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Switching Development

The originating dial pulse register circuit for the No. 5 crossbar system

The originating dial pulse register circuit receives information in the form of dial pulses from a calling subscriber's station and holds it for the marker to use in establishing a connection between the calling station and the line or trunk wanted. The connection between the register and line over which the register receives the dial pulses consists of three wires extended from the register circuit, through the contacts of crossbar switches of the trunk-link and line-link frames, to the line termination on the line-link frame. Two of the wires, the tip and ring, are extended over the outside line to the subscriber's station, and the third, the sleeve, is used for holding the switches in the operated position under control of the register circuit, and for other functions.

When the tip and ring connection has been established, there will be a series circuit consisting of the subscriber's instrument, the line wires, the two line windings of the dial tone transformer in the register, and a winding of the supervisory and pulsing relay L of the register, as shown in Figure 1. Relay L will operate in this circuit, and will cause the connection to be held, unless the subscriber abandons the call by "hanging up." The third winding of the transformer is connected to a source of tone, known as dial tone, which is thus transmitted to the calling station as a signal that the equipment is ready for dialing.

In most areas, the subscriber will dial a three-digit designation for the wanted central office, for example ME6 for Media 6, and then the four numerical digits of the wanted station. Three-digit or one-digit operator codes, such as 211 for the long-distance operator, and 0 for the assistance operator, may also be dialed. Variations in this pattern of digits will be described in a later article. During the return rotation of the dial, a contact opens the tip and ring circuit momentarily a number of times corresponding to the number dialed, once for one, twice for two, etc., up to ten times for zero. A governor controls the speed of the return stroke, so that these pulses occur at the rate of about ten per second. These pulses are counted by the relays at the bottom and right of Figure 1, and at the termination of a train of from one to ten pulses, this count is transferred to two of a group of five relays. The counting relays are then released and prepared for counting the pulses of the succeeding digit. A group of five relays is provided for each digit to be recorded, and thus for seven-digit numbers, seven groups of five relays would be required.

The register circuit is able to recognize the end of a digit by the fact that the dial contact remains closed for more than 0.2 second between digits (trains of pulses), whereas the closed period between the momentary openings of the dial contact within a train will always be less than 0.07 second. A slow-release relay, which will respond to the longer but not to the shorter of these intervals, is used for this purpose. Actuation of this relay causes the pulse count to be transferred to the group of five relays, the pulse counting relays to be released, and the circuit to be advanced so that the next pulse count will be recorded upon the succeeding group of five relays.

When all of the required digits have been recorded, the register engages a marker and transmits to it the called subscriber number or operator code. After the marker has se-

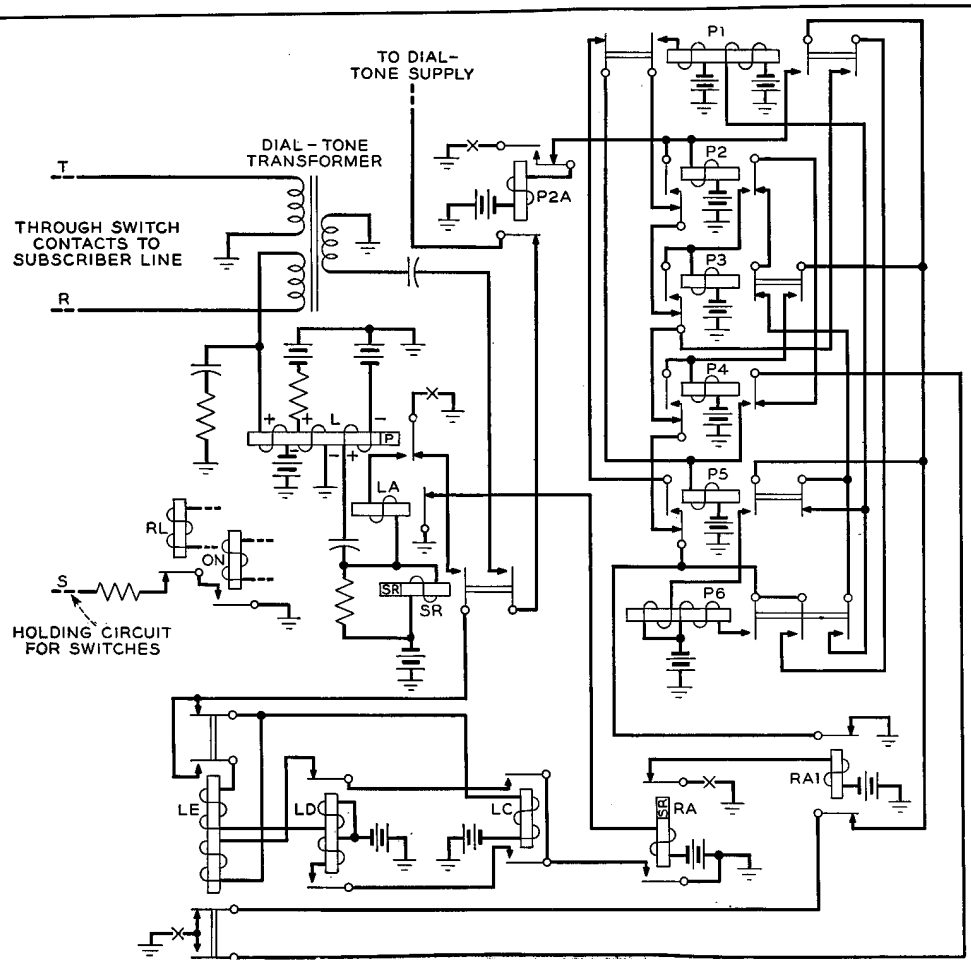

Fig. 1—Dial pulse counting circuit of the originating register.

lected a trunk in the wanted group and has decided what channel through the switches of the line-link and trunk-link frames to use for connecting the line to the trunk, it signals the register circuit to release its connection to the calling line, but it holds the connection between the register and marker so that the information recorded in the register circuit will be available until completion of the marker functions. It is necessary to release the line-to-register connection before setting up the line-to-trunk connection, because part of the apparatus is used for both connections.

When the desired line-to-trunk connection has been established, the connection between the register and marker is released, and both circuits restore to normal and are available for other calls. The register is used about fifteen seconds in the performance of its functions. This time is determined principally by the speed with which the customer dials the call. The marker takes a fraction of a second, determined principally by the time required for testing and selecting an idle trunk and channel and actuating the magnets of the crossbar switches.

Pulse counting is carried out by the LC, LD, LE, RA, RA1, and the six P relays of Figure 1. With the tip and ring wires connected together at the station, the L relay operates, operating the LA and SR relays. The latter is slow in releasing, so that it will remain operated when relay L releases momentarily during dialing, but will release and cause the connection to the line to release if the cus-

tomer abandons the call by replacing the handset. Each momentary opening of the dial contact during dialing causes relays L and LA to release and then reoperate.* The first release of relay LA operates relay RA, which is slow release and remains operated until LA remains operated for a long time—0.2 second or more—at the end of the series of pulses for a digit. In its operated position, relay RA provides a locking circuit for relays LC, LD, and LE and causes the release of RA1. With relay RA1 released, the locking circuits of relays P1 to P6 are established, and the circuit is ready for counting dial pulses. Reference to Figure 2 will help in understanding the following description.

Each momentary release of the L relay closes a circuit for actuating relays LC, LD, and LE. The first release of the L relay operates relay LC, and the reoperation of L causes relay LE to operate in series with LC. The second release of L operates LD and holds LE. Relay LD in operating causes LC to release. When L again reoperates, relays LD and LE release. The third pulse has the same action as the first and the fourth the same as the second. The significant fact is that relay LE is operated by each odd pulse, and released by each even pulse.

The first operation of LE operates relay P1, and the first release of LE operates P2, which releases P1. This operation continues in such a manner that at the end of any number of pulses, the relays will be operated in the pattern shown in Table 1 on the next page.

When a digit has been completed, relay RA releases, and through contacts not shown in Figure 1 but indicated at the left of Figure 3, connects ground to two of the five register wires as shown in Table 1. These five wires are connected through the contacts of the "steering" relays—shown in the upper part of Figure 3—to the five relays of the digit being recorded. The corresponding two relays are operated, thereby recording the number dialed in the standard two out of five code.

The release of relay RA also releases relays LC and LE, if they are operated, and then operates relay RA1, which in turn releases the P-relays, thereby preparing the circuit to count the pulses of the next digit.

Contacts of the RA1 relay, indicated in Figure 3, also control the steering relays, so that the five register wires will be advanced to the register relays of the following digit. This is accomplished in the following manner. Relay AS is operated when the register is selected. When relay P2A operates during the dialing of the first digit, relay EV operates and completes the circuits of the five register wires to the five relays of the A digit. When relay RA1 operates at the end of the first digit, one of its contacts operates relay BS via contacts of EV and AS. Another contact of RA1 provides a holding circuit for AS. When RA1 releases at the beginning of the next digit, the holding circuit of AS is opened, and AS releases, releasing EV. Relay BS remains operated in a circuit through a break contact of CS (not shown), and causes OD to operate through a break contact of EV. The five register wires are now switched into the register relays for the B digit. A similar action takes place for the following digits. The contacts of the operated register relays are used to inform the marker of the called

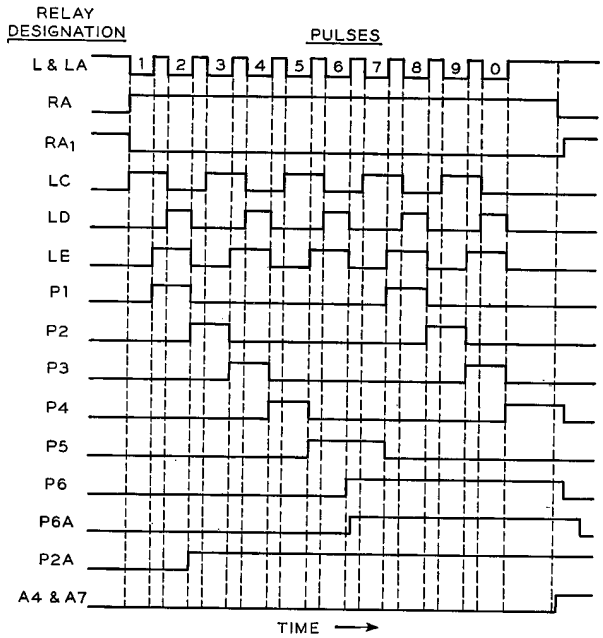

Fig. 2—Time diagram for the operation and release of the relays of Figure 1.

*A pulse correction feature associated with the L relay was described on page 32 of the RECORD for September, 1940.

office designation and subscriber number.

In addition to recording the designation of the wanted line or trunk, the register circuit must perform certain other functions. One of these is recording and remembering certain information with respect to the calling line. These are: its location on the switches, the class of service to which the customer subscribes, and the numerical designation of the linkage used in making the connection between the line and register circuit. This information is recorded on groups of memory relays in the register circuit when the marker is setting up the connection between the calling line and the register circuit, and at the completion of dialing this information is transmitted to the same or another marker for use in establishing the line to trunk connection.

The calling line location is required, so that the marker will know which line should be connected to the selected trunk. The class of service is required for several reasons. The type of station equipment may determine which of several trunk groups to the same destination should be used. Coin and noncoin stations, for example, usually require either different trunk equipments or a universal type of trunk equipment that can arrange itself for either kind of station upon signal from the marker. Another need for class of service is to restrict groups of lines with respect to the offices they are permitted to dial, depending upon their geographical location and the monthly charge for service, and for other purposes of a similar nature.

TABLE I—OPERATION OF THE P RELAYS OF FIG. 1 AND THE GROUNDING OF THE REGISTER WIRES 1, 2, 4, 7 AND 0 OF FIG. 3 THAT RESULT FROM SUCCESSIVE PULSES.

Pulse Number	*Relays Operated*	*Reg. Wires Grounded*
1	P1	0, 1
2	P2	0, 2
3	P3	1, 2
4	P4	0, 4
5	P5	1, 4
6	P5, P6, P6A	2, 4
7	P1, P6, P6A	0, 7
8	P2, P6, P6A	1, 7
9	P3, P6, P6A	2, 7
10	P4, P6, P6A	4, 7

The number designation of the linkage in use on the connection to the register is needed, so that the marker can consider this linkage to be idle when deciding what channel to use in connecting the line to the trunk. Although this linkage is actually in use when the marker selects a channel, it will become available when the register to line connection is released, just prior to establishing the trunk to line connection.

The register is also required to identify which of the parties on a two-party line is calling. In offices equipped with message registers, this information is used to cause the operation of the proper register of the two associated with the line, and in AMA offices it informs the AMA equipment which party is calling, so that the call can be charged to the proper station.

The two parties on a line are distinguishable from each other by dissimilarities in the station instruments. When the tip station is calling and its handset is raised, contacts in the instrument close a circuit from ground through a 1000 ohm ringer winding to the line wires. There is no similar connection at the ring station. The register, having been informed by the marker that the calling line is in the two-party service class, makes two tests to identify the calling station. One test is made before dial tone is transmitted to the calling line, and a similar test is made at the completion of dialing. The two tests are made to avoid errors which might be caused by accidental depression of the buttons that actuate the switchhook contacts, thereby removing the ground at the tip station. If the results of the two tests do not match, the marker will cause a trouble card to be perforated, and will cause the register circuit to transmit busy tone to the subscriber.

To prevent registers from being held out of service unduly long, due to the failure of subscribers or circuits to perform their required functions, each register circuit is provided with an electronic timing circuit, which causes the register circuit to take appropriate action if a function is not completed in a normal time. The principal functions thus timed are the interval required to

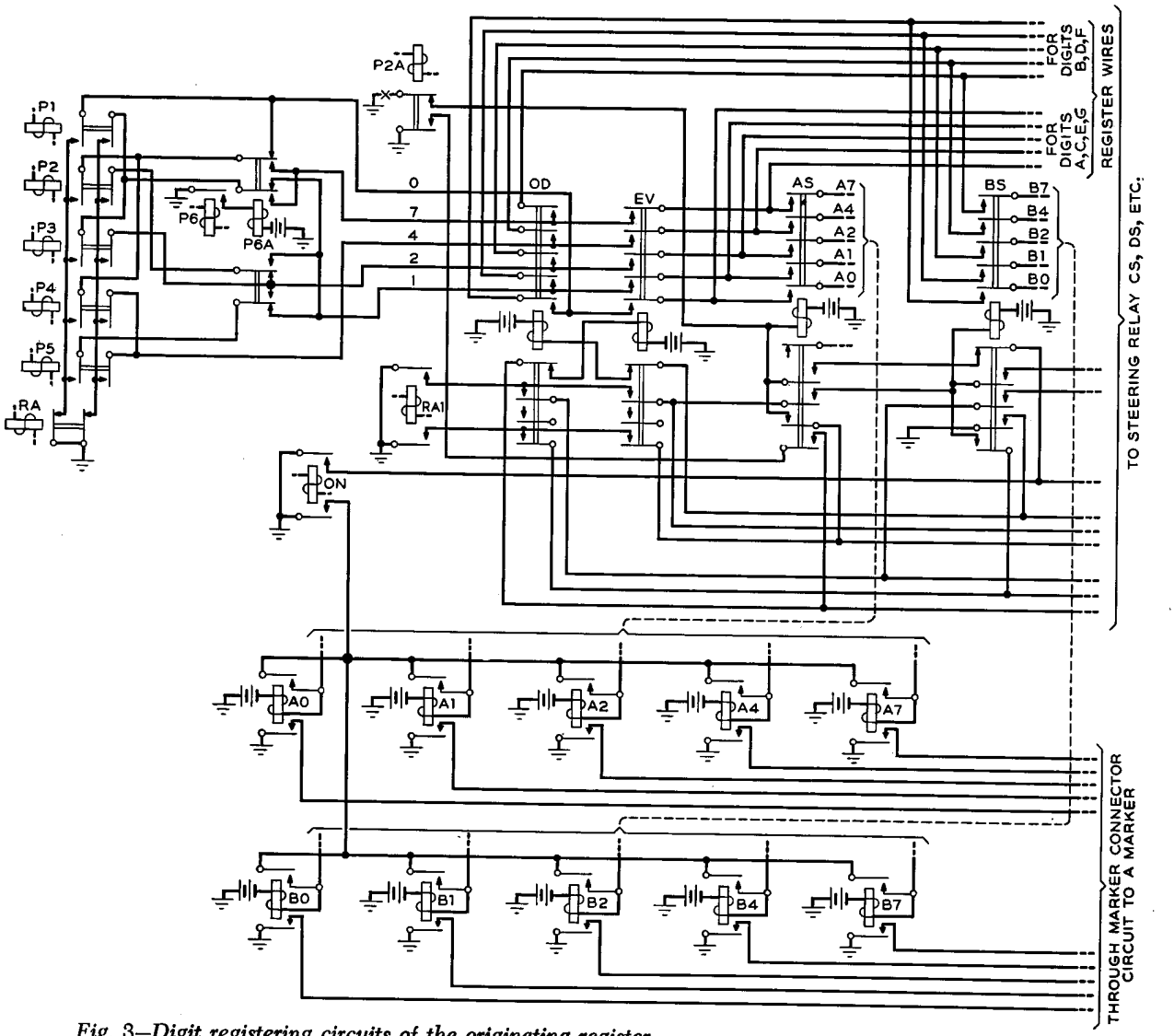

Fig. 3—Digit registering circuits of the originating register.

start dialing the first digit, the interval required for dialing each succeeding digit, and the interval required, after the completion of dialing, for completing the connection and restoring the register circuit to its normal condition.

About twenty-five seconds are allowed, after the register has been selected, for the subscriber to start dialing. If dialing is not started in this time, the register circuit requests a marker to connect the line to a permanent-signal holding trunk, and the register and marker are then released as on a normal call. In this manner the register is restored to useful service in a reasonable time even though a line gives a "permanent signal" due to the handset being accidentally off the cradle, or due to a line fault in the outside plant wires. An operator is signaled by the permanent-signal holding trunk, and means are provided for locating the line that is in trouble.

If the customer starts dialing within the time allowed, the timer is returned to its starting point and restarted. It is returned and restarted at the beginning of each digit,

and allows about twenty-five seconds from the beginning of each digit to the beginning of the next. If the subscriber dials insufficient digits, or dials too slowly, the register will request the marker to connect the line to a partial dial trunk, which will transmit a tone to the subscriber as a signal to reoriginate his call.

During traffic overloads, when there is a shortage of registers, some subscribers do not wait for dial tone, but start dialing before a register is attached to the line. As a result of this, some or all of the digits may not be received by the register. Also, due to accidents to the outside plant, a large number of lines may present permanent signals simultaneously, thus causing another kind of overload on the registers. In any case of register overload, the permanent signal and partial dial time intervals are reduced to about twelve, and six seconds, respectively. These intervals are sufficient for most people, and are used to restore the circuits to service quickly during overloads. During normal operation, the longer intervals are used to salvage those calls on which a customer is unusually slow.

When dialing has been completed, the timer is again restarted, and, if the connection has not been completed and the register restored to normal in about twenty-five seconds, the register will release the connection to the line and restore to normal. The subscriber will then receive dial tone from another register, and will have to dial again. It is expected that this action will not occur unless there is a fault within the register circuit or its associated circuits.