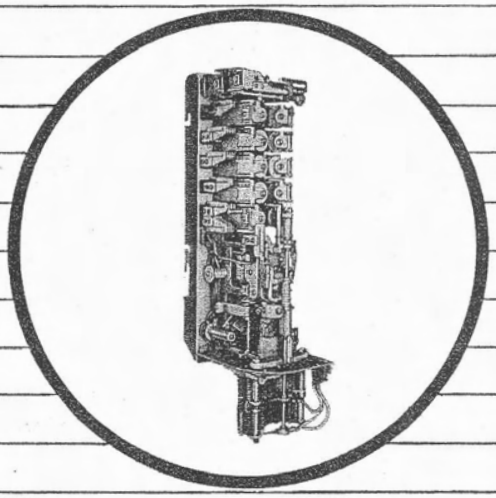
AUTOMATIC ELECTRIC TRAINING SERIES | Bulletin 813

PARTY-LINE CONNECTORS *and* TRUNK-HUNTING CONNECTORS

STROWGER AUTOMATIC TELEPHONE SYSTEMS



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801 Mechanical Principles of Telephony
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May we send you others
pertaining to equipment in your exchange?

PARTY-LINE CONNECTORS AND TRUNK-HUNTING CONNECTORS

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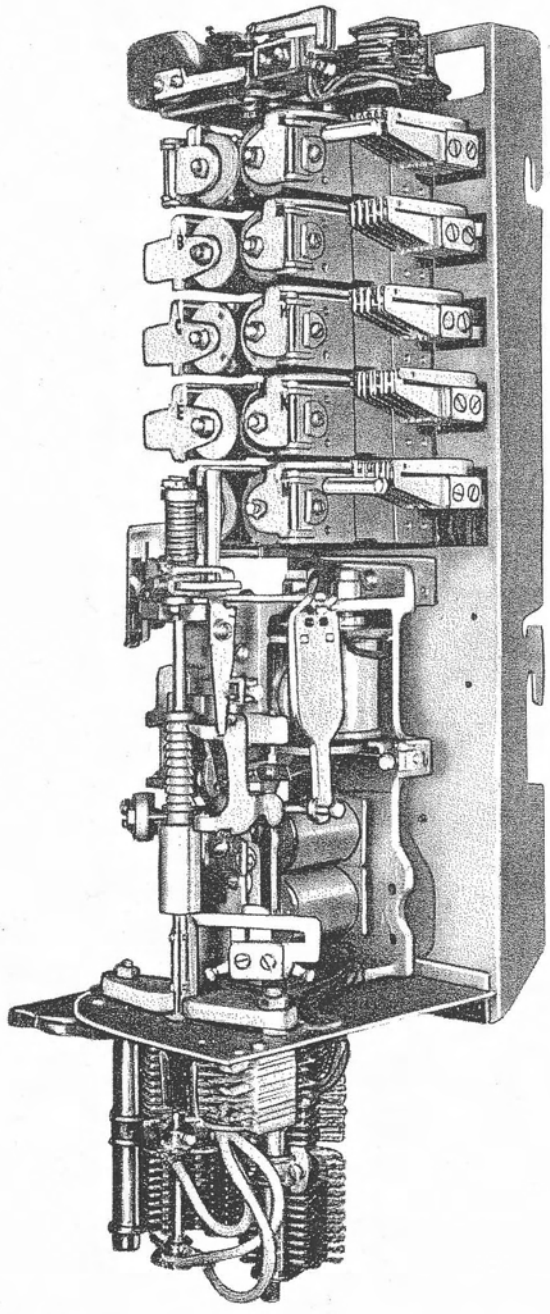

Figure 1. Typical terminal-per-line party-line connector.

PARTY-LINE CONNECTORS

1. SCOPE OF BULLETIN 813

The connector is the only switch which can do nearly every job in establishing a telephone connection. It responds to the dial, rings the called party, supplies transmitter current to calling and called parties, and, when conversation is over, releases the connection. Thus it is just about the most important switch in a switchtrain.

Bulletin 807 described a simple 8-relay connector with the bare essentials. This bulletin 813 describes connectors with additional relays, etc., to handle terminal-per-line* party lines, and subscribers with more than one line.

Automatic Electric Company makes many connectors, all slightly different. This bulletin treats only 2 circuits fully, but these are "typical" and illustrate principles adequately.

2. PARTY-LINE CONNECTOR

2.1 Types. Party-line connectors are available for code or harmonic ringing. Some circuits combine both party-selection and trunk-hunting and/or both local service and toll service in one connector switch.

Harmonic ringing (for which each party-line station has a "tuned" ringer responsive to only one a-c frequency) probably is used somewhat more widely than code ringing. We use code ringing for the example in this bulletin, however, to introduce "pick up" (§2.42).

A typical local, terminal-per-line, code-ringing, ground-connected-generator, party-line connector circuit is shown in figure 19. This connector is for a 5-code system, for 5-party lines with bridged ringing or 10-party lines with divided ringing.** This connector differs from the simple connector described in bulletin 807 in that it is operated by three dialed digits and requires two additional relays and a minor switch. The minor switch, operated by the third digit, selects the ringing-current code and applies it to the proper side of the line.

2.2 Seizure. When a party-line caller lifts his handset, his hookswitch closes the loop circuit and starts at the central office a linefinder which connects him to a selector, from which he receives dial tone. He then dials into selector(s) the first digits of the number of the called station. When he has dialed all but the last three digits, the preceding switch seizes the party-line connector. Connector relay A operates. Relay B operates and grounds lead C which marks the connector busy to other selectors and holds preceding switches in the train, operates relay C through its winding #2 (if not already operated on seizure by ground on lead C from the preceding switch), and operates relay M.

2.3 Dialing. During dialing, relay A releases with each pulse, while slow-to-release relay B remains operated.

2.31 First digit (tens selection). During the first digit, each time relay A releases, it closes a circuit to the vertical magnet which steps the connector wipers. At the start of the first step, vertical-off-normal springs V.O.N. open slow-release relay C winding #2 ..... but pulses thru winding #1 keep relay C operated. After the last pulse, relay A remains operated and keeps relay C winding #1 open so long that (after a tenth of a second or so) slow-release relay C "gets tired", releases, and transfers the pulsing circuit to the rotary magnet.

2.32 Second digit (line selection). During the second digit, each time relay A releases it closes a circuit to the rotary magnet, which steps the connector wipers. When A releases on the first pulse, relay E operates and holds relay M (winding #2). During the first rotary step, rotary-off-normal springs R.O.N. operate, and open relay M winding #1. Slow-to-release relay E does not release when relay A operates between pulses, but when A restores after the last pulse of the series, about a tenth of a second later E releases, and releases relay M, which transfers the pulsing path to the minor-switch rotary magnet.

2.33 Third digit (party selection). During the third digit, each time relay A releases it closes.

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*Automatic Electric Company engineering notes 2030 and 2037 cover terminal-per-STATION party lines. Engineering notes 2030 is based on individual-line-type connectors similar to the one described in bulletin 807. Engineering notes 2037 is based on a connector with 4-conductor banks (+, -, C, and EC for each station).

**Actually, state commissions set rates usually for only 4- or 8-party lines. However, at the time a party's service is terminated you'll find it a convenience that the equipment provides a 5th code or frequency. Then you can add a new subscriber to the line at once (keeping the line filled to 4 or 8 parties) . . . and yet not reassign the discontinued number.

a circuit to the minor-switch rotary magnet, stepping the minor-switch wipers. When relay A releases on the first pulse, relay E operates quickly. During the first step, minor-switch off-normal springs M.S.O.N. are released, and short-circuit unoperated relay F winding #1.

2.34 Busy test. Minor-switch off-normal springs M.S.O.N. connect wiper C to relay H windings #2 and #1 in series. If the called line is idle, relay H does not operate.

> If the called line is busy, at the time of the busy test (before slow-to-release relay E restores), wiper C will be resting on a grounded control lead, and 2-step relay H will operate halfway, closing its contacts "X". When relay E releases, it connects ground from called-line lead C thru relay H contacts 9-10 and 2-3 to relay H winding #1. Relay H operates fully, opens the pulsing path, and connects busy tone back to the calling line.

An idle called line has on lead C negative battery from the cut-off relay.

2.4 Idle-called-line seizure. About a tenth of a second after the last minor-switch pulse, relay E restores, removes the short circuit from relay F winding #1, and connects relay CO to relay L winding #1.

Relay F operates, opens the pulsing path, and, in our example (figure 19), if the last digit is an even* number, operates relay M.

> If operated, relay M would transfer relay K to the +wiper, and, more important, would swing the ringing-generator lead toward the -wiper.

2.41 Cutting off called-line line relay. Line-equipment cut-off relay CO operates immediately, followed by slow-to-operate relay L. Cut-off relay CO cuts off the line relay so the line relay will neither interfere with ringing nor operate when the called party answers. (That is why relay L is made slow to operate: so the line relay will have been cut off before ringing current is applied to the line.)

LAST DIGIT	SIDE OF LINE	RINGING CODE
1	+	———
2	−	— —
3	+	— — — —
4	−	——— —
5	+	——— — —
6	−	———
7	+	— —
8	−	— — — —
9	+	——— —
0	−	——— — —

Figure 2. Standard codes for 10-party divided ringing.

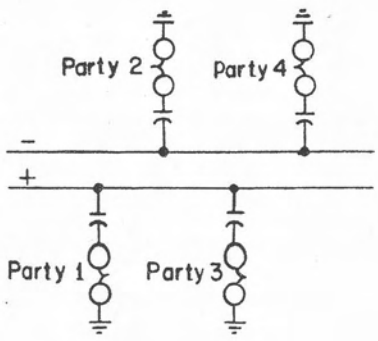
When relay L operates, it locks, short-circuits its own winding #1 to ground wiper C directly, grounds lead R.M. START to start the ringing machine, connects relay K to the called line, and, in our example (code ringing**), connects relay C to the PICK-UP lead.

2.42 Pick-up (code ringing only). For our study-example, let us assume the directory-number final digit was "3". According to figure 2 and figure 3, this calls for 4 short rings. Probably "our" call is not the only call going thru the central office at this time; most likely other calls are in progress and already will have started the ringing machine.

> It is quite possible, for example, that the moment "our" connector relay L operated, the ringing interrupter was at that point in its cycle where it had just sent out the first 2 of the 4 short rings for code 3. If we were to connect the ringing machine to our called line right away, only the remaining 2 short rings would go out during the first ringing cycle, and [instead of our party "3"] party "2" would think he was being rung. Whether he answered by mistake or not, it certainly would be confusing and annoying ... so we obviate this with "pick up".

The next time it is about to start a new series of complete rings, the ringing interrupter sends for about $\frac{1}{4}$ second a ground pulse on the PICK-UP lead (figure 3).

*The purpose of thus alternating the parties (odd=+ and even=-) is to equalize the capacitance-to-ground on the 2 sides of a divided-ringing party line when plant-assignment clerks assign party telephone numbers in logical -1, -2, -3, -4 order.



**If we had harmonic ringing ... which, by the way, is more usual ... the PICK-UP lead would be grounded permanently, and relay C would operate immediately. Although harmonic ringing is more usual, we have chosen to write the party-line section of this booklet around coded ringing, because then we can teach the "pick-up" principle, and make the booklet more educational.

2.43 Ringing. Connector relay C operates, locks, disconnects itself from the PICK-UP lead, sends ring-back tone to the caller, and connects the ringing machine to the called line.

The heavy line in figure 3, an example based on "divided" (earth-return) ringing, shows how (after relay C has operated) ringing-machine interrupter cam-lobes connect the ringing generator to the called line according to the required code. (250Ω resistor A limits current so that if the connector wipers were on a faulty [grounded] line, the generator wouldn't be short-circuited nor overheated.) Ringing current completes its path from the ringer, thru the earth, back to the central-office generator.

If the ringer and its capacitor were "bridged" (=connected across the two wires of the line, without earth return, as in figure 17), the ringer circuit would be completed thru relay K and the central-office battery. It is for this case that relay K is made slow to operate ... to prevent it from being operated by half-cycles of alternating (ringing) current. Meanwhile, the ringer capacitor keeps direct (battery) current from flowing thru relay K.

2.5 Called party answers; ringing cut off. When the called party answers, his hookswitch (figure 3) does away with the ringer-capacitor path (which was for a.c. only), and the hookswitch closes a direct-current circuit from -battery thru relay K winding #1; the called line; the called-telephone transmitter, induction coil, and hookswitch; the other side of the called line; and thru the code cam springs, either thru the generator and thence to ground (+battery), or directly to ground (+battery).

This direct current thru relay K winding #1 closes relay K contacts X. Relay K winding #2 operates relay K completely, removes ground from the R.M. START lead to stop the ringing machine, releases relay C, disconnects ringing current from the called line, and switches the called line thru to battery-feed relay D.

Resistor B makes relay C quick to release, and, during release of C, limits current (from ground thru relay B contacts 8-9 and thru relay C momentarily "bunched" contacts 8-9-10) fed back on the PICK-UP lead to less than the non-operate current of any waiting pick-up relays of other connectors. Relay C restores, and disconnects ring-back tone.

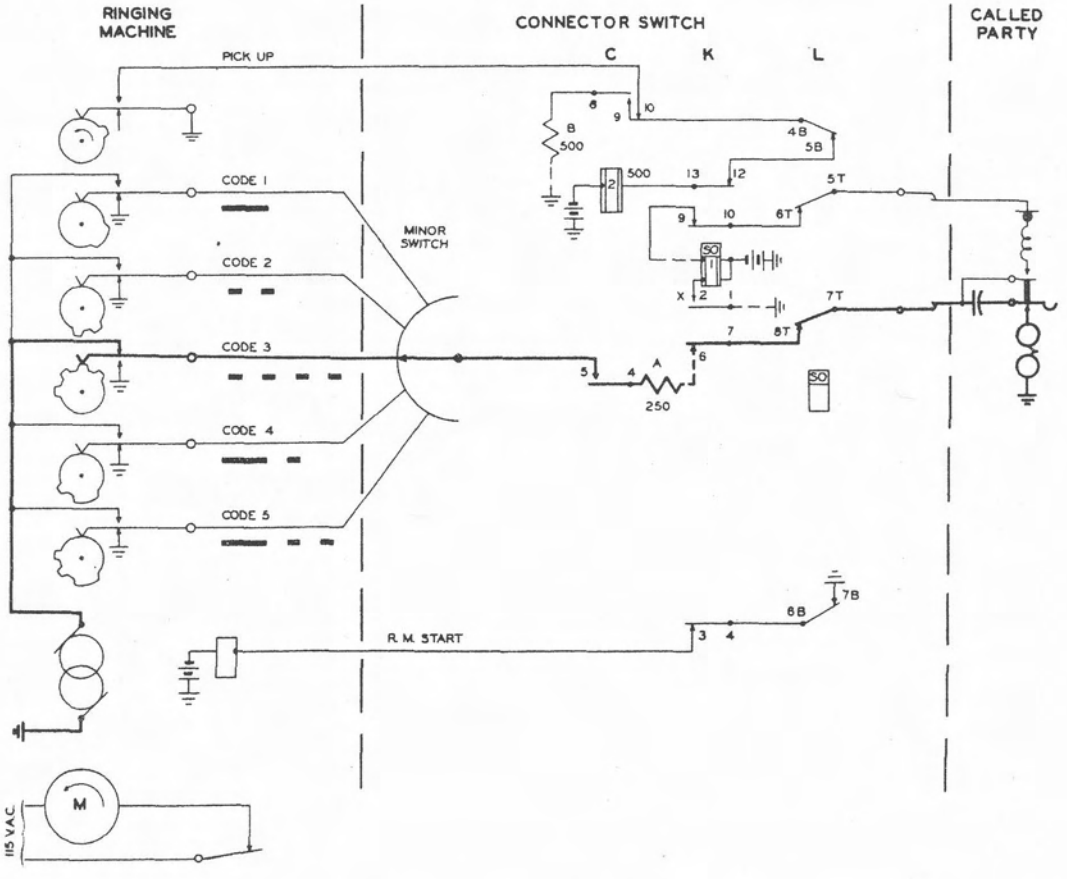


Figure 3. Pick up (for code ringing only). The next time it is about to start a new complete series of code rings, the ringing interrupter sends for about ¼ second a ground pulse on the PICK-UP lead. Heavy line shows ringing circuit.

Relay D supplies transmitter current to the called party; operates; if the connector has usual last-party-release wiring, connects an additional ground to hold relays K and L; and reverses the polarity* of the transmitter current fed from relay A toward the caller.

2.6 Conversation. 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).

Relay L keeps ground on wiper C to hold the called line's cut-off relay.

2.7 Release. The connector may be arranged for either of two types of release.

With relay D spring 5 connected as shown in figure 19, the connector is held until both the caller and the called party hang up. Thus we say the connector is arranged for "last-party release". This is usual.

If relay D spring 5 is disconnected, the called party can do nothing to hold the connector, the connector releases when the caller hangs up, and we say it is arranged for "calling-party release". Calling-party release is less usual. It is found only -

(1) Where all lines have "lock-out" [see bulletin 821],

or

(2) Where trunks from nearby towns come directly into incoming connectors [no selectors].**

Assuming last-party release, figure 19 indicates the sequence of operation and release of the relays and off-normal springs of the connector when the caller is the first to hang up. (Etiquette recommends that the called party should hang up after the caller.)

When the caller hangs up, relay A releases, and operates relay E. When relay B releases, it opens the circuit of slow-release relay E, and removes ground from lead C. The preceding switches release. Slow-to-release relay E remains operated a moment. Then it releases, and connects ground from relay L contacts 3T-4T thru relay E contacts 5-4, relay H contacts 9-10 and 2-1, and relay K 125Ω winding, to lead C to mark the connector as "busy" -- not able yet to accept another call.

Next, the called party hangs up, releasing relay D. Relay D contacts 5-4 release relay M (if operated) and relays K and L. Relay D contacts 2-1 operate the minor-switch release magnet and the Strowger-switch release magnet. Restoring, the minor switch opens its own release-magnet circuit, and also releases relay F. When the Strowger-switch shaft drops to its normal position, it operates the 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.

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

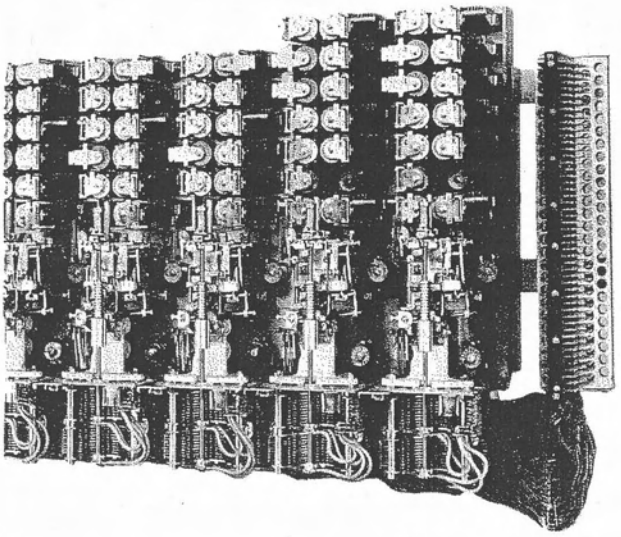
(1) If the call is from a paystation, it results in collection of the charge for the call.

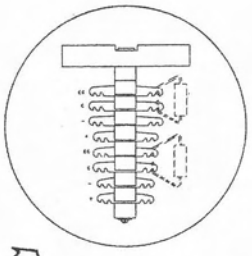
(2) In a measured-service or message-rate exchange, it causes the completed call to be counted.

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

**Altho P-A-X's do not use these frequency-selecting party-line connectors, a P-A-X of under 100 lines [=no selectors] using fan-tail plunger lineswitches needs calling-party release too.

SERVICE TO PRIVATE BRANCH EXCHANGES





Inset: *How radio-type 1200Ω 1-watt resistors (for figures 9, 14, 20, etc.), supported by their leads, mount on the bank terminal block.*

Figure 4. Right-hand end of a shelf of trunk-hunting connectors for night-line service. The local connectors at the left have 11 relays each, as mentioned on page 8. The connectors at the center, with 13 relays each, are combination local-and-toll trunk-hunting connectors. At the right is the bank terminal block, at which all strapping (figure 9 in this case) is done.

3. TRUNK-HUNTING CONNECTORS

3.1 Introduction. The preceding chapter discussed connectors to handle subscribers who share a line. These next 3 chapters discuss connectors which serve subscribers, each of whom has the exclusive use of several lines.

Each multi-line subscriber usually* has a switchboard of its own, to which are brought the "outside" lines or trunks, and also the station lines of the internal organization. Thus the subscriber has a private branch exchange (abbreviated P.B.X.), the trunks and stations of which can be interconnected as required.

The equipment of the operating telephone company should not compel a calling subscriber to try dialing a series of numbers, all serving the same multi-line subscriber, in an effort to find an idle trunk or line. The directory should list but one telephone number for the multi-line subscriber, and the central office must be so equipped that if this directory-listed number is dialed, and is busy, the connector will take the initiative to hunt for an idle line amongst the remaining circuits to the called establishment. This requires, of course, that the several lines must be connected to adjoining or consecutive bank-contact positions.

Circuit variations arise from four questions:

How shall the consecutive-line group be marked in the connector banks? (See §3.2.)

Shall the connectors hunt during the hours the P.B.X. switchboard is not attended, and "night connections" are set up? (See §3.21.)

Does any P.B.X. subscriber have more than the ten trunk lines which represent the normal capacity of one level of a connector-switch bank? (See §5.)

Does the operating telephone company have enough multi-line subscribers to warrant assigning a whole special connector group to them? **

*Sometimes, as for example at a small retail store, there may merely be a couple of order-taking telephones.

**If not, Automatic Electric Company can supply connectors which COMBINE both the party-line and the trunk-hunting functions in every connector.

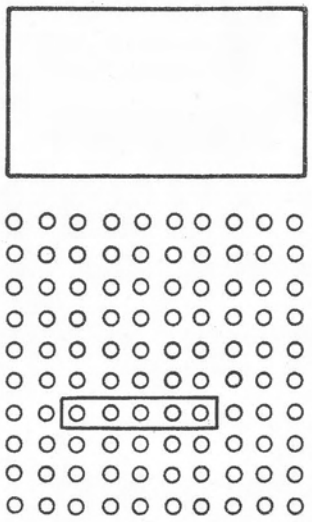


Figure 5. Five consecutive line numbers (43, 44, 45, 46, and 47) in the banks of a connector.

3.2 Bank-marking patterns. A P.B.X. group bank-marking circuit pattern developed in 1918 was so well conceived that it continues in use today in many Strowger trunk-hunting connectors. A fourth lead, the "extra control" lead, abbreviated EC, is required for each line in the trunk-hunting connector banks. Control lead C and extra control lead EC are strapped on all lines in a P.B.X. trunk group, except the last line in the group. For the five lines in figure 5, this is shown schematically in figure 6. The task of strapping leads C and EC is actually simpler than the schematic of figure 6 suggests. Both leads are multipled throughout all banks on a shelf, and strapping is done at the shelf bank terminal block (figure 4) only once for each line.

The trunk-hunting feature of these connectors usually requires two additional relays in each connector: if the regular connectors in the central office have eight relays, the trunk-hunting connectors will have ten relays. If any line (such as 43, first in the group in figure 5) is dialed and is idle, the connector seizes the line in the usual way, namely by grounding lead C to operate the cut-off relay of the called line. Because leads C and EC of line 43 are strapped, in grounding lead C the connector grounds also lead EC at every bank multiple appearance of line 43. If, now, another subscriber dials line 43, during dialing of the last digit 3, the second connector tests lead C of line 43 and finds it busy. Lead EC being grounded, relay-interrupted rotary stepping takes place. During this automatic rotary stepping, the connector, seeking an idle line, looks for absence of ground on lead C, and each grounded contact EC causes another rotary step to be taken. If all lines in the group are busy, the wipers step to the last line in the group. There lead EC is open so no further steps are taken, and ground on lead C causes busy tone to be returned to the calling party.

3.21 Night service. Let us now assume five o'clock has come, the "night connections" shown in figure 8 have been put up, and the P.B.X. operator has gone home. A call to 43 will ring the night watchman, who can inform callers that the establishment opens at such-and-such time the next morning, can give out home numbers for urgent calls, etc. If, however, two calls are made to 43 in close succession, the first will busy 43, the connector for the second call will hunt past 43 and ring 44, and perhaps no one will answer. Again, perhaps the manager is working after hours, and has told

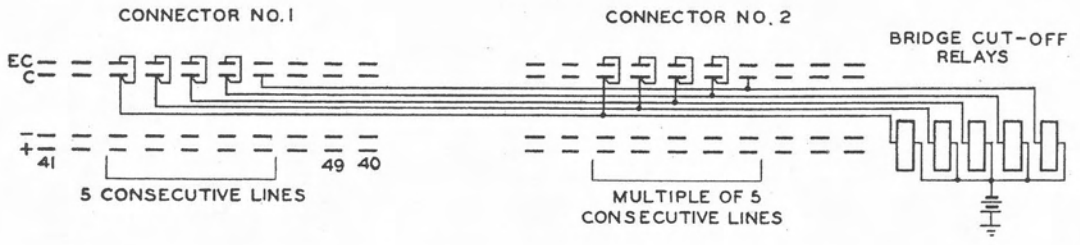


Figure 6. The most common pattern for 100-line connectors. Leads C and EC of all lines in the group, except the last, are strapped.

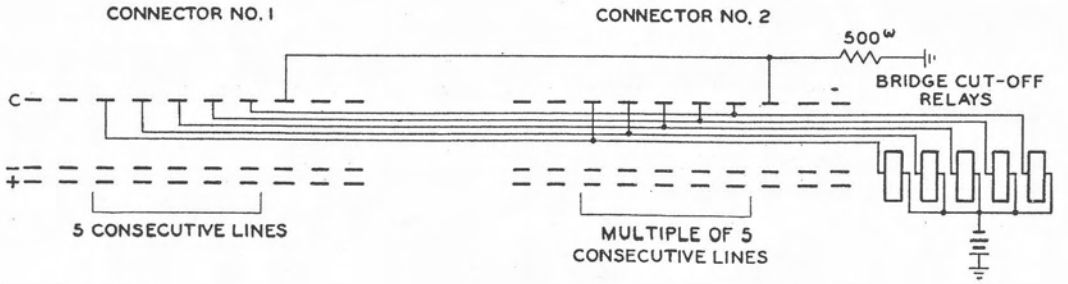


Figure 7. The pattern for 200-line connectors. No special marking on any line used for telephone conversations, but a line is wasted.

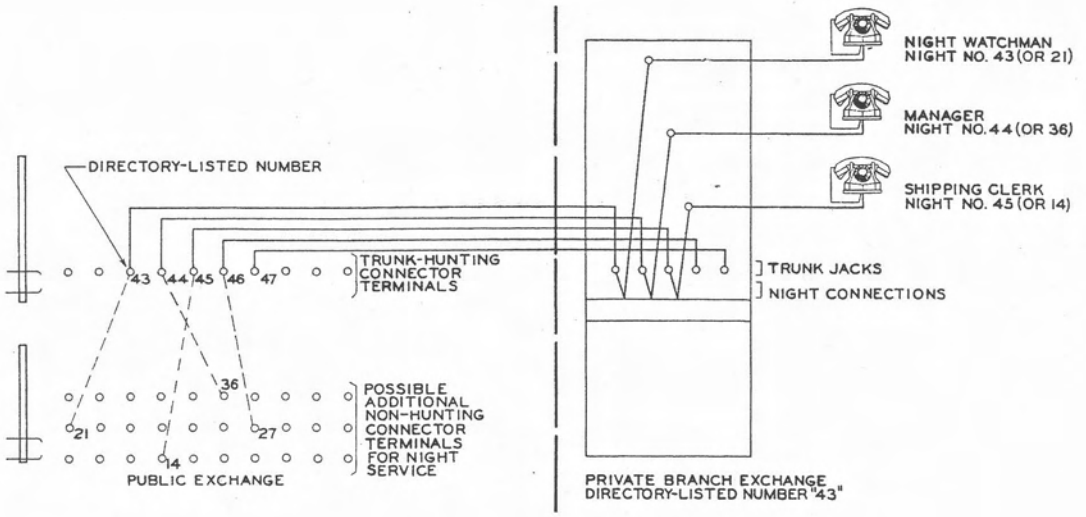


Figure 8. Night connections at a private branch exchange.

people he can be reached during the evening on 44. If meanwhile he calls out, busying 44, a call to 44 finds the line busy, the connector hunts past 44, and 45 will be rung. The station on line 45 probably is in another part of the building and goes unanswered, or is answered by the shipping clerk who must ask the caller (who may be at a paystation!) to hang up and call again later. Inasmuch as night calls are infrequent, little difficulty arises, and for years most operating telephone companies have found the system of figure 6 entirely satisfactory.

If the problem locally is serious, however, two solutions are possible. Simplest is the case of just one individual who works overtime frequently, and wishes his callers to get busy tone when his telephone is in use; he should be plugged into the last line in the P.B.X. trunk group, 47 in figure 8.

But perhaps several people work after hours in widely separated departments. In this case, assign an additional connector terminal to each line requiring night service. The second set of numbers can be assigned at random. Disconnect the line and cut-off relays of the second terminal numbers. If the second numbers are on a trunk-hunting connector shelf, none of their leads C and EC are strapped. Thus all the second numbers appear in effect as the last line of a one-line group, and, if busy, cannot cause hunting, but will return busy tone. Again using figure 8, if the manager dials 21 from his home, he is sure either to ring the night watchman or to hear busy tone. If the manager tells people to call him on 36 at night, they will get him or busy tone; they will never get the shipping clerk. However, the telephone company must give up two sets of numbers, and each P.B.X. station user must ask his most frequent callers to remember two dissimilar numbers, or have a separate night listing in the directory.

The limited suitability of figure 6 to night service led to the introduction in 1932 of the bank-marking circuit pattern of figure 9. This, too, uses a fourth bank contact for extra control lead EC, for each P.B.X. trunk line. The first line in a trunk group has leads C and EC strapped.* Subsequent lines in the group have lead EC open, except the last line in the group which has a 1,200Ω resistor permanently connected between leads C and EC.

*For some circuits, first-line bank contact EC is connected permanently to ground.

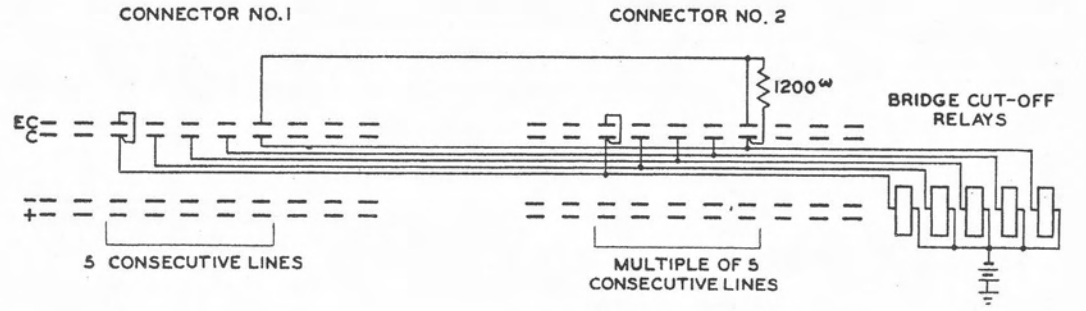


Figure 9. A pattern for 100-line connectors with night-line service and for level-hunting connectors.

The bank wiring of figure 9 usually requires three additional relays in the connector: if the regular connectors in the central office have eight relays, the trunk-hunting connectors will have eleven relays. If any line (such as 43, first in the group in figure 5) is dialed, and is idle, the connector seizes the line in the usual way, namely by grounding lead C to operate the cut-off relay of the called line. If now another subscriber dials line 43, during dialing of the last digit, 3, the second connector tests lead C of line 43, finds it busy, and then tests lead EC. Lead EC being grounded, relay-interrupted rotary stepping takes place. During this automatic rotary stepping, the connector operates on the battery-searching principle, looking for negative battery thru the unoperated cut-off relay of an idle line. If all lines in the group are busy, the wipers step to the last line in the group. There, ground (from lead C) thru high resistance (1,200Ω) marks lead EC to prevent further steps, and the ground on lead C causes busy tone to be returned to the calling party.

Comparing figure 6 and figure 9, we notice that in figure 6 lines in the middle of a group are marked the same as the first line of a group, and cause hunting, whereas in figure 9 lines in the middle of a group lack marking, just as do lines not in a group, and cannot cause hunting. Thus, if any line in the group except the first is dialed, the connector wipers have no opportunity to come to rest on the first line, and the connector does not set itself for hunting. If a caller dials directly any line (other than the first) in a group, he will either ring the line number he dialed, or will hear busy tone; the connector will not attempt to complete his call over another line in the group.

This sort of connector is recommended where special attention to night service is desired, as all terminals of the group except the first one may be used for night listing. It is sometimes referred to as a "night-service" or "pilot-number" connector. If the caller dials the regular directory-listed "pilot" daytime number, and it is busy, the connector sets itself to hunt; if any other number than the first in the group is dialed, as at night, the connector will not hunt. Such connectors make unnecessary the assignment of the extra terminals shown dotted in figure 8. It is such a connector we'll study in §4.

TYPICAL TRUNK-HUNTING CONNECTOR

4. OPERATION OF A TYPICAL TRUNK-HUNTING CONNECTOR

Figure 20 is the circuit of a typical trunk-hunting connector with a chart illustrating the sequence of operation of the relays when a call is made to the first or "pilot" number. The time chart illustrates automatic trunk hunting when the first 3 lines of a group are busy. Figure 9 shows the bank-marking arrangement and the wiring of a level containing a trunk-hunting group of this connector. When the pilot number is dialed and found busy, the connector will hunt until it connects to an idle line. When a number of the group other than the pilot number is dialed and found busy, the connector does not hunt but returns busy tone to the calling party. Thus any number other than the pilot number may serve as a night number.

4.1 Seizure. When a caller lifts his handset, his hookswitch closes the loop circuit, and starts at the central office a linefinder which connects him to a selector, from which he receives dial tone. He then dials. When he has dialed all but the last two digits, the preceding switch seizes the connector. Connector relay A operates. Relay B operates and grounds lead C which marks the connector busy to other selectors and holds the preceding switch train, and (if C was not already operated on seizure by ground from the preceding switch) operates relay C.

4.2 Dialing. During dialing relay A releases with each pulse, but slow-to-release relay B remains operated.

4.21 First digit. Each time A releases during the first digit, it operates the vertical magnet, causing the connector wipers to make a vertical step. During the first step, the V.O.N. springs release, and open relay C winding #2. Pulses from relay A thru winding #1 keep slow-to-release relay C operated. After the last pulse of the series, relay A stays operated, and relay C releases, and transfers the pulsing circuit to the rotary magnet.

4.22 Second digit. Each time A releases during the second digit, it operates the rotary magnet, causing the connector wipers to make a rotary step. Relay E operates on the first pulse, connecting wiper C to relay Z. Slow-to-release relay E will remain operated during dial-controlled rotary stepping.

At the end of the second digit, the wipers are on the dialed line. The connector encounters one of four sets of conditions:

NUMBER DIALED	DIALED LINE	OTHER LINES IN GROUP	SEE
Individual or pilot number	Idle	--	§4.3
Individual number	Busy	--	§4.4
Pilot number	Busy	A line is idle	§4.5
Pilot number	Busy	All lines busy	§4.6

4.3 Called number idle. If the dialed line is idle, wiper C encounters -battery; relay Z will not operate. When A reoperates after the last pulse, it opens the circuits of the rotary magnet and of slow-to-release relay E. Relay E, releasing, connects -battery from the called-line cut-off relay and via wiper C to relay J.

Relay J operates, locks, grounds wiper C to operate the called-line cut-off relay and to mark the called line busy, and operates relay H. Relay H grounds the R.M. START lead to start the ringing machine, connects ringing current (thru relay F) to the called line, and connects ring-back tone to the calling line.

4.4 Called line busy -- Individual line (or in a group, but not the first in the group).

The characteristics of this series of operations are:
Relay Z operates for a short time, and then restores.
Relay K does not operate at all.
Relay G locks thru winding #2, only.

If an individual line is dialed and found busy, wiper C encounters ground, and relay Z operates. When A reoperates after the last pulse, it opens the circuits of the rotary magnet and of slow-to-release relay E. Relay E, releasing, disconnects wiper C from slow-to-release relay Z, and operates relay G. Relay G locks (winding #2 only). Relay Z releases and connects busy tone to the calling line.

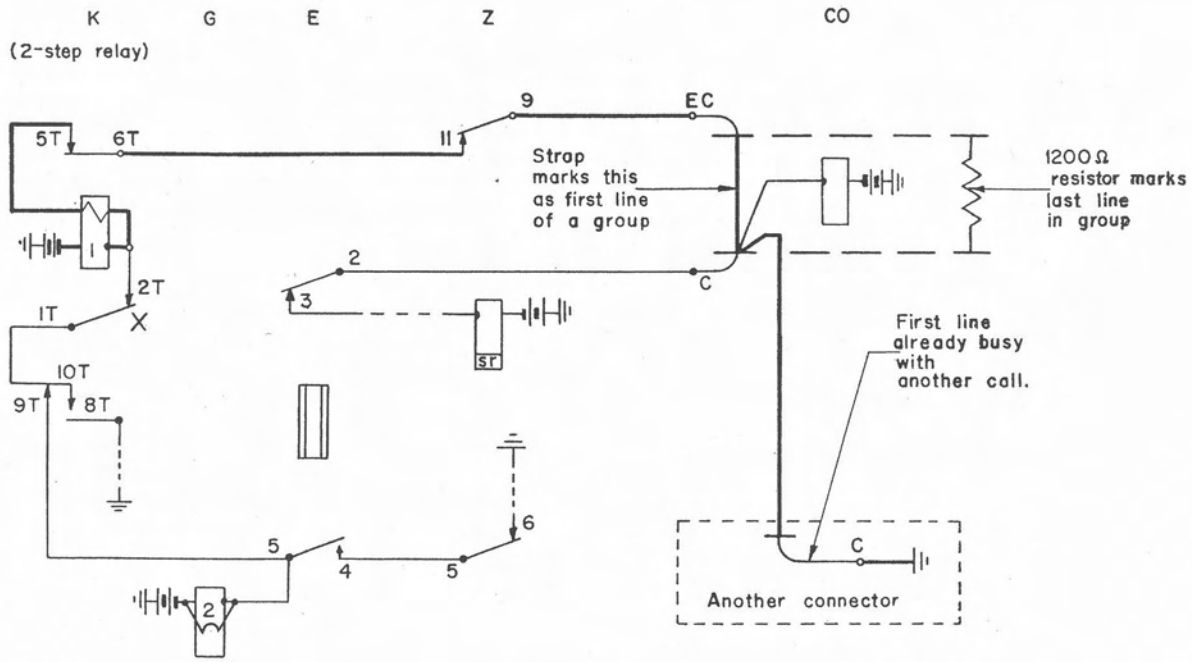


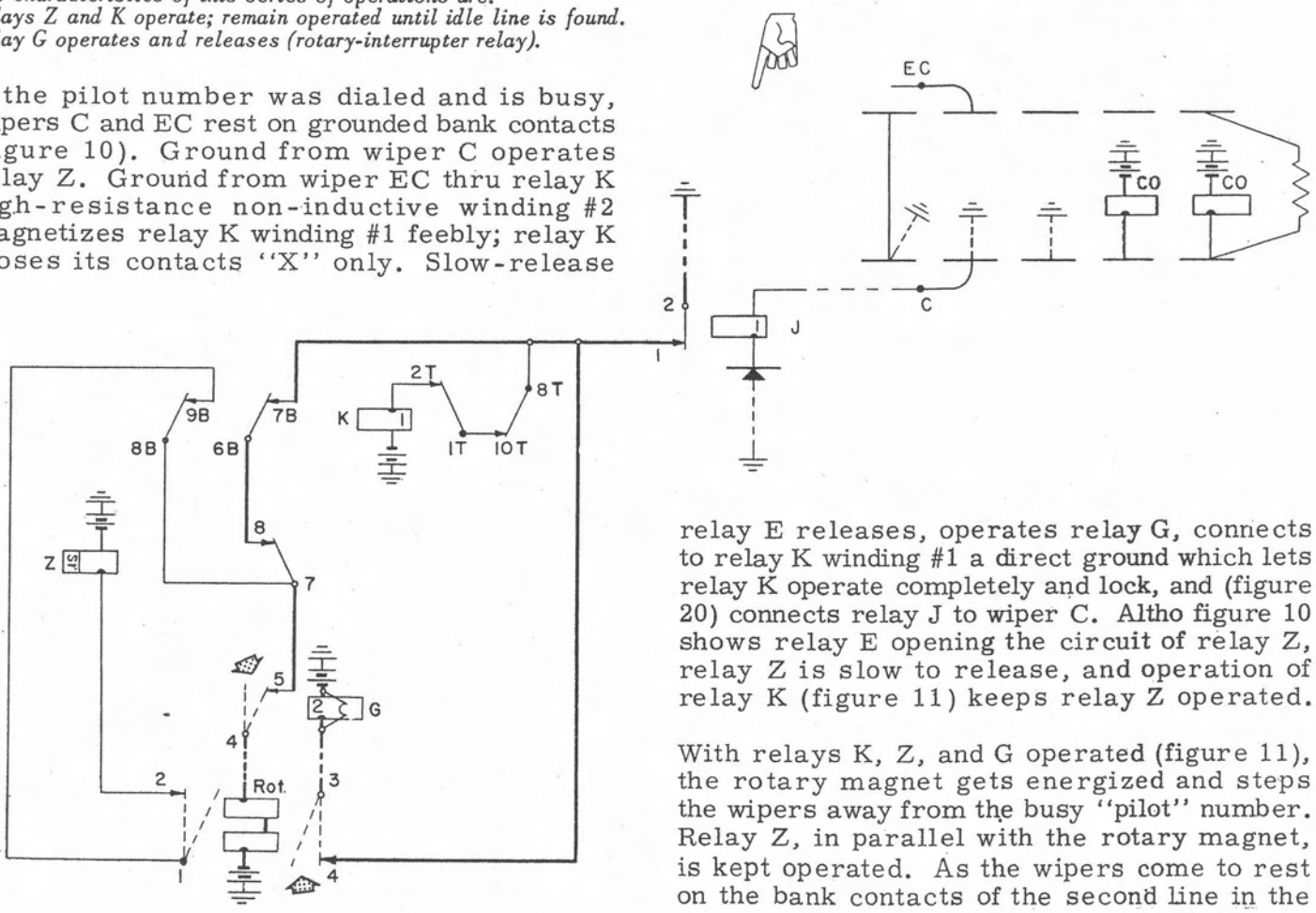
Figure 10. Wipers have just been dialed to first line in group. It is busy. 2-step relay K operates contacts 1T-2T immediately. When slow-release relay E restores, relay K will operate completely, and lock.

4.5 Called line (first line in a group) is busy -- Subsequent line idle.

The characteristics of this series of operations are:
Relays Z and K operate; remain operated until idle line is found.
Relay G operates and releases (rotary-interrupter relay).

If the pilot number was dialed and is busy, wipers C and EC rest on grounded bank contacts (figure 10). Ground from wiper C operates relay Z. Ground from wiper EC thru relay K high-resistance non-inductive winding #2 magnetizes relay K winding #1 feebly; relay K closes its contacts "X" only. Slow-release

Figure 11. Relay G and the rotary magnet step the wipers, relay-interrupted, across other busy lines. When wiper C finds –battery of first idle line, relay J will operate and stop the rotary stepping.



relay E releases, operates relay G, connects to relay K winding #1 a direct ground which lets relay K operate completely and lock, and (figure 20) connects relay J to wiper C. Altho figure 10 shows relay E opening the circuit of relay Z, relay Z is slow to release, and operation of relay K (figure 11) keeps relay Z operated.

With relays K, Z, and G operated (figure 11), the rotary magnet gets energized and steps the wipers away from the busy "pilot" number. Relay Z, in parallel with the rotary magnet, is kept operated. As the wipers come to rest on the bank contacts of the second line in the

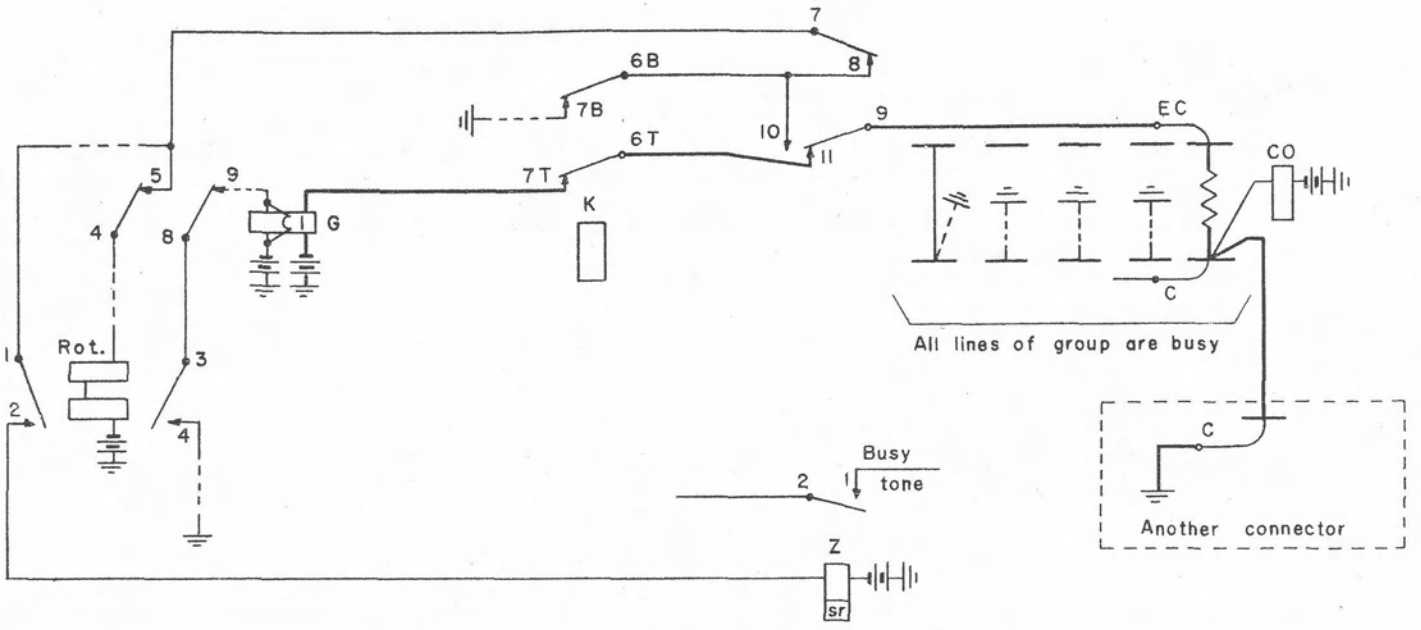


Figure 12. All lines in the group are busy.
Ground on bank-contact EC, holding relay G, prevents rotary magnet from stepping the wipers beyond this group.
Slow-release relay Z finally will fall back, release the rotary magnet, and connect busy tone.
Relay G will be held thru both its windings.

group, rotary-magnet interrupter springs 1-2 open the circuit of slow-release relay Z, and rotary-magnet interrupter springs 3-4 release relay G. Relay G opens the circuit of the rotary magnet.

Notice (figure 11) that +connected relay J and wiper C test line bank contact C not for absence of ground, but for -battery; the connector does its automatic rotary hunting on a purely battery-searching basis. Hunting will continue until -battery on an idle-line bank contact C operates relay J.

In our example (figure 11, wipers on busy second line, fourth line idle), the following things happen in less time than it takes to read about them:

Release of rotary magnet reoperates G,

Relay G reoperates the rotary magnet, stepping the wipers to the third line, where the

Rotary-interrupter springs release G, and

Relay G releases the rotary magnet.

Release of rotary magnet reoperates G, and

Relay G reoperates the rotary magnet, stepping the wipers to the fourth line.

At the fourth line, -battery thru cut-off relay CO operates relay J quickly*, and the rotary magnet and all the rotary-hunting relays of figure 11 release. The connector rings the fourth line as in §4.3.

4.6 All lines in a P.B.X. group are busy.

The characteristics of this series of operations are:
Relay Z operates, remains operated during hunting; releases.
Relay K operates; remains operated until caller hangs up.
Relay G operates and releases during hunting
(interrupter relay for rotary magnet),
and finally is held thru both windings #1 and #2.

If the pilot number is dialed and found busy, the connector will hunt for an idle line as in §4.5. When the connector has hunted thru all lines in the P.B.X. group and arrives at the last line (figure 12), ground from busy-last-line lead C thru a resistor is picked up by wiper EC, and holds relay G (winding #1). So, even tho rotary-magnet interrupter springs 3-4 open relay G winding #2 as in §4.5, relay G cannot release.

Meanwhile, relay G keeps the rotary magnet energized, and rotary-magnet interrupter springs 1-2 stay open so long that slow-release relay Z is forced to release. Relay Z contacts 10-11 hold relay G operated. Relay Z contacts 7-8 release the rotary magnet, leaving the wipers at rest on the busy last line. Rotary-interrupter springs 3-4 reclose the circuit of relay G winding #2. Relay Z contacts 1-2 send busy tone to the caller.

---

*Relay J was already partially magnetized (to insure fast operation on arrival at idle line) when relay B first operated, and relay B contacts 8-9 (figure 20) closed a circuit thru the 3500Ω of resistors B and A to "pre-energize" relay J winding #2.

A rectifier in series with relay J winding #1 (figure 11) prevents operation of relay J if wiper C passes over a busy message-rate line with a meter being operated by booster battery (see Linefinder bulletin 821 -- page 14 §4.41 and figure 18, if you have the May 1955 edition).

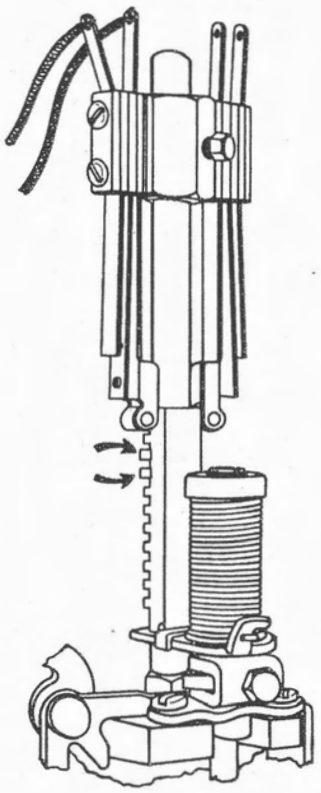


Figure 13. Normal-post springs.
Arrows show cam lugs bent 90° to operate
left normal-post springs when wiper-shaft is opposite
or cut in on level 2 or 3.

4.7 Ringing called party. When relay J operates (§4.3 or §4.5), it operates its wiper-closing slave, relay H, which grounds lead R.M.St. to start the ringing machine (figure 20), and (figure 18) connects the Gen. & Bat. lead (thru relay F) to the -line and the Gen. Grd. return lead to the +line.

A capacitor in series with the called party's ringer (figure 18) if an individual line, or a capacitor in series with the P.B.X. trunk-circuit ring-up relay prevents battery direct current from flowing thru relay F, and relay F, being slow to operate, cannot be operated by brief spurts of half-cycles of alternating ringing current.

4.8 Called line answers. Answer of the called number substitutes for the capacitor circuit a bridge which draws direct current from the central-office battery thru relay F. Relay F closes its contacts "X", locks, operates fully, cuts off the ringing, and extends the called line thru to relay D. Relay D supplies transmitter current toward the called line, and operates. Usually, relay D reverses polarity* of the transmitter current supplied the caller.

> If the P.B.X. called is one to which the telephone company connects the caller free of charge, such as the telephone-company business office, the police or fire department, etc., all 10 lines on that connector level will have been reserved for free service. If the switch shaft was dialed to that level (§4.21), normal-post springs (figure 13) will have operated, and operation now of relay D (figure 20) will not reverse polarity of the transmitter current supplied the caller.

Relay D contacts 4-5 provide an additional path to hold relays F, H, and J, thus giving us last-party release.

4.9 Release. Relays F, H, and J can be held by either the caller (relay B contacts 8-9) or the called party (relay D contacts 4-5), and the release-magnet circuit passes thru both relay B (contacts 1-2) and relay D (contacts 1-2). The connector cannot release until both parties have hung up .... i.e., until the last of the 2 parties to the conversation has hung up. We say the connector is wired for "last-party release".

Etiquette recommends that the caller hang up first (i.e., the called party should not hang up until the caller shows he has completed all purposes of his call). A moment after the caller hangs up, slow-release relay B releases, removing ground from lead C. This releases the caller's cut-off relay, the linefinder, and all intervening selectors. (Even tho the connector itself does not release, the caller's line is disconnected, and he is free to make another call right away.)

When the called party hangs up, relay D releases, releases relays F, H, and J, and operates the release magnet. Release of relay H disconnects the wipers, so they are electrically "dead" as they sweep over earlier lines on the level, while they rotate to the left and off the bank.

When the wiper-shaft drops down to its normal position, vertical-off-normal springs 1-2 open the circuit of the release magnet, and vertical-off-normal springs 3-4 connect -battery (thru relay C winding #2) to lead C to mark this connector idle and available for another call.

---

*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.

LEVEL-HUNTING CONNECTORS

5. LEVEL-HUNTING CONNECTORS

Level-hunting connectors have been made in one form or another for over thirty years, but they are not so well known as they should be.

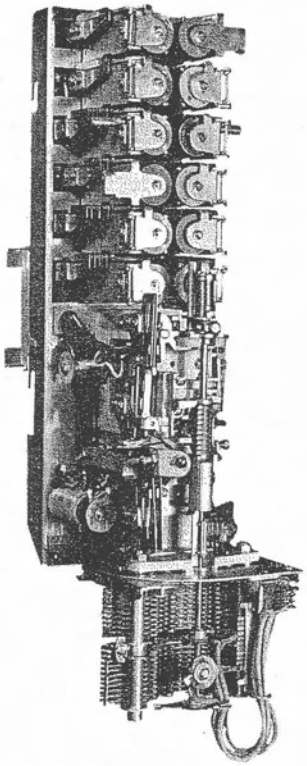


Figure 14. Typical level-hunting connector.

A typical modern level-hunting connector is shown in figure 14. It can reach from one single line to a group of one hundred lines. A calling subscriber dials its wipers to the directory "pilot" number (the first terminal) of a called P.B.X. subscriber. If that first line is busy and bank markings indicate the called subscriber has additional lines, the level-hunting connector hunts across them all until an idle circuit is found.

Twenty trunks in the banks of a level-hunting connector might be arranged as in the lower part of figure 15, the directory number being 23.

A level-hunting connector can hunt across consecutively numbered lines no matter how many levels they occupy. The upper part of figure 15 shows a possible grouping, in the banks of a level-hunting connector, of the lines for a subscriber with thirty-seven P.B.X. trunks, terminals 51 thru 87, accessible by dialing the directory-listed pilot number 51.

Level-hunting connectors are only slightly more expensive than the more conventional single-level trunk-hunting connectors. Ordinary single-level trunk-hunting connectors with night service using bank markings per figure 9 require, as previously stated, eleven relays; as seen in figure 14, ordinary level-hunting connectors require twelve relays -- only one relay more.

The operating company might order a 100-line group of level-hunting connectors if even only one subscriber has, or in the foreseeable future will have, eleven or more P.B.X. trunks.

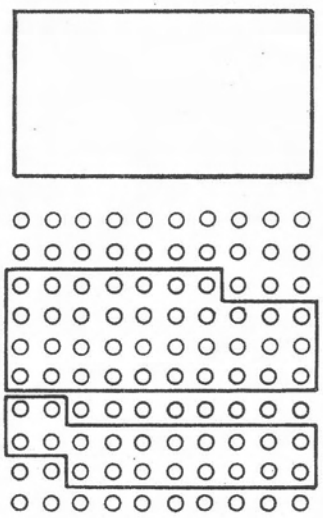


Figure 15. How 20 P.B.X. trunks (directory number 23) or 37 P.B.X. trunks (directory number 51) might be grouped in the banks of a level-hunting connector. It is mechanically preferable, but not electrically necessary, that groups begin at contact #1 of a level....as does the 37-line group above.

Level-hunting connectors are spectacular in their action and it is intriguing to watch them. They use, however, only the ordinary mechanisms found on other Strowger switches such as linefinders. These include the cam springs, vertical bank and wiper*, vertical interrupter springs, etc.

*Functioning here as rotary off-normal contacts.

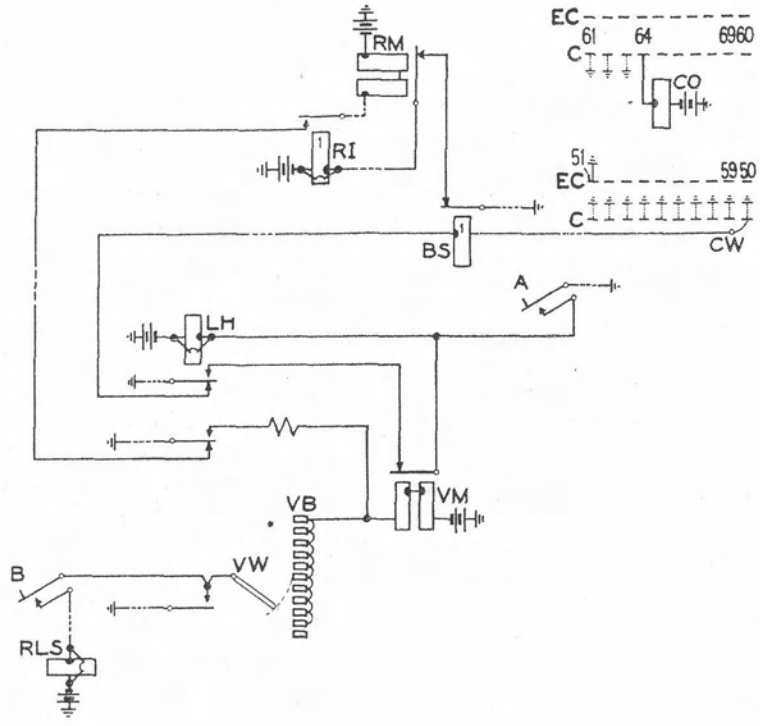


Figure 16. Trunk-hunting automatic rotary and vertical stepping-circuit elements of the level-hunting connector of figure 14. In the upper right-hand corner of this figure are shown levels 5 and 6 of the bank contacts of figure 15. The wipers are shown on bank contact 50, about to take an eleventh rotary step on level 5 and then to be advanced to bank contact 61.

In figure 16, the level-hunting connector of figure 14 has been dialed to 51, the pilot number of the 37-line group shown in figure 15. Vertical wiper VW is thus disengaged from vertical bank VB. Lines 51 thru 63 are busy. Ground on lead EC of line 51 has set the connector for relay-interrupted rotary stepping, battery searching, hunting negative battery through the cut-off relay of the first idle line, 64. Rotary-interrupter relay RI keeps operating, closing the circuit of rotary magnet RM. At each busy contact C reached, ground prevents battery-searching relay BS operating. Relay RI re-operates, etc., and thus we step across 51, 52, 53, 54, 55, 56, 57, 58, and 59 to 50.

When the switch shaft takes the rotary step from contact 50 to the eleventh rotary position, cam springs A and B close. Relay LH operates, locks, thru operated cam springs B closes the circuit of release magnet RLS, and, thru a special resistor, magnetizes the vertical magnet just enough to engage the vertical pawl into the shaft hub (but not enough to lift the shaft nor to lift the release link). Release magnet RLS latches the double dog under the release link. The shaft spring rotates the wipers leftward to rotary normal. Cam springs A and B open.

When the wipers reach rotary normal, the vertical pawl, engaged by the partially operated vertical magnet, prevents the shaft from falling, and vertical wiper VW touches vertical bank VB. The vertical wiper and vertical bank short-circuit the special resistor, grounding vertical magnet VM directly, causing it to operate fully. The vertical magnet steps the wipers up opposite the next higher level, level 6 in figure 16, and unlatches the double dog to hold the shaft there. The vertical interrupter springs release relay LH. Relay LH releases the vertical magnet, re-connects testing ground to battery-searching relay BS, and, thru contacts of operated relay RI, causes the rotary magnet to step the wipers onto bank contact 61.

Relay-interrupted stepping continues across 61, 62, and 63. When control wiper CW reaches line 64, relays BS and CO operate. Relay BS releases rotary-interrupter relay RI, and thus prevents further stepping. Conventional elements of the connector ring line 64 in the usual way, and conversation ensues.

Thus it is seen that level-hunting connectors are not substantially more expensive nor substantially more complicated than single-level trunk-hunting connectors.

Using as they do a bank-marking pattern similar to figure 9, level-hunting connectors give reliable (non-hunting) night service if any number subsequent to the regular daytime directory number is dialed.

GENERATOR CONNECTIONS

6. GENERATOR CONNECTIONS

Figures 17 and 18 show two methods to connect the ringing generator thru the connector to the called-telephone ringer.

Figure 17 illustrates the ground-connected method which is more suitable for open-wire lines common in rural areas. Note that the generator is connected in series with a resistor between ground and one side of the line and ringing cut-off relay K is connected in series with battery between ground and the other side of the line. Rural open-wire lines often run close to trees and high foliage so that contact between the wires and the branches is possible. Sometimes, especially during and after heavy rains, the damp foliage provides a leak path between wires and ground. In the ground-connected arrangement the a.c. flowing thru the leak does not flow thru the ringing cut-off relay.

This guards against premature ringing cut-off before the called party can answer. If the generator side of the line is grounded near the central office, the 250Ω resistor limits current so that the generator is not short-circuited nor damaged.

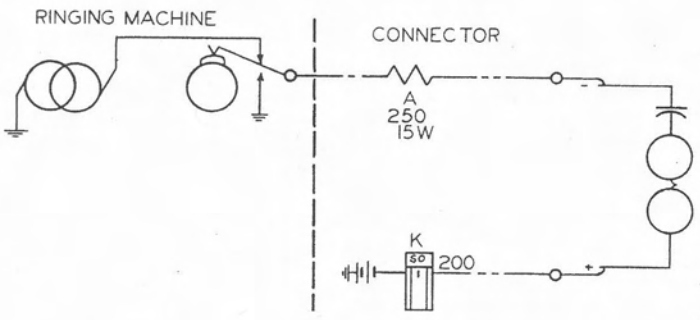


Figure 17. Ground-connected generator (usual for communities with mostly open-wire lines).

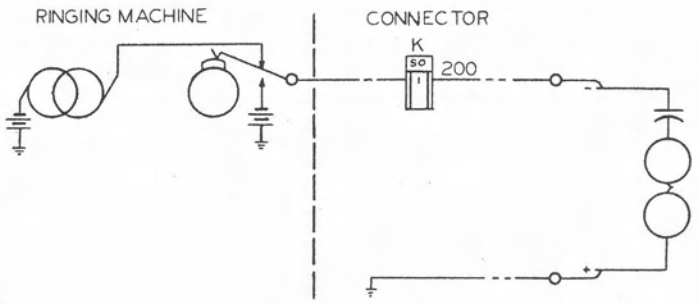


Figure 18. Battery-connected generator (usual for urban areas with most lines in cable).

Figure 18 illustrates the battery-connected method. With this arrangement a high-resistance ground might cause the ring cut-off relay to operate, but, since this method is used with cabled lines common in urban areas, such a condition is not likely to exist. Note that the resistor is eliminated, the generator is connected in series with the battery and the ringing cut-off relay between ground and one side of the line, and the other side of the line is grounded. Ringing cut-off relay inductance helps filter higher frequency harmonics and other ringing-machine electrical disturbances so they tend to be kept out of the cable. This helps keep the cable quiet.

The party-line connector of §2 is shown with ground-connected generator, and the trunk-hunting connector of §4 is shown with battery-connected generator.

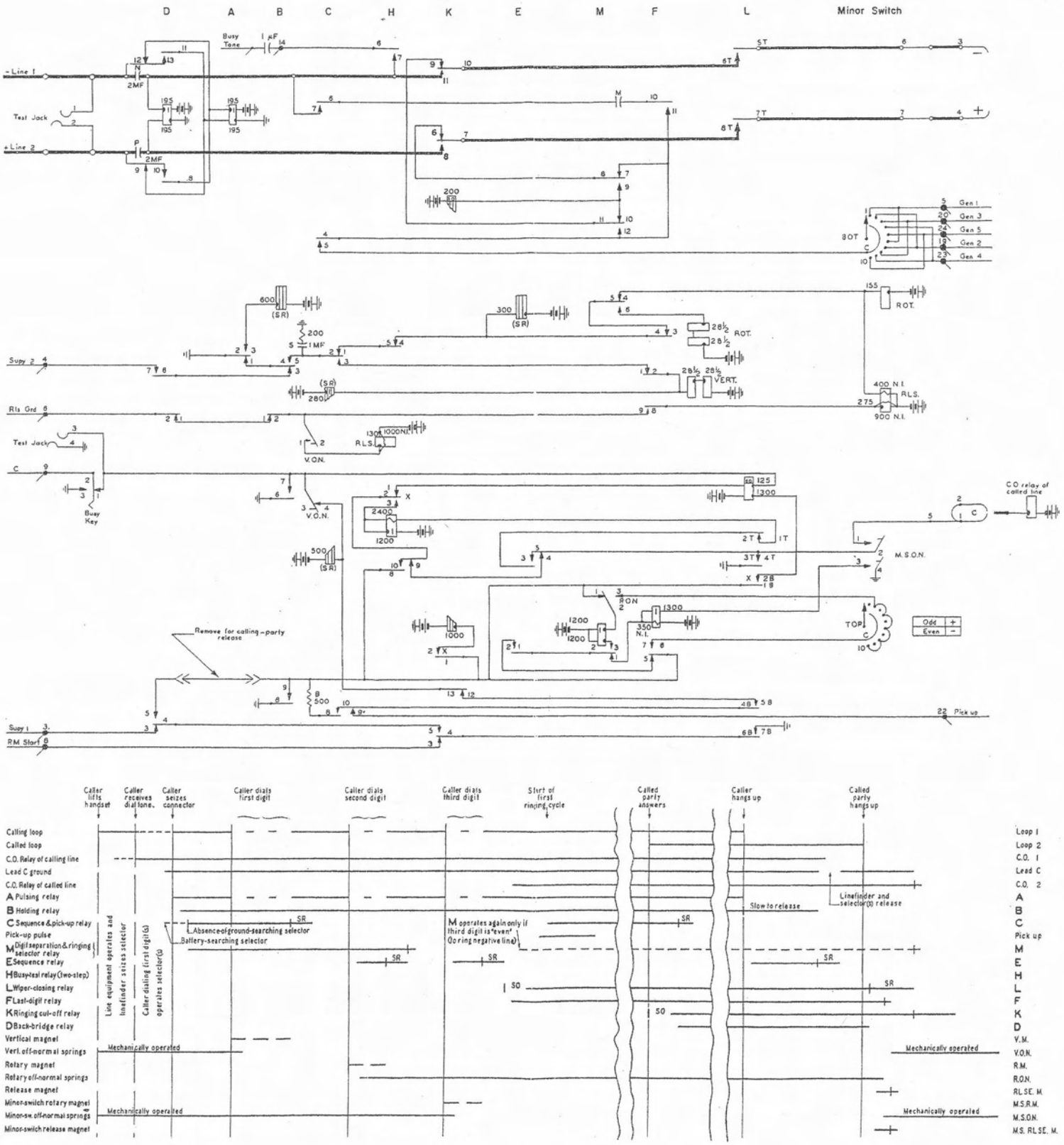


Figure 19. Complete circuit of typical terminal-per-line party-line connector, with relay sequence chart.

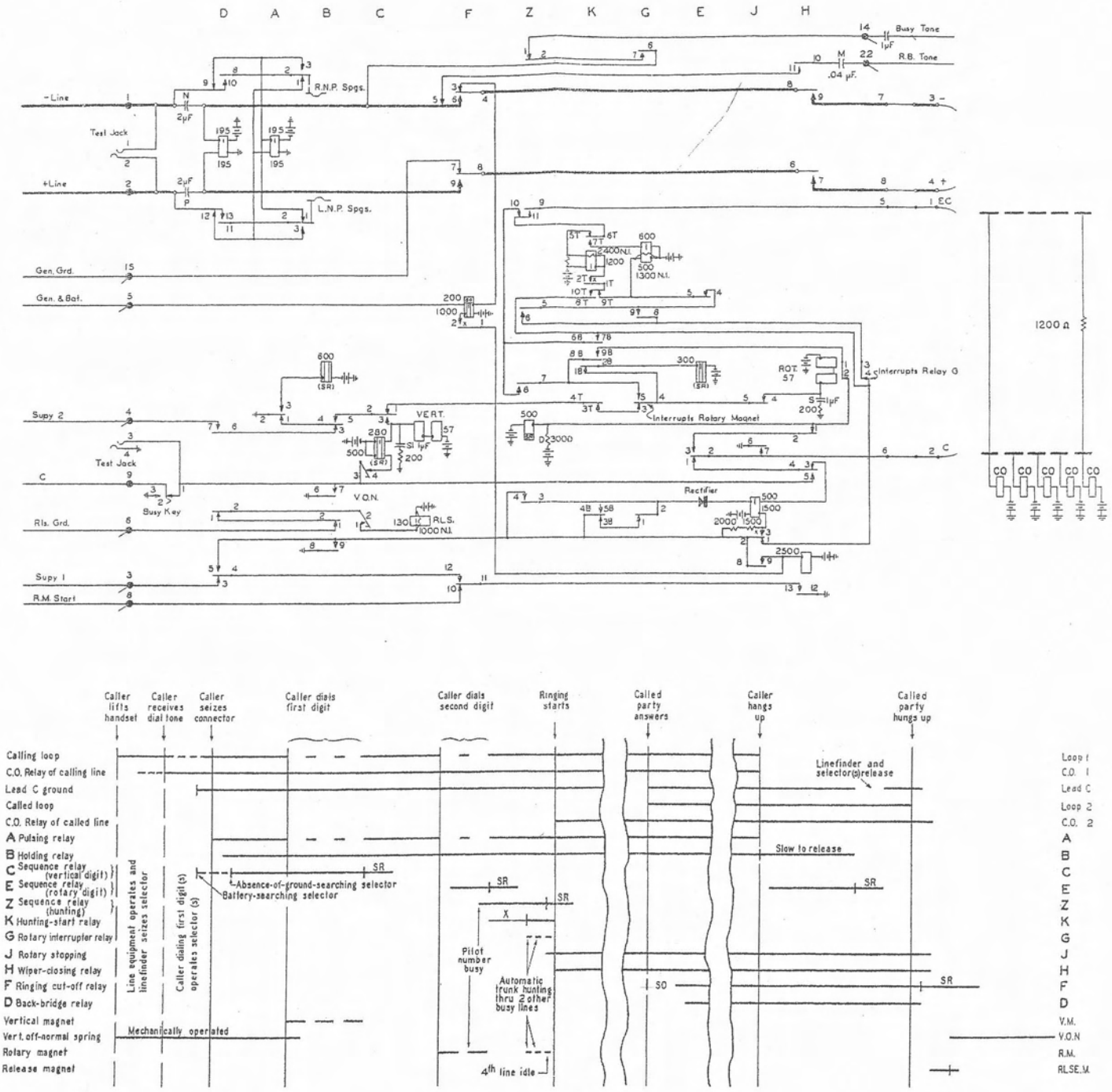


Figure 20. Complete circuit of typical trunk-hunting connector for night-line service, with relay sequence chart.

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