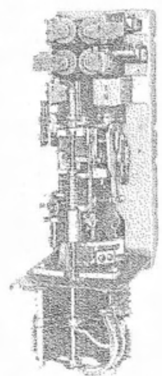
THE SELEC 808

AUTOMATIC ELECTRIC TRAINING SERIES | Bulletin **808**

The SELECTOR

STROWGER AUTOMATIC TELEPHONE SYSTEMS



AUTOMATIC ELECTRIC ®

ORIGINATORS OF THE DIAL TELEPHONE

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AUTOMATIC ELECTRIC TRAINING SERIES
on
STROWGER AUTOMATIC TELEPHONE SYSTEMS

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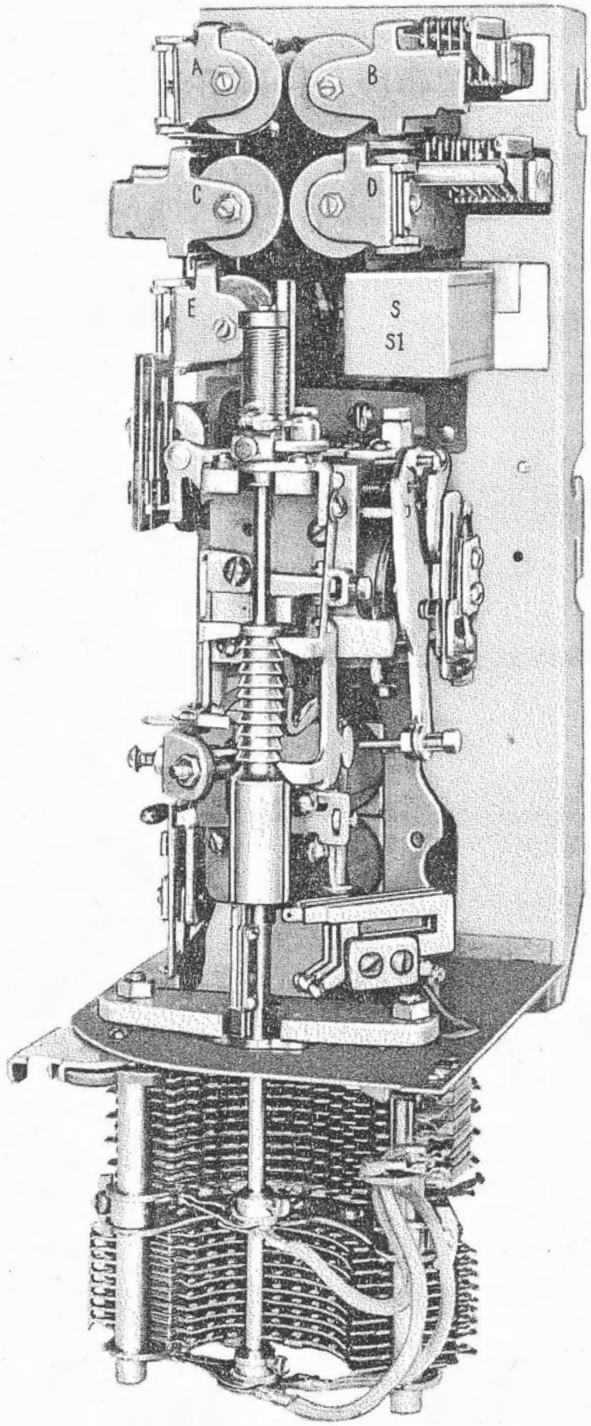

Figure 1. Typical selector.
(The one illustrated is the absence-of-ground-searching selector the circuit of which is shown in figure 3.)

THE SELECTOR

1. GENERAL

When the total number of terminals to be served by a Strowger Automatic exchange is greater than the terminal capacity of the connectors used, one or more selectors must be employed in the switch train by which each connection is set up.

Assuming that 100-terminal connectors are used, a single rank of selectors is required in a 1000-terminal system. The first digit dialed operates a selector to select the desired hundred-group of connectors. The selection of the particular terminal in the hundred-group of connectors (tens and units selections) is the function of the connector switch.

In a 10,000-terminal system, two ranks of selectors are required: the first is operated by the first digit dialed, and selects the thousand-group of trunks* which terminates in the second rank of selectors; the second rank of selectors is operated by the second digit, and selects the desired hundred-group of connectors in the thousand-group previously selected.

Similarly, in a 100,000-terminal system, the first selector in the train will select the desired office unit (comprising 10,000 terminals ultimate); the second selector, the desired thousand-group in that office unit; and the third selector, the desired hundred-group in the thousand-group previously selected.

The selector is a numerical type of group-selecting, trunk-hunting switch which requires but one digit for its operation. It is a two-motion switch employing a shaft which first is raised vertically and then is rotated horizontally. The pulses created by the dial control the vertical motion, which is the movement that selects the desired trunk group. The rotary motion is automatic, and is the trunk-hunting movement of the selector.

2. MECHANICAL ARRANGEMENT

A typical selector is shown in figure 1. The selector comprises a group of control relays mounted on a base on which are mounted also a frame supporting a shaft and a ratchet mechanism for raising and rotating the shaft. Affixed to the lower portion of the shaft are two sets of wipers, termed the "line" and "control" wipers. Mounted within the switch frame are the vertical and rotary stepping magnets, and the magnet which releases the ratchet mechanism and permits the shaft to return to normal when the connection is released. The number of vertical steps the wipers rise depends upon the number of pulses in the digit dialed, and the number of rotary steps the wipers take to the right depends upon the number of "busy" trunks encountered in the selected bank level.

The pulses for vertical stepping energize the vertical magnet, causing the vertical armature to operate and raise the shaft a corresponding number of steps, by means of a pawl affixed to the end of the armature engaging a toothed hub known as the "vertical hub". As soon as vertical stepping is completed, the rotary magnet automatically rotates the shaft until an idle trunk is found in the selected bank level. The automatic stepping motion of the rotary armature is transmitted to the shaft by means of the rotary pawl engaging a toothed hub known as the "rotary hub".

These stepping motions cause the wipers to engage contacts of a semi-cylindrical bank secured to the bottom of the selector. Referring to Figure 1, it will be observed that the bank contacts are arranged in two groups; the upper of the two is termed the "control" bank, and the lower, the "line" bank. A latch with two detents, termed the "double dog", holds the shaft and wipers in the position to which they have been stepped by the vertical and rotary movements.

The shaft is released by the release magnet, which, when energized, operates the release armature. This armature, striking a projection of the double dog, disengages both the vertical and rotary dogs from their respective toothed hubs, which permit the helical restoring spring to return the shaft counterclockwise to disengage the wipers from the bank contacts, and free the shaft hub from the stationary dog, whereupon the shaft drops to its normal position.

Except for the vertical and releasing actions, controlled by the telephone station, the operations of the selector are entirely automatic.

The banks shown in figure 1 really are part of the shelf on which the selector mounts. If a selector is to be removed from the shelf, remove the selector bank-rod nuts.

*American Institute of Electrical Engineers "American Standard Definitions of Electrical Terms" §65.55.100 defines a trunk as "a telephone line or channel between two central offices or switching devices, which is used in providing telephone connections between subscribers generally."

3. FUNCTIONS

The major functions of the selector, in the order in which they take place, are:

3.1 Immediately upon seizure, to hold all preceding switches in the train operated and guarded until the holding (control) circuit is completed to the next (succeeding) switch in the train.

3.2 If it is a unit in a first-selector group, to connect dial tone to the calling line.

3.3 To raise the shaft and wipers in response to pulses from the dial.

3.4 To find and connect with an idle trunk in the selected bank-level (rotary motion). This rotary motion comprises seven functions:

(a) To rotate the shaft automatically.
(b) To keep the line wipers disconnected during rotation.
(c) To test the trunks successively.
(d) To stop the rotary movement at the first idle trunk.
(e) To protect the trunk selected until the holding (control) circuit is completed by the next (succeeding) switch in the train.
(f) To extend the line through to the next (succeeding) switch in the train.
(g) To disconnect all bridges or attachments from the transmission circuit.

3.5 If all trunks in the selected level are engaged, to return an audible busy signal to the caller.

3.6 When the caller hangs up, to release without interfering with other trunks.

4. SELECTOR TYPES

Two basic types of selector circuits have been used widely for many years. The older is spoken of as the "absence-of-ground-searching" selector, a term which refers to the means of marking trunks idle to the switch as it hunts across a selected bank level. The newer type is known as the "battery-searching" selector, a term which also refers to the means of marking trunks idle to the switch.

An absence-of-ground-searching selector searches the trunk control-leads for absence-of-ground which marks a trunk idle and allows the selector to stop (§6.3 and §6.6).

A battery-searching selector seeks negative battery on the trunk control-leads (§5.3 and §5.4).

Busy trunks in both types of switchtrains are marked by ground on the control leads.

Because it is easier to understand, the battery-searching switch will be discussed first (§5). By addition of one relay and normal-post springs (Figure 4), either type can be made to absorb digits as discussed in §7.

5. BATTERY-SEARCHING SELECTOR

Figure 2 shows the circuit of a basic battery-searching selector for use in any selector rank. Dial tone is connected to first selectors only.

5.1 Seizure. When a battery-searching selector is seized, the preceding switch grounds lead C and connects the calling line and telephone across leads -LINE and +LINE.

> When the preceding switch is a linefinder, as soon as the finder starts hunting it connects a 500Ω non-inductive bridge across -LINE and +LINE to seize the selector until the calling line is found. As soon as the calling line is found, the finder removes the 500Ω bridge, and the calling line and telephone hold the selector.

The ground on lead C operates relay C, which, if this is a first selector, at make-before-break contacts 5-6-7 replaces direct ground with ground through a dial-tone transformer winding (not shown). Dial tone, induced into the winding, indicates to the calling line that the linefinder (or line switch) has finished its work and dialing may proceed. Dial tone is not provided in subsequent switches since the interdigital pause (time taken to pull a dial to the next desired digit) is long enough to allow a selector to hunt across and seize one of ten trunks on a level (§5.3).

Relay A operates through a circuit that includes a d-c loop and both its windings in series, and at contacts 2-3 completes a circuit to relay B.

Relay B operates, at contacts 6-7 closes what for the moment is an additional ground on lead C to hold the preceding equipment when it switches through (§5.4) and, if it is other than a first selector, to mark the switch busy to other searching selectors. The same ground also holds relay C through its winding No. 2.

5.2 Vertical stepping. The caller pulls the dial off normal and releases it. During the return to normal, the dial pulse springs open the loop the number of times indicated by the dialed digit. Relay A releases during each open period, at contacts 2-1 completes a circuit through relay B contacts 2-3 and relay C contacts 3-4 to the vertical magnet and to relay C. The copper sleeve on relay B keeps relay B operated even though relay A contacts 2-3 open its circuit momentarily.

The vertical magnet operates, elevates the shaft one step, and the wipers are in line with the first level of bank contacts. For each succeeding pulse, the vertical magnet reoperates and raises the shaft and wipers one step or bank level.

While the shaft is being elevated the first step, the vertical-off-normal springs are released mechanically. Vertical-off-normal springs 3-4 complete a circuit through relay B contacts 11-10, relay F contacts 2T-1T, cam springs 2-1,

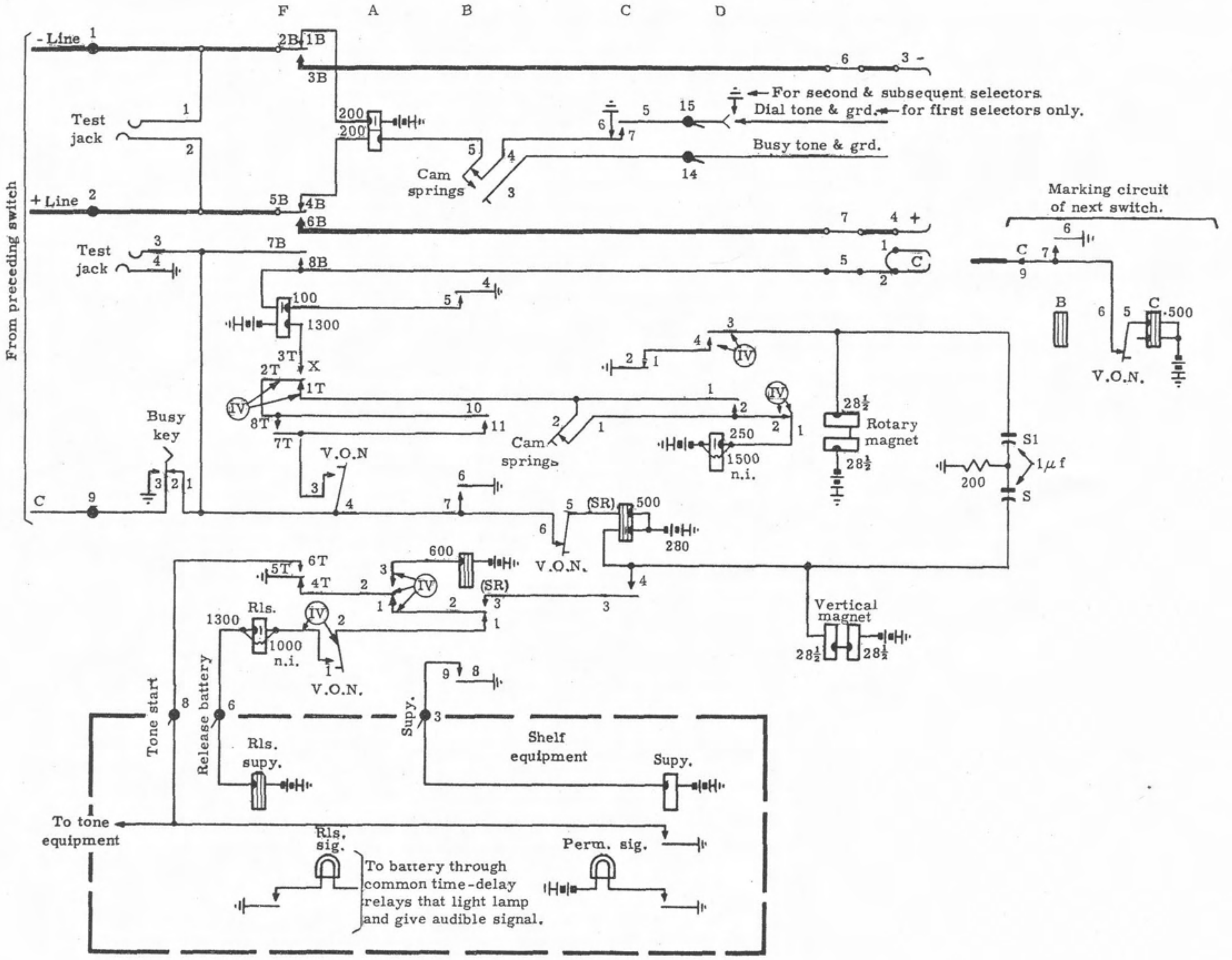

Figure 2. Battery-searching selector circuit.

and rotary-magnet interrupter springs 2-1 to relay D. Relay D operates, at contacts 2-1 short-circuits cam springs 2-1 to insure that an eleventh rotary step (if required) can be completed (§5.5), and at contacts 4-3 prepares a circuit for the rotary magnet. Vertical-off-normal springs 5-6 open the circuit of relay C winding No. 2.

The copper sleeve on relay C keeps relay C operated throughout pulsing, even though relay A contacts 2-1 open its circuit between pulses.

> If the calling line is relatively long (and has few parties) high line resistance limits current flow. Relay A when magnetized may be magnetized only weakly, releases quickly when the dial pulse-springs open, and reoperates slowly when they reclose. This gives relay C an extra-long pulse.
>
> On the other hand, if the calling line is relatively short, relay A when magnetized is magnetized strongly, releases slowly, and reoperates quickly, giving relay C a short pulse.
>
> Because relay A and relay C mount adjacent to each other, their magnetic fields interact. The other-than-usual connection of relay C (not ground, but negative battery connected to "in" terminals) causes the magnetic fields of relays A and C to augment each other. Thus when a long line magnetizes relay A only moderately, flux from relay C assists relay A. And when a short line magnetizes relay A so strongly that the pulse to relay C is short, the strong flux from nearby relay A adds to the magnetization from the Lenz'-law sleeve currents in relay C to help keep relay C operated between pulses.

5.3 Rotary motion. After relay A reoperates following the last open period, relay C releases, at contacts 5-6-7 removes dial tone from the calling line, and at contacts 2-1 completes a circuit through relay D make contacts 3-4 to the rotary magnet. The rotary magnet operates, rotating the shaft and wipers to the first set of bank contacts (trunk No. 1 of the level selected). Just as the rotary-magnet armature completes its stroke, it opens rotary-interrupter contacts 1-2, to release relay D.

If the first trunk of the level selected is in use, ground (or open) will be encountered while selector control wiper C rests on the control bank contact, and switch-through relay F cannot operate. Relay D releases, opening the circuit of the rotary magnet. As the rotary magnet starts to release, interrupter contacts 1-2 reclose the circuit of relay D and the stepping cycle is repeated until an idle trunk is found (§5.4) or all trunks test busy (§5.5).

5.4 Switch-through. Negative battery marks an idle trunk, completing a circuit to switch-through relay F when wiper C engages the control bank contact. Relay F operates, at contacts 1T-2T opens further the circuit of relay D to prevent additional rotary stepping, at "X" make contacts 2T-3T locks through its winding No. 2 through vertical-off-normal springs 4-3 and relay B contacts 10-11 to ground at relay B contacts 6-7, at make contacts 8T-7T and 7B-8B prepares a locking circuit over wiper C that will be completed when relay B in the next switch operates and returns holding ground, at contacts 1B-2B-3B and 4B-5B-6B disconnects relay A and extends the calling loop through to the next switch over wipers (-) and (+), and at break contacts 4T-5T opens the circuit of slow-release relay B. Note that "X" contacts (make that closes before all others) insure a locking circuit before ground at relay B contacts 6-7 short-circuits winding No. 1 through contacts 7B-8B.

The combined operate times of relays A and B in the next switch is much less than the release time of relay B in this circuit, thus insuring that ground will be returned over wiper C to hold relay F before the circuit is broken at relay B contacts 6-7.

Relays A and B release in this switch, and the next digit dialed steps the succeeding switch.

5.5 All trunks busy. If all ten trunks test busy, an eleventh rotary step is taken, at the start of which a cam attached to the shaft operates cam springs 1-2 to prevent relay D from reoperating after the eleventh step. Cam springs 3-5 make and 4-5 break to replace direct ground with ground through a busy-tone transformer winding.

5.6 Release. Before switch-through relay F operates, the release-magnet circuit is held open at relay A contacts 2-1 and at relay B contacts 2-1. If the caller hangs up before relay F operates, relay A and then relay B release, thereby completing the circuit of the release magnet. The release-magnet armature strikes the double-dog, disengaging its two detents from the vertical and rotary ratchets, thus permitting the shaft and wipers to return to their normal position.

When the selector has switched through, relays A and B are normal and the release-magnet circuit is open at relay F break contacts 5T-4T. When the calling party disconnects with the selector in this position, the open calling loop releases relay A in the last switch of the train (usually a connector if the call has been completed). The corresponding relay B releases, removing ground from control lead C to release all switches in the train. Switch-through relay F releases, and at contacts 5T-4T completes the circuit of the release magnet. Notice that make contacts 7T-8T open before contacts 2T-1T close, to prevent battery through relay D from marking the selector idle before it is completely released. Although when the final switch first removes holding ground from the control lead, battery through the 1300Ω of relay F winding No. 2 is connected through make contacts 2T-3T and 7T-8T to lead C, a switch-through relay in a switch hunting across lead C is not sensitive enough to operate from this 1300Ω battery. Finally, notice that relay F contacts 7T-8T disconnect relay F quickly from lead C even before "X" contacts 2T-3T open. This minimizes the possibility for relay F to reoperate if another selector, hunting, momentarily extends 100Ω ground to lead C.

Just before the shaft reaches its normal position, the vertical-off-normal springs reoperate. Springs 1-2 open the release-magnet circuit. Springs 5-6 re-connect battery through relay C winding No. 2 to lead C to mark the switch idle.

6. ABSENCE-OF-GROUND-SEARCHING SELECTOR

Another local selector is the absence-of-ground-searching switch shown in figure 3. It is similar to the battery-searching selector, in that it also has five relays, uses relay-interrupted rotary stepping, and has almost identical A, B, and C relays. It differs in that the switch-through relay has a single winding and is designed to operate from battery through the interrupter relay when not short-circuited by ground marking a busy trunk, the release magnet has contacts that ground lead C during release to give positive guarding, and relay C is not pre-energized over lead C. The mechanical arrangements are practically identical except that this absence-of-ground-searching switch has release-magnet springs.

6.1 Seizure. When an absence-of-ground-searching selector is seized, the seizing switch closes a d-c circuit across leads -LINE and +LINE. Note that, when idle, the switch is marked by neither ground nor battery on lead C and that even though the seizing switch (*linefinder* H-75311 or similar) does ground lead C, relay C is not operated thereby.

Relay A operates, and at contacts 2-3 completes the circuit of relay B.

Relay B operates, at contacts 4-5 grounds lead C to mark the switch busy and to hold the preceding switches, at contacts 6-7 completes the circuit

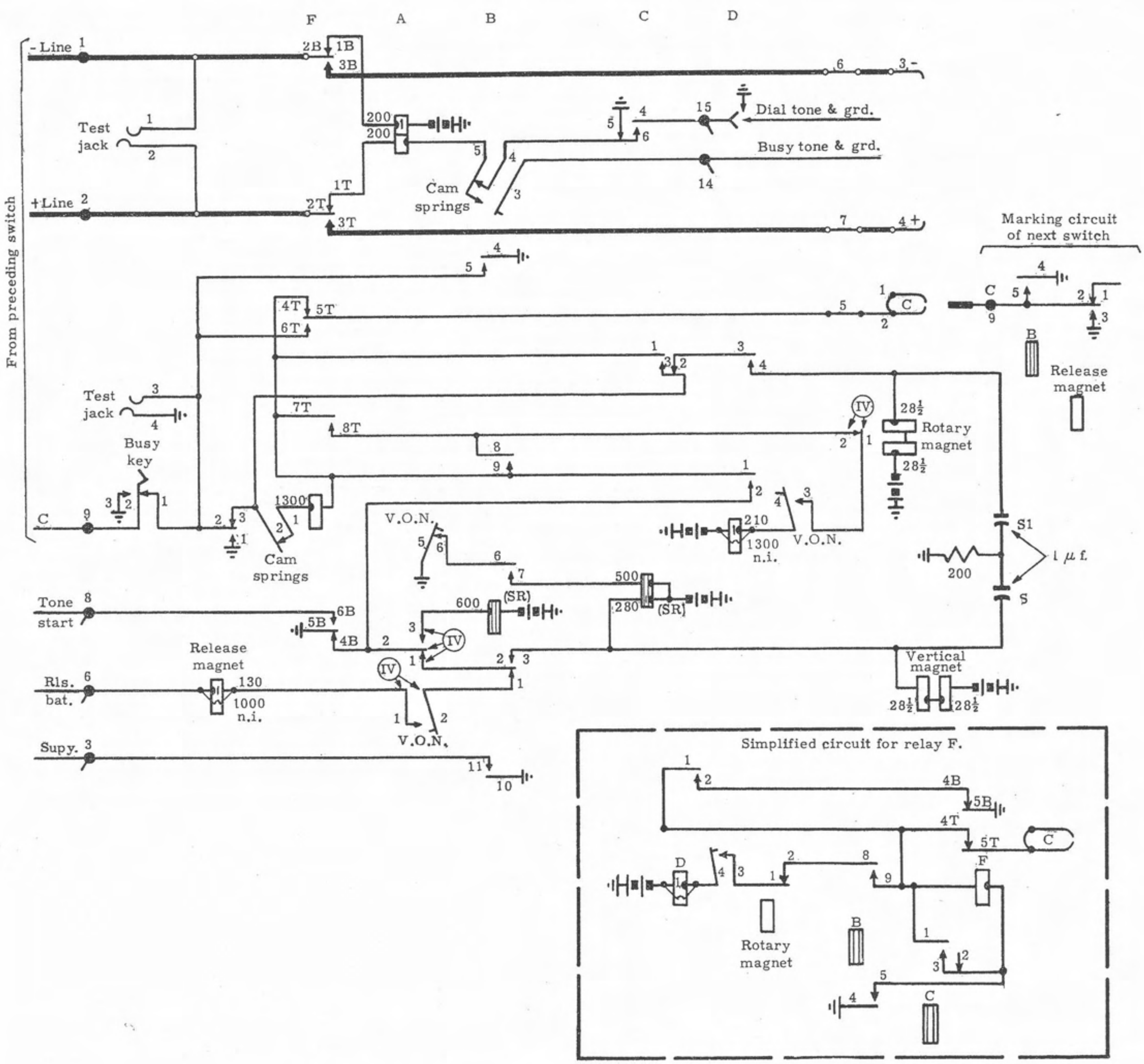

Figure 3. Absence-of-ground-searching selector circuit.

of relay C winding No. 2, at contacts 8-9 prepares a circuit for relay D, and at contacts 10-11 grounds lead SUPY to start dial-tone equipment (§8).

Relay C operates, at contacts 4-6 supplies dial tone (if this is a first selector), and at contacts 1-3 short-circuits unoperated relay F.

6.2 Vertical stepping. Relay A follows the dial pulses, releasing during each open-loop period to pulse relay C winding No. 1 and the vertical magnet. The vertical off-normal springs release during the first vertical step. Vertical off-normal springs 5-6 open the circuit of relay C winding No. 2 (but pulses through winding No. 1 keep relay C operated throughout vertical stepping). Vertical off-normal springs 3-4 close a circuit as follows: from ground at relay B contacts 4-5, through release-magnet springs 2-3, relay C springs 3-1, relay B springs 9-8, rotary-magnet interrupter springs 2-1, and vertical off-normal springs 3-4, to relay D. Relay D operates, locks, and places an additional short circuit around relay F.

After the last vertical step, relay C releases, removes one short circuit from around relay F, and completes a circuit as follows: from ground at relay B-contacts 4-5, through release-magnet springs 2-3, relay C springs 3-2, and relay D springs 3-4 to the rotary magnet.

6.3 Rotary stepping. The rotary magnet operates, and rotates the shaft and wipers to the first set of bank contacts. After the wipers are on these first contacts, and just as the rotary-magnet armature completes its stroke, rotary-magnet interrupter springs 1-2 open the circuit of relay D. Relay D releases, removes its short circuit from relay F, and opens the circuit of the rotary magnet.

If the first trunk is busy, ground encountered by wiper C keeps relay F short-circuited. Also, as the rotary magnet releases, rotary-interrupter springs 2-1 connect the wiper-C ground to relay D. Relay D operates, locks, puts an additional short circuit across relay F, and operates the rotary magnet, stepping the wipers to the next trunk.

6.4 Switch-through. Absence-of-ground marks an idle trunk. When the rotary magnet starts to release after rotating the wipers to such a trunk, interrupter contacts 1-2 close battery from the winding of relay D to relay F. The only ground completing a circuit to relay D now comes through the 1300Ω of relay F, and the resultant current is enough to operate only relay F.

Relay F operates, at contacts 7T-8T provides itself an additional path through relay D to negative battery for use when relay B releases, at contacts 5B-4B opens the circuit of relay B, at contacts 1B-2B-3B and 1T-2T-3T disconnects relay A and extends the calling loop through to the next switch, and at contacts 5T-6T connects wiper C to lead C so that the next switch, returning ground over wiper C, can hold this and preceding switches.

Relays A and B in this switch release.

6.5 All trunks busy. If all ten trunks test busy, an eleventh rotary step is taken, at the start of which a cam attached to the shaft operates cam springs 1-2 to prevent relay F from operating as soon as relay D releases at the end of the

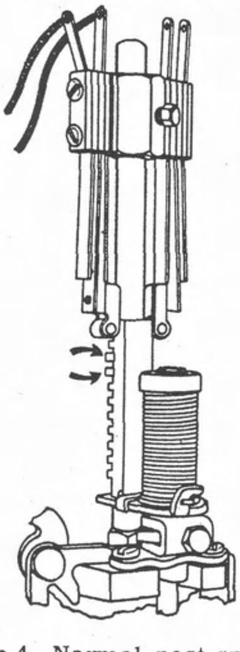

Figure 4. Normal-post springs.
Arrows show cam lugs bent 90° to operate left normal-post springs when wiper-shaft is opposite or cut in on level 2 or 3.

eleventh step. The wipers are off the banks and relay D cannot reoperate. Cam springs 3-5 connect busy tone to the calling line.

6.6 Release. Release is similar to that of a battery-searching selector (§5.6) except that in an absence-of-ground-searching switch, release-magnet springs 2-3 disconnect relay F from lead C and springs 1-2 ground lead C to mark the switch busy.

7. DIGIT-ABSORBING SELECTOR

When two neighboring automatic exchanges are interconnected by free-service dialing trunks, it is desirable to use "universal numbering" and have the first selectors in each office "absorb" the first digit dialed when it indicates the local exchange to save a rank of selectors in each office (see bulletin 819). Figure 5 shows a digit-absorbing selector. The switch shown is an absence-of-ground-searching selector but the digit-absorption feature is available also for battery-searching selectors. Notice that another or sixth relay, F, is used; that normal-post springs (figure 4) are added and are adjusted to operate when a digit-absorbing level is reached during vertical stepping; and that the release magnet is equipped with contact springs.

7.1 Seizure and vertical stepping. Seizure and vertical stepping take place essentially the same as was described in §6.1 and §6.2. During vertical stepping, vertical-off-normal springs 3-4 operate relay C, which locks.

7.2 Non-digit-absorbing level dialed. If the digit is to be permitted to select and gain access to the level (that is, is not to be "absorbed"), when vertical stepping ends, the normal-post springs are normal (unoperated). Relay D releases, closing a circuit from ground at relay E contacts 5B-4B and relay A contacts 2-3 (wiring E) or at relay B contacts 8-9 and relay E contacts 8B-7B (wiring F), vertical off-normal springs 6-5, relay D contacts 2-1, relay F contacts 6-5, and left normal-post springs 2-1, to relay F winding No. 2. Relay F operates, locks, disconnects dial tone (if this is a first selector), and at contacts 7-8 completes the circuit of the rotary magnet. Rotary hunting proceeds as in §6.3.

7.3 Digit-absorbing level dialed. If the digit dialed is to be ineffective in selection of and is to be denied access to the level (that is, if the digit is to be "absorbed", and the switch shaft is to return to normal, to start over when the next digit is dialed), when vertical stepping ends, the switch wiper shaft comes to rest operating the normal-post springs.

Relay D releases, and closes a circuit from ground* through vertical off-normal springs 6-5, relay D contacts 2-1, relay F contacts 6-5, and left normal-post springs 2-3, to the release

*With wiring F, ground is supplied from relay B contacts 8-9 through relay E contacts 8B-7B; with wiring E, ground is supplied from relay E contacts 5B-4B through relay A contacts 2-1.

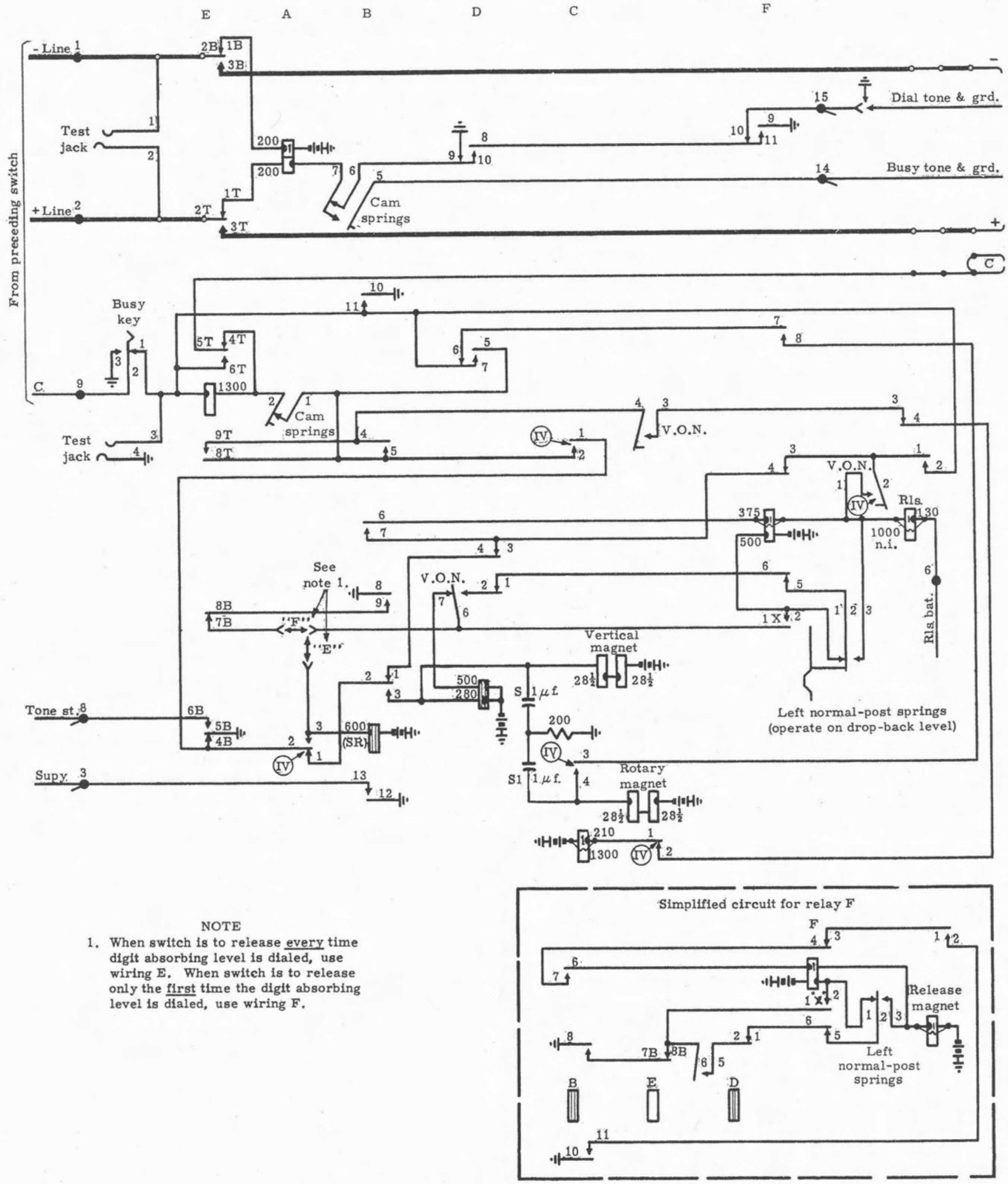

Figure 5. Digit-absorbing selector circuit (absence-of-ground searching).

magnet. At its contacts 1-2 the release magnet locks, and also short-circuits unoperated relay F winding No. 1. At contacts 3-4 the release magnet unlocks and releases relay C.

As the shaft falls away from the level dialed, the left normal-post springs return to normal, and (unless level "1" was dialed) close a circuit from ground* through vertical off-normal springs 6-5, relay D contacts 2-1, relay F contacts 6-5, and left normal-post springs 2-1, to relay F winding No. 2. Relay F operates, locks, and disconnects dial tone (if this is a first selector). When the shaft reaches its normal position, vertical off-normal springs 6-7 reoperate relay D, and vertical off-normal springs 1-2 open the release-magnet circuit.

If level "1" was dialed, during release vertical off-normal springs 5-6 are likely to open before left normal-post springs 1-2 close. Relay F must be operated nevertheless, but a different technique is used. When the shaft reaches its normal position, vertical off-normal springs 6-7 reoperate relay D, and vertical off-normal springs 1-2 remove the short circuit from relay F winding No. 1. Current flowing from ground at relay B contacts 10-11, through release-magnet springs 2-1, relay F contacts 3-4, relay B contacts 7-6, relay F winding No. 1, and the release magnet, causes relay F winding No. 1 to operate its contacts "X", closing the circuit of relay F winding No. 2. Relay F operates fully, disconnects dial tone (if this is a first selector), and at contacts 3-4 opens the circuit of the release magnet.

7.4 Digit-absorbing level need not be wasted (optional - figure 5 wiring F). Notice that, with relay F operated and locked (§7.2 or §7.3), relay F contacts 5-6 make the left normal-post springs ineffective and prevent further release. Thus, the level to which access was denied when dialed on the first digit can, if desired, be accessed (cut in on and used) when dialed on the second digit; digit absorption need not waste the level.

7.5 Digit absorbed repeatedly (optional - figure 5 wiring E). If when relay F operates and locks (§7.2 or §7.3) it locks to relay A spring 3, the relay F locking circuit is opened each time an additional digit is dialed. This permits digit absorption (§7.3) to recur every time the switch is dialed to the level where the normal-post cam lug is bent. In this case, a given digit can be absorbed repeatedly as in §7.3, and §7.4 and §7.6 do not apply.

7.6 Vertical stepping after digit absorption. With the shaft returned to normal and with relay F having operated (§7.3) and having closed its contacts 7-8, the response of the digit-absorbing selector to a second dialed vertical digit will be like that of an ordinary selector (§6.2), namely:

At the first vertical step, vertical off-normal springs 3-4 operate relay C which locks. At the end of vertical stepping, relay D releases, and closes the circuit of the rotary magnet. Rotary stepping, testing, hunting, and switch-through follow as in §6.3 and §6.4.

8. SUPERVISORY LEAD

To start dial and busy tone for the selectors, and to give a visual indication when a selector is being held by a "permanent" or grounded line, a supervisory lead is provided on both selector types and is grounded by selector relay B. The supervisory lead (SUPY) is common to all selectors on a shelf and terminates in a relay (figure 2) which starts the tone equipment and lights a shelf supervisory lamp.

Another supervisory relay (figure 2), in the release battery lead, gives an alarm if any release magnet on the shelf remains operated longer than is normal.

9. TONE START LEAD

The selector switch-through relay (figure 2 relay F for example) grounds lead TONE ST (tone start) to start the busy-tone source for the connectors.

10. SPARK PROTECTION

The non-inductive windings connected in parallel with the operating windings of the interrupter relays and the release magnets offer low-impedance paths for current surges when the associated circuits are opened, thus reducing sparking at the contacts which open the circuits. To protect contacts in the highly-inductive vertical and rotary magnet circuits, the contacts are bridged by capacitors which absorb the surge when the contacts open the circuit. The capacitors are connected in series with a resistor which limits the discharge current when the contacts first reclose. For example, in figure 2, capacitor S and the associated 200Ω resistor bridge relay A contacts 2-1 during vertical stepping. Capacitor S1 and the same 200Ω resistor bridge relay D contacts 3-4 during rotary stepping. Special precious-metal contacts, labeled IV on the circuit diagrams, are used for interrupter contacts and for contacts, such as figure 2 vertical off-normal springs 1-2, that break the release-magnet circuit.

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