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TRAFFIC MANAGEMENT SYSTEMS
DIAL TONE SPEED REGISTER CIRCUIT
FOR USE IN DIAL OFFICES

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SECTION I - GENERAL DESCRIPTION

1. PURPOSE OF CIRCUIT

1.01 This circuit originates test calls on spare subscriber line circuits and thereby provides an indication of the percentage of calls on which dial tone is not received within 3 seconds.

1.02 This circuit can be used in any type of standard dial office and its capacity is 100 or 200 test lines, coin and non-coin. (For connections of line conductors to the arcs, see Note 103).

2. GENERAL DESCRIPTION OF OPERATION

2.01 The description that follows applies to both Fig. 1 (Mfr Disc.) and Fig. 12, unless otherwise specified.

2.02 The test can be started manually by operating a start key located on the unit or at a local or distant traffic register rack, or automatically by means of a program timer. For Fig. 1, it is also possible to start this circuit by operating a key associated with the Dial Tone Speed Indicating Circuit.

2.03 The tip and/or ring lead of spare subscriber line circuits is connected to terminals on arcs of 2.06-type selectors. When a test line is seized, a call is originated in the usual manner. In all offices except step-by-step equipped for TOUCH-TONE calling or common control, the dial tone speed register circuit responds to a coincident change of dc resistance when dial tone is received. In step-by-step TOUCH-TONE offices a dial tone detection circuit (Fig. 13) is employed to detect dial tone directly. In either case, the receipt of dial tone causes the circuit to release the line under test promptly. A timing arrangement controls the progression from one test terminal to the next, the interval being approximately 3 seconds in the case of Fig. 1 and exactly 4 seconds for Fig. 12.

2.04 All test calls are scored on a T register, and dial tone delays exceeding 3 seconds are scored on a D register. One pair of T and D registers can be provided for each arc (20 lines), but it is possible to group the scoring for several arcs on one pair of registers.

2.05 In order to provide flexibility in the assignment of test lines, this circuit (per Fig. 12) is capable of:

(a) A 4-second dwell on unassigned terminals without performing a test.

(b) Skipping one or more unassigned terminals by self-interruption of the step magnet of a selector, subject to certain restrictions, see 3.18.

(c) Bypassing whole arcs of a selector.

2.06 The same skip features, but not the dwell, are provided in the original circuit per Fig. 1. It is important to note that every terminal of a working arc must be (a) a working (assigned) terminal, (b) a skip terminal, or (c) a dwell terminal, depending on whether Fig. 1 or 12 is used. Any open terminal appears to the circuit as a working line, and a false dial tone delay will be scored each time the selector reaches such a terminal.

2.07 Release of the start key at any time will stop the test and return any off-normal selector to its normal position by self-interruption except where ZU option is provided. In this case, even though ground start is removed, the circuit will continue until it has completed a full round of tests.

SECTION II - DETAILED DESCRIPTION

1. GENERAL

HAND-OPERATED SWITCHES - FIG. 1 (MFR DISC.)

1.01 One hand-operated rotary switch is associated with each arc of selectors A and B. Each switch has six positions. The first five positions of each switch control the operation of the registers. The sixth position will cause the test circuit to skip the arc associated with that switch. Similar positions on each switch are multipled.

HAND-OPERATED SWITCHES - FIG. 12

1.02 One hand-operated toggle switch is associated with each arc of selectors A and B. Each switch has two positions. Position 1 is associated with a PA- (or PB-) punching which may be cross-connected to a TD- punching corresponding to a pair of registers. Operating the toggle switch to position 1 associates the arc of the selector with the selected pair of registers. Operating the toggle switch to position 2 causes the associated arc to be skipped.

REGISTERS - FIG. 1 (MFR DISC.) OR FIG. 12

1.03 A maximum of five sets of T and D registers are associated with each group of the hand-operated switches. The T register scores the number of tests made and the D register scores the number of calls which do not receive dial tone within 3 seconds.

1.04 Various arcs may be grouped together to cause registrations on common registers in the same group as follows:

(a) For Fig. 1, by setting the rotary switches in the desired position.

(b) For Fig. 12, first by making the proper cross-connections between the PA- (or PB-) and TD-- punchings, and then, by setting the toggle switches in position 1.

1.05 If necessary to have registers common to both the A and the B groups of switches, only five sets of registers can be used.

2. OPERATION OF CIRCUIT USING FIG. 1 (MFR DISC.)

DIAL TONE MEASUREMENT - FIG. 1 (MFR DISC.)

A. FAST Key Operated (Noncoin Line Tests)

2.01 If dial tone is received in less than a predetermined minimum interval, the line seized is released but the circuit will not proceed to test the next line until the end of this predetermined interval.

2.02 If dial tone is received in more than the predetermined minimum interval but less than 3 seconds, the line seized is released immediately, and the circuit is advanced to test the next line immediately.

2.03 In the first test cycle, if dial tone is not received within 3 seconds, the circuit waits until it is received. If it is received before 2 to 4 minutes, the line seized will be released immediately, and the circuit will advance to test the next line. The D register will operate to record that dial tone was not received within 3 seconds. If dial tone is not received within 2 to 4 minutes, an alarm is sounded.

B. FAST Key Normal

2.04 The function of the FAST key is to speed up the advance of the test selectors. When the FAST key is operated, the circuit advances at a predetermined minimum interval. With the FAST key normal, the advance is extended to 3 seconds.

START OF TEST (LOCAL CONTROL)

2.05 The operation of the start toggle switch or start key ST is not effective unless selectors A and C are normal. With selectors A and C normal and the start toggle switch ST operated, the S relay operates. If the ST key of Fig. 7 or 11 is operated instead of the ST toggle switch, the L relay operates to operate relay S. Relay S operated operates relay S1, and opens the operating circuits for relays P and CT. Relay S1 operated (a) opens the operating circuit for relay T, (b) operates relay S2, and (c) short-circuits capacitor T with the J resistor to remove any charge that may be on the capacitor. Relay S2 operated operates relay ST1 and opens the operating circuit of the S3 relay. Relay ST1 operated (a) locks under control of start key ST, (b) operates relays ST and A, and (c) provides ground to the biasing winding of relay T to hold armature contact 7 to back contact 4. Relay A operated causes an alarm to be sent in, see 2.29. Relay ST operated (a) locks under control of relay ST1, (b) supplies ground to arc C4 for operating the registers, (c) releases relay S, (d) provides ground for operating the S3 relay, and (e) provides ground for the T tube. Relay S released (a) releases relay S1, (b) operates step magnet A, and (c) provides operating ground for relay P. Relay S1 released (a) releases relay S2, (b) closes the circuit of test relays T and CT through to the line circuit to start line hunting, and (c) removes the short circuit from capacitor T to start the tube timing, see 2.08 and 2.09.

2.06 Relay S2 released operates relay S3 which, in turn, operates T register associated with arc A2.

2.07 The circuit now starts testing, and relays ST and ST1 are operated. Relay T or CT is connected to the line under test, register T and step magnet A are operated, tube T starts the test timing interval, see 2.08, and relay A starts timing for a stuck switch, see 2.29.

TIMING

2.08 With relay ST operated, operating ground is connected to the tube T. Capacitor T will start to charge in series with resistors B and B4, receiving its charge from potentiometer T and the mid-point of resistors N and N1. When the potential on capacitor T reaches approximately the same potential as the filament, the grid potential also approaches the filament potential and the tube becomes conducting from filament to plate, causing relay P to operate. With the FAST key normal, this time is approximately 3 seconds. With the FAST key operated this time can be varied by connecting strap 2 to various punchings B1 to B4 on the resistance unit. When strap 2 is connected to punching B1, the shortest time is obtained and this time can be increased by moving the strap to punchings B2, B3, or B4. The farther along the strap is moved, the longer the time becomes. When the strap is connected to punching B4, the time interval is approximately 1.5 seconds. Strap 2 governs the time when this circuit is used independently of the Dial Tone Speed Indicating Circuit. When the Dial Tone Speed Indicating Circuit is used, strap 1 (which is connected to punchings B1 to B4 in a similar manner to strap 2) governs the time.

2.09 When the Dial Tone Speed Indicating Circuit is used, the circuit through strap 2 is opened, and strap 1 is substituted. For an explanation of the tube timing and its calibration, see 5.01.

TESTING NONCOIN LINES

2.10 Relay T is used for testing noncoin lines. Relay T is connected in series with the battery winding of the line relay of the line under test causing the line relay to operate. Relay T does not operate at this time due to the high resistance of the line relay. When the line is found and the mechanical equipment is in position to send out dial tone, the line relay is disconnected and replaced by a lower resistance, thereby, causing relay T to operate. Relay T operated operates relay T1. Relay T1 operated (a) locks independently of relay T under control of relay S1, (b) disconnects relay T from the test lead, causing the mechanical equipment and relay T to release, and (c) provides an operating path for relay S when relay P operates.

A. FAST Key Normal - First Cycle

2.11 With the FAST key normal, the minimum speed of tests is 3 seconds. Should the T and T1 relays operate before the 3-second timing interval is over, the circuit waits until the end of this interval when relay P operates. Relay P operated operates relay S. Relay S operated (a) locks under control of relays S1 and S2, (b) operates relay S1, (c) releases the stepping magnet A, causing the A selector to step to the next terminal, and (d) opens the operating circuit of relay P which releases. Relay S1 operated (a) operates relay S2, (b) releases relay T1 and opens up the ground circuit to the T relay winding, and (c) discharges capacitor T through the 200-ohm resistor J. Relay S2 operated releases relays S and S3. Relay S3 released, releases register T. Relay S released (a) releases relay S1, (b) reoperates stepping magnet A, and (c) reconnects operating ground to the winding of relay P. Relay S1 released (a) releases relay S2, (b) removes the 200-ohm discharge shunt from capacitor T, causing it to charge, and (c) connects ground through the winding of relay T to the next line. Relay S2 released reoperates relay S3 which, in turn, reoperates the T register.

2.12 The circuit is now ready to test the next line. Assume that dial tone is not received within 3 seconds. In this case, when relay P operates at the end of the 3-second timing interval relay RC will operate since relay T1 has not operated. Relay RC operated (a) holds the stepping magnet A operated, (b) connects direct ground to the test lead to prevent relay T from operating and to keep a continuous circuit on the test lead, and (c) operates relays S and S2. Relay S operated operates relay S1 and releases relay P. Relay S1 operated discharges capacitor T through the 200-ohm resistor J. Relay S2 operated releases register T. Relay P released removes the short circuit from relay RC1 which now operates in series with relay RC. Relay RC1 operated (a) provides an operating path for relay D when relay P reoperates, (b) releases relay S, and (c) causes the tube T to fire, thereby reoperating relay P when relay S has fully released. Relay S released (a) holds relays RC and RC1 operated independently of relay T1, (b) holds the stepping magnet A operated independently of relay RC, (c) reconnects ground to the winding of relay P which operates, and (d) releases relay S1. Relay S1 released (a) removes the short circuit from relay T, permitting it to operate when dial tone is received, (b) removes the 200-ohm discharge resistor from across capacitor T. Relay P operated operates relay D which, in turn,

operates relay D1 which operates the D register. The circuit remains in this condition until dial tone is received or until relay A operates to give an alarm, see 2.29.

2.13 When dial tone is received, relay T will operate in turn operating relay T1. Relay T1 operated (a) locks independently of relay T under control of relay S1, (b) disconnects relay T from the test lead causing the mechanical equipment and relay T to release, and (c) releases relay D. Relay D released releases relay D1 which causes the D register to score. Relay S1 operated (a) holds relay S2 independently of relay RC, (b) releases relay T1, and (c) discharges capacitor T through the 200-ohm resistor J. Relay RC released releases stepping magnet A to step the switch to the next terminal. Relay P released releases relay S. Relay S released (a) releases relay S1, (b) reconnects operating ground to the winding of relay P, and (c) reoperates the A stepping magnet. Relay S1 released (a) removes the 200-ohm discharge shunt from capacitor T causing it to charge, (b) connects ground through the winding of relay T to the next line circuit, and (c) releases relay S2. Relay S2 released reoperates relay S3 which reoperates the T register. The circuit is now ready to test the next line.

B. FAST Key Operated - First Cycle

2.14 When the FAST key is operated the minimum speed of tests is governed by the connection of lead 2 to various punchings, B1 to B4, as described in 2.08. Should the T and T1 relays operate before the minimum timing interval is over, the circuit operates the same as described for when the FAST key is normal. Assume that dial tone is received after the first timing interval but before 3 seconds. In this case, when relay P operates at the end of the first timing interval, relay RC will operate since relay T1 has not operated. Relay RC operated (a) holds the stepping magnet A operated, (b) connects direct ground to the test lead to prevent relay T from operating and to keep a continuous circuit on the test lead, and (c) operates relays S and S2. Relay S operated operates relay S1 and releases relay P. Relay S1 operated discharges capacitor T through the 200-ohm resistor J. Relay S2 operated releases register T. Relay P released removes the short circuit from relay RC1 which now operates in series with relay RC. Relay RC1 operated (a) provides an operating path for relay D from relay P should dial tone not be received before 3 seconds, and (b) releases relay S. Relay S released (a) holds relays RC and RC1 operated independently of relay T1, (b) holds the stepping magnet A operated independently of relay RC, (c) reconnects ground to the winding of relay P, and (d) releases relay S1. Relay S1 released (a) removes the short circuit from relay T permitting it to operate when dial tone is received, (b) removes the 200-ohm discharge resistor from across capacitor T causing it to charge. When dial tone is received before relay P operates the second time, relay T will operate, in turn operating relay T1. Relay T1 operated (a) locks independently of relay T under control of relay S1, (b) disconnects relay T from the test lead causing the mechanical equipment and relay T to release, and (c) causes the T capacitor to charge immediately and operate the tube T. This causes relay P to operate. Relay P operated operates relay S. Relay S operated operates relay S1 and releases relays P, RC, and RC1.

2.15 Relay S1 operated (a) holds relay S2 independently of relay RC, (b) releases relay T1, and (c) discharges capacitor T through the 200-ohm resistor J. Relay RC released releases stepping magnet A to step the switch to the next terminal. Relay P released releases relay S. Relay S released (a) releases relay S1, (b) reconnects operating ground to the winding of relay P, and (c) reoperates the A stepping magnet. Relay S1 released (a) removes the 200-ohm discharge shunt from capacitor T causing it to charge, (b) connects ground through the winding of relay T to the next line circuit, and (c) releases relay S2. Relay S2 released reoperates relay S3 which reoperates the T register. The circuit is now ready to test the next line.

2.16 Should it take longer than 3 seconds to receive dial tone, then, when relay P operates at the end of the 3-second interval and with relay T1 normal and relay RC1 operated, the D relay operates. Relay D operated operates the D1 relay which, in turn, operates the D register. The circuit remains in this condition until dial tone is received or until relay A operates to give an alarm, see 2.29. When dial tone is received, relay T operates, in turn, operating relay T1. Relay T1 operated (a) releases relay D, (b) locks independently of relay T under control of relay S1, (c) disconnects relay T from the test lead causing the mechanical equipment and relay T to release, and (d) provides an operating path for relay S when relay D releases. Relay D released operates relay S and releases relay D1 which, in turn, releases the D register. Relay D is slow release to insure operation of the D register. With relay S operated, the circuit now functions as described for an OK test call where dial tone is received between the first timing interval and 3 seconds.

CIRCUIT ADVANCE AFTER FIRST TEST CYCLE

2.17 During the first test cycle, the advance from one test terminal to the next requires the receipt of dial tone. If dial tone is not received, the circuit does

not advance and alarm is given after 2 to 4 minutes. However, at the completion of the first test cycle, ground from arc C2 operates relay E on its primary winding. Relay E operated locks on its secondary winding to ground on the start key and connects relay D2 in the circuit. The circuit functions on subsequent test calls in the same manner as described in 2.10 and 2.18 except that, if dial tone is not received within 3 seconds, the circuit does not wait but proceeds as follows. When relay D operated, it caused relay D1 and the D register to operate, and at the same time it operated relay D2. Relay D2 operated connects battery to operate relay T1 which now causes the circuit to function as on an OK test and advance the circuit to the next test terminal.

TESTING COIN LINES

A. Speed of Test

2.18 When control switch C selects an arc to which coin lines are connected for test, relay CN operates. With relay CN operated, the advance from one test to another is advanced to 3 seconds. Should the FAST key be normal at the time of testing, the operation of the CN relay performs no function.

B. Step-by-Step Offices

2.19 Coin lines in step-by-step offices requiring ground start are tested by using the noncoin test and furnishing Fig. 3 and 4.

2.20 The coin line circuits used for tests have ground disconnected from the tip. Both tip and ring are then connected to relay CL (Fig. 3 - one per line circuit). When the line is seized, relay CL operates connecting the tip to the winding of the LSC relay of Fig. 4. When the mechanical equipment is in a position for dialing, ground is connected to the tip operating relay LSC. Relay LSC operates relay T1 which opens the circuit to the test lead releasing relays CL and LSC and the mechanical equipment. The T relay does not function on this call, and the circuit functions as previously described for a noncoin line.

2.21 Coin lines in step-by-step offices requiring battery start are tested by using Z option. Battery start and ground start lines must not be mixed on any arc of selectors A or B.

2.22 Relay CT is connected in series with the ground winding of the line relay of the line under test causing relay CT to operate in series with resistor M and the line relay. Due to the high resistance of M, the line relay will not operate. When relay CT operates, relay CT1 operates. Relay CT1 operated short-circuits resistor M and places resistor AB in parallel with relay [illegible] causing the line relay to operate. With relays CT and CT1 operated, the T relay is short-circuited. When the line is found, the line relay is disconnected and replaced by a higher resistance thereby causing relay CT to release. Relay CT released removes the short circuit from the T relay which now operates. From this point on, the circuit functions as described in 2.10.

C. Panel and Crossbar Offices

2.23 In panel and crossbar offices, tests on coin lines are made in the same manner as noncoin lines except that the test interval is always 3 seconds.

2.24 In Crossbar No. 5 Offices:

(a) An error is introduced in measuring the dial tone delay time when observing on coin first coin lines. This error is brought about as follows: as soon as the originating register completes the coin test (which is a nonoperate condition for the test relay in the Dial Tone Speed Indicating Circuit), the dialing circuit is connected to the ring and is held by a 1500-ohm resistor to ground until the C2 relay releases. This condition satisfies the dial tone speed register circuit which will indicate that dial tone has been received. However, dial tone is not connected to the line until the C2 relay has released and removed the 1500-ohm ground. Consequently, the time error is equal to the releasing time of the C2 relay which is 0.16 to 0.34 second.

(b) Those lines with rate treatments requiring a reversal of polarity may not be assigned for dial tone speed testing.

VACANT TERMINAL TEST

2.25 Battery from the midpoint of resistor W through the VT relay is connected to all vacant terminals of arcs 2 to 6 of selectors A and B. When either selector A or B steps to a vacant terminal, relay VT operates but test relay T or CT does not operate due to the high resistance of relay VT. Since the stepping magnet is operated, the operation of relay VT operates relay VT1. Relay VT1 operated locks independently of relay VT and releases step magnet A or B and short-circuits the T capacitor with the J resistor to prevent the tube from timing. The stepping magnet released steps the selector to the next terminal and short-circuits relay VT1 which releases. Relay VT1 released reoperates the step magnet. If the next terminal is vacant, relays VT and VT1 again operate and the stepping continues as described until a working terminal is reached, in which case relays VT and VT1 will not reoperate and the step magnet remains operated until a test call is completed or the circuit is restored to normal. Relay S2 is held operated by relay VT so as to prevent a false operation of the T register.

ADVANCING TEST FROM ONE ARC TO ANOTHER

2.26 When selector A or B reaches terminal 21 ground from arc 1 will operate the C stepping magnet. Also since terminals 21 and 22 of selectors A and B are wired as vacant terminals, the A and B switches are moved off these terminals as described in 2.25. When selector A or B moves off terminal 22, the C stepping magnet releases thereby stepping the C switch to the next terminal. The next arc of selector A or B is now in a position to be tested or the testing is transferred to selector B, see 2.28.

BYPASSING OF ARCS

2.27 Should it be desired to bypass an entire arc, the manually operated switch corresponding to the arc to be bypassed is set on position 6. When the C selector steps to the terminal serving the arc to be bypassed, ground is connected through arc C4 and the manual switch to operate relay SKA. Relay SKA operated (a) self-interrupts the C selector magnet causing the C selector to step, (b) holds relay S2, (c) opens the circuit to test relays T and CT, and (d) short-circuits capacitor T to prevent the tube from timing. Relay S2 operated performs no function at this time. The C switch will continue to step until relay SKA releases.

TRANSFER OF TESTS FROM SELECTOR A TO SELECTOR B

2.28 When selector C moves to terminal 6 the VT1 and SW relays operate in series. Relay SW operated (a) opens the circuit of relay VT1 which releases, (b) locks independently of terminal 6 of selector C, (c) operates relay SWA, (d) connects ground to lead 5, and (e) transfers the stepping circuit ground of test relays RC and S from stepping magnet A to stepping magnet B. Relay SWA operated (a) transfers the alarm relays A and A1 from selector A arc 1 to selector B arc 1, and (b) connects terminals 21 and 22 of arc B1 to stepping magnet C. The alarm relays A and A1 now function for selector B as described for selector A. The operation of selector B is now the same as described for selector A.

STUCK SWITCH ALARM

2.29 When relay ST1 operates, it connects terminal 1 of arc A1 to the other odd-numbered terminals on that arc and connects terminals 21 and 22 of arc A1 to the step magnet of selector C. With selector A arc 1 on terminal 1, the circuit to relay A is closed. Relay A is very slow operate (2 to 4 minutes) and if selector A remains on terminal 1 for an abnormal time, relay A operates, in turn, operating relay AL which sends in an alarm and lights the DT alarm lamp. If selector A moves from terminal 1 to terminal 2 before relay A operates, then the circuit to relay A is opened when the selector leaves terminal 1 and when terminal 2 is reached, relay A1 operates and the circuit to relay A is again closed, this time in parallel with relay A1. Relay A continues to operate. If the selector stops on terminal 2 too long, the A relay will operate and bring in an alarm. When selector A steps from terminal 2 to terminal 3, the circuit to relays A and A1 is opened and both relays release. Relay A1 is slow release to keep the circuit of relay A opened so as to insure its completely release before being connected to terminal 3. The circuit now functions for subsequent odd and even terminals as described for terminals 1 and 2, respectively.

Note: If relay A operates on any odd terminal and brings in an alarm, the alarm may not be restored when the A selector steps to the next even terminal. This is due to the A1 relay operating before the A relay releases.

2.30 When the B selector is used for testing, the SWA relay operates. Relay SWA operated connects all odd-numbered terminals of selector B arc 1 to relay A and all even-numbered terminals to the winding of relay A1. The stuck switch alarm feature then operates for selector B in the same way as described for selector A.

REMOTE STARTING AND REGISTRATION

2.31 When the registers are located on a remote traffic register rack, Fig. 6 and 10 and Q wiring are furnished. The start key is also equipped per Fig. 7 or 11 or as shown on the Traffic Register Circuit. In this case, the circuit is started over the cable pair and registration on one set of registers is also done over the same cable pair as described below. Registration on other sets of registers is done over separate cable pairs also described below. Those classes of service which are to record their traffic on registers which are operated over the cable pair used for starting shall have their hand-operated switches set on position 1. Those classes of service whose hand-operated switches are set on positions other than position 1 will have their traffic recorded on registers associated with other cable pairs. When the ST key is operated, ground is connected through relays D and T of Fig. 6 to the ring and tip causing relays D and T and also the L relay to operate. Relay L operated performs the same function as the local start key ST, and the test circuit now operates as described in 2.05 to 2.07 except that the RR relay operates when relay ST of Fig. 1 operates and the C selector reaches a position where the associated hand-operated switch is turned to position 1. With relays T and D operated, relay ST

of Fig. 6 operates. Relay ST of Fig. 6 operated locks under control of the ST key independently of relays T and D. When the S2 relay of Fig. 1 releases, relay T of Fig. 6 releases thereby operating the T register. Therefore, at the beginning of each test, relay T and register D are released and relay D and register T are operated. When a test is completed, the S2 relay of Fig. 1 operates operating the T relay of Fig. 6 causing the T register to release. When dial tone is not received within 3 seconds, relay D of Fig. 1 operates releasing relay D of Fig. 6 operating the D register.

2.32 When traffic is to be recorded on registers associated with separate cable pairs, the circuit functions as described in 2.10 and 2.18 causing the S3 and D1 relays to operate. However, the operation of these relays instead of operating the T and D registers directly will operate the T and D relays of Fig. 10 over the cable pair. These relays in turn will operate the T and D registers located on the remote traffic register rack.

DIAL TONE SPEED INDICATING CIRCUIT (MFR DISC.)

2.33 This circuit may be used with the Dial Tone Speed Indicating Circuit. When the start key in the Dial Tone Speed Indicating Circuit is operated, leads A and B are short-circuited, and ground is connected to lead ST to operate relay E. With relay E operated, ground on lead ST is connected to this circuit, and with leads A and B short-circuited, the functions of the ST key are simulated and the circuit functions as described in 2.05. Relay E operated also disconnects its primary winding from the ST1 lead and connects relay D2 in the circuit for use in advancing the circuit as described later. Also the initial timing circuit of the tube T is changed by opening lead F and closing lead F'. Ground is connected to lead H to light the R lamp of Fig. 8 as an indication not to use the lock-in feature, and ground is removed from lead J to make the operation of the SD key of Fig. 8 ineffective. When a test call does not receive dial tone within 3 seconds, the D relay operates in the usual manner. This operates relay D2 which connects ground to lead D which, in turn, causes the indicating circuit to indicate this condition. Relay D2 operated also connects battery to operate relay T1 to advance this circuit to the next line in the usual way. As the control selector C steps from terminal to terminal, ground from arc C2 is connected to terminals A2 to A6 and B2 to indicate to the indicating circuit which arc of selectors A and B are under test. Also when all arcs are tested, ground from arc C2 is connected to lead ST1 to indicate the end of a test cycle. When the indicating circuit is arranged for unit testing, the operation of the unit key will remove ground from lead K to prevent the operation of the [illegible] circuit. Also all nonoperated unit keys will cause ground from arc C2 terminals 1 to 10 to be relayed through the [illegible] circuit to lead L to operate the SX relay so as to skip testing of undesired arcs as determined by the setting of the unit keys. When prepay coin lines are tested, the D relay will be operated causing the advance of the register circuit to be extended to 3 seconds irrespective of the position of the FAST key.

RESTORING TO NORMAL

2.34 When the ST key of Fig. 7 or 11 is released, the L relay releases to release relay ST1. If, however, the ST toggle switch has been operated instead to start the test, the release of this switch causes relay ST1 to release.

2.35 In any event, relay ST1 released releases the ST relay to stop the test. The C selector self-interrupts to position 1 from ground at 2 and 3 top of ST1 relay. The A selector, if off normal, self-interrupts to terminal 1 from ground on brush feed of A1 arc through contacts of arc 1 and 10 and 9 bottom contacts of ST relay to interrupter spring of A step magnet. The B selector, if off-normal, self-interrupts to terminal 1 from ground on brush feed of B1 arc through terminals of arc 1 and normal contacts of the SA and SWA relay to interrupter spring of B step magnet.

ALARM LOCK-IN CIRCUIT - FIG. 8 (MFR DISC.)

2.36 The alarm lock-in circuit is a special test feature controlled by the SD key which locks-in any test where it takes more than 3 seconds to receive dial tone. This feature cannot be used when this circuit is controlled either from a traffic register rack or from the Dial Tone Speed Indicating Circuit. In these cases, the white lamp R is lighted and the operation of the SD key is ineffective. When this circuit is controlled locally, the ST key operated operates relay R. Relay R operated (a) provides a path for operating the AT relay when the D relay operates, (b) [illegible], as a locking circuit for relay R, and (c) provides a path for operating the T1 relay when the SD key is released. When a test call is made and it requires more than 3 seconds to receive dial tone, relay D operates in the usual way and locks under control of relay R and operates relay AL to bring in an alarm. Should dial tone be received after relay D has operated, relays T and T1 or CT, CT1, and [illegible] operate to dismiss the mechanical equipment but the circuit will lock until the SD key is released. When the SD key is released, relays D and R release, and the circuit now functions as described in [illegible]. If dial tone is not received and the SD key is released after relay T has operated, the T and R relays release, and shortly [illegible] release time of relay T the AT relay operates.

The circuit now functions in the usual way and advances to test the next line.

3. OPERATION OF CIRCUIT USING FIG. 12 - START CONTROL OPERATED

START OF TEST

3.01 The operation of the start toggle switch or the start ST key is not effective unless selectors A and C are normal. With selectors A and C normal and the start toggle switch operated, the S relay operates from ground at the A selector brush feed arc 1, 9 and 10 top normal contacts of the ST relay, brush feed and terminal 1 of the C selector arc 3, operate contact of the ST toggle switch, and 4 and 5 top normal contacts of the ST relay to the winding of the S relay. The start toggle switch ST operated, also operates relay E which cancels the blocking feature as described in 4. If an external start control is operated instead of the ST toggle switch, relay L operates. Operated contacts 3 and 4 bottom of the L relay parallel the contacts of the nonoperated ST toggle switch to operate relay S as previously described. Relay S operated operates the S1 relay and opens the operating circuits for relays P and CT. Relay S1 operated opens the operating circuit for relay T and operates relay S2. Relay S2 operated operates relay ST1 and opens the operating circuit for relay S3. Relay ST1 operated locks under control of the ST key, operates relay ST, and provides ground to the biasing winding of relay T to hold armature contact 7 to back contact 4. Ground from arc 1 of selector A through ST1 operated (4 and 5 top) is also used to activate the alarm arrangement under certain conditions. For a description, see 4.07 to 4.14. Relay ST operated (a) locks under control of relay ST1, (b) supplies ground to arc C4 for operating the registers, (c) releases relay S, and (d) provides ground for operating the S3 relay. Relay S released releases relay S1, operates step magnet A, and provides operating ground for relay P. Relay S1 released releases relay S2 and closes through ground or battery to the line under test when the ST2 relay operates under control of the 4-second cam of the Timer. Relay S2 released, operates relay S3 which, in turn, operates T register associated with arc A2. The circuit is now ready to test.

TIMING

3.02 The purpose of the cam timer is to start a call every 4 seconds and to check for a satisfactory test at the end of 3 seconds. If a satisfactory test is made, the dial equipment is released immediately but the test circuit does not advance until the condition is checked at the end of 3 seconds. On a satisfactory call, the T register scores and the circuit advances to the next line. If dial tone is not received within 3 seconds, both the T and D registers score, the line is released and the circuit advances to the next line. This is the general operation for all cycles except when the circuit is controlled locally by means of the TST key for a special maintenance test, see 4.

TESTING NONCOIN LINES

A. All Offices Except Step-by-Step Equipped for TOUCH-TONE Calling or Common Control

3.03 Ground start is used in testing these noncoin lines. Ground is provided through 5 and 4 bottom relay ST, 2 and 3 bottom relay SKA, 2 and 1 top relay S1, 1 and 2, bottom relay T1, 6 and 5 top relay VT3, ZZ wiring, 5 and 6 top relay ST2, primary winding relay T, arc 5 of selector C, through the cross-connect punchings to arcs 2-6 of selectors A or B, to the line relay to start the test. The line relay is operated, but relay T does not operate at this time due to the high resistance of the line relay. When the mechanical equipment is in a position to send out dial tone, the line relay is disconnected and replaced by a lower resistance thereby causing relay T to operate. Relay T1 will now operate and lock under control of relay S1. Relay T1 disconnects relay T from the test lead and causes the equipment being tested to release. Relay T1 also provides a path to operate relay S when relay P operates, see 3.06 and 3.07.

B. Step-by-Step Offices Equipped for TOUCH-TONE Calling or Common Control

3.04 Dial tone speed testing is conducted over both tip and ring to satisfy the loop closure required by the originating registers or TOUCH-TONE to dial pulse converters in such offices.

3.05 To start a test, ground is provided through 5 and 4 bottom relay ST, 2 and 3 bottom relay SKA, 2 and 1 top relay S1, 1 and 2 bottom relay T1, 6 and 5 top relay VT3, resistor RT (ZV option), 5 and 6 top relay ST2, primary winding relay T, arc 6 of selector C, through the cross-connect punchings to arcs 2-6 of selector A or B, over the ring conductor to operate the line relay. Dial tone, when received, is transmitted over the tip conductor, through arc 5 of selector C to the input of the dial tone detector. The dial tone detector TN relay will operate and cause relay T1 to operate. Operation of relay T is prevented by the current limiting resistor RT. The circuit advances as described in 3.03.

C. Dial Tone Received Within 3 Seconds

3.06 The 3-second cam of the Timer makes contact 3 seconds after the start of

the call and operates the P1 relay. P1 operated operates P, in turn, operating relay S which locks to the S1 and S2 relays. S operated (a) operates S1, (b) releases the A step magnet causing the A selector to step to the next terminal, (c) opens the operating circuit of relay P which releases, and (d) releases relay ST2. Relay S1 operated (a) operates S2, (b) releases T1, and (c) opens the ground to the T relay primary winding. The ST2 relay released also opens the ground to the T relay primary winding and closes a locking circuit for relay S2. Relay S2 operated releases S and S3. When S3 is released, the T register scores. Relay S released, (a) releases S1, (b) reoperates the A step magnet, and (c) reconnects ground to the P relay winding. Relay S1 released, closes in part the ground to the winding of relay T for testing the next line. The circuit is now ready to start the test of the next line when the ST2 relay is operated by the 4-second cam of the Timer.

D. Dial Tone Not Received Within 3 Seconds

3.07 The 3-second cam of the Timer makes contact 3 seconds after the start of the call and operates the P1 relay. P1 operated operates P which now operates relay RC since the T1 relay has not operated. RC operated (a) holds the A stepping magnet operated, (b) connects direct ground to the test lead to prevent relay T from operating and to keep a continuous circuit on the test lead, (c) operates relays S and S2, and (d) locks P1 operated. S operated operates S1 and releases P and ST2. S2 operated releases relay S3 which causes the T register to score. P released removes the short circuit from relay RC1 which now operates in series with relay RC. Relay RC operated, holds ground to the T relay winding when relay ST2 releases. RC1 operated releases S which reoperates P. Relay D now operates from ground on the ST key operated, through P operated, T1 and VT1 normal, and RC1 operated. D operated operates relays D1 and D2. Relay D1 operated operates the D register. D2 operated operates relay T1. T1 operated operates S, releases relay T and the line, and releases D. D released, releases D1 and D2. D1 released causes the D register to score. Relay S operated operates S1 and releases P and RC. RC released releases P1 and the A step magnet which advances the circuit to the next test line. Relay S1 operated releases T1 and releases S, in turn, releases S1. The circuit is now ready to test the next line when the 4-second cam of the Timer makes contact, operating the ST2 relay.

TESTING COIN LINES

A. Step-by-Step Not Equipped for TOUCH-TONE Calling or Common Control

3.08 Coin lines in this type office, which are tested by using ground start, require a Fig. 3 per line and a Fig. 4 per dial tone speed register circuit. Such coin lines have ground disconnected from the tip and both tip and ring are connected to relay CL (Fig. 3). The test operation is similar to that described for noncoin ground start.

3.09 When the line is seized relay CL operates connecting the tip to the winding of relay LSC (Fig. 4). When the mechanical equipment is in a position for dialing, ground is connected to the tip operating relay LSC. Relay LSC operates relay T1 thus opening the ground to the test lead. Relays CL, LSC, and the equipment under test release. Relay T does not operate during this test.

3.10 Coin lines to be tested battery start require ZJ option. Battery start lines must not be mixed on any arc of selector A or B with ground start lines.

3.11 Battery is provided through relay CT, resistor M, 3 and 4 top relay SKA, 12 and 11 bottom relay ST, 8 and 7 top relay S, 3 and 2 top relay VT3, 3 and 4 top relay ST2, 4 and 5 top relay T1, arc 5 of selector C, and an arc of selector A or B to the line relay. Relay CT operates. However, resistor M prevents the line relay from operating. Relay CT operated relay CT1. Relay CT1 operated short-circuits resistor M and places resistor AB in parallel with relay CT, permitting the line relay to operate. With relays CT and CT1 operated relay T is short-circuited. On connection of dial tone, the line relay is replaced by a higher resistance causing relay CT to release. In releasing relay CT removes the short circuit from relay T, allowing it to operate. The circuit advances as described in 3.03.

B. Step-by-Step Equipped for TOUCH-TONE Calling or Common Control

3.12 Coin lines assigned for dial tone speed testing, in this type office, must connect to arc 2 of selector A and/or arc 2 of selector B.

3.13 The circuit to seize the line relay and measure dial tone speed is similar to that described for noncoin lines, in 3.04 and 3.05, except that series resistors CA and/or CB increase the ground ring start resistance to approximately 1100 ohms. This total resistance satisfies the coin box trunk circuit ST relay check.

C. Panel and Crossbar Offices

3.14 In panel and crossbar offices, tests on coin lines are made in the same manner as noncoin lines. It is necessary, however, to impose the following restriction when assigning coin lines to the terminals of a particular arc: When a single

coin line requires multiple appearances on one arc, it is necessary to intersperse between each pair of such terminals at least one dwell terminal or one appearance of another coin line. Otherwise, the coin line just released on one terminal may be caught off-normal when a new call is started on the succeeding terminal because the coin control trunk has not released the coin line.

3.15 In Crossbar No. 5 Offices:

(a) An error is introduced in measuring the dial tone delay time when observing on coin first coin lines. This error is brought about as follows: as soon as the originating register completes the coin test (which is a nonoperate condition for the test relay in the Dial Tone Speed Indicating Circuit), the dialing circuit is connected to the ring and is held by a 1500-ohm resistor to ground until the C2 relay releases. This condition satisfies the dial tone speed register circuit which will indicate that dial tone has been received. However, dial tone is not connected to the line until the C2 relay has released and removed the 1500-ohm ground. Consequently, the time error is equal to the releasing time of the C2 relay which is 0.16 to 0.34 second.

(b) Those lines with rate treatments requiring a reversal of polarity may not be assigned for dial tone speed testing.

UNASSIGNED DWELL TERMINALS

3.16 The uniform spacing of 4 seconds between test calls enables this circuit to make a maximum of 900 tests per hour. In small offices, this number can be reduced by arranging the circuit to dwell on selected unassigned terminals without performing a test and without scoring the T register. This is accomplished as follows. All unassigned terminals of this kink will be connected to the VT lead, and the VT relay will operate when the selector encounters one of these terminals and the ST2 relay has operated. The VT relay operated will operate the VT1 relay and hold the S2 relay. The VT1 relay operated locks to the S relay normal. The circuit remains in this condition until the P1 relay is operated. When the P1 relay operates, the T1 relay is operated from battery through the V resistor, 5 and 4 top contacts of the P1 relay, and 4 and 3 bottom contacts of the VT1 relay. The T1 relay operated releases the VT relay. The P1 relay also operates the P relay which operates the S relay through the operated contacts of the T1 relay. The S relay operated (a) releases the ST2 relay which closes a locking circuit for the S2 relay and releases the P1 relay if operated, (b) releases the VT1 relay, (c) releases the A step magnet which advances the selector to the next terminal, and (d) operates the S1 relay. The S1 relay operated releases the T1 and S relays. The circuit is now ready to test the next line when the ST2 relay operates.

UNASSIGNED SKIP TERMINALS

3.17 The dial tone speed register circuit can be arranged to skip certain unassigned terminals without interfering with the normal 4-second spacing between test calls or dwells, and without scoring the T register. Such terminals shall be connected to the VT2 lead and may appear on any arc of selectors A and B subject to the following restrictions:

(a) Any individual terminal except the first and last of a working arc may be skipped without restriction.

(b) When 2 or more adjacent terminals are skipped, the next terminal in the sequence must be a dwell.

3.18 These restrictions do not apply when an entire arc is to be skipped as described in 1.02. The circuit action is as follows. When the 3-second cam of the Timer makes contact, the selector leaves the assigned or dwell terminal as earlier described in 3.03.

3.19 When the selector brush arrives at the first vacant terminal, relay VT2 operates. When S releases and with VT2 operated, relay VT3 will operate from ground on 4 bottom of S, through SKA normal (2 and 1 top) and ST1 operated (1 and 2 bottom). Relay VT3 operated (5 and 4 bottom) causes the step magnet of the selector to self-interrupt and advances the circuit to the next terminal. When the selector brush leaves the vacant terminal, relay VT2 releases reoperating the step magnet.

3.20 When the terminal is an individual unassigned terminal, the next one will be either a working or a dwell terminal. For this case, relay VT2 does not reoperate, and the VT3 relay releases. The step magnet is held operated through VT2 normal (5 and 3 top). When the 4-second cam of the Timer makes contact, the circuit proceeds to test the line connected to this terminal or to dwell on this terminal for 3 seconds without performing a test depending on the terminal.

3.21 If 2 or more adjacent terminals are to be skipped, assume that the selector has left the first and landed on the second. The VT2 relay immediately reoperates and

reconnects ground to one side of the VT3 relay winding. The VT3 being a slow-release relay does not release during the transfer time of the selector brush from the first to the second terminal. The reoperation of relay VT2 with relay VT3 held operated causes the step magnet to self-interrupt and advances the circuit to the next terminal. This circuit action is repeated for the remaining skip terminals in the sequence until the selector brush eventually reaches the dwell terminal in accordance with restriction mentioned in 3.17(b).

3.22 The reason for this requirement is best illustrated by considering a relatively long sequence of skip terminals. It is evident that some time during the stepping action of the selector, the 4-second cam of the timer will have made contact. This marks the start of a 3-second testing interval, and if the selector had landed on an assigned terminal, some part of that test interval would have been lost. Any possibility of error due to this effect has thus been eliminated by not making a dial tone test on the terminal immediately following the sequence of skip terminals.

3.23 In order to permit this circuit to continue its stepping action after the 4-second cam of the timer has made contact operating relay ST2, battery through 43,000-ohm resistor VT2 or VT2' is now connected to relay VT2 through make contacts of relays VT3 and ST2. For the path through resistor VT2' these contacts are: VT3 4 and 5 top and ST2, 5 and 6 top; for the path through VT2 resistor these contacts are: VT3 1 and 2 top and ST2 3 and 4 top.

3.24 When the dwell terminal is reached, relay VT3 releases and relay VT operates operating relay VT1. The circuit now functions as described in 3.16.

ADVANCING TEST FROM ONE ARC TO ANOTHER

3.25 When the A or B selector is advanced to terminal 20 for test, the PB relay is operated which energizes the C selector and grounds the alarm lead. When test is completed on terminal 20, the A or B selector is advanced to terminal 21 in the regular manner which releases the PB relay and the C selector step magnet which advances the C selector one step. The A or B selector spins to terminal 1 by self-interruption.

BYPASSING OF ARCS

3.26 When the C selector encounters a terminal of which the associated toggle switch is set in position 2, ground through 2 and 1 bottom of the ST relay and arc C 4 and the toggle switch is connected to the winding of the SKA relay. This operates and forwards this ground through 4 and 5 bottom of SKA and arc C1 to the interrupter contac[illegible]e 3 step magnet which spins the C [illegible]or off the terminal.

3.27 In the case of a Fig. 12 modified from a Fig. 1, the above operation is accomplished by setting the rotary switch, corresponding to the arc to be bypassed, to position 6.

TRANSFER OF TESTS FROM SELECTOR A TO SELECTOR B

3.28 When the C selector advances to terminal 6, the SW relay operates which operates the SWA relay which, in turn, transfers the stepping control and alarm leads to the B selector. This arrangement continues through terminal 10 of the C selector.

RESTORING TO NORMAL

A. Restore on Removal of Start Ground

3.29 The circuit restores to normal on removal of start ground on circuits not wired with option ZU. When start ground at the remote location is removed, relay L releases, in turn releasing relay ST1. If the test was started by the local start key, release of this key releases relay ST1.

3.30 Relay ST1 released, releases relay ST to stop the test. The circuit restores to normal as described in 2.34 for Fig. 1.

B. Complete Test Cycle on Removal of Start Ground

3.31 Circuits required to complete test cycle on removal of start ground will provide option ZU. This option is restricted to circuits where starting is controlled by a start key or a timer at a remote office or where starting is controlled by a timer in the local office.

3.32 When start ground is removed, relay L remains locked by ground from arc 2 selector C terminals 1 to 10. When selector C reaches position 11, relay L releases, releasing relay ST1. The circuit now advances as in 3.30.

DIAL TONE DETECTOR - FIG. 13

3.33 The dial-tone detector consists of a transistorized amplifier, detector, two pulse stretcher amplifiers, and a relay.

The TOUCH-TONE dial tone, 350 and 440 cps, applied to the input of this circuit results in operation of its tone relay TN.

3.34 An ac signal is coupled through capacitor C1 and is amplified by transistor Q1. Resistors R1 and R2 provide reverse bias for Q1, and R3 acts as a small feedback path and also provides temperature stabilization for Q1. The amplified signal at collector load resistor R4 is coupled through capacitor C2 to a clipper circuit made up of resistor R5 and varistor RV1. Varistor RV1 clips the positive and negative peaks from the ac signal so that the signal becomes a square wave of 0.6 volt peak amplitude. Capacitor C3 and inductor L1 form a filter while resistor R6 provides coupling. This filter is centerd at approximately 400 cps with a fairly sensitive bandpass ranging between 330 and 460 cps. A component of the dial tone, now contained in the square-wave output of varistor RV1, will pass through the filter with little loss and be applied to the base of transistor Q2. Resistors R8 and R7 form a voltage divider to provide a small reverse bias at the emitter of Q2. Transistor Q2 acts as a biased detector and responds only to negative peaks of the applied square wave which exceed the negative bias on its emitter. The output at the collector of Q2 is a series of ground pulses which charges capacitor C4 through resistor R9. Capacitor C4 discharges slowly through resistor R10 and the base of transistor Q3, turning Q3 on and holding for as long as pulses from Q2 continue to charge C4. Transistor Q3 on supplies -20 volt battery through resistor R12. Until this time, resistor R13 and varistors RV4 and RV5 formed a bias circuit to hold transistor Q4 off. Now, with transistor Q3 on, transistor Q4 turns on and provides a path to operate relay TN.

4. OPERATION OF CIRCUIT USING FIG. 12 - MAINTENANCE CHECK USING TEST KEY

GENERAL

4.01 When this circuit is controlled by the ST key, as described in 3., the circuit advances every 4 seconds in all cycles. This is to insure a consistent number of test calls for each hour of testing. There is, therefore, no provision in the circuit per Fig. 12 for checking the line circuits during regular operation for possible trouble conditions. This feature was provided in the original circuit per Fig. 1, whereby the circuit would block during the first cycle of operation on any line where dial tone was not received.

4.02 Using Fig. 12, it is necessary to make a maintenance check of the connected line circuits periodically during an off hour when no dial tone delays are expected. Use of the TST key for this test causes the circuit to block indefinitely if dial tone is not received, presumably because of a trouble. After 20 to 30 seconds (or 2 to 4 minutes, if the circuit is a Fig. 12 modified from a Fig. 1), a minor alarm will sound and the DT alarm lamp will light. The attention of the maintenance man is thus directed to a likely trouble condition such as an open terminal or a defective line relay.

START OF TEST

4.03 The circuit must be at rest when the TST key is operated to start the check test. The TST key operated operates relay TST which opens the operate path of relay E to prevent the sequence described in 3. Relay TST operated starts the circuit in the usual way by operating relay S. When dial tone is received within 3 seconds after a call is started, the operation is the same as described in 3.

DIAL TONE NOT RECEIVED WITHIN 3 SECONDS

4.04 The 3-second cam of the Timer causes relay P1 to operate 3 seconds after the start of the call. The T register will score, and when relay D1 has operated, the D register will operate ready to score when the line is released. For a detailed description of relay operations up to this point, refer to 3.09.

4.05 The circuit remains in this condition and waits for dial tone. The cam timer keeps rotating but performs no functions.

4.06 If dial tone is received after 3 seconds but before the alarm sounds, relay T will operate, in turn, operating relay T1. Relay T1 operated releases the dial equipment and relay T. It also releases relay D, in turn, releasing relay D1 which causes the D register to score. The D relay released operates relay S. S operated operates S1 and releases relays P, RC, and RC1. The release of RC causes the A step magnet to release, thereby advancing the circuit to the next test line. The release of RC also causes P1 to release. Relay S1 operated releases T1 and S which causes S1 to release. The circuit is now ready to test the new line when the 4-second cam of the timer operates. Operation of the 3-second cam of the timer between seizure of the new line and the operation of the 4-second cam is ineffective.

STUCK SWITCH ALARM

4.07 When dial tone is not received within 20 to 30 seconds after a call is started (2 to 4 minutes for circuits modified from Fig. 1 to Fig. 12), a minor alarm is sounded, and alarm lamp DT will light. Should dial tone be received after this interval, the circuit will cause the D register to score, release the line, silence the alarm, and advance to the next line.

4.08 Assuming that the alarm persists, maintenance action should be taken. The arc and terminal number of the line in trouble should be noted, and the TST key released to return the circuit to normal. The trouble should be cleared immediately, but if this is not possible, the terminal in trouble should be disconnected from the line and temporarily strapped to the VT2 lead. This causes the terminal in question to be skipped when the TST key is reoperated, allowing the test to proceed.

Caution: Be sure the trouble is cleared and the line circuit reconnected before the next regular period of operation.

4.09 A timing arrangement, consisting of a thermal relay A and a magnetic relay A2, governs the delay time of 20 to 30 seconds. Since this interval depends on the cooling time of the thermal relay A, the reset time of the arrangement is negligible.

4.10 The heater of thermal relay has a heating period of 5 to 15 seconds and a constant cooling period of 15 seconds. Should a selector step from one terminal to the next just at the end of the heating period, then an alrm will be sent in after a 15-second dwell on this last terminal, being the cooling time of the heating element of relay A. It is expected that this condition will not often be encountered so that under actual operating conditions an interval of 20 to 30 seconds is required before an alarm is sounded.

4.11 The circuit action is as follows. When relay ST1 operates, it connects terminal 1 of arc A1 to the other odd-numbered terminals on that arc. With selector A arc 1 on terminal 1, the operate path to relay A through its heating element (terminal 2-3) is closed. Almost immediately hereafter, contact 1-8 of relay A opens. At the end of the heating period, contact 5-7 closes. This action operates relay A2, from ground on arc A1 through relay A1 normal (contact 3-2), winding of relay A2, relay A operated (contact 5-7), and the AL resistor to battery. Relay A2 operated locks independently of relay A under control of A1. Contact 2-3 top of A2 opens the operate path for relay A and its heater starts to cool. At the end of the cooling period, contact 1-8 of the A relay recloses. Relay AL now operates from ground through 1-2 bottom of TST, through 1-8 of A, and 4-5 top of A2. Relay AL operated sends in an alarm and lights the DT lamp.

4.12 When the selector brush leaves terminal 1 before relay AL is operated, relay A2 releases during the transfer time from this terminal to the next. Relay A2 released opens the operate path of AL. When the brush arrives on terminal 2, relay A1 operates. The operate time of this relay insures relay A2 is released before an operate path is again connected to relay A. With relay A operated, the heater of A heats [illegible] until 5-7 of A closes, allowing A2 to operate. Relay A2 operated starts the cooling period, and when the selector remains on terminal 2 long enough to permit contact 1-8 of A to reclose, an alarm will be sent in when AL operates. Should the selector step to terminal 3 before relay AL operates, the same description applies as for the transfer from terminal 1 to 2, only now the slow release of A1 insures that relay A2 is released before an operate path of relay A is again closed through terminal 3 of the selector. For subsequent odd and even terminals, the circuit functions are as described for terminals 1 and 2, respectively.

4.13 Once an alarm is sent in, this condition is maintained as long as the selector remains on that terminal. Relay A2 is locked operated under control of relay A1, so relay AL is held operated. When the selector leaves this terminal, the alarm is restored because of the release of relay A2 which releases AL.

4.14 When the B selector is used for testing, the SWA relay operates. Relay SWA operated connects all odd-numbered terminals of selector B arc 1 to relay A and all even-numbered terminals to the winding of relay A1. The stuck switch alarm feature then functions for selector B in the same way as described for selector A.

5. SPECIAL FEATURES

PREVENTING FALSE START CONDITION IN CROSSBAR

5.01 In crossbar No. 1 offices, the CB relay of Fig. 5 is furnished. This relay operates under control of the T relay. When dial tone is received, the T relay will operate. However, the T relay in this case does not operate the T1 relay directly but releases the CB relay, and after the CB relay releases, the circuit to relay T1 is closed. The circuit now functions as described above. The slow-release CB relay is used to insure a minimum closure to the crossbar system before opening the test lead so as to prevent simulating a false start condition and bringing in a time-out condition in the crossbar system. When testing 2-party message rate line circuits, the tip side is grounded in order to prevent the operation of the test relay T until the 2-party test has been completed. This insures that the test circuit T relay does not operate until the sender L relay is connected.

REMOTE REGISTRATION

A. Start Control in Remote Office, Option ZU Not Provided

5.02 Under this condition start control, by start key or program timer, is installed at a remote location. Option ZU not provided permits the dial tone speed circuit to restore to normal on removal of start ground.

5.03 A Fig. 6 is provided at the remote location. The dial tone speed circuit is started and registration on one set of T and D registers is done over a single pair, leads T and R, connecting to Fig. 6. Also at the remote location a separate Fig. 10 is installed for each additional pair of registers required. Each Fig. 10 requires a cable pair.

5.04 Those classes of service, which are to record their traffic on registers which are operated over the cable pair used for starting, shall have their toggle switches TA- or TB-, operated to position 1, the corresponding PA- punchings cross-connected to punching TD1, and the corresponding PB- punchings cross-connected to punching TD6. When relay ST of Fig. 12 operates and the C selector finds a position where the associated toggle switch is cross-connected to punching TD1 or TD6, relay RR operates. For a detailed description of the operation of the relays per Fig. 6 and 10, controlling the start of this circuit and the operation of the remote registers, the reader is referred to 2.31.

B. Start Control in Remote Office, Option ZU Provided

5.05 Start control, by start key or program timer, is installed at a remote location. Under this condition a separate conductor is used for start control. At the remote location, a Fig. 10 is installed for each pair of registers required. Each Fig. 10 requires a cable pair. Providing option ZU will permit the dial tone speed circuit to complete its cycle on removal of start ground.

C. Timer in Local Office

5.06 When the program timer is installed at the local office the dial tone speed circuit may be wired with or without ZU option. At the remote location, a Fig. 10 is installed for each pair of registers required. Each Fig. 10 requires a cable pair.

6. MISCELLANEOUS

TIME CALIBRATION AND OPERATION OF TUBE CIRCUIT - FIG. 1 (MFR DISC.)

A. Reason for Calibration

6.01 The following variable factors enter into the 3-second interval provided by this circuit for measuring dial tone time (a) resistances associated with tube and T capacitor charging circuit, (b) capacitor T, (c) relay times entering into the 3-second interval, and (d) tube characteristics. Voltage is not a considerable factor because the major portion of the time (that produced by the tube circuit) is compensated for voltage to a large extent as will be explained.

B. Method of Calibration

6.02 The circuit should be calibrated with the circuit voltage between 48.5 and 50 volts. The following method of calibration may be followed:

(a) Operate CAL, FAST, and ST keys.

(b) With a stop watch, determine time it takes for the A selector to take 20 steps.

6.03 When Fig. 5 is furnished, this should be 60.8 to 61.8 seconds. When Fig. 5 is not furnished, this should be 59.2 to 60.2 seconds.

(a) If the time is greater than this, the potentiometer T should be turned counterclockwise; if less, clockwise.

(b) Repeat (a) until limits are met.

C. Operation of Tube Circuit

6.04 The operation of the tube timing arrangement is as follows. It is assumed that the CAL, FAST, and ST keys are operated and the circuit is in operation.

6.05 When S1 releases, it removes the 200-ohm shunt from the T capacitor. Since this resistance is low compared to the B resistors, the T capacitor may be considered as short-circuited with the 200-ohm shunt on, and therefore, having no charge. When the shunt is removed, the T capacitor changes from a negative potential received from potentiometer T to a positive potential received from the fixed potentiometer consisting of the filament circuit of tube T. The capacitor charges slowly since its charging current is supplied through the B resistors (400 k total). When the plate of capacitor T that is connected to the grid of the tube through resistor E reaches approximately the same potential as the filament, the tube will fire and conduct a current in its plate circuit which will operate relay P.

6.06 Since the voltage on the plate of capacitor T connected to the grid is directly proportional to the central office voltage after any given time and since the voltage of the filament is proportional to the central office voltage, the effect of the central office battery voltage on time balances out, except for the minor effect of the change in the grid to filament voltage for firing due to the change in plate voltage and filament current.

6.07 When the potentiometer slider is turned counterclockwise, (that is away from the battery end of potentiometer T), the voltage to which capacitor T must rise to fire the tube is reduced, and therefore, the time is reduced.

6.08 Resistor D limits the current in the plate circuit of the tube to a value which will not damage the tube. Resistor

C prevents the plate of the [illegible] attaining potentials while the [illegible] circuit is open which might cause [illegible] operation of the tube when the plate circuit is closed.

D. Theory of Calibration

6.09 When the P relay operates (after S1 released and the tube fired), it operates RC, S, and S1 in cascade; and S1 operated releases S and S1 in cascade. While S is operated P releases, RC1 operates, and selector A operates. When S releases, RC and RC1 release. The T capacitor is discharged with S and S1 operated. Therefore, when S1 releases, the cycle repeats.

6.10 It will be noted that the total time per cycle during calibration consists of the following individual times: Tube operates with 400 k in series with the T capacitor + P operate + RC operate + S operate + S1 operate + S release + S1 release.

6.11 As was described previously, the following operation occurs during the time the circuit is timing a 3-second delay interval in actual operation. Assume that W wiring is used and lead 2 is connected to punching B3.

6.12 The S1 relay released closes the circuit to the line relay and removes the shunt from the T capacitor which starts charging in the same circuit as that described above in connection with the calibration cycle except that the series resistors are B, B1, and B2 which total 150 k instead of 400 k. When the capacitor charges to the same value as the circuit was set for when calibrated, the tube fires and operates P. P operates RC, S, and S1 in cascade, and S1 releases S and S1 in cascade whereupon capacitor T starts charging as before except in series with 250 k because the RC1 relay is operated. (During the time S and S1 were operated, P released and capacitor T was discharged.) When the tube operates a second time, P operates operating the D relay (assuming T1 has not operated) and a delay will be registered.

6.13 It will be seen from the foregoing that the time required to register a delay is as follows: First tube time (150 k) + second tube time (250 k) + P operate + RC operate + S operate + S1 operate + S release + S1 release + P operate + D operate. This time should equal 3 seconds + T operate + CB release + T1 operate because after dial tone is received, these three relays must function before D operates in order to prevent a delay indication.

6.14 It should be noted that in both the calibration time cycle and the service condition cycle for measuring the 3-second delay, the following times are common: P operate + S1 operate + S release + S1 release. Let the sum of these times = K. Then, the following equations may be written:

(a) Tube time (400 k) + K = Time of calibration cycle = T_c.

(b) First tube time (150 k) + second tube time (250 k) + K + P operate + D operate = 3 + T operate + CB release + T1 operate.

If C =

T operate + CB release + T1 operate - P operate - D operate then equation B may be written:

(c) First tube time (150 k) + second tube time (250 k) + K = 3 + C.

6.15 To reduce these equations further, the following fact is used. With everything else equal, the time for capacitor T to reach a potential which will cause the tube to fire is directly proportional to the charging resistance. From this, it follows that first tube time (150 k) + second tube time (250 k) = Tube time (400 k) = T.

6.16 Obviously with the arrangement used in the circuit, T will always be the same regardless of the B punching to which lead 2 is connected because the resistance used for the first tube time plus the resistance used for the second tube time equals 400 k. (When the FAST key is normal, the first tube time is T and the second is approximately zero.

Therefore,

$T + K = T_c$

$T + K = 3 + C$

$T_c = 3 + C$

C is a constant determined by relay characteristics to be +0.065 second when the CB relay of Fig. 5 is furnished and -0.015 second otherwise.

6.17 To get the time to be allowed for 20 steps, both sides of the equation are multiplied by 20 and we get.

$T_{20} = 20 \times 3.065 = 61.3$ seconds when Fig. 5 is furnished

$T_{20} = 20 \times 2.985 = 59.7$ seconds otherwise

Allowing 1/2 second tolerance, the time limits then become 60.8 to 61.8 seconds when using Fig. 5 or 59.2 to 60.2 seconds otherwise.

SECTION III - REFERENCE DATA

1. WORKING LIMITS

1.01 When operating on remote control basis, D and T relays Fig. 6 and 10 and L relay Fig. 1.

(a) Maximum External Conductor Loop / Earth Potential

1880 ohms	±20 volts
2560 ohms	±15 volts
3260 ohms	±10 volts
3940 ohms	± 5 volts
4600 ohms	0 volts

(b) Minimum insulation resistance is 30 k.

1.02

Type of Office	Max Cond Res in T or R Lead*
Step-by-Step	Between this circuit and first select, 2-party M.R. trunk or prepay coin box trunk - 45 ohms
Panel	Between this circuit and subscriber sender - 35 ohms
Crossbar No. 1	Between this circuit and subscriber sender - 50 ohms
Crossbar No. 5	Between this circuit and original register - 50 ohms

1.03 In crossbar No. 1, panel, and step-by-step offices, this circuit (except Fig. 6 and associated Fig. 2, 7, 9, and 10) and all central office equipment which it tests shall be located in the same building.

1.04 In crossbar No. 5, this circuit (except Fig. 6 and associated Fig. 2, 7, 9 and 10) and all central office equipment which it tests shall be operated from the same battery.

2. FUNCTIONAL DESIGNATIONS

None.

3. FUNCTIONS

Note: Unless otherwise specified, the functions listed apply on both Fig. 1 and 12.

3.01 To start the test manually by operating a start key on the unit, one associated with a local or distant traffic register rack, or one associated with the Dial Tone Speed Indicating Circuit (the latter for Fig. 1 only).

3.02 To start the test automatically under control of a program timer, Fig. 12.

*Maximum Conductor Resistance includes resistance of any relay in T and R lead between circuits mentioned.

3.03 To provide variable test timing intervals, Fig. 1.

3.04 To provide a constant timing interval of 4 seconds, Fig. 12.

3.05 To test coin or noncoin lines.

3.06 To register total number of calls made on each arc.

3.07 To register number of calls made on each arc which do not receive dial tone within 3 seconds.

3.08 To provide for individual registration on each arc or common registration for several arcs.

3.09 To cancel registration when used with the Dial Tone Speed Indicating Circuit, Fig. 1.

3.10 To operate registers on local or distant traffic register rack.

3.11 On the first test cycle, to give an alarm when dial tone is not received within 2 to 4 minutes and, on subsequent test cycles, to advance the circuit to the next terminal at the end of the 3-second interval when dial tone is not received, Fig. 1.

3.12 To advance the circuit to the next terminal at regular 4-second intervals, Fig. 12, ST key controlled.

3.13 To advance the circuit to the next terminal only when dial tone is received, and when dial tone is not received within 20 to 30 seconds, to give an alarm Fig. 12, TST key controlled.

3.14 To lock in test calls that require more than 3 seconds to receive dial tone and to prevent the circuit from advancing, Fig. 1.

3.15 To control the advance of the circuit to the next terminal after it has been locked in, Fig. 1.

3.16 To light a guard lamp when the circuit is being used with the Dial Tone Speed Indicating Circuit or by the remote control circuit, Fig. 1.

3.17 To make the alarm lock-in ineffective if the circuit is used with the indicating circuit or the remote control circuit, Fig. 1.

3.18 To advance the circuit to the next terminal after recording has been made by the indicating circuit, Fig. 1.

3.19 To change minimum advancing time when used with the indicating circuit, Fig. 1.

3.20 To provide means for calibrating the tube timing circuit, Fig. 1.

3.21 To bypass an entire arc of selector A or B.

3.22 To skip unassigned terminals, Fig. 1.

3.23 To provide for a 4-second dwell on unassigned terminals without performing a test, Fig. 12.

3.24 To skip any single unassigned terminal except the first and last of a working arc without restriction, Fig. 12.

3.25 To skip 2 or more successive unassigned terminals with the restriction that the terminal immediately following the sequence of skip terminals, be a dwell terminal.

3.26 To restore circuit to normal on removal of start ground.

3.27 To provide for completion of test cycle on removal of start ground (option ZU), Fig. 12.

4. CONNECTING CIRCUITS

4.01 When this circuit is listed on a key-sheet, the connecting information thereon is to be followed:

REGISTER CIRCUITS

(a) Panel

(1) Battery Central Office - Miscellaneous Register Circuit - SD-21537-01.

(2) Ground Central Office - Miscellaneous Register Circuit - SD-20141-01.

(b) Step-by-Step - 355A - Miscellaneous Alarm Circuit (Reg.) - SD-31976-01.

(c) No. 1 and 350A

(1) Traffic Register Circuit - SD-31109-01 or SD-30896-01.

(2) 360A - Traffic Register Circuit - SD-31265-01.

(d) Crossbar No. 1

(1) Traffic Register Circuit - SD-25317-01 or SD-25942-01.

(2) No. 5 - Traffic Register Circuit - SD-25892-01.

OTHER CONNECTING CIRCUITS

(e) Panel Line Switch Circuit - ES-207698.

(f) Panel Line Circuit - ES-207196, SD-21715-01, SD-21712-01.

(g) Step-by-Step Subscriber Line Circuit - SD-31777-01 or SD-32133-01.

(h) Step-by-Step Line Switch Circuit - SD-31644-01 or SD-31259-01.

(i) Crossbar No. 1 Subscriber Line Circuit - SD-25003-01.

(j) Dial Tone Speed Indicating Circuit - SD-96419-01.

(k) Crossbar No. 5 Line, Line Link, and Connector Circuit - SD-25548-01.

(l) Alarm Circuits - SD-21203-01, SD-31573-01, SD-31548-01, SD-31209-01, SD-96188-01, SD-31980-01, SD-31970-01, or SD-25761-01.

(m) Timer (as provided).

(n) Line Concentrator Control Circuit - SD-94815-01 or SD-96536-01.

SECTION IV - REASONS FOR REISSUE

B. Changes in Apparatus

B.1 Removed

CN resistor, 18BJ - Fig. 12
TT resistor, 19EY - Fig. 12
F network, 177A - Fig. 12

B.2

Removed	Replaced by
VT2 resistor 43 K (KS-13491,L1) - Fig. 12	VT2 resistor 3.9 K (KS-13491,L1) - Fig. 12
VT2' resistor 43 K (KS-13491,L1) - Fig. 12	VT2' resistor 3.9 K (KS-13491,L1) - Fig. 12

B.3 Added

CA resistor 18AC - Fig. 13
CB resistor 18AC - Fig. 13
RT resistor 18AC - Fig. 13
TT resistor 18AC - Fig. 13
VTB resistor 39 K (KS-13491,L1) Fig. 12

D. Description of Changes

D.1 Resistors CN and TT are removed. These were added to Fig. 12 as ZV apparatus in issue 29AC.

D.2 In Fig. 4 all wiring designated ZV and ZZ is removed.

D.3 ZV wiring connections to selector C, arc 5, terminals 6-10 are removed. These connections did not appear in any CAD Fig.

D.4 New ZV and ZZ wiring options between contact 4T of relay VT3 and contact 5T of relay ST2 are added. Wiring option ZV, connecting to contact 3T of relay 3KA is reused. Option ZV is required for step-by-step offices equipped for TOUCH-TONE calling or common control and option ZZ is required for all other systems.

D.5 Resistors CA, CB, RT, and TT are added to Fig. 13. Resistors CA, RT, and TT connect to Fig. 12. Resistor CB connects to Fig. D.

D.6 Punchings TA2-6 and TB2-6 are added to Fig. 13 and are covered by new CAD Fig. 68 and 69.

D.7 Circuit Notes 119 and 120 are added and apply to step-by-step offices equipped for TOUCH-TONE calling or common control.

D.8 Network F is removed.

D.9 Resistors VT2 and VT2' are changed from 43,000 ohms to 3,900 ohms.

D.10 Resistor VTB, 39,000 ohms, is added at the winding of relay VT2.

D.11 Circuit Note 121 is added.

D.12 Equipment Note 204, step-by-step section, is changed.

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