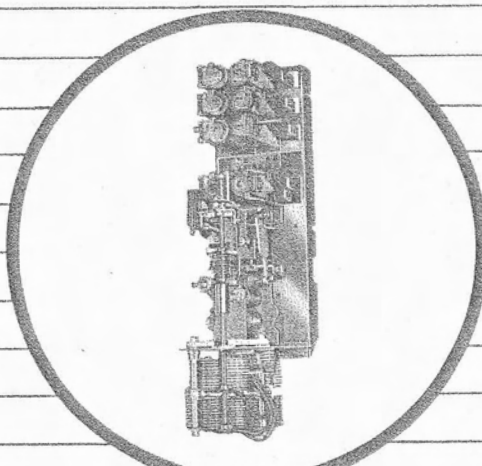
The Conne[illegible] 807

AUTOMATIC ELECTRIC TRAINING SERIES | Bulletin **807**

The CONNECTOR



STROWGER AUTOMATIC TELEPHONE SYSTEMS

AUTOMATIC ELECTRIC ®

ORIGINATORS OF THE DIAL TELEPHONE

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AUTOMATIC ELECTRIC TRAINING SERIES
on
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May we send you others
pertaining to equipment in your exchange?

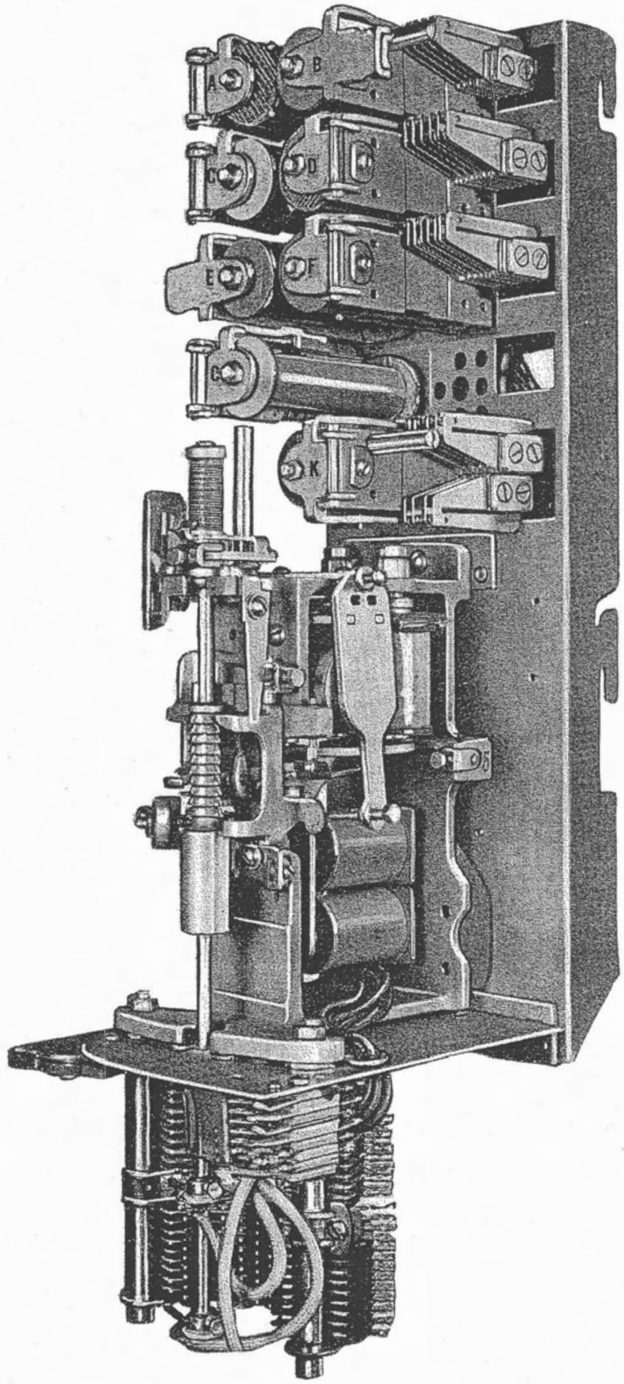

Figure 1. Typical single-frequency local connector.

THE CONNECTOR

1. WHAT THE CONNECTOR DOES

The connector is the only switch which can do nearly every job in establishing a telephone connection. It is just about the most important switch in a switchtrain.

The connector is analogous to a manual-switchboard operator's arm, front plug, ringing key, etc.

Typically, the connector has access to 100 lines, and the last 2 digits the caller dials control the connector.

Because automatic switchboards are inherently "multiple" switchboards, the connector tests whether the called line is busy. If the called line is idle, the connector rings out on the line.

When the called party answers, the connector cuts off the ringing, and supplies transmitter current to both the calling and the called parties.

When both parties hang up, the connector releases itself and other equipment used during the conversation.

The connector, supplying busy tone, ringing current, transmitter current, disconnect control, etc., is virtually a self-sufficient switch. If the exchange has less than 100 lines and does not require selectors, a complete central office can be built of just linefinders and connectors.*

2. SCOPE OF BULLETIN 807; BIBLIOGRAPHY

This bulletin 807 describes a typical 8-relay connector in its simplest form ... but complete with everything necessary to serve individual** lines.

*Plus outside-line protectors, power equipment, etc.

**Also, in a terminal-per-station central office,

(a) it can serve 2-party divided-ringing party lines.

(b) with single-frequency semi-selective ringing on 4-party lines, it can serve "1-ring" parties.

(c) with harmonic ringing, it can serve party lines on the "frequency-per-shelf" basis.

Automatic Electric Company makes many connectors, all slightly different, to meet local needs. Other publications*** describe features of some of these.

3. TYPICAL CONNECTOR (figure 1)

The operating elements of this connector are eight relays, a shaft with ratchet mechanism and wipers, magnets to raise and rotate the shaft, vertical-off-normal springs, a magnet to release the shaft, and a helical spring to restore the shaft.

Each connector is mounted above two contact banks which are part of the shelf on which connectors are mounted. As shown in figures 1 and 4, the contact banks are bolted to the connector.

In response to signals from the caller's dial, the connector raises its shaft to the level corresponding to one dialed digit, and rotates the shaft until the wipers reach the rotary position corresponding to the next dialed digit. Thus the wipers come to rest on bank contacts connected to the called party's telephone line.

4. CONTACT BANKS (figure 2)

Each connector has one upper and one lower bank (figure 2).

In the lower bank ("line bank") are 200 brass contacts ... 100 pairs ... terminals for the wires of 100 telephone lines.

***For example:

Terminal-per-line party-line connectors	Bulletin 813
Trunk-hunting connectors	Bulletin 813
Level-hunting connectors	Bulletin 813
Test connectors	Bulletin 815
Toll connectors	Bulletin 816
Terminal-per-station plan	Engineering notes 2030
Individual ringing control	Engineering notes 2037

Engineering notes 2037 is based on a terminal-per-station connector with 4-conductor banks (+, -, C, and EC for each station), sometimes called the "frequency-per-terminal" system.

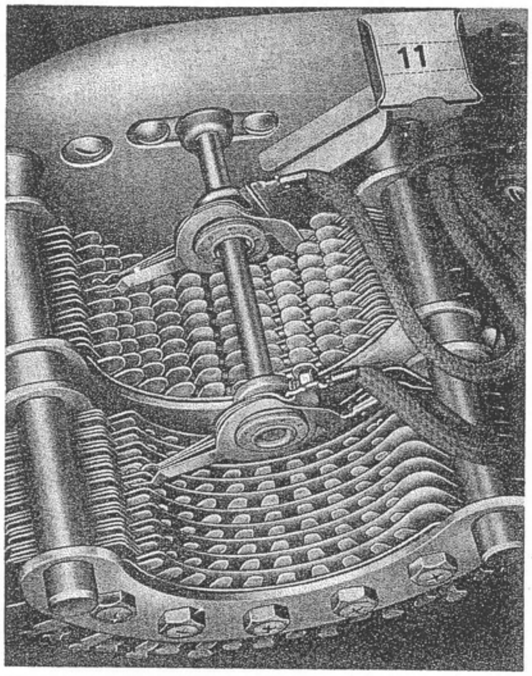

Figure 2. Banks and wipers.

01	02	03	04	05	06	07	08	09	00
91	92	93	94	95	96	97	98	99	90
81	82	83	84	85	86	87	88	89	80
71	72	73	74	75	76	77	78	79	70
61	62	63	64	65	66	67	68	69	60
51	52	53	54	55	56	57	58	59	50
41	42	43	44	45	46	47	48	49	40
31	32	33	34	35	36	37	38	39	30
21	22	23	24	25	26	27	28	29	20
11	12	13	14	15	16	17	18	19	10

Figure 3. Bank-contact position numbering.

In the upper bank ("control bank") are 100 single contacts, terminals of a third wire, control lead C, for each line. Control lead C (analogous to the manual-switchboard "sleeve") is an intra-office wire; it does not go outside the central-office building. The connector uses lead C:

(a) To test whether the called line is busy.

(b) To cut off (during a call to the line) equipment used when the subscriber makes a call from his telephone.

(c) To mark the called line "busy".

The positions of the contacts of each bank are numbered with 2-digit numbers. The tens digit represents the level in which the contact lies; the units digit represents the rotary position of the contact in the level. When it occurs as a tens digit (e.g., 03), "0" represents the tenth or top level, and when it occurs as a units digit (e.g., 30) "0" represents the tenth or last rotary position. The first level's first rotary position is position 11; the first level's last rotary position is position 10. Figure 3 shows position numbering as seen from the front of a contact bank. The number assigned to each position is the number that must be dialed to bring the connector wipers to that position.

5. A CONNECTOR SHELF (figure 4)

100 telephones are served by a shelf of connectors. The number of connectors on the shelf will be the maximum number of simultaneous calls expected to be made often to the 100 telephones. Shelves are made in several sizes, to hold 11, 16, or 21 connectors. One is a test connector, not available for subscriber calls.

Figure 4 shows a shelf of nine connectors with room for expansion* to eleven connectors. The connector on the left, with only three relays, is the test connector.

The wires of all 100 lines appear in the banks below each connector. All banks on the shelf are "multipled" together, and then the 300 wires from the banks come to the terminal block at the right-hand end of the shelf. There the switchboard installer solders cables which carry the wires thru other central-office equipment (line-finder shelf, distributing frame(s), etc.) and finally (2 wires only) to the subscriber lines.

Sometimes another smaller terminal block is used for leads into the shelf; it would be mounted on the end opposite the bank terminal block. If (as in figure 4) there is no such terminal block, the cables bringing leads into the connectors are soldered directly to the shelf jacks.

On the fuse panel are 2 supervisory lamps, the release-alarm lamp, the fuse-alarm lamp, and a fuse for each connector. If either party fails to hang up after a call is completed, one of the white supervisory lamps will light. If a connector release magnet drew current too long,

*When the time comes to do so, it is a simple matter to add a connector in one of the vacant positions on the shelf: Just jack the connector into the shelf, bolt its banks (already on the shelf) to the connector, check the wipers for alignment with the banks, and add a fuse to the fuse panel.

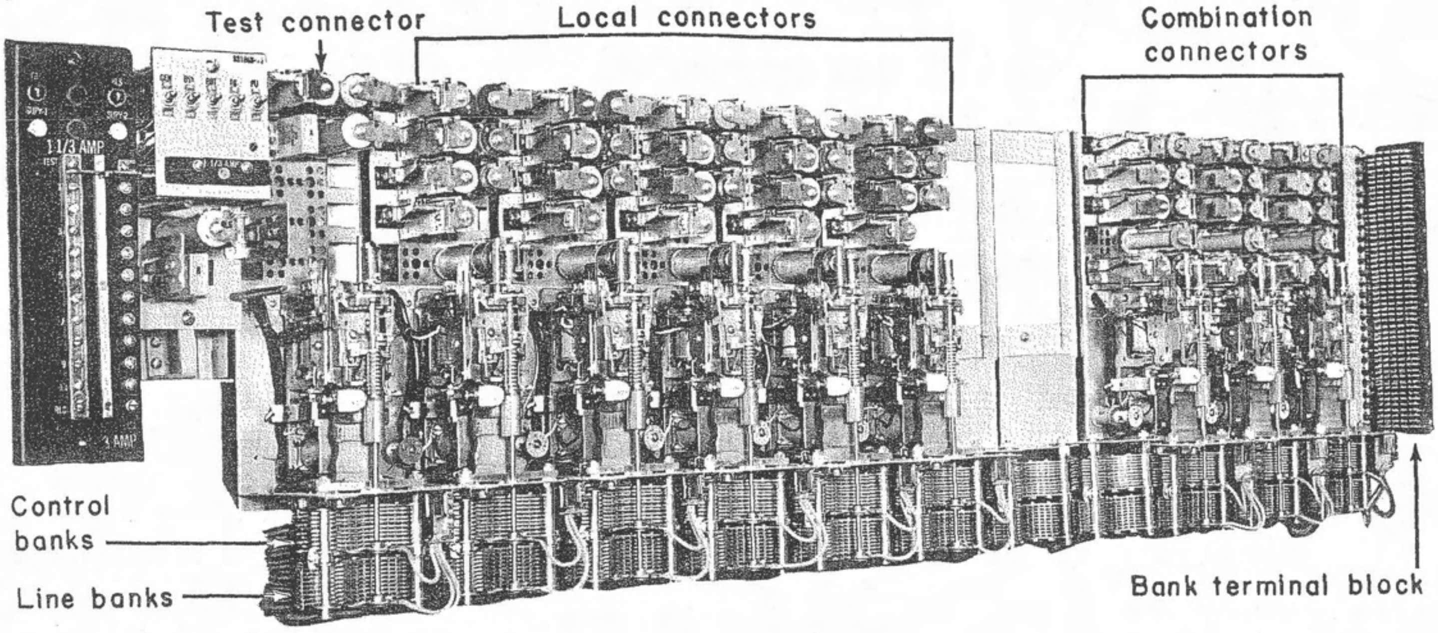

Figure 4. Connector shelf.

indicating the shaft had failed to restore, the green release-alarm lamp would light. If trouble in any switch on the shelf blew a fuse, the red fuse-alarm lamp would light.

Immediately to the right of the fuse panel in figure 4 are toggle switches for the leads from the ringing machine and the tone equipment. Below the toggle switches are the release-alarm relay and the busy-tone capacitor, which serve all switches on the shelf. On different shelves, these shelf accessories may be arranged differently.

The first five connectors on the right of the test connector in figure 4 are the local type described in this bulletin. The three connectors at the right of the vacant positions can serve toll calls as well as local calls, and have an extra relay in their circuit. Local calls choose first the local connectors; when all local connectors are in use, local calls can use the combination connectors.

Toll calls can use only the combination local-and-toll connectors, however. Thus, five local and three toll calls, eight local calls, or any intermediate combination can be handled simultaneously by the connector shelf shown in figure 4.

Each connector has its own 3-terminal* position in the local-selector-shelf contact banks. Thus, a shelf of 10 connectors requires 30 leads from local selector shelves, plus a few other leads for battery, ground, ringing current, busy tone, etc.

*Combination connectors require 4 terminals in the toll selector banks.

6. MECHANICAL OPERATION

The dial breaks and quickly re-closes the line circuit. Each number on the dial breaks the line circuit that number of times, except of course "0", which interrupts the line 10 times. After previous digits have operated other equipment to find an idle connector, the tens-digit pulses control the connector vertical magnet. The vertical magnet operates the ratchet mechanism to raise the shaft one step for each pulse. The pause between the tens digit and the units digit allows a relay to transfer the stepping circuit from the vertical to the rotary magnet. The pulses from the units digit then cause the shaft to be rotated, one step for each pulse, to the desired position in the contact banks. After rotation, the shaft rests on a fixed detent to the left of the shaft, called the stationary dog, and the rotary tooth of a detent called the "double dog" holds it in position with the wipers on the called-line contacts. If the line is not busy, connection will be made and the called line will be rung.

At the end of a call, the release magnet operates an armature which disengages the double-dog and releases the shaft. The stationary dog holds the shaft on the level while the restoring spring at the top of the shaft rotates the shaft to remove the wipers from the contact banks; then the shaft falls by its own weight.

At the first vertical step, the connector shaft releases a lever which allows the vertical-off-normal springs to restore. When the connector releases and the shaft falls, the lever is depressed and reoperates the vertical-off-normal springs. This opens the release-magnet circuit and prepares the connector for the next call.

7. CONNECTOR RELAYS

Interaction of the connector's 8 relays direct its operations. Relays A, D, and G are ordinary fast-acting relays. Relay A, often called the pulsing relay, supplies transmitter current to the caller, and receives dial pulses and transmits them to other relays and to the vertical or the rotary magnet. Relay D, the back-bridge relay, is so called because it provides transmitter current to the called party bridged across the "back" end of the connection. Relay G is the busy-test relay.

Relays B, C, and E all have copper sleeves around their cores to make them slow to release.* Holding-relay B grounds the connector's control lead to mark that switch busy and hold all preceding switches in the train. It is slow to release so that it will not release while relay A momentarily interrupts the relay B circuit to send pulses to the magnets. Thus, relay B can distinguish between a short duration break in the loop circuit at the dial springs, and a longer break at the hookswitch caused by hanging up.

Relays C and E, the vertical sequence relay and the rotary sequence relay, are slow-to-release so that they will remain operated during a series of pulses from relay A. These relays distinguish the separately dialed digits, remaining operated when relay A breaks their circuit in short rapid sequence during a digit, and releasing when relay A breaks their circuit for the longer interval between two separate digits. Relay C is operated during vertical stepping, and then releases to prepare the rotary stepping circuit. During rotary stepping, relay E operates; after the wipers reach the called line, during the relay E release delay, the line is busy-tested.

Relay K, the wiper-closing relay, has a copper slug on its armature end to make it slow to operate. Wiper-closing relay K connects the connector relays, etc., to the wipers resting on the called party's line-bank contacts. It is slow-to-operate so the called party's cut-off relay will have time to remove the line equipment from the called line before ringing current is connected to the line.

Another relay with an armature-end slug is ringing cut-off relay F in the path for alternating current from the ringing machine to the called-telephone ringer. It must be slow to operate so that it will not be operated by $\frac{1}{2}$ cycles of alternating (ringing) current. Besides the copper slug, relay F has a copper sleeve around its core to lower its inductive reactance to alternating current from the ringing machine.

> The winding of relay C is connected somewhat different from the ordinary, with battery rather than ground connected to the "inside" or start-of-winding terminals. This causes the magnetic fields of adjacent relays A and C to augment one another. Thus, when relay A receives short pulses (and so sends long pulses to relay C) from a high-resistance line, magnetic flux from relay C aids relay A. When relay A receives long pulses (and so sends short pulses to relay C) from a short low-resistance line, flux from relay A helps keep relay C operated between pulses.

8. LINE EQUIPMENT

Altho it is usually part of a linefinder shelf (see bulletin 821 especially [perhaps also bulletins 805 and 806]) and is never part of the connector, line equipment affects and is affected by the connector. Line equipment serves as a gate thru which calls made <u>from</u> the line are channeled differently than calls made <u>to</u> the line. A call <u>from</u> the line starts a linefinder which picks up the call and routes it to dial tone and to dial-controlled equipment. A call <u>to</u> the line requires a clear path which will not start a linefinder nor bring in dial tone.

Each line has a line relay bridged across the line, and, on the control lead, a cut-off relay to disconnect the line relay.

When a caller lifts his handset to make a call, the line relay brings in a linefinder and a selector (with dial tone). When the calling line has been found, ground on the control lead operates the cut-off relay, which disconnects the line relay, releasing it ... thereby doing away with the "linefinder start" signal. Thus, once a calling line has been found, we want the line relay out of the way so it won't try to start any <u>more</u> linefinders. For this reason, as soon as the call is extended to the connector, the connector holds the caller's cut-off relay.

Likewise, on a call <u>to</u> the telephone-subscriber line, we want the line relay out of the way because we won't want it to start a linefinder. For this reason, the connector operates the called line's cut-off relay, and it cuts off the line relay.

The control-lead ground which operates a calling or called line's cut-off relay, appears on that line's lead C multipled thruout the connector-shelf banks (figure 4), and marks the line "busy" in the banks of every connector which could have access to it.

*A slow relay's release delay is only a fraction of a second ... for example a third of a second for relay B, and a tenth of a second for relays C and E. If these sound like short amounts of time about which to make a fuss, remember: a camera often does its work in only 1/50 second! Utilization of these delays of a tenth or a third of a second makes possible most of the marvels of dial-controlled telephone switching.

9. SUMMARY OF FUNCTIONS

The connector is designed to:

(a) hold the preceding switches in the train operated

(b) direct and connect the wipers to the terminals of the called line

(c) keep line wipers disconnected during rotation to prevent interference with other lines

(d) apply a busy test to the called line

(e) if the line is busy, give the busy signal and prevent connection

(f) if the line is idle, connect calling and called lines and mark them busy to other calls

(g) clear the line equipment from the called line

(h) connect ringing current to the called line and supply ringback tone to the calling line

(i) remove ringing current and ringback tone when the called party answers

(j) supply transmitter current to both parties

(k) release all switches when the call is concluded.

LOCAL-CONNECTOR CIRCUITRY

10. SEIZURE (figure 5)

When a caller lifts his handset, he closes a circuit to the central office and operates his line equipment to call for a linefinder. The linefinder connects him to a selector which provides dial tone. As the caller dials the first digits of the called party's number, one or more selectors are operated. The last selector will find and connect the caller to an idle connector having access to the called line. Either a battery-searching or an absence-of-ground-searching selector could precede this connector.

When a battery-searching selector brings its wipers to the terminals of lines to an idle connector (figure 5), battery thru connector relay C operates relay C and energizes selector relay F winding #1, closing relay F contacts X. Contacts X close a circuit thru relay F battery-connected winding #2, which operates all relay F contacts. Relay F now closes a circuit from the calling telephone thru the line wires to connector relay A, connects together preceding-switch lead C with wiper C which rests on lead C of the connector ahead, and opens the circuit of selector slow-to-release relay B. Meanwhile, connector relay A closes contacts 2-3, operating connector relay B. Relay B contacts 8-9 ground lead C to hold selector relay F and other preceding switches, and to mark this connector busy. Relay B contacts 4-5 and relay C contacts 2-3 prepare the circuit to the vertical magnet. The connector, marked busy to other selectors by the ground on lead C, is now ready to receive pulses from the dial.

If an absence-of-ground-searching selector is used with this connector, selector relay F will have only one winding, and will operate unless lead C is grounded and short-circuits relay F. Relay F operates as above, closes a circuit thru connector relay A, and connects preceding-switch lead C to lead C of the connector ahead. In this case, battery for operation of relay F comes from within the selector, and connector relay C does not operate simultaneously with selector relay F, but is operated by ground from the selector immediately after relay F operates.

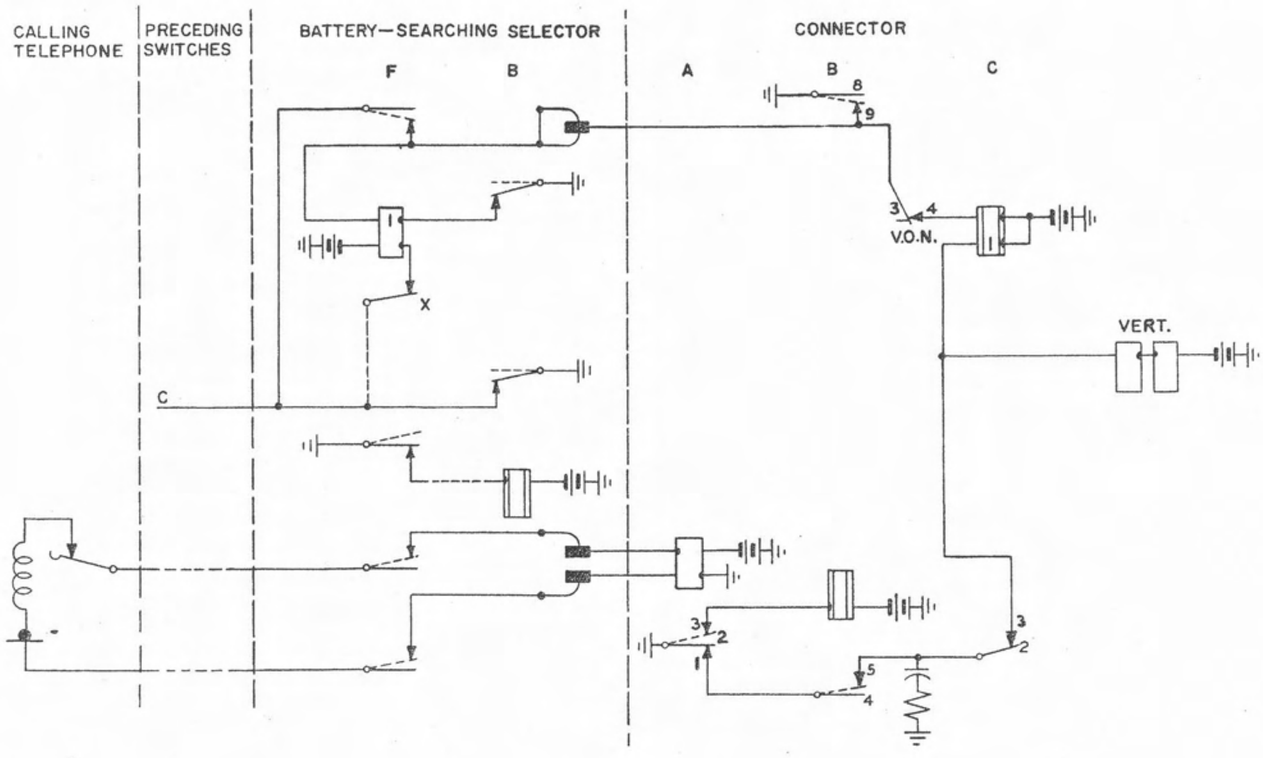

Figure 5. Seizure.
Solid armatures show initial conditions when relay F contacts "X" close.
Dotted armatures show final conditions.

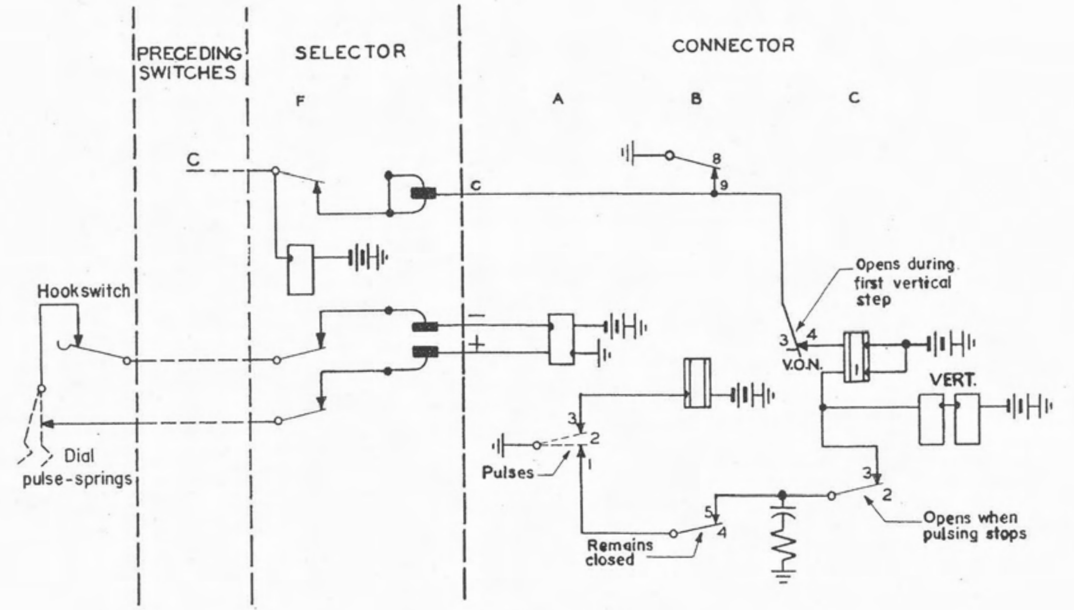

Figure 6. Vertical stepping.

11. VERTICAL STEPPING (figure 6)

As the caller dials the tens digit of the called number, his dial alternately opens and closes the circuit of relay A. The number of times the circuit is interrupted corresponds to the digit dialed. Relay A releases during each interruption, but slow-to-release relay B remains operated continuously. Each time relay A releases, its contacts 1-2 close a circuit thru the vertical magnet, operating the vertical magnet and raising the shaft one step. Each time relay A re-operates*, the vertical magnet releases, preparing its armature and pawl mechanism for another step. During the first step, V.O.N. springs 3-4 open the circuit of relay C winding #2.** However, relay C winding #1, in parallel with the vertical magnet, energizes during the first pulse, and keeps slow-to-release relay C operated until pulses from the tens digit stop. Then the interval between the tens digit and the units digit will be so long that relay C will release. The dial pulse-springs are closed, and relay A holds relay B during the interval between the two digits.

12. ROTARY STEPPING (figure 7)

The release of relay C prepared the circuit for the rotary magnet. When the units digit is dialed, relay A again releases and reoperates quickly several times, and at contacts 1-2 sends pulses to the rotary magnet and relay E. The rotary magnet rotates the shaft and wipers one step for each pulse. Slow-to-release relay E

*Each time relay A contacts 1-2 open, the capacitor connected to relay B contact 5 charges, and tends to absorb the high voltage induced in the stepping magnet when the stepping-magnet circuit is opened. This suppresses sparking at relay A contacts 1-2. Each time relay A contacts 1-2 re-close, the resistor limits the capacitor discharge current, so there'll be no possibility that relay A contacts 1-2 might be spot-welded together.

**Also during the first step, the vertical magnet unlatches the "release link", which allows the double dog to drop into the shaft hub and hold the shaft at each level to which it is raised. (Compare the footnote on page 14.)

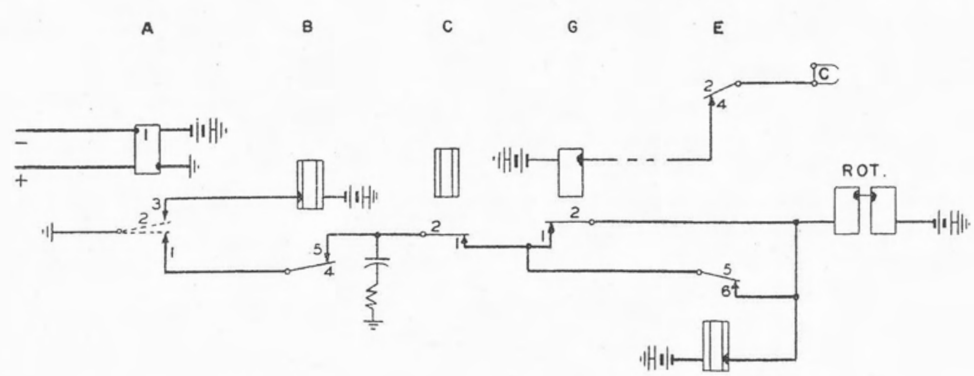

Figure 7. Rotary stepping.

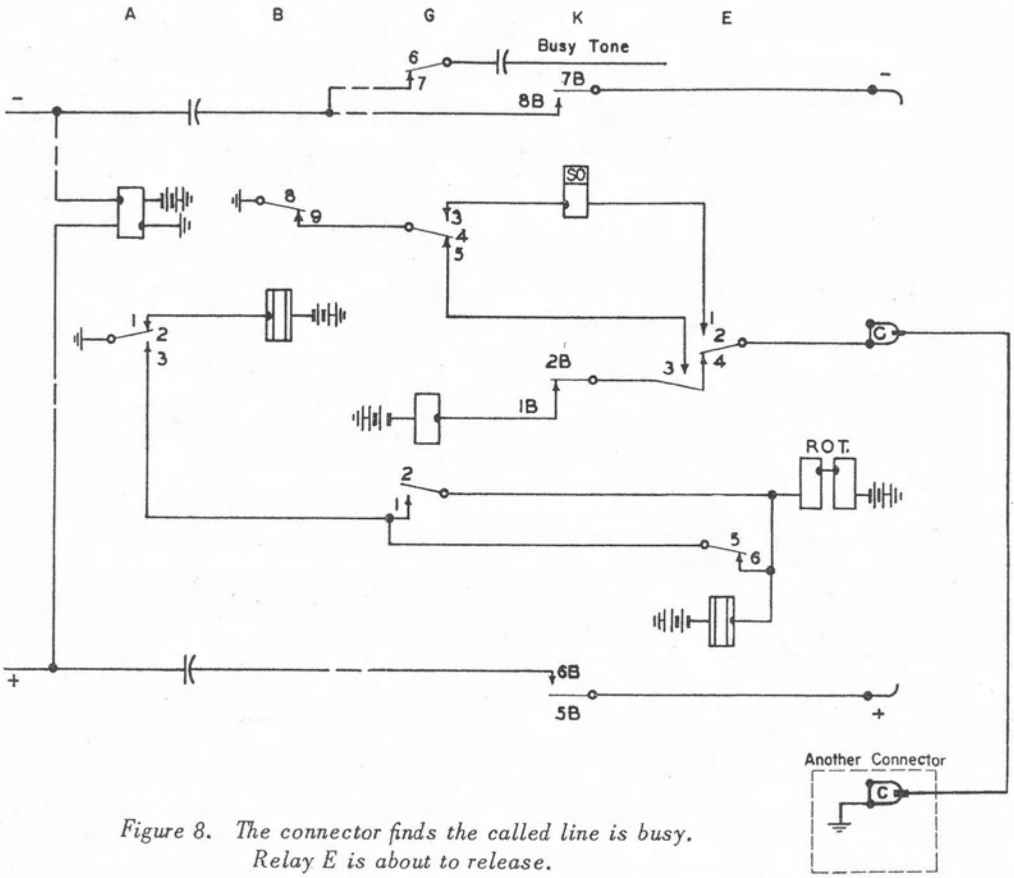

Figure 8. *The connector finds the called line is busy. Relay E is about to release.*

operates on the first pulse and remains operated until after pulsing stops. Relay E contacts 2-4 connect wiper C to relay G to prepare for the busy test. Relay E contacts 5-6 prevent interruption of the rotary-magnet circuit if wiper C sweeps over a grounded (busy) contact and momentarily operates relay G.

13. TESTING THE CALLED LINE

13.1 Called line busy (figure 8). The last rotary step puts the wipers at the called line. At a busy line, wiper C finds ground from another connector, and relay G operates. Relay G contacts 4-5 prepare a locking circuit, and contacts 6-7 send the caller busy tone. (The first selector has already started the busy-tone generator-and-interrupter, figure 11.) After a moment, relay E (figure 8) releases, contacts 5-6 prevent further stepping, contacts 3-4 make before contacts 2-4 break, permitting relay G to lock. Relay G contacts 3-4 prevent relay K operating if the called line were to be freed before the caller hangs up. Altho the wipers rest on bank contacts of the called line, they stand "dead" at relay G contact 3 and at relay K contacts 7B and 5B; notice that there is really no connection to called line.

13.2 Called line idle (figure 9). If the called line is idle, wiper C encounters battery from the called party's cut-off relay. Relay G does not operate. After a moment, relay E releases, and closes a circuit from battery thru relay CO, wiper C, relay E contacts 2-1, relay K winding #1, relay G contacts 3-4 to relay B contacts 9-8 and ground.

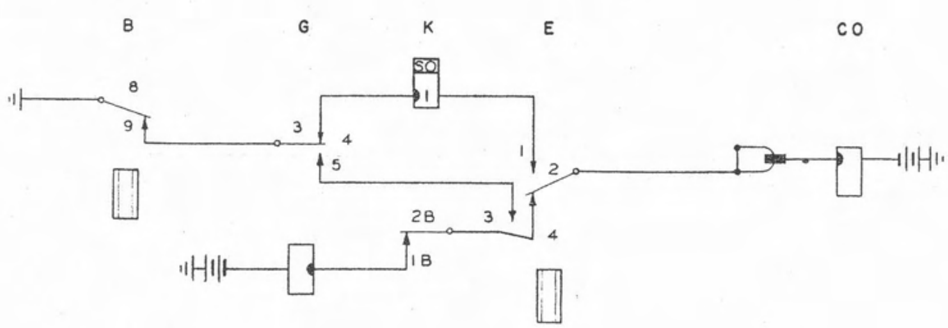

Figure 9. *The connector finds the called line is idle. Relay E is about to release.*

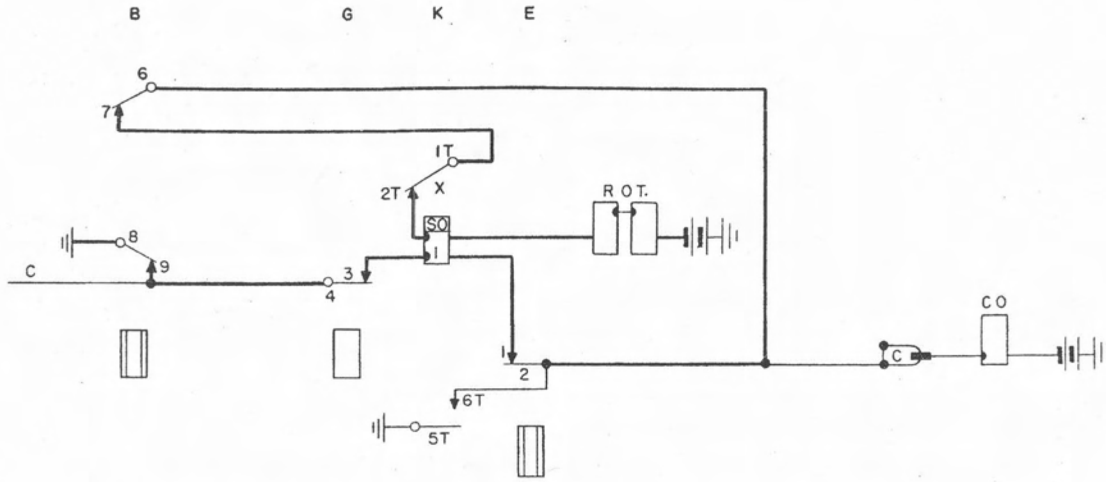

Figure 10. Seizure of the called line. Relay K winding #1 has just closed contacts "X".

14. SEIZURE OF THE CALLED LINE (figure 10)

The current thru winding #1 energizes relay K enough to close only "X" contacts 1T-2T. For just a moment, they connect relay K winding #2 in parallel with relay CO and in series with relay K winding #1. The circuit ... in figure 10 the heavy line ... is from battery thru the rotary magnet, relay K winding #2 and contacts 2T-1T, relay B contacts 7-6, relay E contacts 2-1, relay K winding #1, relay G contacts 3-4, and relay B contacts 9-8, to ground. The high resistance of relay K winding #2 allows only a small current flow thru the rotary magnet; the rotary magnet does not operate. Winding #2 operates relay K fully, and contacts 5T-6T short-circuit winding #1 and connect solid ground to winding #2 and relay CO.

15. RINGING

If this connector is in a small central office where the ringing machine does not run continuously, relay K (figure 12) contacts 7T-8T start the ringing machine.

Figure 11 shows a typical single-frequency ringing machine. It consists of duplicate sets of equipment, so there'll always be a spare for emergencies. The motor-driven ringing generator to the left produces alternating current of about 90 volts and 20~.

You recall from your own experience, a telephone bell or "ringer" does not ring continuously, but rather briefly, with a few seconds' silence between rings. This is timed by an interrupter. The interrupter may be a group of slow-acting relays, etc., or it may be motor-driven as in figure 11 lower right corner. Typically, the ringing interrupter might work on a 6-second cycle, ringing 1.2 seconds, silent 4.8 seconds.

Relay K contacts 5B-6B and 7B-8B set up the ringing circuit ... in figure 12 the heavy line. About 1.2 seconds out of 6, the ringing-interrupter cam connects the ringing generator to the called line as shown by figure 12 heavy line, and rings the ringer (bell). The capacitor in series with the called-telephone ringer allows only alternating current to flow thru relay F. Relay F is slow to operate so that it will not be operated by alternating current.

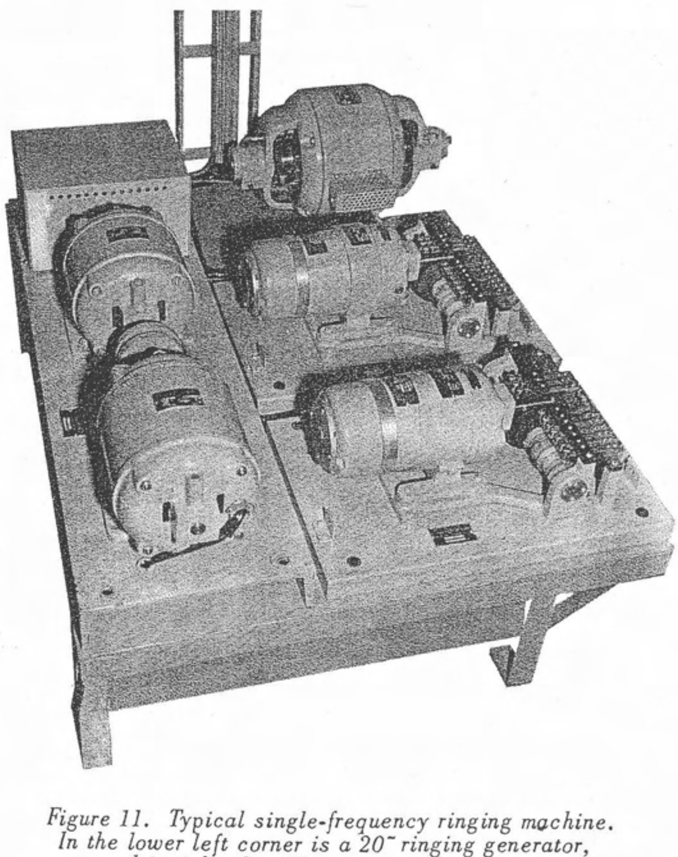

Figure 11. Typical single-frequency ringing machine. In the lower left corner is a 20~ ringing generator, driven by the 60~ a-c motor above it. The machine in the lower right corner generates dial tone, interrupts dial tone into busy tone, interrupts ringing current to provide the silent periods, etc. The 2 upper right machines are standby units to operate from central-office battery during commercial-power failures. At the upper left is an isolating transformer which keeps the trip-battery d.c. (§19.1) out of the ringing-generator windings.

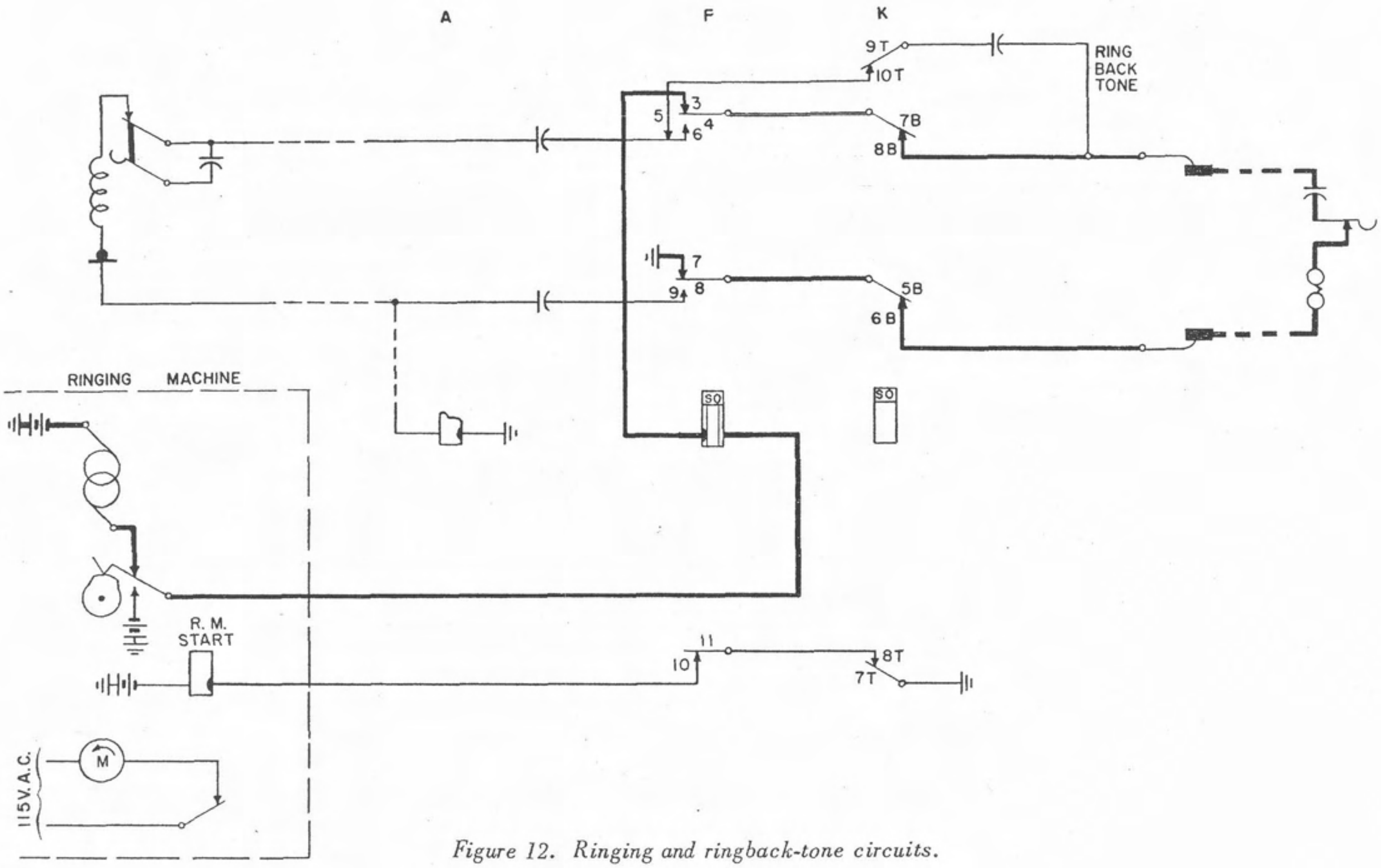

Figure 12. Ringing and ringback-tone circuits.

Relay K contacts 9T-10T close the ringback-tone circuit. Ringback tone is tapped from the ringing-current circuit, taken thru a small-capacitance capacitor, sent thru the calling telephone, and returned thru relay A, etc., to ground.

In figure 12, at the ringing interrupter, the central-office battery voltage is offered out on the line, both during the ringing intervals (thru the generator and relay F), and during the silent intervals (thru relay F). In figure 12, with the called telephone on the hook, the ringer capacitor blocks the battery d.c., no d.c. flows, and slow-to-operate relay F cannot operate.

16. CALLED PARTY ANSWERS; RINGING CUT OFF

When the called party answers (figure 13), his hookswitch removes the a-c path thru capacitor and ringer, and replaces it with a direct-current circuit thru transmitter, induction coil, etc., for relay F winding #1. Relay F winding #1 closes "X" contacts 1-2, energizing winding #2.

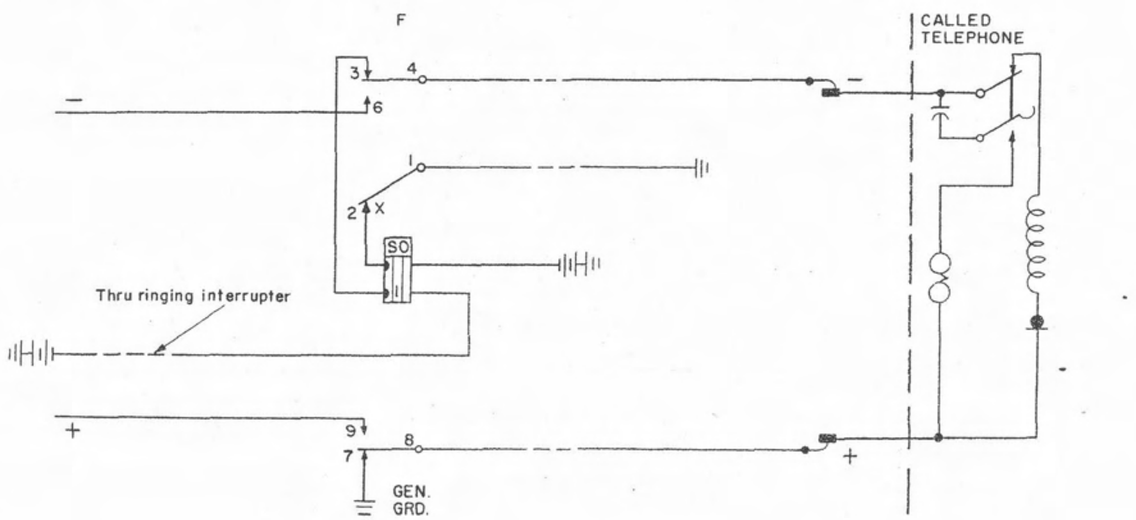

Figure 13. Called party answers. Relay F has just closed contacts "X".

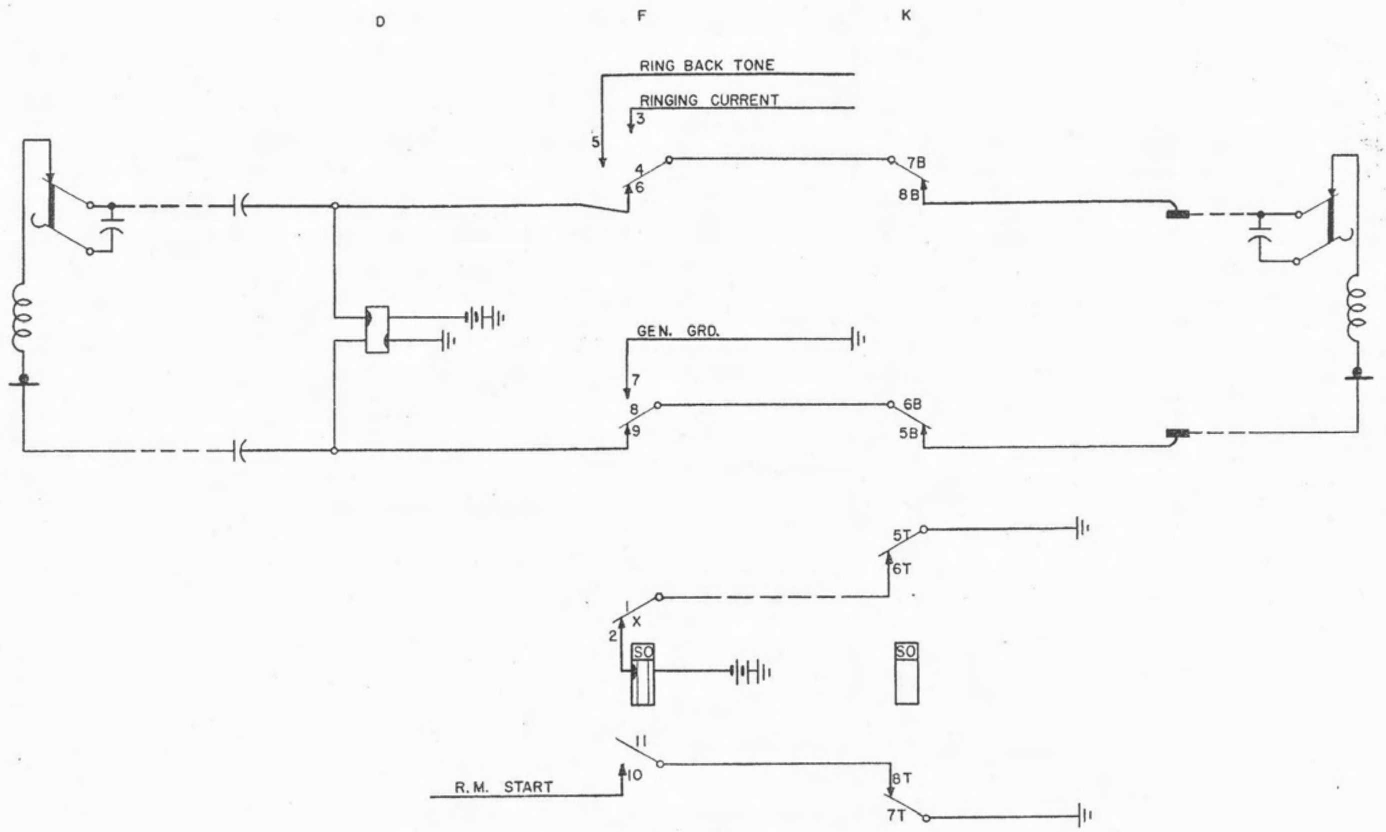

Figure 14. Relay F has operated fully. Ringing cut off.

Relay F operates fully (figure 14); contacts 3-4-5-6 cut off ringing current and ringback tone, and complete one side of the transmission line; contacts 7-8-9 disconnect generator ground and complete the other side of the transmission line; and contacts 10-11 stop the ringing machine.

The called party draws transmitter current thru relay D (figure 14). Relay D operates, and (figure 15) its make-before-break contacts 8-9-10 and 11-12-13 reverse the polarity* of the transmitter current which relay A supplies toward the caller.

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*For most calls, this battery reversal is of no significance. It has a useful function in these cases:

(1) If the call is from a paystation, it results in collection of the charge for the call.

(2) In a measured-service or message-rate exchange, it causes the completed call to be counted.

(3) If the call is from an operator, it gives her "off-hook" (dark) supervision.

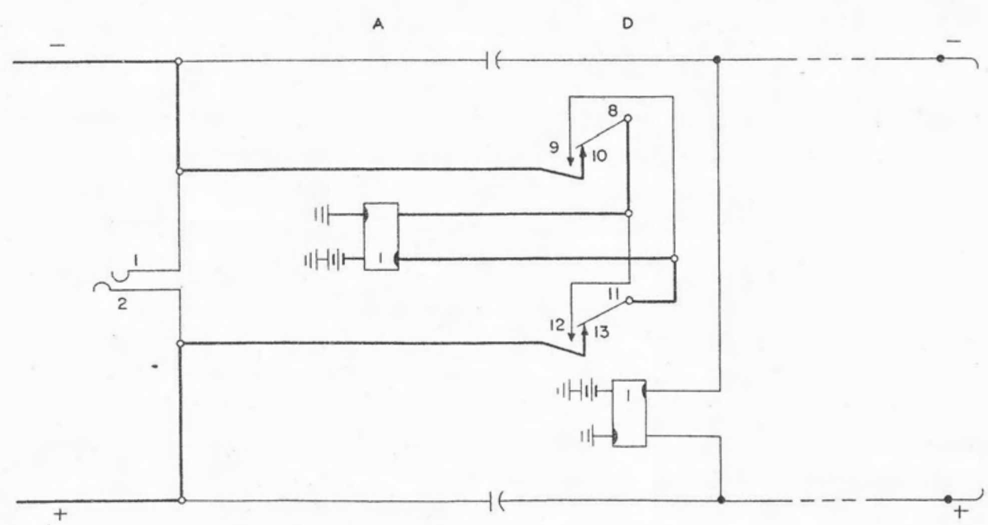


Figure 15. Caller's transmitter-current polarity reversed.

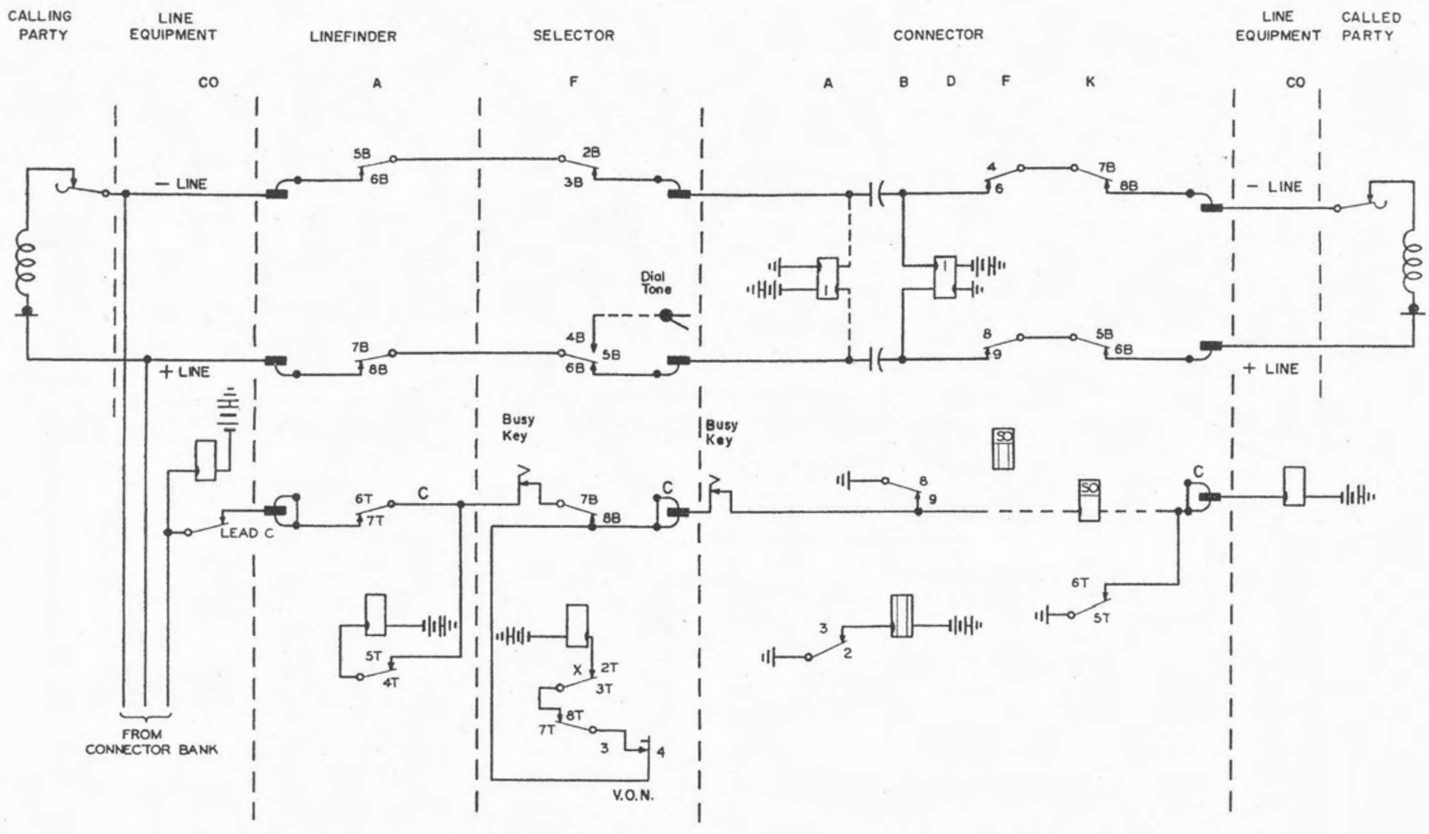


Figure 16. Conversation thru local switch train in a 1000-line central office.

17. CONVERSATION (figure 16)

Figure 16 shows conditions during conversation, and shows the position of the connector in a typical 1000-line switch train. Capacitors (between relays A and D) couple caller and called party for voice transmission. Notice that connector relays A and D are the only relays connected across the transmission path.

Relay A supplies transmitter current to the caller, and relay D supplies transmitter current to the called party. Relay A holds relay B, which keeps ground on control lead C to hold:

The caller's line-equipment cut-off relay

Linefinder

Selector(s)

and to mark the caller's line busy at the banks of all connectors on the shelf which serves his 100-line group.

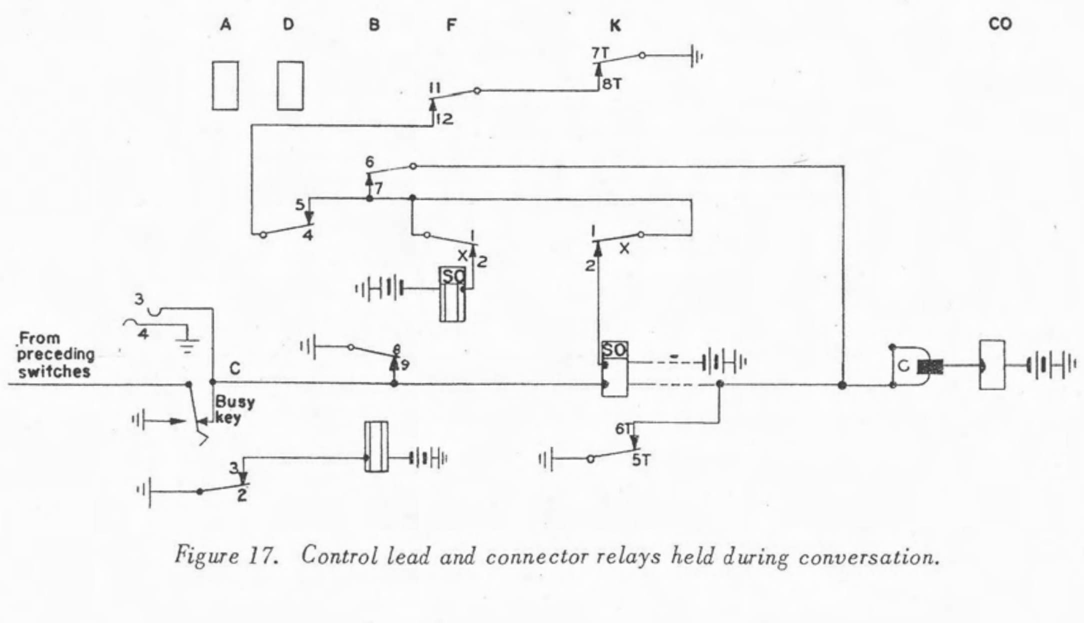


Figure 17. Control lead and connector relays held during conversation.

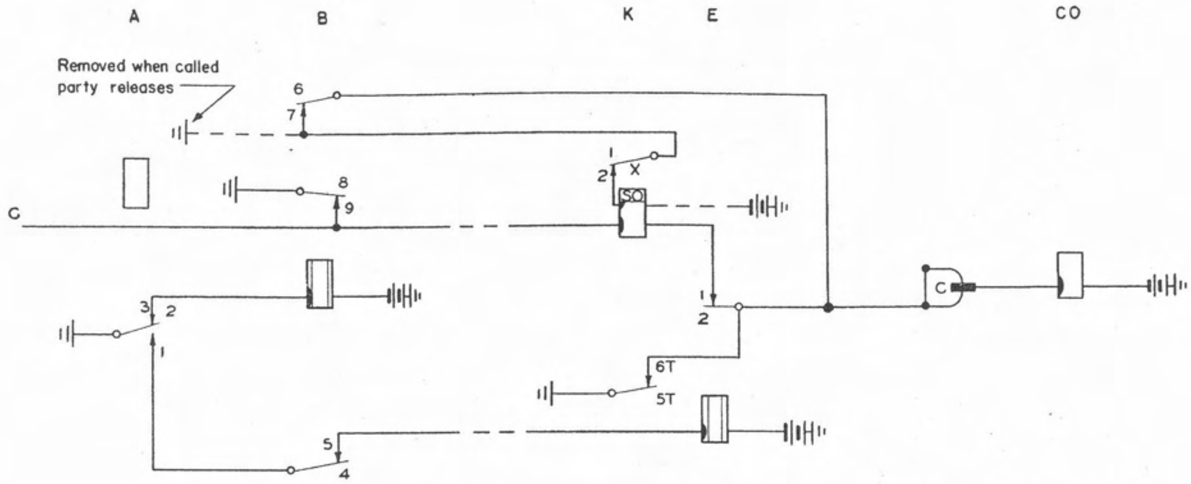


Figure 18. Connector circuits for dropping preceding switches.

Relay K keeps ground on wiper C to hold the called line's cut-off relay, and to mark the called line busy.

Figure 17 shows holding-circuit details within the connector itself. Relay A holds relay B. Thru relay K contacts 5T-6T and relay B contacts 6-7, the caller holds relays F and K to keep the transmission path closed thru. This, like most connectors, is a "last-party-release" connector: thru relay K contacts 7T-8T and relay D contacts 4-5, the called party, too, holds relays F and K to keep the transmission path closed thru. Thus, the two conversing parties have joint control of the connector. Either or both can hold it. It holds its wipers at the called line until the last of the 2 parties to hang up has hung up.

18. RELEASE

18.1 If caller hangs up first. The caller may have called about more than one thing, so, to be sure he can complete all purposes of his call, etiquette recommends that the called party should wait and allow the caller to be the first to hang up.

When the caller hangs up, his hookswitch (figure 16) opens the circuit of relay A (figure 18). Relay A releases, opens the circuit of slow-to-release relay B, and operates relay E. When relay B releases, it removes ground from lead C, and opens the circuit of slow-release relay E. The preceding switches release. Slow-to-release relay E remains operated a moment. Then it releases, and connects ground from relay

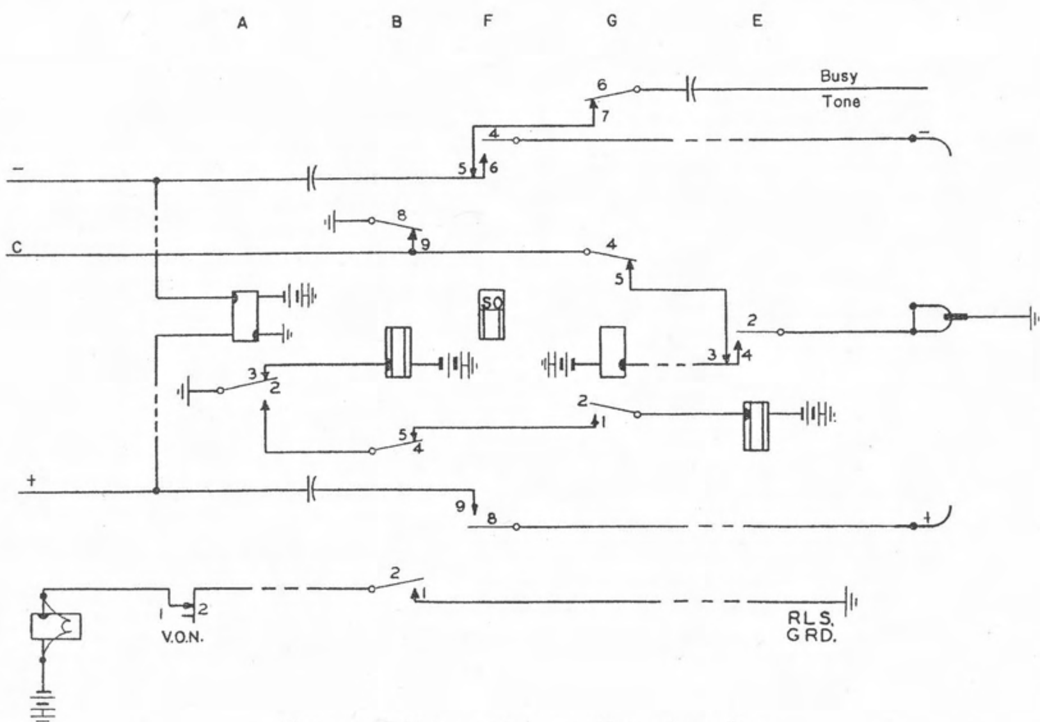


Figure 19. Release from a call to a busy line.

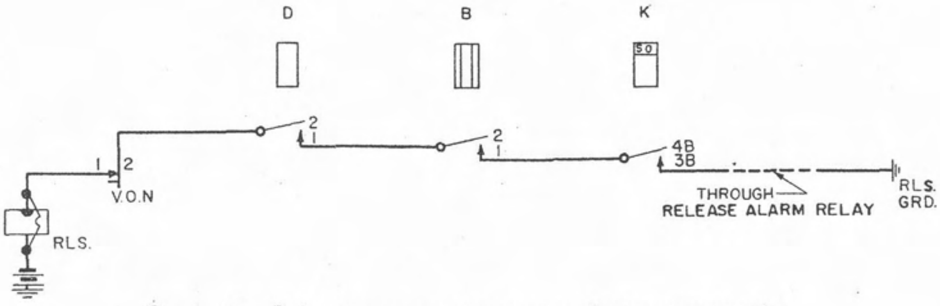


Figure 20. Release-magnet circuit open during conversation.

K contacts 5T-6T thru relay E contacts 2-1, relay K low-resistance (125Ω) winding #1, (and [figure 25] relay G contacts 3-4), to lead C to mark the connector "busy" . . . not able yet to accept another call.

Next, the called party hangs up, releasing relay D. Relay D contacts 4-5 (figure 17) release relays F and K. Relay K opens the wipers (so that during release they will be electrically "dead" when they rotate over other lines), and relay K contacts 3B-4B operate the release magnet. See §18.5.

18.2 If called party hangs up first, relay D releases, opening its contacts 4-5 (figure 17) as in the paragraph above . . . but this time relay B contacts 6-7 continue to hold relays F and K. There is no further action until the caller hangs up, restoring relay A. Relay E operates again, but has no function. Relay B releases, removes ground from lead C to release the switch train, and opens the circuits of relays E, K, and F. Relay K disconnects the wipers, and (figure 25) operates the release magnet. See §18.5.

18.3 Release after calling a busy line (figure 19). If the called line was busy, relays K, F, and D did not operate, so only relays A, B, and G must be released (figure 19). When the caller hangs up, relay A releases, opening the circuit thru relay B. Relay B removes ground from lead C to release the preceding switches, releases relay G, and operates the release magnet. See §18.5.

18.4 Release from an unanswered call. If the call is unanswered, release is the same as when the caller hangs up last (§18.2), except that relay F will not have operated. Release of relay K opens the ringing circuit, stops the ringing machine, opens the ringback-tone circuit, and operates the release magnet. See §18.5.

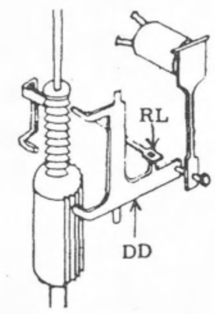
18.5 Mechanical restoration. Referring to figure 20, when the caller's phone "on hook" has released relay B, the called phone "on hook" has released relay D, both "on hook" have released relay K, and relay K has disconnected the wipers, the release magnet withdraws the "double dog", and latches it under the "release link"*.

Tension in the helical spring atop the shaft rotates shaft and wipers to the left and off the banks. Then gravity takes over, and pulls the shaft down to its normal position.

When the switch shaft drops to its normal position, it operates vertical off-normal springs V.O.N.: springs 1-2 open the release-magnet circuit, and springs 3-4 connect battery thru relay C 500Ω winding #2 to lead C to tell battery-searching selectors this connector is ready to handle another call.

---

*When the connector is preceded by absence-of-ground-searching selectors, after figure 20 release-magnet circuit is closed, it is not impossible that a new call might seize the connector, operate relay B, and open the release-magnet circuit before the shaft has restored to normal. With release link RL having latched double dog DD, the shaft will restore completely nevertheless. (Compare the footnote on page 7).



VARIATIONS

19. GENERATOR CONNECTIONS

19.1 We need battery for ringing cut-off. Page 10 mentions the ringing circuit needs central-office battery to operate the ringing cut-off relay. There are 2 ways to connect central-office battery into the ringing circuit.

19.2 Battery-connected generator is usual in urban areas, where most lines are in cable. In figures 12 and 21 the ringing generator is connected directly to the central-office battery.

Advantages are simplicity, and the fact that the ringing cut-off relay's inductance impedes higher-frequency harmonics and other ringing-machine electrical disturbances so they tend to be kept out of the cable. This helps keep the cable-lines quiet.

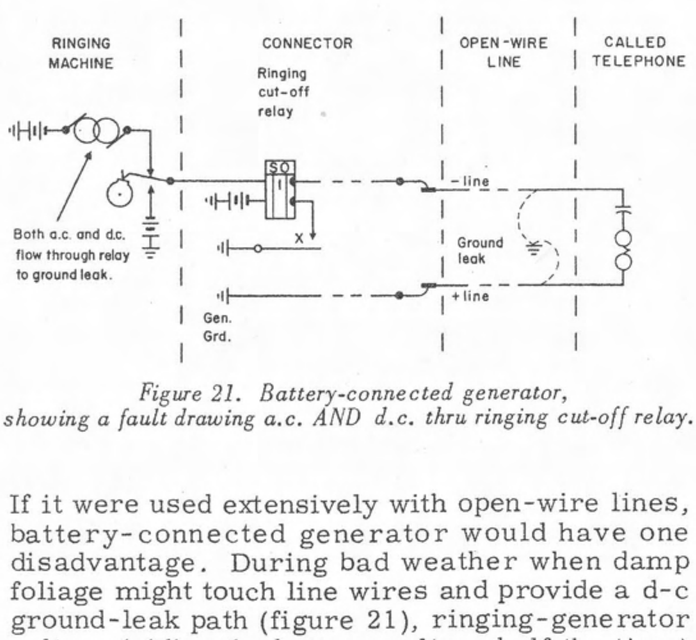


Figure 21. Battery-connected generator, showing a fault drawing a.c. AND d.c. thru ringing cut-off relay.

If it were used extensively with open-wire lines, battery-connected generator would have one disadvantage. During bad weather when damp foliage might touch line wires and provide a d-c ground-leak path (figure 21), ringing-generator voltage (aiding the battery voltage half the time) might, at the generator-voltage peak, send enough current thru the ringing cut-off relay to operate it, and cut off the ringing before the called party had answered.

19.3 Ground-connected generator is preferable for open-wire lines common in rural areas. The central-office battery is connected directly to the connectors' ringing cut-off relays (figure 22).

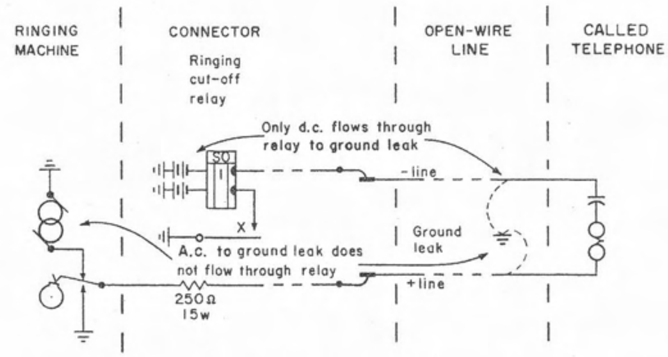


Figure 22. Ground-connected generator, showing a fault drawing only d.c. thru ringing cut-off relay.

The advantage is that a ground leak of high enough resistance that it doesn't put a "permanent" seizure on the line, also cannot cause premature ringing cut off. In figure 22 a –line ground leak draws thru the ringing cut-off relay current from the battery only, not peaked by the a-c generator. A +line ground leak draws no current thru the ringing cut-off relay.

Figure 22 shows each connector requires a 250Ω 15-watt resistor. If there is a low-resistance fault-ground on the +line near the central office, the 250Ω resistor limits current flow so the generator won't overheat. This resistor brings about the less favorable aspects of ground-connected generator: one more part per connector, no inductance to suppress noise-frequency a.c., and a tendency of the extra resistance to lower the maximum loop resistance permissible in lines the connector serves.

20. CALLING-PARTY RELEASE

In certain cases, it is desirable for the connector to release when the caller hangs up rather than when the last party hangs up. Then we omit the wire for relay D spring 5. Relays K and F then are held only by relay B. Relay D will be released when the wiper-closing relay releases or when the called party hangs up, whichever happens first. Thus, the caller can release relays A, B, K, F, and D, operate the release magnet, and re-connect the "off-hook" called party to his line equipment. Calling-party release is not so usual as last-party release, and will be found only in the following 3 cases:

(a) Where all lines have "lock out" (see bulletin 821), there is no reason to hold a connector when the called party is slow to hang up. Avoidance of prolonged unwarranted connector holding is a great advantage in a small central office with few switches. When the caller hangs up, the connector releases, and re-connects the called party's line equipment. This locks him out.

"Lock out" prevents the called party's line equipment from bringing in a linefinder and a selector while his telephone remains "off-hook" from the conversation just concluded. Of course, when he hangs up, the "lock out" removes itself automatically.

(b) In a central office so small it requires no selectors, and 2-wire trunks from adjoining towns come directly into incoming connectors, the only place a trunk is marked busy in the distant office is at lead C in the banks of selectors having access to the outgoing pulse repeaters. Since lead C is not extended between central offices, a last-party-release incoming connector, held by the called party in the small office, would not be marked busy at the outgoing end. A selector serving another distant party would not be prevented from seizing the held connector, and would connect the new caller to the off-hook telephone. Calling-party release solves this problem by enabling the caller to release the switches in both offices.

(c) In a P-A-X of under 100 lines with fan-tail plunger lineswitches (no linefinders nor selectors), calling-party release prevents a called party who does not hang up from tying up the line of the party who just called him. If last-party release were used, the called party, failing to hang up, could continue to hold the connector. The caller's lineswitch (the only lineswitch not denied access to the called party's connector) would remain positioned to preselect the connector held by the off-hook telephone, and would continue to connect the caller to the party he had previously called.

ALARMS AND MISCELLANEOUS

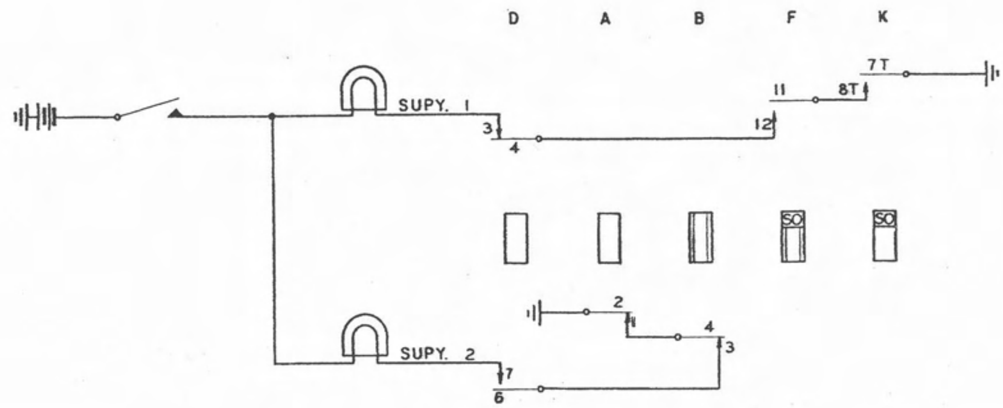


Figure 23. Supervisory circuits of an idle connector.

21. DISCONNECT-DELAY SUPERVISION (figure 23)

The supervisory circuit will light a white lamp on the shelf fuse panel (figure 4) when a conversation has been completed, but the party slower to hang up holds the connector. The SUPY. 1 lamp can light when the caller is slower to hang up; the SUPY. 2 lamp can light when the called party holds the connector. However, all connector white SUPY lamp circuits normally are kept open at a central toggle switch, and will be closed only during slack periods ... for example, at night ... as a check for "permanent" lines.

If the calling party holds the line, the SUPY. 1 circuit (figure 23) is completed thru relay D contacts 3-4, relay F contacts 11-12, and relay K contacts 7T-8T.

If the called party holds the line, the SUPY. 2 circuit is completed thru relay D contacts 6-7, relay B contacts 3-4, and relay A contacts 1-2.

Neither lamp will light if the call is not completed, since they require the operation of either relay D or relay F. Likewise, both supervisory circuits will be held open during conversation, SUPY. 1 by relay D, SUPY. 2 by relay A.

22. RELEASE-ALARM CIRCUIT

When a mechanical defect prevents a connector shaft from rotating or falling during release, the release magnet (figure 20) will remain operated and cause the green release-alarm lamp on the shelf fuse panel (figure 4) to light a few seconds later. This is accomplished by supplying ground to the release magnet thru the low-resistance winding of the shelf release-alarm relay. This relay operates in series with any release magnet on the shelf, and connects the release-alarm lamp to a timer that will light the lamp and sound an alarm (and perhaps light an aisle lamp and a centrally located release-alarm lamp) to inform switchmen of the trouble. Typical timers for this purpose allow the release-alarm relay to be operated from 9 to 20 seconds before they close the alarm circuits.

23. FUSE-ALARM CIRCUIT

If trouble in one of the switches blows a fuse, the red lamp on fuse panel (figure 4) will light. Figure 24 shows a good fuse and a blown fuse. When the fuse wire melts, it releases 2 leaf springs, one of which touches a bus bar on the fuse panel (figure 4), connected to the red lamp. The fuse-alarm circuit also sounds a general alarm and perhaps lights an aisle lamp and a centrally located fuse-alarm lamp.

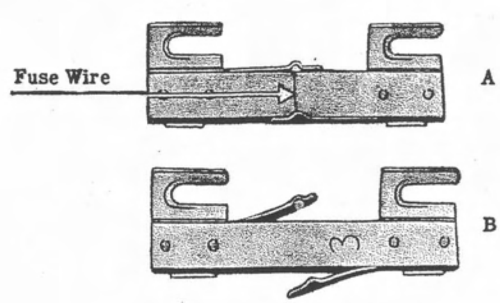


Figure 24. Alarm fuse.
A = good fuse.
B = blown fuse.

24. BUSY KEY (figures 1, 16, and 17)

Above the contact banks on the left side of the connector is the busy key. This key will ground the control lead and mark the connector busy for repair work or testing.

25. TEST JACK (figures 1, 15, and 17)

The "test jack", opposite the busy key and above the wiper terminals, has 2 pairs of springs.

A conductor (penny, screwdriver tip, etc.) inserted between test-jack springs 3-4 will ground the control lead. To "trace" a call, ground lead C at test-jack springs 3-4 (rather than at the busy key, which would release preceding switches during the travel time from one contact to the other).

Test equipment can be connected between springs 1-2 for monitoring or testing across the transmission lines. The usual "test" is to dial "99". Normally the connector makes all 9 steps up and all 9 steps around accurately ... no steps lost, and no overstepping beyond 9 ... showing that the switch pulsing elements are in good adjustment.

Often more than one test is made, one with a low-resistance leaky line simulated, another with a high-resistance line simulated. Usually these 2 pulsing tests are made during the 2 ring-talk-busy test calls described in §26.

26. BAY TEST JACK; ROUTINE TESTS

In addition to the individual-connector test jacks (§25), each connector bay has a pair of test jacks. To the bay test jacks the installer wires battery and ground, and, multipled together, line "99" from every connector shelf in the bay.

At intervals (in a large central office this is often a weekly routine), a switchman makes operation tests of the connectors, using a portable test set or "tea wagon".

The switchman puts the portable test set's twin plug into the bay test jacks. They supply battery and ground to operate the test set, and connect to the test set line 99 of any and every connector in the bay.

The switchman puts the portable test set's Strowger-switch-type test plug into the test jack (§25) of the first idle connector. Using the portable test set's dial, the switchman makes 2 calls to "99".

For the first call he uses a portable-test-set key to make 99 "busy", and he should hear busy tone.

For the second call, the switchman allows the connector to ring into the portable test set. If the test set has a "false TRIP" test key, the switchman operates it during a ringing interval; it should not cut off the ringing. Next, in a silent period, the switchman operates the ANS key, which should operate the connector ringing cut-off relay. Then he checks for transmission, battery reversal, etc.

The switchman repeats the tests for all connectors in the bay.

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("fn" after page number means "footnote" on that page)

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