical magnet 303 at its left back contact after it has completed its locking circuit at its left front contact. Card 352 is held operated by its horizontal bar while horizontal magnet 322 remains operated. Following the release of magnet 303, transfer relay 332 operates in the locking circuit of magnet 322, opening the initial energizing circuit of magnet 322 and prepares a circuit at its right front contact for operating magnet 333 associated with the register elements for registering the third letter of the code.

Upon the depression of key 315 for L, the third letter of the code, which has been assumed to have a digit value of 5, vertical magnet 305 and horizontal magnet 323 are operated and rotate their respective associated bars, which, in conjunction with each other, operate the card 353 located at the junction of the operated bars, thereby completing the registration of L, the third letter of the code, in a manner similar to that described for registration of the first and second letters of the code. As a result of the operation of horizontal magnet 323, transfer relay 333 is operated and associates the register elements for registering the thousands digit with the recording keys in the same manner as previously described in the operation of transfer relay 331.

In response to the successive depression of keys 312, 314, 318 and 313 which have a digit value of 2, 4, 8 and 3 respectively as previously recited, the magnets 302 and 324, 304 and 325, 308, and 326, and 303 and 327 are successively operated and rotate their associated bars to operate cards 354, 355, 356 and 357 to set a thousands register element, a hundreds register element, a tens register element and a units register element respectively.

The hundreds register element, tens register element, units register element and the stations register element are successively associated with the recording keys in a manner similar to that previously described for associating the thousands register element and the register elements for the letters of the code with the recording keys.

Upon the depression of key 319, it having been assumed that the stations designation is W with a digit value of 9, vertical magnet 309 and horizontal magnet 328 are operated to rotate their associated bars to operate the card 358 to register the stations registration in the same manner as previously described for the operation of preceding cards. Transfer relay 338 operates upon the operation of horizontal magnet 328 and disassociates the stations register elements from the recording keys. The recording keys are now disassociated from every register element of the registering mechanism.

The registration of the designation of the wanted line having been completed, the operator inserts the plug 110 of her cord 130 into the jack 210 of the trunk outgoing to the automatic exchange.

The insertion of the plug 110 into the jack 210 completes a circuit from ground, high resistance 212, sleeve of jack 210 and plug 110, conductor 126, through the windings of marginal relay 108 and sensitive relay 114 in series to grounded battery. Relay 114 operates in this circuit but marginal relay 108 is not operated due to the presence of high resistance 212 in the circuit. Marginal relay 108 is operated only when the plug 110 of the cord 130 is inserted into the jack of a local P. B. X. subscriber's line and hence its operation is not described herein, since the establishment of a connection to a local P. B. X. subscriber's line is not an essential part of this invention.

After having recorded the wanted designation on her keyboard and having plugged into the jack 210 of the outgoing trunk, the operator depresses the start key 211, which completes an obvious circuit for operating relay 203. Relay 203, in operating, completes at its outermost left contact and left armature a circuit for operating marginal relay 105 in the operator's cord circuit. This circuit may be traced from grounded battery, winding of relay 105, upper middle contact of key 103, conductor 122, left back contact of relay 202 to ground on the outermost left front contact and outer left armature of relay 203. Marginal relay 105 operates and relay 201 releases at this time since ground at the outer left front contact of relay 203 shunts out the winding of relay 201. The operation of relay 203 completes a circuit at its inner left contact for retaining the off-normal lamp 207 lighted after relay 201 is released. The release of relay 201 removes operating ground from conductor 341 in order to render subsequent accidental depressions of the keys ineffective.

When relay 105 operates, a circuit is completed for operating relay 202 from grounded battery on the inner left hand armature and innermost front contact of relay 203, winding of relay 202, conductor 124, upper inner front contact of relay 105, upper middle contact of relay 103, conductor 122, left

back contact of relay 202 to ground on the outer left front armature of relay 203. Marginal relay 105 in operating completes a locking circuit for relay 203 from grounded battery, winding and right front contact of relay 203, left back contact of relay 204, conductor 123, lower inner front contact of relay 105 to ground on the front contact of relay 114. Relay 202, in operating, completes a locking circuit for itself by closing its left front contact before opening its left back contact from grounded battery on the innermost left front contact of relay 203, winding and left front contact of relay 202 to ground on the left front contact of relay 203. Relay 202, in closing its left front contact, also completes a locking circuit for relay 105, which may be traced from grounded battery through its winding and upper inner front contact, conductor 124, left front contact of relay 202 to ground on the outer left armature of relay 203.

Relay 105, in operating, connects the fundamental interrupter impulser circuit through the tip and ring of the outgoing trunk to the sender in the automatic exchange. This circuit may be traced from the sender through the tip of jack 210 and plug 110, conductor 128, upper outer front contact of relay 105, left closed contact of unoperated emergency key 111, conductor 121, outer left back contact of relay 206 and closed interrupter contact 217 in parallel, conductor 120, right closed contact of unoperated emergency key 111, lower outer front contact of relay 105, conductor 127, ring of plug 110 and jack 210 to the sender.

When relay 203 operates it completes a circuit for operating slow release relay 219 from grounded battery on the inner right back contact of 0′ counting relay 230, winding of slow release relay 219 to ground on the outer left contact of relay 203. The operation of relay 219 prepares at its right front contact a circuit for operating relay 213 upon the next closure of contact 216 of the constantly rotating interrupter 215. When interrupter contact 216 closes, relay 213 operates in a circuit from grounded battery on the inner right back contact of 0′ counting relay 230, right front contact of relay 219, winding of relay 213, inner left back contact of relay 206 to ground through closed interrupter contact 216. Relay 213, in operating, completes an obvious circuit for operating relay 214 to provide ground for holding the counting relays 1 and 1′ to 9 and 9′ after they have been operated. At its left front contact relay 213 completes a locking circuit for itself through its winding, as previously described, and the winding of slow operating relay 206 in series to ground on its left front contact. During the closure of interrupter contact 216, relay 206 remains unoperated due to the fact that its winding is shunted by ground on the interrupter contact 216 over its left inner back contact.

When interrupter contact 216 is opened, the shunt around the winding of slow operating relay 206 is removed and relay 206 thereupon operates. Immediately after the opening of interrupter contact 216, interrupter contact 217 closes and in so doing closes the fundamental circuit before slow operating relay 206 can open the fundamental circuit at its outer left back contact. Relay 206 is designed as a slow operating relay in order to assure the closure of interrupter contact 217 after the opening of interrupter contact 216 before relay 206 can operate to open the fundamental circuit at its outer left back contact. Otherwise, the fundamental circuit would be opened for a short period and a false pulse transmitted over the line upon the closure of interrupter contact 217 after the opening of the outer left back contact of relay 206.

With relay 206 operated, a circuit is prepared upon the next closure of interrupter contact 216 for operating the counting relay corresponding to the registration set up by a register element of the registering mechanism for the first letter of the code. When interrupter contact 217 next opens, the fundamental circuit is opened since relay 206 is operated and its outer left back contact is open. When interrupter contact 216 next closes after the opening of interrupter contact 217, sufficient current passes through the winding of relay 206 to hold relay 206 operated. With interrupter contact 216 closed at this time, a circuit is completed from grounded battery, winding of the No. 1 counting relay 221, outer right back contact of No 1′ counting relay 231, conductor 362, contact of card 351, conductor 371, right front contact of horizontal magnet 321, conductor 346, inner front contacts of relay 206 to ground through closed interrupter contact 216. The No. 1 counting relay 221 operates and at its left front contact completes a locking circuit for itself from grounded battery through its winding and the winding of the No. 1′ counting relay 231 in series, the left front contact of the No. 1 counting relay 221 to ground on the outer left front contact of relay 214. The No. 1′ counting relay fails to operate in this circuit at this time due to its winding being shunted by ground through the interrupter contact 216.

When interrupter contact 216 next opens, the shunt around the winding of the No. 1′ counting relay is removed and this counting relay operates over the circuit previously described. Following the opening of interrupter contact 216, the fundamental circuit is again closed by the closing of interrupter contact 217, and a pulse has thus been trans-

mitted over the outgoing trunk and recorded in the sender of the automatic exchange.

The No. 1′ counting relay 231 in operating completes at its front contact a circuit for the No. 0 counting relay 220 as soon as the interrupter contact 216 again closes. This circuit may be traced from battery through the winding of relay 220, the outer right back contact of relay 230, the front contact of relay 231, conductor 362, thence to ground through interrupter contact 216 as previously traced. Relay 220 operates and at its right contact completes a locking circuit for itself from grounded battery through its winding and the winding of the No. 0′ counting relay 230 in series, the right front contact of relay 220 to ground on the left front contact of relay 219. The No. 0′ relay does not operate in this circuit until the next opening of contact 216.

When interrupter contact 216 next opens, the shunt around the winding of the No. 0′ counting relay is removed and this relay operates. Following the opening of interrupter contact 216, the fundamental circuit is again closed by the closing of interrupter contact 217 and a second pulse of the first code series is thus completely transmitted.

The No. 0′ counting relay 230, in operating, completes at its left front contact a short circuit of the fundamental circuit so as to render the action of interrupter 215 ineffective to transmit further impuls s for the time being. Counting relay 230, in operating, by removing grounded battery at its inner right back contact, opens the operating circuits of slow release relay 219 and relays 213 and 206, causing their release. Relay 213, in releasing, causes the release of relay 214. Relay 214, upon releasing, opens the circuits of relays 221 and 231. Relay 206, in releasing, again closes the fundamental circuit at its outer left back contact. Relay 219, in releasing, opens the locking circuits of the operated counting relays 220 and 230, thereby causing th ir release. Relay 219 is designed as a slow release relay to assure the release of relay 206 and the closing of the fundamental circuit at the outer left back contact of relay 206 before counting relay 230 releases and opens the short circuit on the fundamental circuit in order to render the action of the impulse interrupter 215 ineffective to interrupt the fundamental circuit at this time.

When counting relay 230 was operated, a circuit was completed for shunting the horizontal magnet 321 and causing its release. This circuit may be traced from grounded battery on the right front contact of counting relay 230, conductor 347, inner left front contact of transfer relay 331, winding of relay 331, conductor 344 to ground on the outermost right back contact of relay 204. Horizontal magnet 321 is shunted by this circuit since it will be recalled that battery for energizing this magnet is derived from the same source connected to conductor 342. The release of horizontal magnet 321 restores its associated horizontal bar and register card 351 to their normal positions.

Horizontal magnet 321, in releasing, opens at its left front contact the initial energizing circuit of transfer relay 331 and at its right back contact prepares a circuit for associating the interrupter impulser circuit with the counting relays in accordance with the setting on the register elements for the second letter of the code.

When counting relay 230 releases, it opens the energizing circuit of transfer relay 331, causing it to release since its initial energizing circuit is opened upon the release of the horizontal magnet 321.

It will be observed that the fundamental circuit was only opened twice before the operation of the 0′ counting relay 230 and that the pulses caused by twice opening the fundamental circuit correspond with the assumed value of letter B, the first letter of the code.

The pulses for the first letter of the code having been transmitted over the line, the interrupter impulser circuit prepares to transmit the series of pulses for the second letter of the code under the control of the counting relays, determined by the registration set up by a second register element of the registering mechanism in the same manner as described for sending the pulses for the first letter of the code. Upon the release of counting relay 230, relays 219, 206, 213 and 214 are operated as previously described. With relay 206 operated, upon the next opening of interrupter contact 217, the fundamental circuit is opened. Upon the subsequent closure of interrupter contact 216, a circuit is completed from grounded battery, winding of the No. 2 counting relay 222, back contact of the No. 2′ counting relay 232, conductor 363, contact of card 352, conductor 372, right front contact of horizontal magnet 322 and right back contact of horizontal magnet 321 in series, conductor 346, inner front contacts of relay 206 to ground through interrupter contact 216. The No. 2 counting relay operates and at its left front contact completes a locking circuit for itself to ground on the outer left front contact of relay 214. The No. 2′ counting relay fails to operate in this circuit since its winding is shunted by ground on the interrupter contact 216. Upon the subsequent opening of interrupter contact 216, the No. 2′ counting relay operates and is locked up over the circuit for holding the No. 2 counting relay. Upon the subsequent closing of interrupter 217, the fundamental circuit is again closed and the first pulse of

the series of pulses corresponding to the second letter of the code is transmitted over the outgoing trunk.

The No. 2′ counting relay, in operating, prepares a circuit at its right front contact for operating the No. 1 counting relay upon the next closure of interrupter contact 216. When interrupter contact 217 opens, it opens the fundamental circuit since relay 206 is held operated as previously described. When interrupter contact 216 closes following the opening of interrupter contact 217, the No. 1 counting relay is operated over a circuit including the right front contact of the No. 2′ counting relay to ground on interrupter contact 216 as previously described and completes a locking circuit for itself through its left front contact to ground on the outer left front contact of relay 214. When interrupter contact 216 again opens, the No. 1′ counting relay is operated and completes a circuit for operating the No. 0 counting relay upon the next closure of interrupter contact 216. After the opening of interrupter contact 216, interrupter contact 217 again closes, and in so doing again closes the fundamental circuit. Interrupter contact 217 again opens, and in so doing opens the fundamental circuit. Upon the subsequent closure of interrupter contact 216, the No. 0 counting relay is operated over a circuit including the right front contacts of the No. 1′ and 2′ counting relays to ground on interrupter contact 216 as previously described and completes a locking circuit for itself through its right front contact to ground on the left front contact of relay 219. Upon the following opening of interrupter contact 216, the No. 0′ counting relay is operated and locked up over the same circuit for holding the No. 0 counting relay.

The No. 0′ counting relay, in operating, completes at its left front contact a short circuit for the fundamental circuit so as to render the action of the interrupter 215 ineffective to transmit further pulses over the fundamental circuit for the time being. Upon the operation of the No. 0′ counting relays 219, 206, 213 and 214 are released as previously described. Relay 214 in releasing removes holding ground from the circuits of counting relays 221, 222, 231 and 232, causing their release. Relay 206, in releasing, closes at its outer left back contact the fundamental circuit. Slow release relay 219 releases, and in so doing opens at its left front contact the energizing circuits of counting relays 220 and 230, causing their release. Relay 219 is designed as slow releasing in order to permit relay 206 to release and close the fundamental circuit before the release of the No. 0′ counting relay 230, so as to continue to render the action of the interrupter 215 ineffective to transmit pulses until after the next operation of relay 206.

When the No. 0′ counting relay operates it completes at its right front contact a circuit for shunting horizontal magnet 322 causing it to release. This circuit may be traced from grounded battery, right front contact of the No. 0′ counting relay, conductor 347, left back contact of transfer relay 331, inner left front contact of transfer relay 332, conductor 344 to ground on the outer right front contact of relay 204. Horizontal magnet 322 deenergizes and prepares at its right back contact a circuit for associating the register element for the third letter of the code with the interrupter impulser circuit. The release of horizontal magnet 322 restores its associated horizontal bar and register card 352 to normal.

It will be noted that interrupter contact 217 opened and closed three times after the operation of relay 206 to transmit three pulses over the fundamental circuit corresponding to the assumed value of the second letter of the code E before the operation of the No. 0′ counting relay renders the operation of the interrupter 215 ineffective to transmit further impulses for the second letter of the code.

In a manner similar to that described for the transmission of the series of pulses for the first and second letters of the code, the interrupter impulse circuit is progressively associated with the register element for the third letter of the code, and with the register elements for the thousands, hundreds, tens, units and stations designations. Series of five pulses for the third letter of the code, series of two, four, eight and three pulses for the thousands, hundreds, tens and units designations, respectively, and a series of nine pulses for the station designation W which was assumed to have a digit value of nine, are transmitted over the outgoing trunk to the sender in the automatic exchange in accordance with the registrations recorded at the respective register elements. Following the transmission of the series of pulses for the third letter of the code and for the thousands, hundreds, tens, units and stations designations, the horizontal magnets 323, 324, 325, 326, 327 and 328, respectively are released and restore their respectively associated horizontal bars and register cards 353, 354, 355, 356, 357 and 358 to normal in a manner similar to that described in connection with the release of horizontal magnets 321 and 322 after the transmission of series of pulses for the first and second letters of the code.

After the transmission of the station designation series of pulses, relays 219, 213, 206 and 214 are operated in the same manner as previously described after the transmission

of the series of pulses for the first and second letters of the code.

Upon the release of horizontal magnet 328 after the transmission of the series of pulses for the station designation a circuit is established from ground on the right back contact of horizontal magnet 328, right back contacts in series of all other horizontal magnets, conductor 346, right back contact of relay 206, right front contact of relay 202 to grounded battery through the winding of relay 218. Relay 218 operates in this circuit and provides a locking circuit for itself through its left armature and outer contact to ground at the outer left contact of relay 203 and completes a circuit for operation relay 204 from grounded battery, winding of relay 204, through the inner left front contact of relay 218 to ground at the left armature of relay 203. Relay 204 in operating opens its right back contacts to remove ground from the energizing circuits of the transfer relays but has no effect at this time since the transfer relays are deenergized. Relay 204 in operating opens at its left back contact the locking circuit of relay 203 causing it to deenergize.

The release of relay 203 opens the operating circuit of relay 219 causing it to release and in turn to release relays 206 and 213. The release of relay 213 effects the release of relay 214 which in turn causes the release of all the counting relays locked to ground on the front contacts of relay 214. Relay 203 in releasing removes ground from the energizing circuits of relays 218 and 204. Relay 204 releases but relay 218 does not release until its initial energizing circuit is opened upon the release of relay 202.

As soon as relay 203 releases, the shunt circuit around the winding of relay 201 is removed and relay 201 is thereupon operated. Marginal relay 105 releases because of the presence of the winding of relay 201 in the circuit which may be traced through either the left front contact or the left back contact of the make-before-break spring contact combination of relay 202 depending upon whether at this instant, relay 202 is still operated or released following the release of relay 203.

Relay 203 in releasing removes ground from the operating circuit of relay 202 causing it to release. The release of relay 202 opens the initial energizing circuit of relay 218 causing its release. With relay 202 released a circuit is completed from grounded battery on the left front contact of relay 201, through the winding of relay 205, right back contact of relay 202, right back contact of relay 206, conductor 346 to ground through the right back contacts of the horizontal magnets in series. Relay 205 operates and at its right front contact completes a shunt circuit for extinguishing the off-normal lamp 207. Relay 201 in operating provides ground at its right front contact for operating the vertical magnets upon the depression of the recording keys for the next wanted line designation.

Relay 105 in releasing detaches at its upper and lower outer front contacts the register sending mechanism from the cord 130 and at its upper lower outer back contacts cuts the talking conductors of the cord 130 through to permit the P. B. X. calling subscriber to converse with the called subscriber upon the establishment of the talking connection in the automatic exchange.

When the P. B. X. operator sees that the off-normal lamp 207 is extinguished, she restores the talking key 103 thereby removing grounded battery from the operating circuit of relay 201. Relay 201 releases and in so doing causes the release of relay 205.

Associated with the operator's cord 130 are the usual supervisory relays 112 and 113 and the supervisory signal lamps 116 and 117 associated therewith respectively. When the P. B. X. subscriber at station 115 restores his receiver, a circuit through supervisory relay 112 is opened causing it to deenergize to complete a circuit for lighting lamp 116 whereupon the P. B. X. operator removes the plug 101 of the cord from the answering jack 102 and extinguishes the lamp 116.

If after the called subscriber in the automatic exchange has restored his receiver, the calling P. B. X. subscriber fails to hang up, and a call is incoming from the automatic exchange over the trunk with which the trunk cord 130 is connected, a circuit for operating relay 113 is completed in the manner well known in the art. Relay 113 now completes an obvious circuit for lighting lamp 117. When the P. B. X. operator observes that signal lamp 117 is lighted she operates the talking key to connect her head set to the line incoming from the automatic exchange and ascertains from the calling subscriber the number of the desired P. B. X. subscriber. Having ascertained the desired number she removes the plug 101 from jack 102 and inserts the plug 101 into the jack of the desired P. B. X. subscriber after which she releases the talking key 103.

If while the off-normal lamp 207 is lighted indicating that the impulse sending mechanism is still in use, the operator observes that signal lamp 116 is operated indicating that the calling P. B. X. subscriber has disconnected, the operator releases the sender in the automatic exchange by removing plug 110 from the outgoing trunk jack 210. The removal of the plug 110 from the outgoing trunk jack 210 sets up the well known "wipe out" condition in

the automatic telephone exchange system, the same as that which occurs when the calling subscriber in an automatic exchange disconnects before the establishment of a talking connection with a called party.

The operator then restores her register impulse sending mechanism to normal by operating "wipe out" key 241 which completes an obvious circuit for operating release relay 218. Relay 218 in operating completes a circuit for operating relay 204 from grounded battery, inner left front contact of relay 218, to ground at the outer left front contact of relay 203. Relay 204 operates and in so doing opens at its right back contacts the locking circuits of all the horizontal magnets and transfer relays causing them to release. The release of the horizontal magnets restores their associated horizontal bars and the operated register cards to normal. In the manner similar to that previously described for restoring the impulse interrupter circuit to normal after the release of the horizontal magnet 328, the impulse interrupter circuit is restored to normal.

The operator may cause a "wipe out" condition in the sender of the automatic exchange and the immediate restoration of the impulse sending mechanism upon the calling P. B. X. subscriber disconnecting before station designations series of impulses are transmitted by operating the "wipe out" key 241 and restoring the talking key 103. The operation of the "wipe out" key 241 causes the restoration of the interrupter impulse sending mechanism in the same manner as that previously described. The release of relay 203 during the restoration of the interrupter impulse sending mechanism causes the operation of relay 201 and the consequent release of relay 105. The release of relay 105, however, does not effect the "wipe out" condition of the sender of the automatic exchange since the closure of the back contacts of the make-before-break spring contact combinations of relay 105 completes a loop circuit which may be traced from the tip side 128 of the plug 110 and jack 210, upper back contact of relay 105, uppermost closed contact of talking key 103 to the tip side of the operator's head set through the outer right back contact of relay 107, ring side of the operator's head set, lower closed contact of the talking key 103, lowermost back contact of relay 105, ring conductor 127, ring side of plug 110 and jack 210 to the sender in the automatic telephone exchange. However, when the operator restores her talking key this loop circuit is opened and the "wipe out" condition is caused in the sender.

If for any reason the impulse sending mechanism associated with the registering mechanism and keyboard fails to properly function, the P. B. X. operator operates the emergency key 111 which detaches the registering impulse sending mechanism from and connects the dial impulse sender 125 with the cord 130 for sending out dial pulses in a manner well known in the art.

What is claimed is:

1. An impulse sending mechanism comprising a set of recording keys representing the several digits of a decimal system, a unitary registering mechanism of the crossbar switch type adapted to set up a registration in accordance with the digits recorded on said recording keys, and means under the control of said registering mechanism for transmitting series of pulses corresponding to the digits recorded on said recording keys.

2. An impulse sending mechanism comprising a set of recording keys representing the several digits of a decimal system, a unitary registering mechanism of the crossbar switch type adapted to set up a registration in accordance with the digits recorded on said recording keys, impulse transmitting means, and means under the control of the registration set up in said unitary registering mechanism to cause said last mentioned means to transmit said pulses in series corresponding to the digits recorded on said recording keys.

3. An impulse sending mechanism comprising a set of recording keys representing the several digits of a decimal system, a unitary registering mechanism of the crossbar switch type for registering the digits recorded on said keys, a start key, means for transmitting pulses over a circuit in response to the operation of said start key and means under the control of said unitary registering mechanism to cause said transmitting means to transmit said pulses over said circuit in series corresponding to the digits recorded on said recording keys.

4. An impulse sending mechanism comprising a set of recording keys representing the several digits of a decimal system, a unitary registering mechanism of the coordinate switch type adapted to set up registrations in accordance with the digits recorded on said recording keys, a start key, means for transmitting pulses over a circuit in response to the operation of said start key and a set of counting relays operated under the control of said unitary registering mechanism to cause said transmitting mechanism to transmit said pulses over said circuit in series corresponding to the digits recorded on said recording keys.

5. An impulse sending mechanism comprising a set of recording keys representing the several digits of a decimal system, a unitary registering mechanism of the coordinate switch type for registering the digits recorded on the recording keys, impulse

transmitting means comprising a constantly rotating interrupter for interrupting a closed circuit, means for normally short-circuiting said interrupter for rendering it ineffective to interrupt said closed circuit, a start key, means operative in response to the operation of said start key to open said short circuit, and means including a set of counting relays operative under the control of said unitary registering mechanism for causing said impulse transmitting means to transmit series of pulses corresponding to the digits recorded on the recording keys.

6. An impulse sending mechanism comprising a set of recording keys representing the several digits of a decimal system, a unitary registering mechanism for registering the digits recorded on said recording keys, impulse transmitting means comprising a constantly rotating interrupter for interrupting a closed circuit, means for normally short-circuiting said interrupter for rendering it ineffective to interrupt said closed circuit, a start key, means responsive to the operation of said start key to open said short circuit to render said interrupter effective to interrupt said closed circuit, and means for thereafter intermittently short-circuiting said closed circuit under the control of said unitary registering mechanism to render said interrupter ineffective to transmit series of pulses corresponding to the digits recorded on said recording keys.

7. In a telephone system, an impulse transmitter including a key adapted for successive actuation to set up the same digit a plurality of times and a registering mechanism of the cross-bar switch type for registering the digits set up.

8. In a registering mechanism the combination of a single set of recording keys representing the several digits of a decimal system and a registering mechanism of the cross-bar switch type for successively registering the digits recorded on said recording keys.

9. In a telephone exchange system, an impulse transmitter including a single set of recording keys representing the several digits of the decimal system, a unitary registering mechanism of the cross-bar switch type having a plurality of groups of register elements for registering the digits recorded on said recording keys, and means for progressively associating each of said plurality of groups of register elements with said recording keys.

10. In a telephone exchange system, an impulse transmitter including a single set of recording keys, a unitary registering mechanism of the cross-bar switch type, said register having a plurality of groups of register elements one of which is normally associated with said recording keys for registering the first digit of a line designation and means for progressively associating each of the other groups of said register elements with said recording keys for registering the succeeding digits of said line designation.

11. In a telephone exchange system, an impulse transmitter including a single set of recording keys, a unitary registering mechanism of the cross-bar switch type, said registering mechanism having a plurality of groups of register elements one of which is normally associated with said recording keys for registering the first digit of a line designation, and means operative upon the registration of a digit of a line designation to associate the next succeeding group of said register elements with said recording keys.

12. In a telephone exchange system, an impulse transmitter including a single set of recording keys, a unitary registering mechanism of the cross-bar switch type said unitary registering mechanism having a plurality of groups of register elements for registering the digits of line designations recorded on said recording keys, one of said register elements normally associated with said recording keys and arranged to operate upon the recording of the first digit of a designation, a series of transfer relays one of which is associated with each group of register elements and arranged to operate upon the operation of its associated register elements to associate the register elements for the next digit of the designation with the recording keys.

13. In a telephone system, an impulse transmitter including a single set of recording keys, a unitary registering mechanism of the coordinate switch type having a plurality of groups of register elements each arranged to register the digits of a designation recorded on said recording keys, means for transmitting series of impulses, and a set of counting relays operative under the control of said unitary registering mechanism to govern said transmitting means for effecting the transmission of series of impulses corresponding to the digits recorded on said recording keys.

14. In a telephone exchange system, an impulse transmitter, a single set of recording keys, a unitary registering mechanism of the coordinate switch type for registering the digits recorded on said recording keys, said registering mechanism having a plurality of groups of register elements arranged to respectively register the digits of recorded line designations, a set of counting relays operative under the control of said plurality of groups of register elements for governing said impulse transmitter to effect the transmission of series of impulses corresponding to the digits recorded, and a series

of transfer relays for progressively associating each of said plurality of groups of register elements with said recording keys during the recording of a designation and thereafter for progressively associating each of said plurality of groups of register elements with said counting relays.

15. In a telephone exchange system, an impulse transmitter including a single set of recording keys, a unitary registering mechanism of the cross-bar switch type for registering the digits recorded on said recording keys, a signal lamp, and means for lighting said lamp during the operation of said unitary registering mechanism.

16. In a telephone exchange system, an impulse transmitter, a single set of recording keys, a unitary registering mechanism of the coordinate switch type, said registering mechanism having a plurality of groups of register elements arranged to progressively register the digits of a line designation recorded on said keys, a set of counting relays, means for successively associating each of said groups of register elements with said counting relays, said counting relays operative under the control of each of said groups of register elements for governing said impulse transmitter to effect the transmission of series of pulses corresponding to the digits registered in each of said groups of register elements, and means under the control of said counting relays to progressively release each of said plurality of groups of register elements upon the termination of a series of pulses corresponding to the registration set up in each of said groups of register elements respectively.

17. In a telephone exchange system, an impulse transmitter, a set of recording keys, a unitary registering mechanism of the cross-bar switch type operative in response to the depression of said recording keys to register a line designation, a wipe out key, and means operative in response to the operation of said key to release said unitary registering mechanism.

18. In a telephone exchange system, an impulse transmitter, a single set of recording keys, a unitary registering mechanism of the coordinate switch type for registering the digits recorded on said recording keys, said registering mechanism having a plurality of groups of register elements arranged to respectively register the digits of recorded line designations, a set of counting relays operative under the control of said plurality of groups of register elements for governing said impulse transmitter to effect the transmission of series of impulses corresponding to the digits recorded, a series of transfer relays, means for progressively operating said transfer relays to successively associate each of said plurality of groups of register elements with said recording keys during the recording of a designation, and means for thereafter progressively releasing said transfer relays for successively associating each of said plurality of groups of register elements with said counting relays.

19. In a telephone exchange system, an impulse transmitter, a single set of recording keys, a unitary registering mechanism of the coordinate switch type for registering the digits recorded on said recording keys, said registering mechanism having a plurality of groups of register elements arranged to respectively register the digits of recorded line designations, a set of counting relays operative under the control of said plurality of groups of register elements for governing said impulse transmitter to effect the transmission of series of impulses corresponding to the digits recorded, a series of transfer relays, means for progressively operating said transfer relays to successively associate each of said plurality of groups of register elements with said recording keys during the recording of a designation, and means for thereafter progressively releasing said transfer relays in the order in which they were operated for successively associating each of said plurality of groups of register elements with said counting relays.

20. In a telephone exchange system, an impulse transmitter including a single set of recording keys, a unitary registering mechanism of the coordinate switch type having a plurality of register elements arranged in vertical and horizontal groups, a vertical operating magnet associated with each vertical group of elements and a horizontal magnet associated with each horizontal group of elements, each of said vertical magnets being individual to and operable through contacts of one of said keys, a series of transfer relays, said relays being paired with said horizontal magnets, and means under the control of said vertical magnets to progressively operate said pairs of horizontal magnets and transfer relays to render said horizontal groups of register elements operable upon successive actuations of said keys.

In witness whereof, I hereunto subscribe my name this 12th day of June A. D. 1924.

ROBERT W. HARPER.