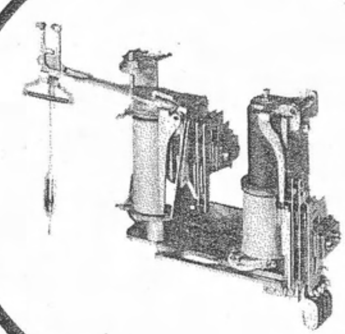
Plunger S[illegible]h 805

AUTOMATIC ELECTRIC TRAINING SERIES | Bulletin **805**

The PLUNGER LINESWITCH and ASSOCIATED MASTER-SWITCH

STROWGER AUTOMATIC TELEPHONE SYSTEMS



AUTOMATIC ELECTRIC ®

ORIGINATORS OF THE DIAL TELEPHONE

This is one of the helpful booklets in the
AUTOMATIC ELECTRIC TRAINING SERIES
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STROWGER AUTOMATIC TELEPHONE SYSTEMS

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801 Mechanical Principles of Telephony
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818 Private Automatic Exchanges with PABX Appendix
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May we send you others
pertaining to equipment in your exchange?

THE PLUNGER LINESWITCH

AND

ASSOCIATED MASTER-SWITCH

1. LINE-EQUIPMENT FUNCTIONS

1.1 Calls FROM a line

When a caller takes his handset "off hook", his line equipment signals the central office that he wishes a connection set up. When the central office responds with "Number, please?" (for a manual office) or with "dial tone" (for an automatic office), the line signal's work is done and the signal is cut off.

1.2 Calls TO a line

Apparatus used only to get attention ("Number, please?" or "dial tone") for calls from a line must be cut off by the line equipment when someone makes a call to the line. (If the attention-getting apparatus were not cut off, it would remain bridged across the line and (a) would interfere with ringing and (b) when the called party answered, his "off-hook" would call in an operator or bring in a selector with dial tone.)

1.3 Summary.

The line equipment serves as a gate through which calls can be made both from and to the line: calls from the line either signal an operator or are routed to the dial tone and dial-controlled equipment; and calls to the line are routed directly out onto the line (with the attention-getting-apparatus-bridge cut off).

2. LINE EQUIPMENT

In a magneto system the line equipment is the drop and the jack with cut-off springs. In manual common-battery* systems the line equipment is the line lamp, line relay, cut-off relay, and jack(s).

In the first automatic switchboards, each subscriber's line had its own connector switch. In larger switchboards, each subscriber's line had a selector switch. Each connector or selector had several relays and 300 bank contacts and was used only a few minutes each day; it stood idle most of the time. The time-efficiency of the subscriber's telephone line and of the switching equipment associated therewith is very low; therefore, it is more economical from the standpoint of initial cost and maintenance to provide individual line equipment of simpler design and with fewer functions. In 1906, a smaller and less expensive switch, the "lineswitch", was introduced. In a lineswitch system, each subscriber's line has a lineswitch. When the caller lifts his handset to make a call, the lineswitch automatically connects the line to an idle selector or connector. Fewer expensive selectors and connectors are required. Since each selector or connector is used by more than one line, it is in use for a larger percentage of the time; therefore, the more expensive equipment is used more efficiently.

In modern Strowger automatic systems, the line equipment is a line relay and a cut-off relay either (a) with a lineswitch or (b) with starting and marking leads to linefinders.

3. LINESWITCHES

There are two basic kinds of lineswitch: (a) the plunger lineswitch, described in this bulletin 805; and (b) the rotary lineswitch, described in Automatic Electric Company bulletin 806.

4. PLUNGER LINESWITCH

Plunger lineswitches are found in Strowger main and private plants as line equipment. They are often referred to as the "Keith" type lineswitch after the inventor, Alexander E. Keith. The

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*The first manual common-battery central office was not put in operation until December 1893. More than a year earlier, November 3, 1892, the first Strowger automatic central office was cut over.

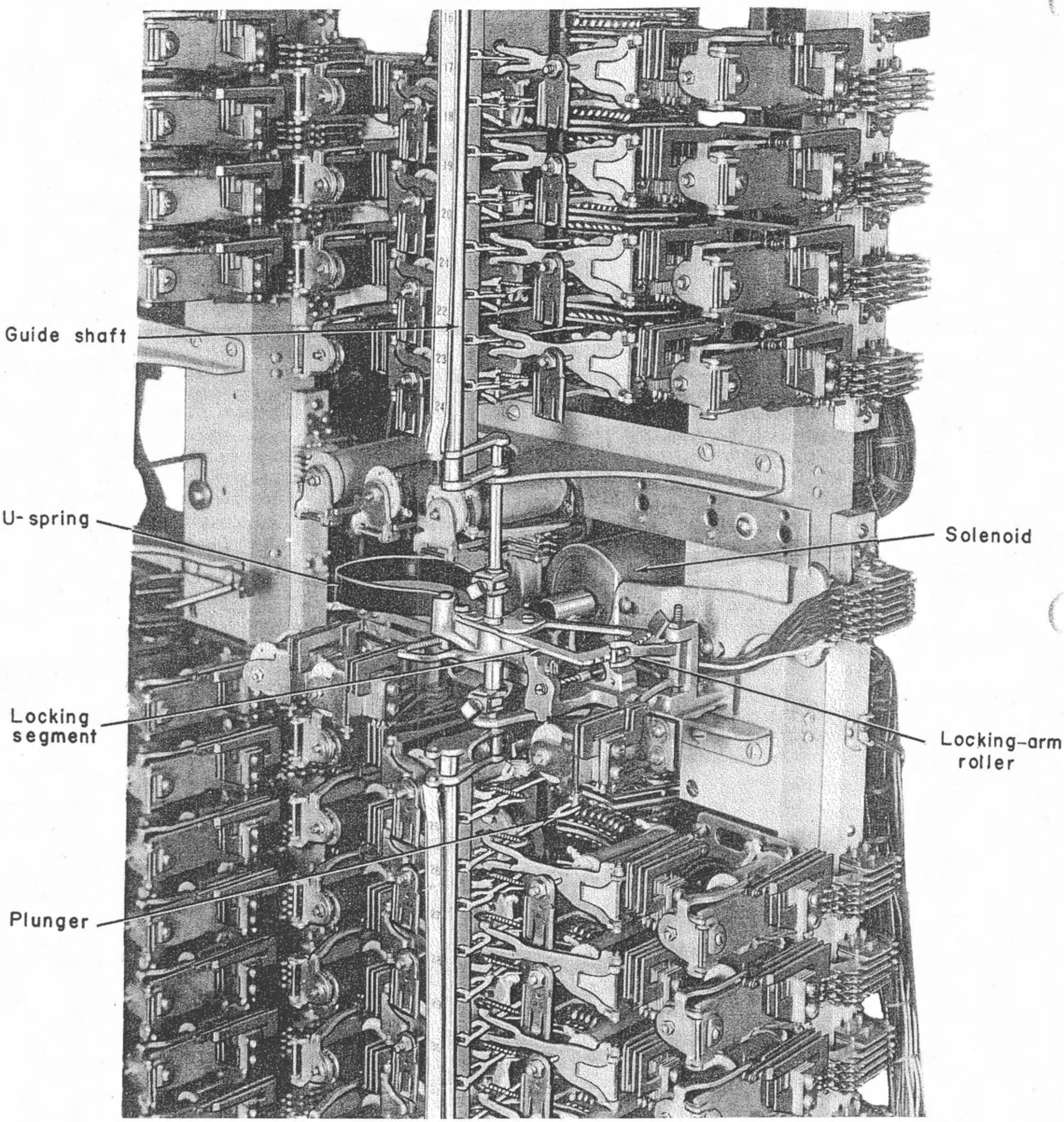

Figure 1. Master-switch and self-aligning plunger lineswitches.
(Vertical mounting, usual for public main exchanges.)

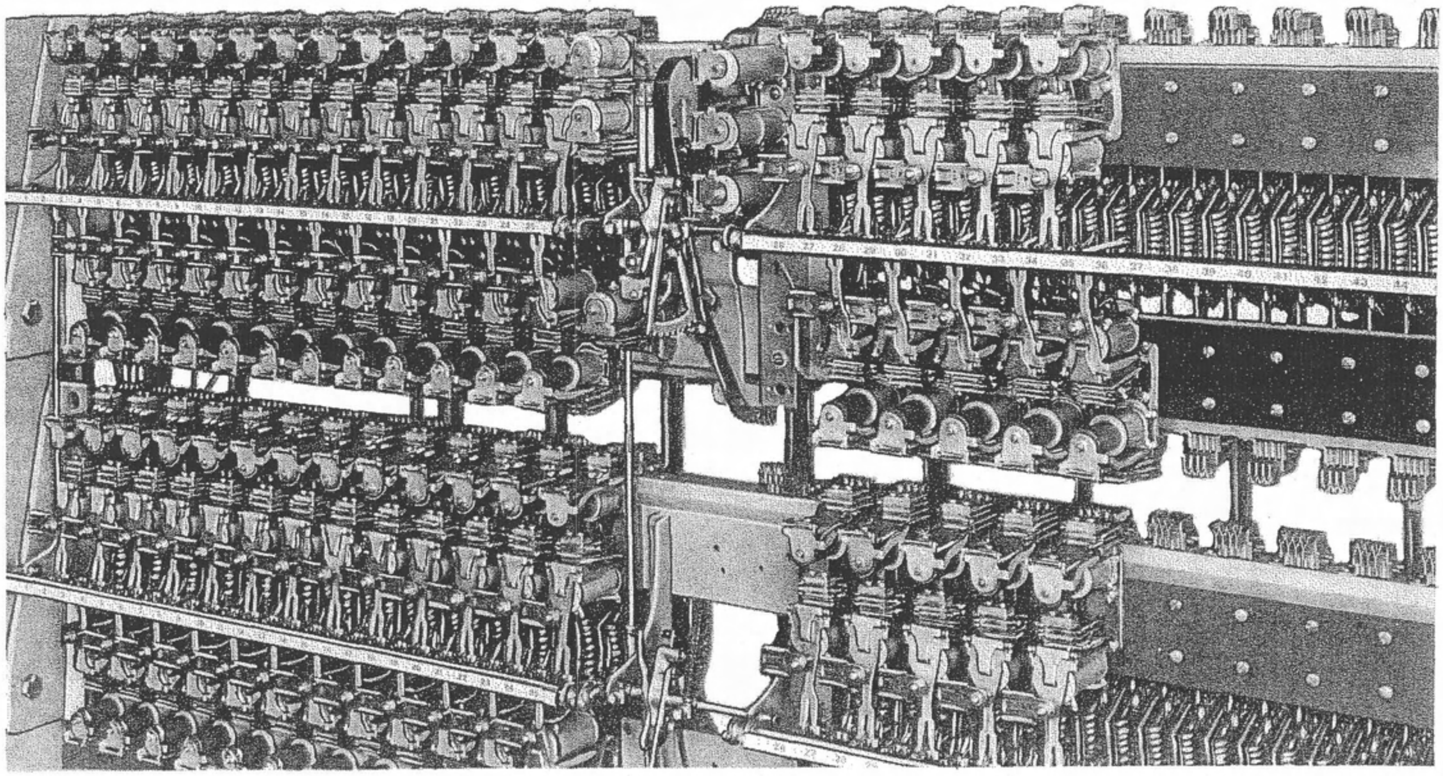

Figure 2. Master-switch and self-aligning plunger lineswitches.
(Horizontal mounting, usual for private automatic exchanges and for private automatic branch exchanges.)

plunger lineswitch is an ingenious mechanism which can connect the associated telephone line to any one of 10 trunks* each leading to a Strowger numerical switch. Figure 1 shows vertically-mounted plunger lineswitches and their associated master-switch, found in central offices rendering regular public telephone service. Figure 2 shows horizontally-mounted plunger lineswitches and their associated master-switch, used in private automatic exchanges (P-A-X).

The plunger lineswitch consists of a line relay and an operating magnet which actuates an armature carrying a pivoted plunger. This magnet has two windings: one called the "pull-down coil" (PDC), and the other the "bridge cut-off" (BCO) winding. The bank contacts are visible in both photographs and are arranged in such a manner that the plunger can engage any one of the ten sets of bank contacts.

When the caller restores his handset, the connection releases, and in the "self-aligning"** lineswitch (type 27), the plunger aligns automatically with the idle lineswitch plungers on the master-switch guide shaft.

Plunger lineswitches are grouped under the control of master-switches. Lineswitch groups are mechanically linked when they are served by one master-switch. One master-switch usually serves up to one hundred lineswitches. Each lineswitch group usually consists of from twenty-five to one hundred lineswitches per master-switch, and has access to a maximum of ten trunks.

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

**Earlier, the fan-tail lineswitch (sometimes known as type 26) was in widespread use. This switch is still in production for replacements and additions. The fan-tail type differs from the self-aligning type in the construction of the plunger which (in the fan-tail type) has a slotted fan-shaped tail that engages the spline of the master-switch guide shaft. The fan-tail is entirely withdrawn from the spline when the plunger engages one of the set of ten bank contacts. Just after the caller hangs up, the plunger releases, but does not align with the other idle lineswitch plungers until the master-switch in its cycle of oscillations passes the trunk previously used by that lineswitch. Then the spline of the master-switch will engage the plunger, and will move it along with the other idle lineswitch plungers.

When the station loop is closed, the plunger is thrust into the bank, and the insulated rollers attached near the end of the plunger press the bank springs associated with the line into contact with those of the trunk which the plunger has engaged.

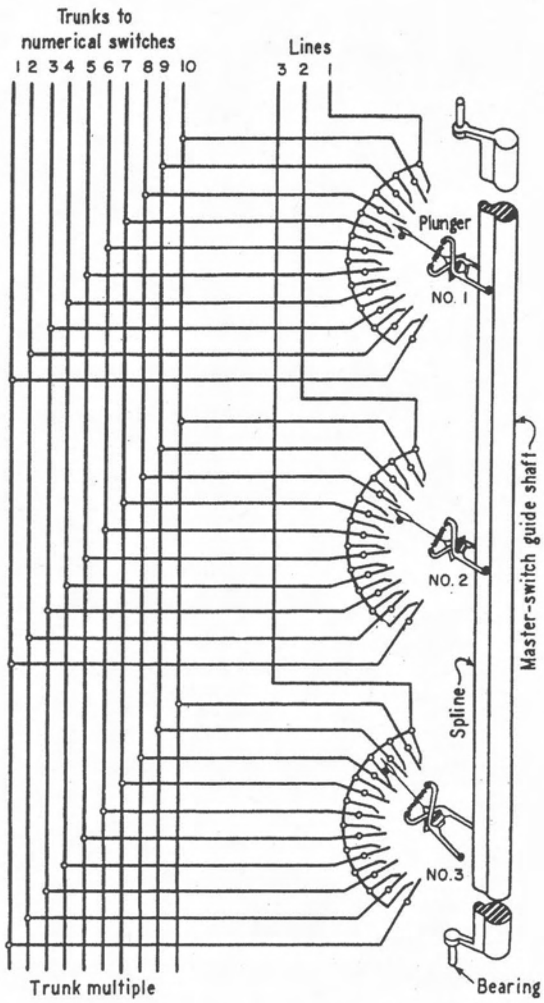

Figure 3. Relation of plunger lineswitches and trunks.

Figure 3 is a schematic layout showing a partial group of self-aligning plunger lineswitches. Only three lineswitches of the group are represented, although in practice there are from twenty-five to one hundred lineswitches in a group. All the lineswitch plungers comprising any one group are controlled by a master-switch and its respective guide shaft; therefore, the position of the plungers with relation to the trunks is determined by the guide shaft. Each lineswitch plunger of the group will have access to the ten sets of contacts in its associated bank, thus providing each line with the possibility of seizing any one of the available trunks leading to the numerical switches. The arrangement of the bank multiple and the individual line is also shown in Figure 3. Each single line in the illustration represents either a trunk or subscriber's line.

Of the three subscribers' lines represented in figure 3, lineswitch No. 3 is shown as having originated a call, causing the plunger of this lineswitch to be thrust into the bank, thus connecting line No. 3 with trunk No. 8. The remaining plungers have been moved away by the guide shaft and are aligned opposite trunk No. 7 which is assumed to be idle.

5. FUNCTIONS OF THE PLUNGER LINESWITCH

5.1 Outgoing calls

On calls originating at the telephone (outgoing calls), the functions of the lineswitch are:

(a) To extend the line through to an idle selector (or connector) trunk.

(b) To busy the line at connector bank terminals against intrusion by incoming calls, immediately upon operation of the lineswitch line relay.

(c) To "cut off" or disconnect the battery-connected line relay and ground from the line.

5.2 Incoming calls

On calls to the telephone (incoming calls), the functions of the lineswitch are:

(a) To "cut off" or disconnect the battery-connected line relay and ground from the line.

(b) To prevent the lineswitch plunger from engaging a selector or connector trunk.

6. ASSOCIATED MASTER-SWITCH

The position of the plungers of each group of lineswitches is controlled by a mechanism termed the "master-switch." This control is through the movement of the plunger guide shaft.

The prime function of the master-switch is to keep the plungers of all lineswitches resting opposite the bank contacts of an idle trunk. Each time a trunk is engaged, the master-switch immediately moves, or steps, all the remaining idle lineswitch plungers to a position opposite an available trunk. The plunger type lineswitch is thus preselecting in operation; that is, the idle trunk is selected prior to the initiation of a call.

The functions of the master-switch may be summarized as follows:

(a) To provide "supervised" ground (+ battery) to the associated lineswitches.

(b) To seek an idle trunk whenever a lineswitch engages the preselected trunk.

(c) To prevent any lineswitch from plunging while the master-switch is seeking an idle trunk.

(d) To lock the plunger guide shaft in the trunk position chosen.

(e) To control the self-aligning lineswitches on rapid recalls.

The power for moving the master-switch from trunk No. 1 to No. 10 is supplied by a solenoid type magnet. During the movement from trunk No. 10 to No. 1 the master-switch selects trunks, and a "U" shaped spring furnishes the motive power for this stepping movement. The speed at which the plunger guide shaft and the associated lineswitch plungers move is controlled by a governor, and is generally between the limits of 104 and 112 oscillations per minute. The master-switch bank wipers are so fastened to the plunger guide shaft that when the lineswitch plungers are opposite trunk No. 10, the master-switch wiper is resting on master-switch bank contact No. 10, etc.

7. SELF-ALIGNING LINESWITCH CIRCUIT

Figure 4 is a typical schematic circuit of a self-aligning lineswitch and the associated master-switch. This figure includes the essential parts of the numerical switch to which the primary lineswitch trunk connects. In this example a selector is assumed. Connections for a connector would be established in a like manner, connecting the "+", "-", and "C" leads.

7.1 Chain circuit

When the lineswitch and master-switch circuit is normal, as shown, a local circuit is maintained from ground (+ battery) at the double break contacts of start relay A-1, through the 2200-ohm winding of delay relay E-1, through the double break contacts of chain relay F-1, serially through the double break contacts of all line relays of the lineswitches associated with the master-switch, and thence through the 12,000-ohm winding of open-chain relay B-1 to "-" battery. Open-chain relay B-1 is thus held operated as long as no line relays are operated. At this time, the current flow through the 2200-ohm winding of delay relay E-1 is not sufficient to cause its armature to operate, due to the high resistance (12,000 ohms) of the winding of open-chain relay B-1 in series with it.

The double-break contacts of this chain circuit, through all the lineswitches of the group, insures continuity of the chain, as both contacts must be open before the chain circuit is interrupted.

7.2 Line and operating circuit

On originating calls, when the calling person removes the handset from the cradle, a circuit is established from "-" battery, through the 800-ohm winding of line relay A, break contacts of the B.C.O. relay, over the "-" line, through the telephone, back over the "+" line, and through the break contacts on the B.C.O. relay to ground (+ battery).* The line relay A operates, interrupting the chain circuit at its double-break contacts which permits the open chain relay B-1 to restore to normal and in turn complete a circuit from ground (+ battery), through the supervisory lamp and over the common tell-tale lead to delay relay equipment, not shown.

The operation of the line relay (A) also establishes a circuit from ground (+ battery) at the break contacts of start relay A-1, through the 2200-ohm winding of delay relay E-1, through the double-break contacts of chain control relay F-1, through the make contact of line relay A, and through the 240-ohm "pull-down" winding of the operating relay (B) to "-" battery. Ground (+ battery), through make contacts on relay A, is connected to the control normal lead (C) to protect the line against intrusion by other calls via the connector.

7.3 Delay circuit

The 2200-ohm winding of the delay relay (E-1) is now energized in series with the "pull down" coil of relay B. Relay B does not operate at this time, due to the high resistance of delay relay E-1. This delay relay is slow in operating, due to the counter magnetic effect produced by its short-circuited 8-ohm winding. Upon operating, relay E-1 connects its 8-ohm winding in parallel with the 2200-ohm winding, thus reducing the resistance in series with the 240-ohm P.D.C. (pull-down coil) of relay B. The current flow through the 240-ohm "pull down" coil of relay B is now sufficient to operate both the plunger and the B.C.O. armatures.

7.4 Operation of B.C.O. Armature

The B.C.O. armature operating, interrupts the circuit to line relay A, but this relay does not release immediately, due to the magnetic effect produced by the copper slug. The operation of the plunger armature closes spring contacts associated with it, establishing a circuit from ground (+ battery) at a make contact of line relay A, through the contacts of the plunger armature springs, and through the 1200-ohm winding of relay B to the "-" battery. The B.C.O. winding when energized will hold the plunger and the B.C.O. armatures operated.

*Line relay "A" is a slow acting type relay due to the copper slug or collar attached on the armature end of the core. It is not generally known that the slow-to-operate feature of the relay is as necessary as the slow-to-release feature. When the circuit is closed, the copper slug prevents the magnetic field from reaching the armature until the core of the relay is fully saturated. This delay in the attraction of the armature becomes important a moment later when relay B operates and opens the circuit to relay A. If the induced current were insufficiently strong, the armature of relay A would release before selector relay B-2 could operate to ground control lead C. Thus the full saturation of the core must precede the attraction of the armature.

7.5 Operation of plunger

The plunger engaging the bank, establishes simultaneously two connections; one from ground (+ battery) at line relay (A), via the control lead (C), through the lineswitch bank contacts, through a master-switch bank contact and the master-switch wiper, and through the 1075-ohm winding of start relay A-1 to "-" battery; the other extends the "-" line and the "+" line through to the selector. It should be recalled that the circuit to relay A of the lineswitch has been opened but the line relay A has not yet released. Start relay A-1 operating, interrupts the circuit to the pull-down coil of lineswitch relay B. The plunger and the B.C.O. armatures are now held operated by the 1200-ohm B.C.O. winding which is still supplied ground (+ battery) from a make contact of line relay A. The subscriber's line circuit extended through to the selector by the plunger engaging the bank may be traced from the "-" battery, through the upper 200-ohm winding of line relay A-2 of the selector, over the "-" trunk, through the lineswitch bank contacts, out over the "-" line, through the telephone, back over the "+" line, through the lineswitch bank contacts, over the "+" trunk, and through the lower 200-ohm winding of relay A-2 to ground (+ battery).

After the foregoing operation has taken place, line relay A of the lineswitch will release. It is apparent from the description that in order to prevent the release of the lineswitch, relay B-2 of the selector must operate and return ground (+ battery) over the control lead (C) to the B.C.O. winding of the lineswitch before line relay A of the lineswitch has released. The adjustment of line relay A, which is of the slow-acting type, cares for this time interval.

Line relay A-2 of the selector operating, establishes a local circuit through the 800-ohm winding of release relay B-2. Relay B-2 operating, connects ground (+ battery) to the control lead (C). This connection may be traced from ground (+ battery), through make contacts on release relay B-2 of the selector, through the lineswitch bank contacts, through the plunger armature spring contacts, and through the 1200-ohm B.C.O. winding of relay B, to "-" battery, thus maintaining the B.C.O. winding energized and preventing the release of the plunger armature at this time.

Ground (+ battery) at the make contacts of release relay B-2 of the selector is also maintained on the master-switch bank contact, preventing the seizure of the selector by another lineswitch. This same ground (+ battery) connection is maintained on the control normal (C) to the connector banks.

8. MASTER-SWITCH OPERATION

As previously mentioned, when the lineswitch plunger first engages the bank, a connection is completed from ground (+ battery) at a make contact of relay A of the lineswitch, through the lineswitch bank contacts, through the master-switch bank contact and associated wiper, and through the 1075-ohm winding of start relay A-1 to "-" battery. The start relay (A-1) operating, opens the circuit of the P.D.C. (pull-down coil) of relay B, and establishes a circuit from ground (+ battery), through the make contacts of relay A-1, and through the 105-ohm winding of the locking magnet D-1 to "-" battery. The locking magnet operating, disengages the lock lever from the locking segment, and allows the "U" spring to move the guide shaft, thus moving all lineswitch plungers in a counter-clockwise direction.

When the master-switch wiper is disengaged from the master-switch bank contact position No. 10, the circuit to the start relay A-1 will be opened, causing this relay to restore to normal and release locking magnet D-1. The operations just described will permit the lock lever to engage the next notch of the locking segment, which will hold all idle lineswitch plungers opposite trunk No. 9. During the period the locking magnet D-1 is operated, a circuit is closed from ground (+ battery) at the locking magnet springs, through the 800-ohm winding of chain control relay F-1 to "-" battery which operates and opens the chain circuit of the lineswitches to prevent any lineswitch from plunging while the master-switch is seeking an idle trunk. In moving from trunk No. 10, should trunk No. 9 be in use, ground (+ battery) will be maintained on master-switch bank No. 9, and in this case the start relay (A-1) will be prevented from releasing. The "U" spring will then move the locking segment and the guide shaft to trunk No. 8. Similarly, if trunk No. 8 tests busy, the locking segment and guide shaft will continue to step in succession to trunks 7, 6, 5, etc., until the first idle trunk is found.

8.1 Return motion of master-switch

Searching for an idle trunk will continue until trunk No. 1 is reached, at which point arm No. 1 on the locking segment will push the arm springs into contact. When trunk No. 1 becomes busy, start relay A-1 will operate as previously described. The start relay (A-1) operating, will close a circuit to locking magnet D-1 which, in turn, will complete a circuit through the 800-ohm winding of chain control relay F-1 causing it to operate. Since the arm springs are closed,when the locking segment is in trunk No. 1 position, the operation of the start relay (A-1) at this time establishes a circuit from ground (+ battery) at a make contact on start relay A-1, through the contacts of the arm springs, and through the 500-ohm winding of trip relay C-1 to "-" battery. The trip relay (C-1) operating, will mechanically lock its armature, by the extension of the armature spring on this relay engaging the catch on the locking spring. This mechanical lock is to maintain the trip relay springs in an operated position after the trip relay (C-1) has been de-energized by the interruption of its circuit at the contacts of the arm springs; these arm springs break contact immediately after the master-switch moves from trunk No. 1. A circuit is now maintained from ground (+ battery) through make contacts of the trip relay (C-1), and through the winding of the solenoid magnet to "-" battery. The solenoid energizing will pull its plunger into the coil, thus moving the locking segment and the guide shaft in a clockwise direction, and also the lineswitch plungers from a position opposite trunk No. 1 to a position opposite trunk No. 10. When the trunk position No. 10 is reached, the locking segment will be so positioned that arm No. 10 will disengage the mechanical lock thereby releasing the trip-relay armature. This will open the circuits to locking magnet D-1 and chain control relay F-1 permitting them to restore to normal. The trip relay (C-1) releasing also interrupts the circuit to the solenoid magnet, stopping its movement.

8.2 Delay and chain control relays

Because the 8-ohm winding of delay relay E-1 normally is short-circuited, the operation of the plunger of the lineswitch associated with a line which is originating a call is momentarily delayed. This is to care for a condition arising when a subscriber, after originating a call, releases the lineswitch and then recalls before the lineswitch plunger has had time to realign itself with the other idle lineswitch plungers. By slightly delaying the reoperation of the lineswitch plunger, the possibility of the lineswitch engaging a busy trunk is eliminated.

When the 2-ohm winding is short-circuited, chain relay F-1 will be slow to release (just as if the relay had a copper slug). In this case, however, the quick operation of relay F-1 is not affected, since the 2-ohm winding is not short-circuited until relay F-1 has operated. This slow-release feature of relay F-1 is provided to hold the chain circuit open until line relay A of a lineswitch (which has engaged a trunk) has released. This feature prevents the delay relay from reoperating and causing false operation of the peg-count meter, not shown in figure 3, in case the master-switch completes its stepping motion from the engaged trunk to an idle trunk before the lineswitch has disconnected the P.D.C. from the chain circuit.

8.3 Purpose of the chain contacts

The purpose of the chain circuit, through make contacts of all switches in the group, is to prevent more than one lineswitch from operating at precisely the same instant, which might permit more than one lineswitch plunger to engage the same trunk. In case more than one line relay (A) in the same group of lineswitches operates at the same instant, the operated line relay (A) nearest the ground (+ battery) end of the chain will function first and connect ground (+ battery) to its associated pull-down coil (P.D.C.). At the same time it will disconnect ground (+ battery) from that portion of the chain circuit leading to the pull-down coil associated with the other operated lineswitch A relay. The plunger of the operated lineswitch located in the chain circuit nearest to the ground (+ battery) terminal of the circuit, therefore, will be the first to plunge into the lineswitch bank. The plungers of the other lineswitches located farther along in the chain cannot plunge until the master-switch has moved to an idle trunk and the line relay (A) of the lineswitch nearest the ground (+ battery) terminus of the chain circuit has restored to normal, thus reestablishing continuity of the chain circuit.

8.4 Self-aligning feature

If a call is originated when the plungers of all idle lineswitches are resting opposite a trunk which, due to some fault, is open circuited, the plunger will engage the lineswitch bank contacts associated with this trunk, but since ground (+ battery) cannot be returned over the control lead (C) from the selector to energize the B.C.O. winding and there hold the plunger in engagement with the bank contacts, the plunger armature will release almost immediately. The plunger will instantly realign with the other idle lineswitch plungers opposite the next unoccupied trunk (the master-switch having meanwhile sought the idle trunk), and then plunge again, engaging the good free trunk.

8.5 Incoming calls

Figure 1 shows each B.C.O. armature and plunger armature independently centered on a common pivot. The B.C.O. armature, which is outside the plunger armature, has its tip bent at a right angle, so it can project through a slot in the plunger armature. Because of this, the air gap between the core and the B.C.O. armature is shorter than the air gap between the core and the plunger armature. Thus, a smaller reluctance is offered the magnetic flux passing from the core to the B.C.O. armature.

On an incoming call, the connector engages the line, and grounds control lead (C) which completes a circuit through the B.C.O. coil. The current flow through the B.C.O. coil produces a magnetic field strong enough to operate the B.C.O. armature, but insufficiently strong to pull down the plunger armature. The B.C.O. armature in operating disconnects ground (+ battery) from the + line and cuts off or disconnects the line relay from the - line. The connector then rings the called line. When the called party answers, the connector supplies transmission current to the called line.

The above explanation of the B.C.O. and plunger armatures must not be confused with their action on an outgoing call, where the B.C.O. coil has enough magnetic pull to hold both armatures once they are operated.

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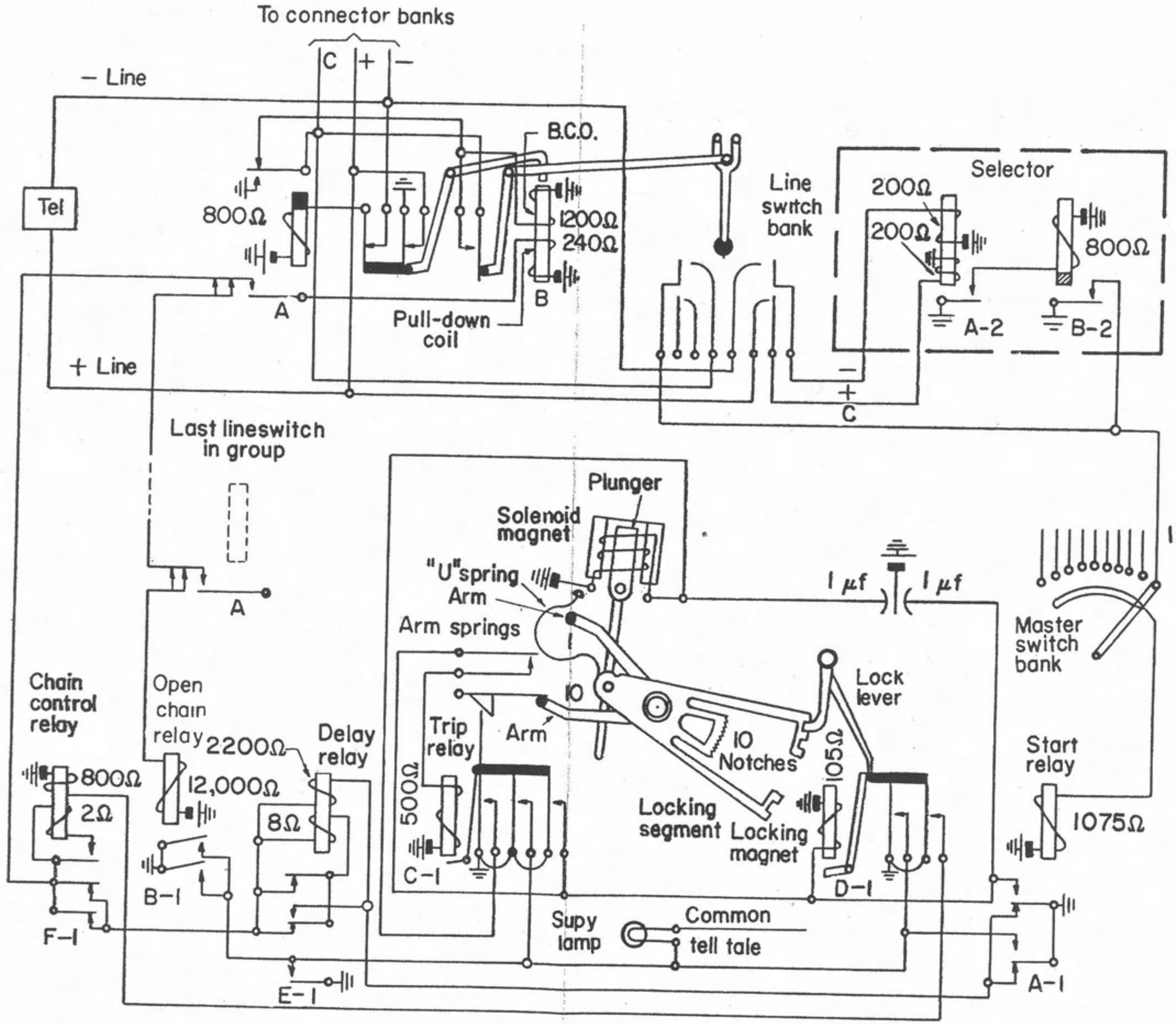

Figure 4. Circuit of self-aligning plunger lineswitch, master-switch, and parts of a selector.

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