

Aug. 7, 1945.

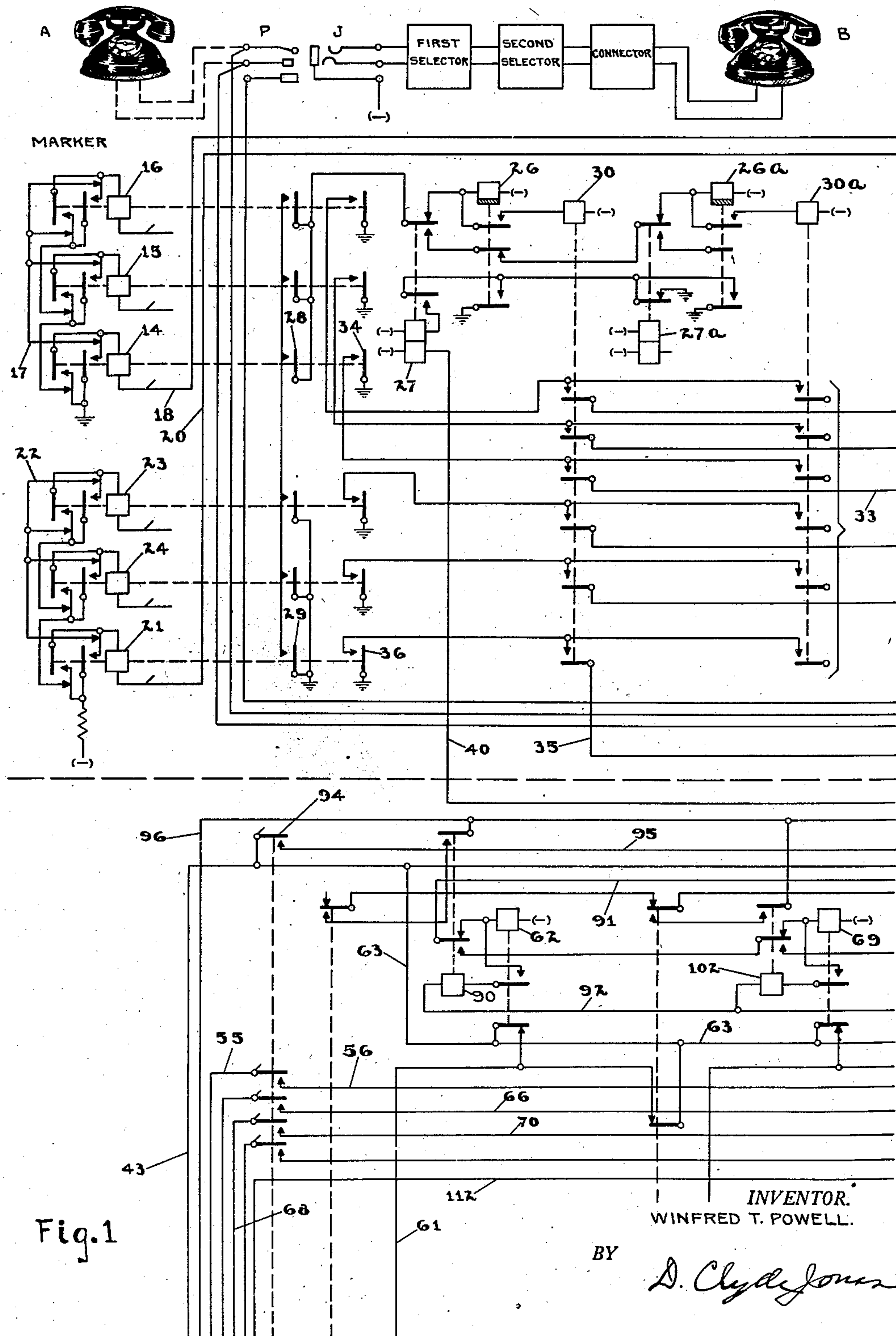
W. T. POWELL

2,381,516

RELAY TYPE KEY SENDER

Filed Oct. 16, 1943

5 Sheets-Sheet 1



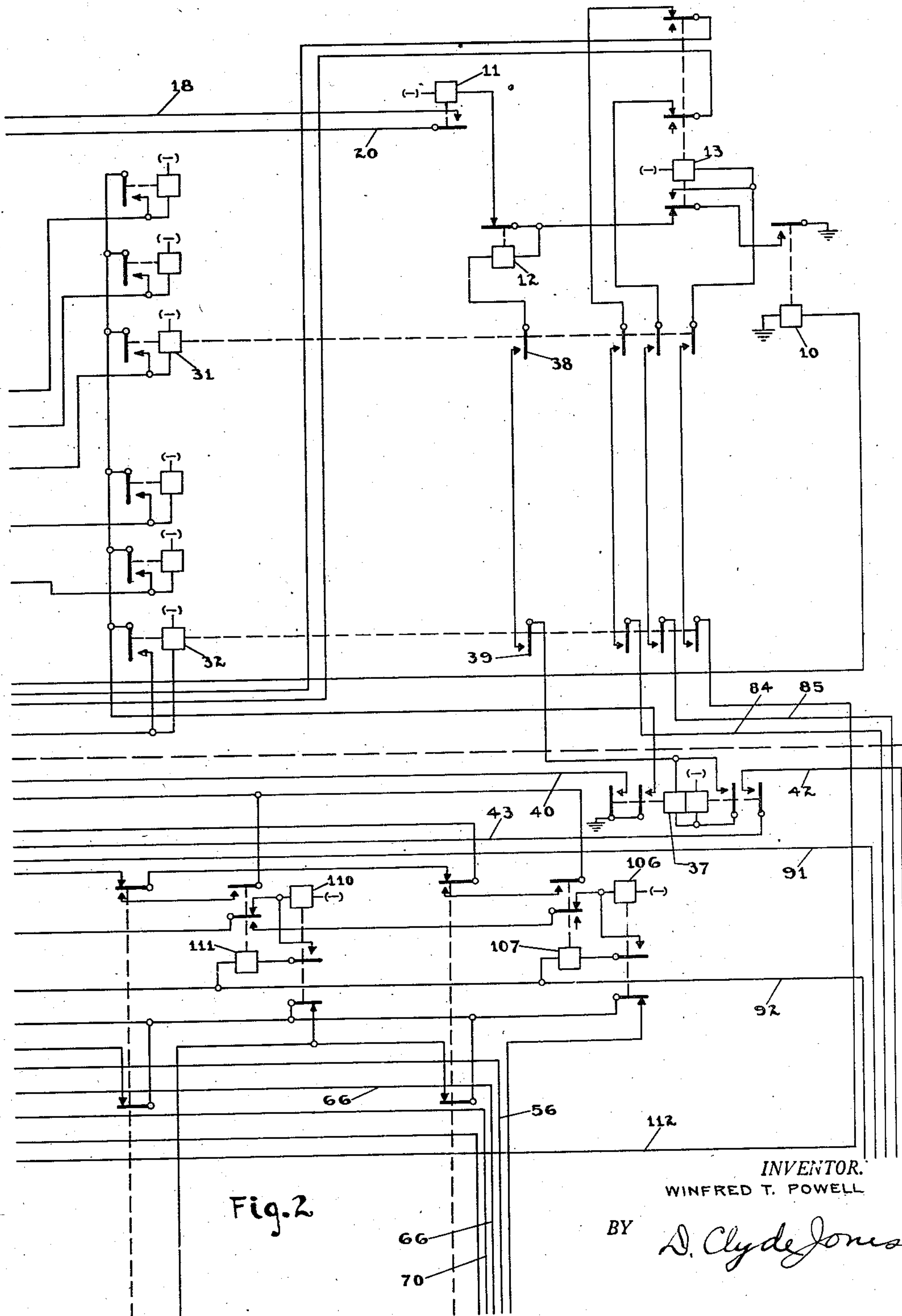
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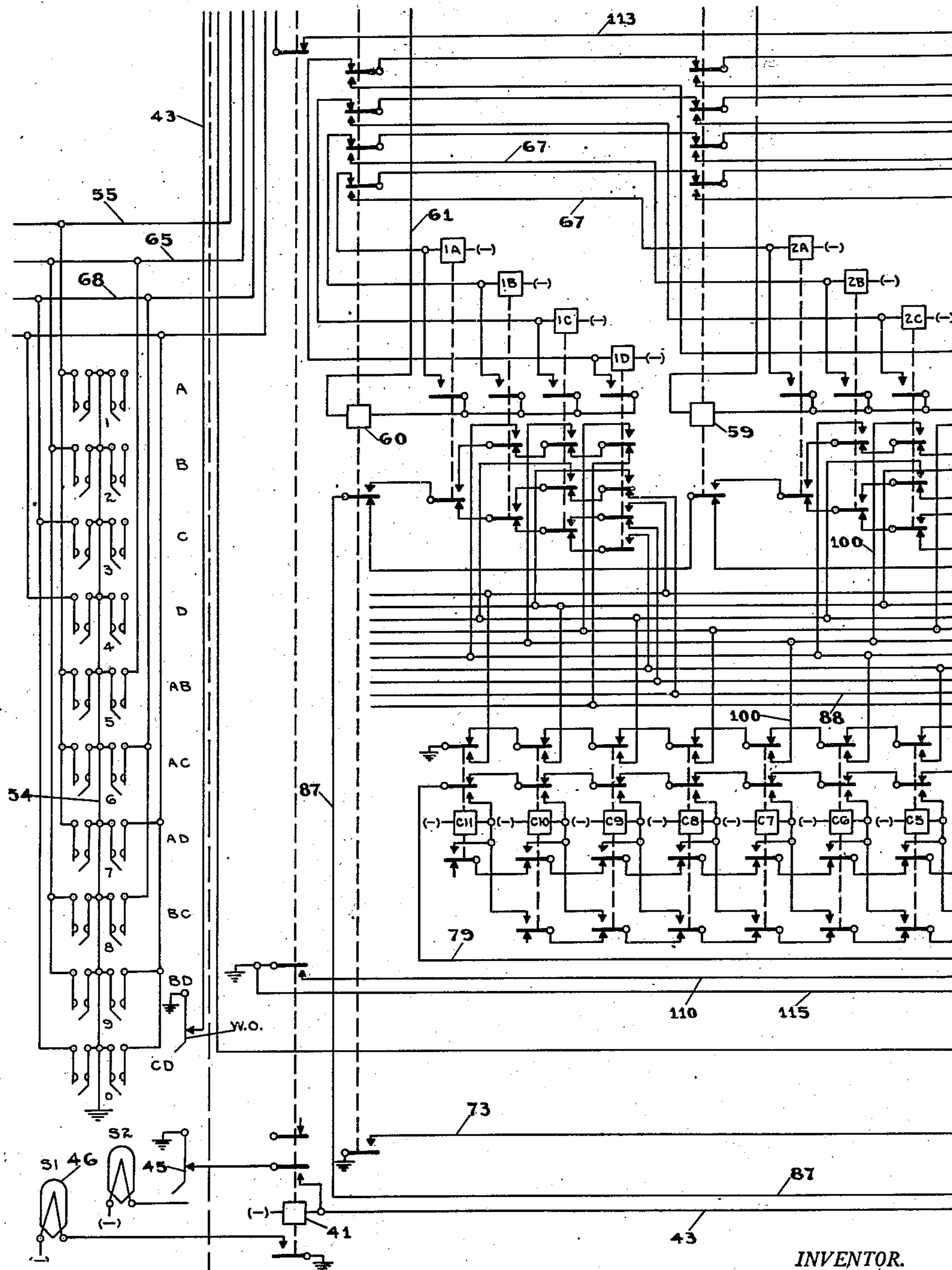
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RELAY TYPE KEY SENDER

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5 Sheets-Sheet 3



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RELAY TYPE KEY SENDER

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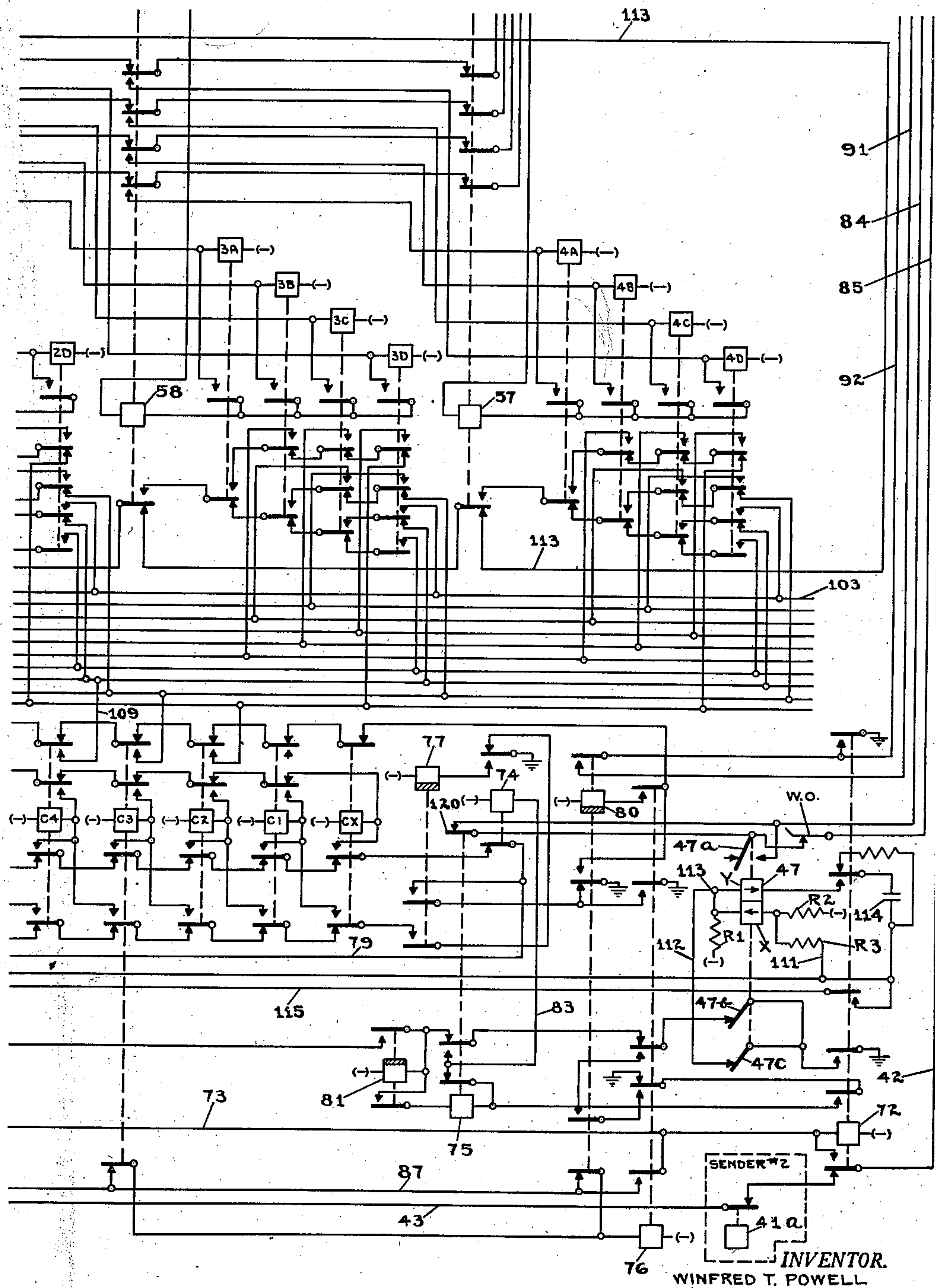


Fig. 4

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5 Sheets-Sheet 5

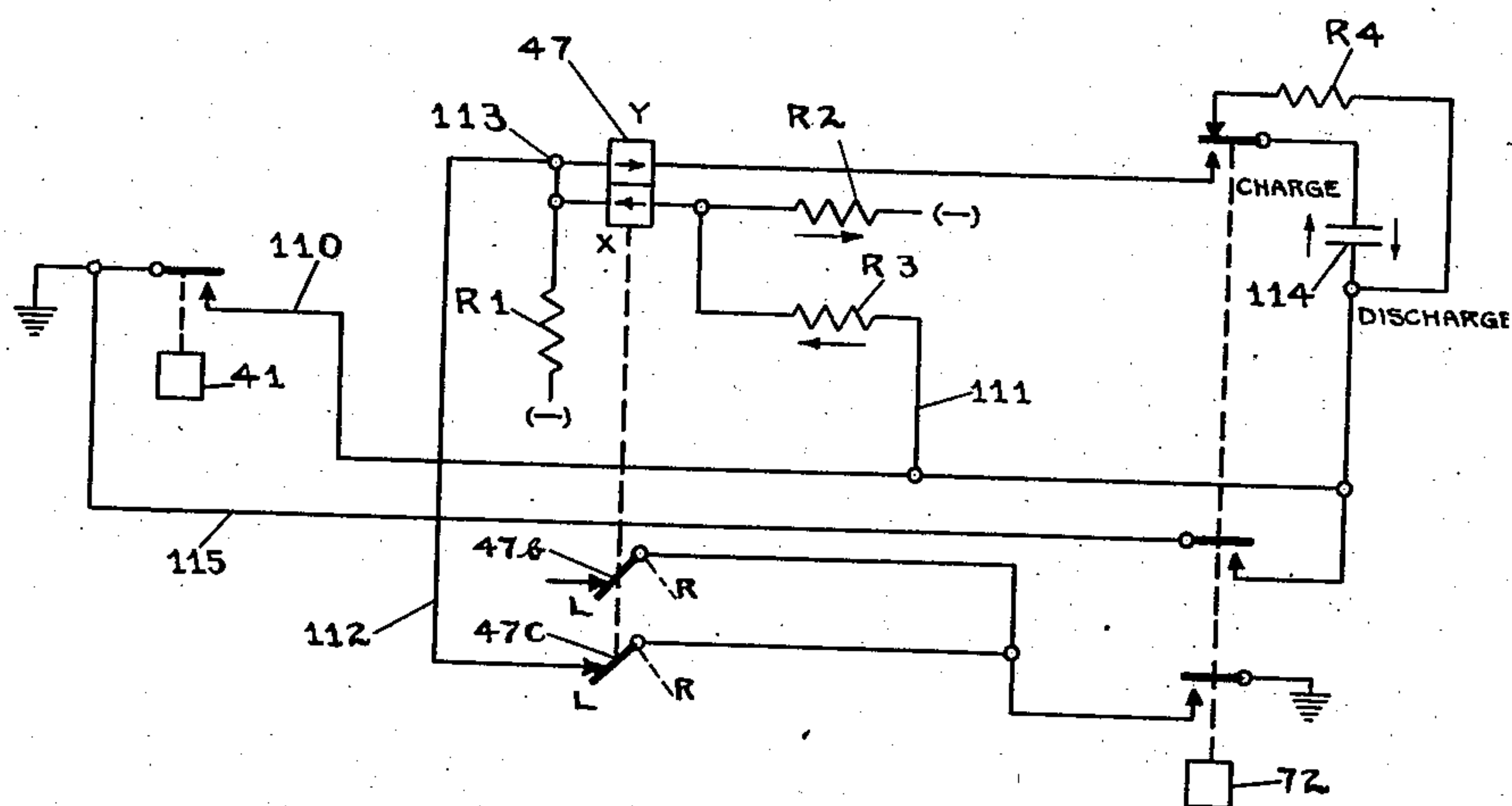


Fig. 5

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2,381,516

RELAY TYPE KEY SENDER

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Application October 16, 1943, Serial No. 506,604

8 Claims. (Cl. 179-27)

This invention relates to automatic telephone systems and more particularly to impulse sending arrangements for use therein.

In accordance with the main feature of the invention there is provided a key-operated register sender and a related counting relay chain which cooperate to control the transmission of relay-generated impulses for selective operation of switching devices.

Another feature of the invention relates to a novel relay arrangement for generating properly timed impulses useful in the operation of automatic telephone systems.

Other features of the invention will appear from the detailed description and claims when taken with the drawings in which; Figs. 1 and 2 when arranged in the order named and with Figs. 3 and 4 respectively placed below Figs. 1 and 2 diagrammatically represent an automatic telephone system including an operator's position together with a key-operated register sender and impulse generating means, all cooperating to control selector and connector switches indicated by rectangles; and Fig. 5 is a simplified diagram showing the circuits for operating the impulse-generating relay.

It is believed that the invention will best be understood by describing the operation involved in establishing a telephone connection from substation A to substation B. In initiating a call, the subscriber at A removes his telephone handset from its cradle to close the related telephone line. Thereupon switching means (not shown) connects this line to the cord circuit which terminates in plug P.

When the operator inserts the calling plug P of the cord circuit into the jack J of a trunk leading to the machine switching office, the sleeve relay 10 is energized in an obvious circuit. As soon as this sleeve relay is operated, it closes a circuit for operating the line relay 11 from the negative pole of battery, winding of this relay, back contact and armature of the cut-off relay 12, back contact and armature of relay 13, front contact and armature of the sleeve relay 10 to the positive pole of battery. The energization of the line relay 11 completes a circuit for operating in series, one of the tens lock-out relays in the marker and one of the units lock-out relays also in the marker, which cooperate to insure that the calls are answered in sequence. This lock-out circuit can be traced from the positive pole of battery, continuity spring and back contact of the tens lock-out relay 14 through the continuity springs and back contacts of the relays

15 and 16, conductor 17 inner back contact and continuity spring of relay 14, winding of this relay, conductor 18, front contact and armature of relay 11, conductor 20, winding of the units lock-out relay 21, its inner continuity spring and back contact, conductor 22, outer back contacts and continuity springs of lock-out relays 23, 24 and 21, to the negative pole of battery. The tens relay 14 and the units relay 21 are energized in this circuit and complete a locking circuit, as follows, independently of the remaining relays of the marker. At the tens relay 14, the locking circuit is completed through the inner continuity spring and armature of relay 14 to positive pole of battery, while at the units relay 21, this locking circuit is completed through the inner continuity spring and armature of this relay to negative pole of battery. It will be noted that while the relays 14 and 21 are thus locked operated, the remaining tens and units relays in the marker are prevented from operating since their operating circuits are interrupted at the relays 14 and 21. With the tens relay 14 and the units relay 21 energized, the relay 26 of the allotter is operated in a circuit from the negative pole of battery, winding of this relay, uppermost back contact and armature of the relay 27, armature 28 and front contact of relay 14, front contact and armature 29 of relay 21, to the positive pole of battery. The relay 26 which is of the slow releasing type, closes a circuit in multiple with its operating circuit, for energizing the relay 30. With the relay 30 of the allotter operated, the tens finder relay 31 and the units finder relay 32 of the No. 1 finder, function to connect the idle sender, allotted by the allotter, to the mentioned cord circuit connected to the trunk leading to the automatic switchboard. The operating circuit for the relay 31 extends from the negative pole of battery, winding of this relay, conductor 33, armature and front contact of relay 30, front contact and armature 34 of the tens lock-out relay 14 to the positive pole of battery. Similarly, the circuit of the units finder relay 32 is traceable from the negative pole of battery, winding of this relay, conductor 35, lowermost armature and front contact of relay 30, front contact and armature 36 of units lock-out relay 21, to the positive pole of battery. Finder relays 31 and 32, when thus operated, not only extend the allotted sender to the cord circuit taken for use but also close a circuit for operating the cut-off relay 12 and the holding relay 37. This circuit is completed from the positive pole of battery, armature and front contact of the relay 10, arma-

ture and back contact of the relay 13, winding of the cut-off relay 12, armature 38 and front contact of the tens finder relay 31, front contact and armature 39 of the units finder relay 32 through the high and low resistance windings in series of the relay 37, to the negative pole of battery. Relay 12 does not operate in series with the high resistance winding of relay 37, but does operate after relay 37 operates and short circuits its high winding at its own inner right hand armature and front contact.

When the cut-off relay 12 operates, it opens the operating circuit of the line relay 11 which relay releases to open the operating circuit and thereby release the marker relays 14 and 21 so that the marker is available for use in connection with succeeding calls.

Also, when the holding relay 37 is operated, it completes an energizing circuit for relay 27 of the allotter, this circuit extending from the negative pole of battery, lower winding of this relay, conductor 40, left-hand front contact and armature of relay 37, to the positive pole of battery. Relay 27, on operating, closes a locking circuit for itself from the negative pole of battery, its upper winding, front contact and lowermost armature of relay 26, to the positive pole of battery. The relay 27 interrupts the circuits of the relays 26 and 30 and extends the allotting circuit to the relays 26a and 30a associated with a second finder (not shown).

Furthermore, on the operation of the holding relay 37, the relay 41 of the sender (Fig. 3) is energized in a circuit completed from the negative pole of battery, winding of this relay, conductor 43, armature and back contact of a similar relay 41a at a second sender of the group (provided relay 41a is not operated), armature and back contact of relay 72, conductor 42, outer front contact and armature of relay 37, conductor 43, contacts of the wipe-out key W. O., to the positive pole of battery. Relay 41, on operating, closes a locking circuit for itself through its upper front contact and armature and through the contacts of the sender cut-off key 45 to the positive pole of battery. Also, at the lower armature and front contact of relay 41, a circuit is closed for lighting the signal lamp 46, as an indication that sender #1 is in use. Furthermore, relay 37 closes a locking circuit for finder relays 31 and 32, at its left hand inner front contact. In addition, a circuit is completed by relay 41 for operating the polarized relay 47 which is provided with armatures 47a, 47b and 47c. This polarized relay is of the construction wherein its armatures 47a, 47b and 47c remain in the positions to which they are moved when the relay operates. It should be pointed out that when either of the windings of this relay is energized in the direction of the arrows, these armatures move to the left.

It may be well, at this point, to interrupt the general description of the system to point out in detail how the polarized relay 47 swings its armatures 47a, 47b and 47c alternately to the right and to the left at a speed of about ten complete cycles per second to simulate the impulses commonly generated by a dial sender, the operation of this relay proceeding continuously while it is transmitting a series of impulses corresponding to a given digit. For convenience in understanding the operation of the relay 47, the circuits thereof are shown in simplified form in Fig. 5.

When the relay 41 operates, as above described, it closes an actuating circuit for the relay 47,

traceable from the positive pole of battery, armature and front contact of relay 41, conductors 110 and 111, through resistance R3, through the lower winding of relay 47, resistance coil R1 to the negative pole of battery, also through the resistance R2 in multiple to the negative pole of battery. Since only the lower winding X of relay 47 is energized, the energization being in the direction of the arrow, relay 47 quickly swings its armatures to the left, as illustrated assuming the armatures to have been in their right hand positions. For convenience in description this operation is designated I.

When somewhat later, the relay 72 is energized, it causes the relay 47 to quickly swing its armatures to the right. This action is effected in a circuit traceable from the positive pole of battery, armature and front contact of relay 72, armature 47c and front contact, conductor 112 to junction 113 where the circuit divides, one branch extending through the resistance R1 to the negative pole of battery and the other branch extending through the winding X of relay 47, resistance R2 to the negative pole of battery. It will be noted that the current is therefore reversed in the lower winding X of relay 47 so that this relay swings its armatures to the right. Also, when the relay 72 is operated, the condenser 114 and the winding Y of relay 47 are short-circuited at this time, by a circuit extending from the positive pole of battery, armature and front contact of relay 72, armature 47c and front contact, conductor 112, winding Y of relay 47, upper front contact and armature of relay 72, condenser 114, front contact and armature of relay 72, conductor 115 to the positive pole of battery. Since the direction of the current in the winding X of relay 47 is now reversed and since the current in winding Y is short-circuited, relay 47 operates its armatures to the right. This operation is conveniently referred to as II.

When the relay 47 moves its armatures to the right, the positive potential at the junction point 113 is removed. Then, a circuit is completed from the positive pole of battery, conductor 115, armature and front contact of relay 72, condenser 114, upper armature and front contact of relay 72, winding Y of relay 47 to the negative pole of battery, either through the resistor R1 or through the winding X of relay 47 and the resistor R2. This circuit causes the condenser 114 to start charging. While this condenser is charging, the current flowing through the Y winding of relay 47 opposes any tendency of this relay to operate its armatures to the left even though the current in winding X tends to reverse, as in the case of operation I, above. When the charging current through the winding Y of relay 47 drops below a certain value as the condenser 114 becomes charged, the current flowing in the winding X of relay 47 will become effective to cause the relay 47 to operate its armatures to the left. This may be called operation III.

When the polarized relay 47 has moved its armatures to the left, positive potential is replaced at the junction 113 of the relay windings X and Y. Condenser 114 will then discharge through winding Y, tending to hold the armatures of the relay 47 in their left-hand position. Current is reversed in winding X as in operation II, but this current in X tries to operate the armatures of relay 47 to the right, but cannot do so until condenser discharge current in winding Y from condenser 114 drops below a certain value. At such time, relay 47 moves its armatures to the right.

This operation is conveniently referred to as #IV. Operations III and IV recur alternately during the transmission of impulses. Operations I and II are quickly effected, while III and IV are comparatively slow operations.

The allotted sender, that is the one herein illustrated, is now in condition to be operated to store digits corresponding to the called subscriber's line designation and then send out impulses in accordance therewith. This sender, as well as other senders in the group, is selectively controlled by a single strip of ten digits keys which can be selectively associated with a sender taken for use. Each sender includes a relay register for each digit of the subscriber's designation so that a thousands, a hundreds, a tens and a units register are herein provided. Each register comprises four relays, marked A, B, C and D. It will be appreciated that by selectively operating the four mentioned relays of any register, ten different combinations thereof may be established to enable this register to store any one of ten digits. The combinations of these relays, necessary to record any one of ten digits, is shown opposite the corresponding key of the mentioned strip of ten sender keys. Where the finder relays 31 and 32 were operated (as previously explained) to connect the sender to the cord, a closed circuit including back contact 120 of relay 75 is placed across the line leading to the automatic switchboard, by way of the plug and jack P and J.

Let it be assumed that the wanted number is #2630, the operator will first depress the #2 sender key. This completes a circuit from the positive pole of battery, conductor 54, contacts of the #2 key, conductor 65, armature and front contact of the sender relay 41, and conductor 66, armatures and back contacts of the transfer relays 57, 58, 59 and 60 of the units, tens, hundreds and thousands registers respectively, winding of the register relay 1B to the negative pole of battery. Relay 1B, on operating, completes a locking circuit for itself (after the key is released) from the negative pole of battery, its winding, as well as its inner front contact and armature, winding of the transfer relay 60, conductor 61, lower back contact and armature of relay 62, conductors 63 and 43 to the positive pole of battery at the wipe-out key W. O. Relay 60 operates in the locking circuit of relay 1B.

The operator continues to operate selectively the sender keys to store up the remainder of the subscriber's designation in the hundreds register, the tens register and in the units register. In the case of the hundreds digit #6, the operator presses the #6 key to close a circuit from the positive pole of battery, conductor 54 contacts of this key, thence over conductor 55, front contact and armature of the sender relay 41, conductor 56, armatures and back contacts of the transfer relays 57, 58 and 59, armature and front contact of the thousands transfer relay 60, conductor 67, winding of the hundreds register relay 2A, to the negative pole of battery. Relay 2A, on operating, closes a locking circuit for itself (after the key is released) through its winding, its front contact and armature, winding of the hundreds transfer relay 59, back contact and armature of the relay 69, conductors 63 and 43, and thence to the positive pole of battery at the wipe-out key W. O.

In addition, when the operator depresses the #6 key, a circuit is closed for the hundreds register relay 2C from the positive pole of battery,

conductor 54, contacts of key #6, conductor 68, front contact and armature of relay 41, conductor 70, armatures and back contacts of relays 57, 58, and 59, armature and front contact of relay 60, winding of relay 2C to the negative pole of battery. Relay 2C, when operated, locks itself (after the key is released) in this condition in multiple with relay 2A. Relay 59 operates in series with this locking circuit.

Similarly, when the operator presses the #3 key of the sender corresponding to the #3 tens digit, the relay 3C of the tens register will be operated and will lock itself operated (after the key is released) in series with the tens transfer relay 58, in a circuit including the conductors 63 and 43, extending to the positive pole of battery at the wipe-out key W. O.

Next, the operator depresses the #0 key of the sender to register the units digit #0 by operating the relays 4C and 4D of the units register. Relays 4C and 4D, on operation, close their locking circuits (after the key is released), as well as an operating circuit for the units transfer relay 57 similar to that described in the case of the other registers.

As soon as the operator has caused the thousands relay to store the thousands digit with the consequent operation of the thousands transfer relay 60 and while the operator is continuing to set up the hundreds, tens and units digits on the corresponding registers, other operations take place.

When the transfer relay 60 of the thousands register is operated, it closes an energizing circuit for the relay 72 (Fig. 4) from the negative pole of battery, winding of this relay, conductor 73, front contact and armature of relay 60 to the positive pole of battery. Relay 72 on operation closes a locking circuit for itself through its front contact and armature, conductor 42, front contact and armature of relay 37 and thence over conductor 43, wipe-out key W. O. to the positive pole of battery. It will be recalled that the polarized relay 47 moved its armatures to the left as soon as the relay 41 operated on the seizure of the #1 sender. However, on the energization of relay 72, the polarized relay moves its armatures to the right constituting the #II operation previously described. Relay 72 also closes an operating circuit for the impulse responsive relay 74 from the negative pole of battery, winding of this relay, back contact and armature of relay 75, front contact and armature of relay 72, armature and back contact of relay 76 to the positive pole of battery. The operation of the impulse responsive relay 74 closes an obvious circuit for the slow releasing relay 77. The operation of this relay in turn effects the operation of the relay CX from the negative pole of battery, winding of this relay, upper back contacts and armatures of counting relays C1 to C11 inclusive, conductor 79, front contact and armature of relay 77, back contact and armature of the relay 80, to the positive pole of battery. The polarized relay 47 (impulse generating) now continues to repeat its operations III and IV, described above, to swing its armatures alternately to the left and to the right at a speed of about ten complete cycles per second to simulate the impulses commonly generated by a dial sender. When the polarized relay 47 now swings its armature to the left in accordance with the first #III operation, the slow operate relay 81 is energized from the negative pole of battery winding of this relay, back con-

tact and armature of the relay 75, back contact and armature of the change-over relay 76, armature 47B, front contact and armature of relay 72, to the positive pole of battery. It should be mentioned that while the relay 81 is slow-operating, it should be fast enough to operate within the time of a pulse generated by the polarized relay 47. It should be noted that while the armature 47b is in its left-hand position, it short-circuits the relay 75. When, however, the polarized relay moves its armatures to the right, the relay 75 is energized in series with the relay 81, this circuit extending from the negative pole of battery, winding of the relay 81, its front contact and armature, winding of the relay 75, front contact and armature of relay 72, armature and back contact of relay 76, to the positive pole of battery. Also, when the relay 75 operates, it interrupts at its armature 120 and back contact, the trunk line circuit including the conductors 84 and 85, so that the making and breaking of this circuit to transmit code impulses corresponding to digits of the wanted number is now controlled by the armature 47a of polarized relay 47. As soon as the relay 75 operates, it opens the energizing circuit of the impulse responsive relay 74 which deenergizes. When the impulse responsive relay 74 releases, it closes a circuit for operating the C1 counting relay from the negative pole of battery, winding of this relay, lowermost front contact and armature of the relay CX, front contact and armature of the relay 77, which is too slow to release on the temporary interruptions of its operating circuit by the release of the impulse relay, and thence to the positive pole of battery at the upper back contact and armature of the impulse responsive relay 74. Now, when the polarized relay 47 moves its armatures to the left again, the impulse responsive relay 74 is again energized from the negative pole of battery, winding of this relay, conductor 83, front contact and armature of relay 75, back contact and armature of change-over relay 76, back contact and armature 47b, front contact and armature of relay 72, to the positive pole of battery. Also, when the polarized relay 47 moves its armatures to the left, it opens the impulse circuit including conductors 84 and 85 respectively connected to the tip and ring conductors of the cord circuit now in use. It should be pointed out that the continuity of the impulse circuit, including the conductors 84 and 85, is controlled at one of the contacts of the wipe-out key W. O. The mentioned opening of this impulse circuit constitutes the first thousands digit impulse transmitted through the cord circuit and the trunk to the automatic switches. In response to the last-mentioned operation of the impulse responsive relay 74, the relay CX releases but the counting relay C1 is now locked operated from the negative pole of battery, winding of this relay, its inner, upper front contact and armature through the back contacts and armatures of the counting relays, namely, C2 to C11 inclusive, conductor 79, front contact and armature of relay 77, back contact and armature of relay 80 to the positive pole of battery. When the polarized relay 47 next swings its armatures to the right thereby ending the first trunk impulse, the operating circuit of the impulse responsive relay 74 will be interrupted again at the armature 47b and the trunk circuit will be closed at armature 47a. Counting relay C2 will now be operated from the negative pole of battery,

winding of this relay, lowermost front contact and armature of relay C1, back contact and armature of relay CX, front contact and armature of relay 77, back contact and armature of the impulse responsive relay 74, to the positive pole of battery. When the polarized relay 47 now moves to the left, it interrupts the mentioned impulse circuit including the conductors 84 and 85 to start the second impulse over the trunk. Also, under this condition, the impulse responsive relay 74 is energized in a circuit previously described. When the impulse responsive relay 74 is thus operated, it opens the circuit which has been holding the counting relay C1 operated so that this last-named relay releases. Now, when the polarized relay 74 moves its armatures to the right, it interrupts the operating circuit of the impulse responsive relay 74, and closes the impulse circuit including the conductors 84 and 85 to end the #2 impulse. When the impulse responsive relay 74 releases, it closes an energizing circuit for the counting relay C3 from the negative pole of battery, winding of this relay, front contact and armature of the relay C2, back contacts and armatures of relay C1 and CX, front contact and armature of relay 77, back contact and armature of the impulse responsive relay 74 to the positive pole of battery. Since that portion of the counting relay chain corresponding to the transmission of two impulses has been actuated, change-over relay 76 is now operated in a circuit traceable from the negative pole of battery, winding of this relay, armature and back contact of the relay 80, conductor 87, armature and front contact of the thousands register transfer relay 60, armature and back contact of relay 1A, armature and front contact of relay 1B, armatures and back contacts of relays 1C and 1D, conductor 88, front contact and armature of counting relay C3 and thence through the back contacts and armatures of the remaining counting relays C4 to C11 inclusive, to the positive pole of battery. Relay 76, on operating, completes a locking circuit for itself from the negative pole of battery, winding of this relay, back contact and armature of relay 80, front contact and armature of relay 76, front contact and armature of relay 72, and thence through conductors 42 and 43 to the positive pole battery at the wipe-out key W. O. When the change-over relay 76 operates, it interrupts the circuit which has been holding the relays 75 and 81 operated, thereby causing these relays to release. Since the impulse responsive relay 74 is released for a relatively long period, the slow-releasing relay 77 will now release to cause the release of the counting relays C2 and C3. When these last two relays release, the relay 80 will be energized in a circuit traceable from the negative pole of battery, winding of this relay, front contact and armature of the change-over relay 76, through the back contacts and armatures of the relays CX to C11 inclusive to the positive pole of battery.

When the relay 80 energizes, it effects the operation of the relay 62 in a circuit extending from the negative pole of battery, winding of this relay, back contact and armature of relay 90, conductor 91, front contact and armature of relay 80, front contact and armature of relay 72, to the positive pole of battery. Relay 62 on operation prepares a locking circuit for itself in series with the relay 90, but which is not yet effective because relay 90 has both terminals of its winding connected to positive battery. On

the operation of the relay 62, the thousands register relay 1B and the thousands register transfer relay 60 release but only if the hundreds register transfer relay 59 has been operated as a result of the completion of the registration of the hundreds digit by the operator.

It will be understood that if the relay 59 of the hundreds register has not been operated, then a substitute holding circuit for the thousands register transfer relay 60 and the thousands register relay is completed through back contact and armature of relay 59, conductors 63 and 43, to the positive pole of battery, at the wipe-out key W. O.

Following the transmission of the impulses corresponding to the thousands digit, it is necessary to introduce a delay before the hundreds series of impulses is transmitted. This is essential in order to afford time for the switching means in the automatic equipment to complete the trunk hunting operation in the group corresponding to the thousands digit. This delay is interposed by again operating a portion of the chain of counting relays, the interval being terminated by the operation of the counting relay C3. It should be mentioned that this second operation of the counting relay C3 has no relation to the prior operation of this same relay in the course of sending the thousands digit which was assumed to be #2. It should be pointed out that during this operation of the counting relay chain to interpose the mentioned delay, the actuation of the armature 47a of the polarized relay 47 will not transmit impulses over the signalling circuit to the distant office, since at this time the signalling circuit is maintained uninterrupted at the back contact and armature 120 of the relay 75.

On the next operation of the armatures of the polarized relay 47 to the left, following the operation of the relay 80, the impulse responsive relay 74 will be operated and it will in turn effect the operation of the slow releasing relay 77. Also, the relay CX of the counting relay chain will be operated. When the polarized relay 47 operates to the right, the impulse responsive relay 74 will deenergize and the counting relay C1 will operate. Now, when the polarized relay moves to the left, the impulse responsive relay 74 will operate again which in turn causes the relay CX to release. The polarized relay next operates to the right which causes the impulse responsive relay 74 to release and cause the counting relay C2 to operate. On the next operation of the polarized relay to the left, impulse responsive relay 74 operates and C1 releases. The polarized relay now operates to the right to effect the release of impulse responsive relay 74 and the operation of relay C3. Since the counting relay C3 and also the relay 80 are operated at this time, the operating circuit as well as the locking circuit for the change-over relay 76 are interrupted so that this relay releases. The change-over relay, on releasing, interrupts at its uppermost armature and front contact, the operating circuit of the slow releasing relay 80 which shortly thereafter releases. The release of relay 76 closes a circuit from the positive pole of battery, back contact of relay 76, inner upper front contact of relay 72, inner upper back contact of relay 75 and winding of relay 74 to the negative pole of battery for operating relay 74. During the interval between the release of relay 76 and the release of relay 80, positive battery is removed from conductor 79 which effects the

release of relays C2 and C3. The release of the relay 80 again closes the previously described energizing circuit for the relay CX. With the armature 47b of the polarized relay in its left-hand position, the slow-operate relay 81 is operated from the negative pole of battery, winding of this relay, back contact and armature of relay 75, back contact and armature of relay 76, armature 47b, front contact and armature of relay 72, to positive pole of battery. If the hundreds transfer relay 59 has been operated as a result of the completion of the registration of the hundreds digit, then when polarized relay 47 is operated to the right for removing positive pole of battery from the junction of the relays 81 and 75, the relay 75 will operate from the negative pole of battery, winding of the relay 81, its lower front contact and armature, winding of relay 75, front contact and armature of relay 72, back contact and armature of the change-over relay 76, to the positive pole of battery. The operation of the relay 75 interrupts the energizing circuit of the impulse responsive relay 74 which releases and in turn causes the operation of the relay C1, as previously described. The release of relay 80 disconnects positive battery from conductor 91 which permits relay 90 to operate in series with the locking circuit of relay 62. This circuit may be traced from the negative pole of battery, winding and front contact of relay 62, winding of relay 90, conductor 92 and upper front contact of relay 72 to the positive pole of battery.

In the event that the registration of the hundreds digit has not been completed at this time, then the hundreds transfer relay 59 will not be operated with the result that there will be a short circuit around the relay 75 to prevent the operation of this relay and consequently the sending out of the impulses corresponding to the hundreds digit until this digit has been recorded on the hundreds register. The mentioned short circuit for the relay 75 is traceable from the positive pole of battery at the wipe-out key W. O., conductor 43, armature 94 and front contact of the sender relay 41, conductor 95, uppermost armature and back contacts of the units transfer relay 57, the tens transfer relay 58 and of the hundreds transfer relay 59 (which is assumed not to be operated), front contact and armature of relay 60, front contact and armature of relay 90, conductor 96, upper front contact and armature of the relay 81 and also the lower front contact and armature of this relay to one terminal of the winding of relay 75, the other terminal of this winding being also connected to the positive pole of battery, through the front contact and armature of relay 72, and through the back contact and armature of relay 76.

When the polarized relay 47 moves to the left, the impulse responsive relay 74 is again operated and causes the release of the relay CX, as previously described. The relay 47 will continue to swing its armatures alternately to the right and to the left as above described and as it does so it transmits impulses to the distant office over the impulse circuit including the conductors 84 and 85. During this impulsing, the counting relay chain will continue to operate and release its relays in succession until it has counted off the number of impulses corresponding to the relays 2A and 2C operated in the hundreds register as a result of recording the hundreds digit #6 therein. When the counting

relay C7 operates, following #6 impulse, it connects ground potential to change-over relay 76, and thereby stops the sending of further hundreds digit impulses over the impulse circuit, including conductors 84 and 85, as will now be set forth. When the polarized relay 74 operates its armatures toward the right, it effects the closure of the impulse conductors 84 and 85 to end the sixth impulse of the hundreds series. Also, with the armatures of the polarized relay in their right-hand positions, the release of the impulse responsive relay 74 is effected, its circuit being interrupted at armature 47b. When the impulse responsive relay 74 releases, it closes an energizing circuit for the counting relay C7, from the negative pole of battery, winding of relay C7, front contact and armature of relay C6 and thence through the lowermost back contacts and armatures C5 to CX inclusive, front contact and armature of slow-releasing relay 77, back contact and armature of the impulse responsive relay 74, to the positive pole of battery. Change-over relay 76 is now operated from the negative pole of battery, winding of this relay, armature and back contact of relay 80, conductor 87, armature and back contact of relay 80, armature and front contact of relay 59, armature and front contact of relay 2A, armature and back contact of relay 2B, armature and front contact of relay 2C, conductor 100, uppermost front contact and armature of relay C7 and thence through the back contacts and armatures of relays C8 to C11 inclusive, to the positive pole of battery. When the change-over relay operates, it interrupts the holding circuit of the relays 81 and 75 which release. Since the impulse responsive relay 74 has released for a relatively long interval, the slow-releasing relay 77 will also release. This, in turn, effects the release of the counting relays C7 and C6. With the change-over relay 76 operated and with the counting relays C6 and C7 released, slow-releasing relay 80 will be operated from the negative pole of battery, winding of this relay, front contact and armature of relay 76, uppermost back contacts and armatures of relays CX to C11 inclusive, to the positive pole of battery.

When relay 80 operates, it effects the energization of the relay 69 in a circuit that extends from the negative pole of battery, winding of this relay, upper armature and back contact of relay 102, front contact and armature of relay 90, conductor 91, front contact and armature of relay 30, upper front contact and armature of relay 72, to positive pole of battery. With the relay 69 thus operated, it closes a locking circuit for itself in series with the relay 102 which later results in the operation of the relay 102, after the measuring off of the intra-digit impulses for providing the intra-digit pause. This circuit is completed from the negative pole of battery, winding of relay 69, its front contact and armature, winding of relay 102, conductor 92, front contact and armature of relay 72 to the positive pole of battery. Before the release of relay 80, relay 102 is short circuited by the positive pole of battery on conductor 91. The hundreds transfer relay 59 will have one of its operating circuits interrupted at the lowermost back contact and armature of relay 69. However, the relay 59 will release only if the tens transfer relay 58 has been operated as a result of the complete registration of the tens digit by the operator, since otherwise, relay 59

will be maintained operated over a circuit completed at an armature and back contact of relay 58, conductors 83 and 43, to the positive pole of battery at wipe-out key W. O. Of course, when the tens transfer relay is energized, it interrupts the locking circuits for the operated hundreds register relays 2A and 2C.

On the next operation of the polarized relay 47 to the left, after the operation of the relay 80, the impulse responsive relay 74 will be operated. The impulse responsive relay 74 causes the slow-releasing relay 77 to operate, which in turn causes the relay CX of the chain to be operated. The chain of counting relays will then be operated in succession, to effect a delay between the hundreds digit and the tens digit, the interval being terminated by the operation of the counting relay C3, as already described. Relay C3 causes the change-over relay 76 and the relay 80 to release again in preparation for the transmission of the tens digit. If at this time the tens digit has been registered, the tens transfer relay 58 will then operate and the transmission of the tens digit impulses will take place over the impulse circuit including the conductors 84 and 85, in the manner previously described. In the course of transmitting these tens impulses, the counting relay chain will operate until its relay C4 is energized. With relay C4 operated, the change-over relay 76 will be operated in a circuit extending from the negative pole of battery, winding of this relay, armature and back contact of relay 80, conductor 87, back contacts and armatures of the thousands transfer relay 60 and of the hundreds transfer relay 59, armature and front contact of the tens transfer relay 58, armatures and back contacts of register relays 3A and 3B armature and front contact of relay 3C, armature and back contact of relay 3D, conductor 109, front contact and armature of relay C4 through the back contacts and armatures of the relays C5 to C11 inclusive, to the positive pole of battery. The change-over relay will lock itself operated as previously set forth. As a result of the operation of this relay, impulse responsive relay 74 will fail to operate and, in turn, will effect the release of the slow-releasing relay 77. Relay 77 effects the release of all the relays of the counting chain. Next, the relay 80 operates in the manner previously set forth. On the operation of relay 80, the relay 110 (Fig. 2) will operate in the same manner as relay 69, as described above. To effect a similar delay following the transmission of the tens digit impulses, the counting relay chain will operate its relays in succession, as previously described, until the relay C3 operates. Thereupon, change-over relay 76 and the relay 80 will be released again in preparation for the transmission of the units digit impulses, if the units transfer relay 57 has been operated, otherwise the apparatus will wait until relay 57 is operated.

Meanwhile, after the operator has completed the registration of the units digit, she operates the sender cut-off key 45. This interrupts the locking circuit which has held the relay 41 operated. The release of relay 41 frees the key set from sender #1 which has been in use. The release of relay 41, at its lower armature and front contact, extinguishes the signal lamp 46 to indicate to the operator that the key set has been disconnected from sender #1. Since the relay 41 is released, it is possible to use sender #2 at once to handle the next call without waiting for the #1 sender to finish the impulsing in

accordance with the designation stored in the #1 sender.

It will be assumed that the units digit is #0 and that impulsing is in progress on this last digit of the wanted line designation to the stage where the ninth impulse has been completed. When the polarized relay 47 operates to the left to start the tenth impulse of the units digit, relay 74 is operated thereby and the relay 47 at its armature 47a opens the impulse circuit to start the tenth impulse, counting relay C9 releases but counting relay C10 is now in its operated position. When the polarized relay 47 operates to the right, the impulse circuit including the conductors 84 and 85, is closed to end the tenth impulse. Also, the impulse responsive relay 74 of the sender releases and counting relay C11 of the chain will operate as a result thereof. Change-over relay 76 will now be energized from the negative pole of battery, winding of relay 76, back contact of relay 80, conductor 87, back contacts and armatures of the transfer relays 60, 59 and 58, armature and front contact of transfer relay 57, armatures and back contacts of relays 4A and 4B, front contacts and armatures of relays 4C and 4D, conductor 103, upper front contact and armature of relay C11 to ground. Relay 76, on operation, effects the release of the relays 81 and 75, sender impulse responsive relay 74 will remain released long enough to effect the release of the relay 77. When relay 77 releases, it causes the release of the counting relays C10 and C11. With the change-over relay 76 operated and with the counting relays all released, the relay 80 is again energized from the negative pole of battery, winding of this relay, front contact and armature of the change-over relay 76 through the back contacts and armatures of the relays CX to C11 inclusive, to the positive pole of battery. When the relay 80 operates, it effects the energization of the relay 106 which closes a locking circuit for itself which is effective after relay 80 releases and which is then in series with the relay 107 and over the conductor 92, in the manner previously described. Also, when the relay 106 operates, it interrupts the circuit of the transfer relay 57 and of the operated register relays causing these relays to release.

At this time, the switching relay 13 associated with the cord circuit disconnects this cord circuit from the sender and closes break points in this circuit. The operating circuit for the switching relay 13 extends from the negative pole of battery, winding of this relay, outer armatures and front contacts of finder relays 31 and 32, conductor 112, armature and back contact of relay 41, conductor 113, back contacts and armatures of the transfer relays 57, 58, 59 and 60, conductor 87, front contact and armature of the change-over relay 76, front contact and armature of the relay 72, conductor 42, outer front contact and armature of relay 37, conductor 43, to the positive pole of battery at the wipe-out key W. O. Also, at the time of operation of the switching relay 13, it opens the circuit of the cut-off relay 12 of the cord circuit, and also the holding relay 37 of the sender causing these last named relays to release. It will be recalled that the locking circuit of the relay 72 of the sender has been maintained operated at the right-hand front contact and armature of the holding relay 37. Thus, when relay 37 releases, it effects the release of relay 72. All of the operated relays in sender #1 and in the finder that was used are restored

to their released condition. A discharging resistance is placed across the condenser 114. Thus, the #1 sender is in condition to handle another call whenever the common key set is available. It should be pointed out that the operation of the wipe-out key W. O. will restore the operated registers of the operated registers of the sender to its normal condition so that it is possible to start over again if any mistake has been made in the recording of a wanted line designation.

It will be noted that relays 41 and 41a of senders #1 and #2 are inter-locked so that the operation of either one of these relays prevents the operation of the other. The four register control conductors leading from the keys are connected in multiple to contacts of all sender relays, like relay 41, in order that these keys can control the register relays in any register as determined by the particular sender relay which is operated. The inter-lock prevents the connection of the keys to more than one sender at any one time.

In the previous description it was pointed out that relay 60 is operated when the first digit is recorded on the thousands relay register and that (A) relay 90 is operated following the transmission of the first digit and the pause thereafter. Also that (B) relay 59 is operated when the second digit is recorded on the hundreds relay register and that relay 60 is not released until both (A) and (B) have been effected.

Following the transmission of the second digit and the pause thereafter, (C) relay 102 is operated and (D) relay 58 is operated when the third digit is recorded on the tens relay register. Relay 58 is not released until both (C) and (D) have been effected. The same "hold off" is effected in connection with the third and fourth digits by means of relays 111, 58, 107 and 57. Consequently, impulse transmission is held off, if the operator delays operating the keys between digits, until after the previous digit and the pause thereafter.

What is claimed is:

1. In an automatic telephone system, a plurality of telephone lines, a plurality of switching devices selectively operated in response to several groups of impulses to interconnect said lines, an impulse circuit over which impulses are transmitted to said switching devices, register means comprising a plurality of selectively operated units for storing therein the several digits corresponding to a given selecting condition, impulse generating means including a polarized relay, means including a chain of counting relays successively associated with the units of said register and being arranged to count groups of impulses generated by said generating means, the number of impulses in the several groups corresponding to the digits stored in the respective storing units, and means including said chain of relays for governing the transmission of groups of impulses over said impulse circuit, the number of transmitted impulses in each group corresponding respectively to the number of impulses counted in each group by said relay chain.

2. In an automatic telephone system a plurality of telephone lines, a plurality of switching devices selectively operated in response to several groups of impulses to interconnect said lines, an impulse circuit over which said impulses are transmitted to said switching devices, register means comprising a plurality of selectively operated units for storing therein the several digits corresponding to a wanted line designation, means for generating impulses, means including

a chain of counting relays successively associated with the units of said register and being arranged to count groups of directive impulses generated by said generating means, the number of impulses in the several groups corresponding to the digits stored in the respective storing units, means including a given portion of said relay chain for counting a predetermined number of generated impulses to interpose a delay between each of said groups of directive impulses, and means including said chain of relays for governing the transmission of groups of directive impulses over said impulse circuit, the number of transmitted impulses in each group corresponding respectively to the number of directive impulses counted in each group by said relay chain.

3. In an automatic telephone system a plurality of telephone lines, a plurality of switching devices selectively operated in response to several groups of impulses to interconnect said lines, an impulse circuit over which said impulses are transmitted to said switching devices, register means comprising a plurality of selectively operated units for storing therein the several digits corresponding to a wanted line designation, means including a polarized relay for generating impulses, means including a chain of counting relays successively associated with the units of said register and being arranged to count groups of directive impulses generated by said generating means, the number of impulses in the several groups corresponding to the digits stored in the respective storing units, means including a given portion of said relay chain for counting a predetermined number of generated impulses to interpose a delay between each of said groups of directive impulses, and means including said chain of relays for governing the transmission of groups of directive impulses over said impulse circuit, the number of transmitted impulses in each group corresponding respectively to the number of directive impulses counted in each group by said relay chain.

4. In an automatic telephone system a plurality of telephone lines a plurality of switching devices selectively operated in response to several groups of impulses to interconnect said lines, an impulse circuit over which said impulses are transmitted to control said switching devices, a register sender comprising a plurality of digit storing units, means for selectively operating said units in succession to store therein digits corresponding to the designation of a wanted line, impulse generating means operating continuously, during the storing of digits in said units, means immediately responsive to the completion of the storing of a digit in the first unit of the sender for transmitting over said impulse circuit a number of impulses corresponding to the digit stored in said first unit, as well as normally continuing the transmission of groups of impulses corresponding to the digits stored in the remaining units, and means effective as a result of the delay in storing a digit in any of the succeeding units for preventing the further transmission over said impulse circuit of impulses generated by said generating means until such delayed digit is stored.

5. In an automatic telephone system a plurality of telephone lines, a plurality of switching devices selectively operated in response to several groups of impulses to interconnect said lines, an impulse circuit over which said impulses are transmitted to control said switching devices, a sender comprising a register for storing each digit

of a wanted line designation, a single set of individual digit keys for repeated operation in effecting the registration in said registers of the digits of a wanted line designation, transfer means for placing each register in succession under the control of said set of keys, impulse generating means operating continuously during the storage of digits in said sender to transmit groups of said generated impulses over said impulses circuit, and means including said transfer means for holding up the transmission of a group of impulses pending the operation of that one of the registers which determines the number of impulses to be included in said last mentioned group.

6. An impulse generator comprising a polarized relay provided with movable contacts and cooperating fixed contacts, certain of which contacts are adapted to generate impulses, said relay having at least a first winding and a second winding, the first winding when energized in one sense serving to move said movable contacts in one direction and when energized in the opposite sense serving to move said movable contacts in the opposite direction, circuits effective for alternately energizing said first winding in the mentioned senses, and means including a capacitance and said second winding for controlling the interval of energization of said first winding.

7. In a register sender, a plurality of register units for registering the number of a called line, a plurality of digit keys, a plurality of digit registering relays for each register unit less in number than the number of said keys, means responsive to the operation of different ones of said keys for operating the digit registering relays of each unit in different combinations, an impulse generating relay, an impulse responsive relay responsive to impulses generated by said impulse generating relay, a plurality of counting relays for counting the impulses generated by said impulse generating relay, means controlled by said impulse generating relay for impulsing a trunk line circuit to select said called line, test circuits selected by said digit registering relays and said counting relays, and means controlled by the selection of the same test circuit by said digit registering relays and said counting relays for stopping the impulsing of said trunk line circuit while said impulse generating relay continues to generate impulses.

8. In a register sender, a plurality of register units for registering the number of a called line, a plurality of digit keys, a plurality of digit registering relays for each register unit less in number than the number of said keys, means responsive to the operation of different ones of said keys, for operating the digit registering relays of each unit in different combinations, an impulse generating relay, an impulse responsive relay responsive to impulses generated by said impulse generating relay, a plurality of counting relays for counting the impulses generated by said impulse generating relay, means controlled by said impulse generating relay for impulsing a trunk line circuit to select said called line, test circuits selected by said digit registering relays and said counting relays, and means controlled by the continued operation of said impulse generating relay after the stopping of the impulsing of said trunk line circuit for causing said impulse responsive relay and said counting relays to measure off the required time interval between digits of said called line number.

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