# CIRCUITS*

## Substation Circuits:

### Individual, Two Party and Four Party Semi-Selective Lines:

The substation circuit ured on individual, two party, and four party semi-selective lines working in conjunction with a machine switching office, is shown on drawing No. 807-72. The relation between the transmitter, receiver, induction coil, bell and condenser, are the same as in the present standard circuit for manual substations. In addition there are provided the pulse contact springs and the off-normal contact springs, mounted within fhe case of the dial and actuated by the dialing mechanism.

The line is carried through the pulse contacts and as the dial returns to normal the contacts are opened intermittently, the number of breaks corresponding to the digit dialed, except that when zero is dialed there are ten interruptions of the contacts.

When the dial is in an off-normal position the off-normal contacts open the receiver circuit so as to eliminate dialing clicks and they also short-circuit the transmitter in order 30 remove its variable resistance from the line and thus establish practically constant conditions during the dialing interval.

### Four-Party Selective Lines:

The substation circuit used on four-party selective lines working in conjunction with a machine switching office is shown on Drawing No. 807-73. As described above for individual linse the pulse oontacta on the dial interrupt the line circuit as

*Note: On the drawings the symbol  signifies a slow releasing relay.

the dial returns to normal, and the off-normal contacts on the dial short circuit the transmitter and open the receiver circuit when the dial is rotated from normal position. The relation between the other elements of the circuit is the same as in a manual four-party selective circuit with exception that an additional condenser is required. This condenser is of 1/2 mf. capacity and is placed in series with the substation relay. Its use is necessary to insure that the relay will not be operated by the dial pulses thus grounding one side of the line and preventing the proper operation of the central office mechanisms.

The various types of substation equipment and circuits used in connection with machine switching central offices will be covered in detail in the Hand-book Specifications on Machine Switching Substations.

A. T. & T. Co.
Eng. Dept.

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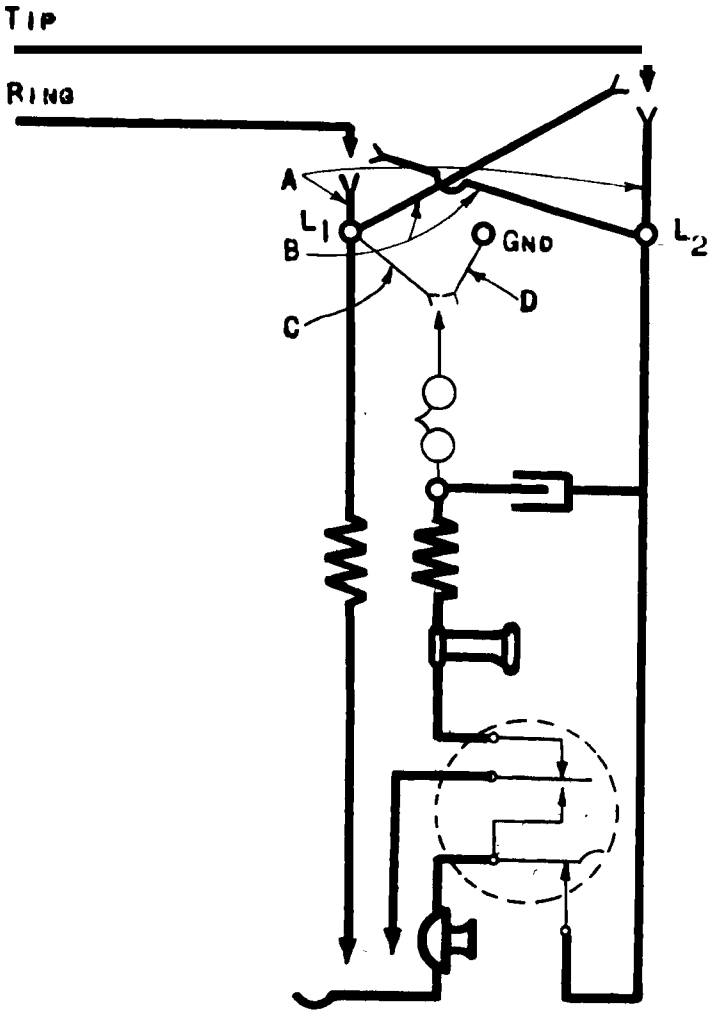
Information
Engineer Emm
Draftsman
May 1, 1920

# STEP BY STEP MACHINE SWITCHING SYSTEM

## Substation Circuit for Individual, Two-Party and Four-Party Semi-Selective Lines




Note: On individual lines use "A" and "C" wiring. On party lines, use "A" and "D" wiring for stations rung over tip side of line, and "B" and "D" wiring for stations rung over ring side of line.

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Issue 2 ARK
Parties 2 and 3
Interchanged

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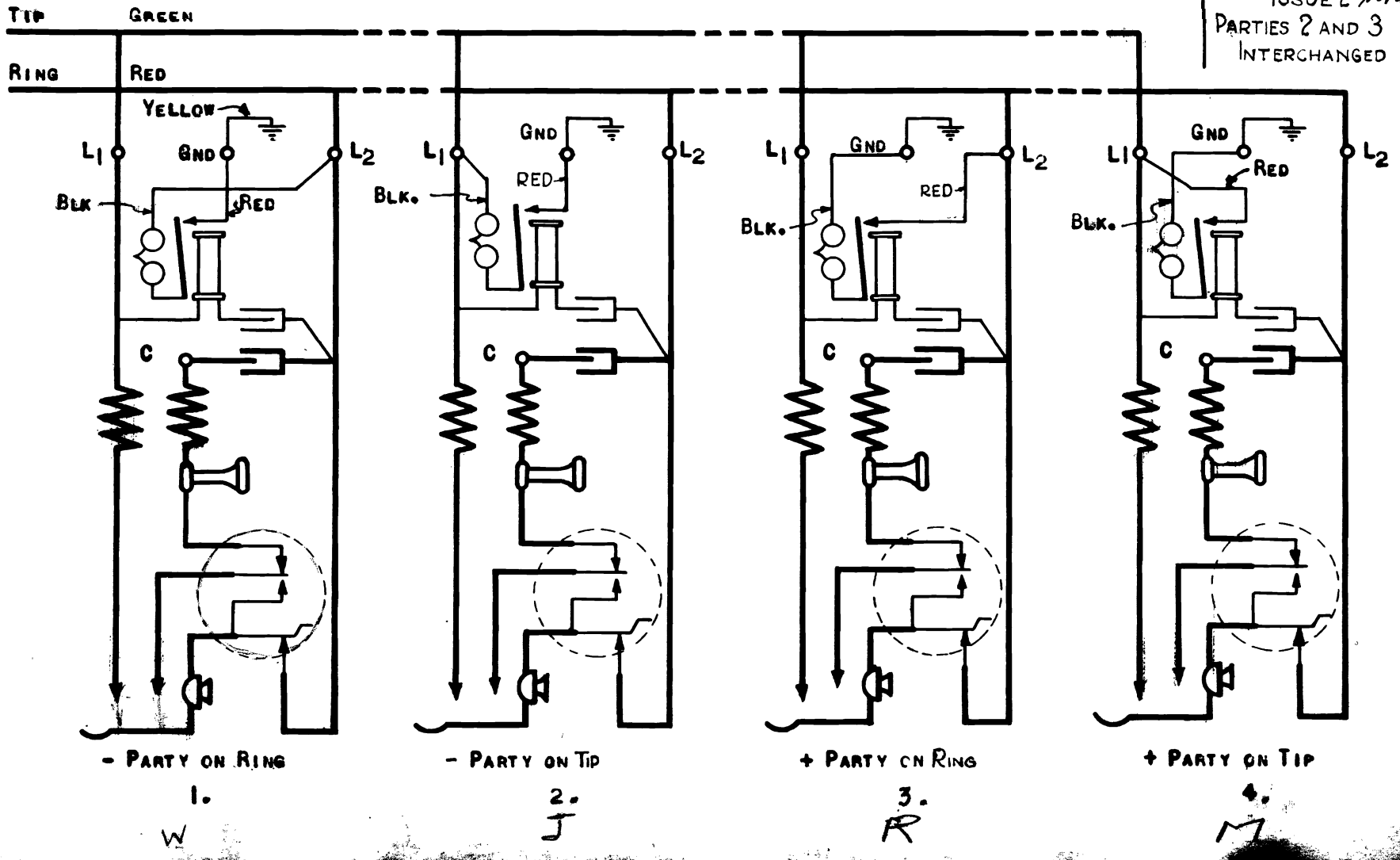
# STEP BY STEP MACHINE SWITCHING SYSTEM

## Substation Circuit for Four Party Selective Line



Subscriber's Line Circuit with Plunger Type Primary Line Switch and without Secondary Line Switch:

Drawing No. 807-1 showe the circuit for a subscriber's line provided with a plunger type line switch and employing a solenoid type master switch.

The essential functions of the line switch equipment on an originating call are to connect the calling line to an idle first selector as soon as possible after the removal of the receiver from its hook and to establish a "test busy" condition at all connector terminals corresponding to the stations on the calling line in order to prevent the line from being seized for an incoming call. It also clears the line of bridged equipment on incoming calls.

As in the present standard manual practice, the subscriber's line is terminated on the vertical side of the M.D.F., is cross-connected to the horizontal side, and is cabled to the horizontal side of the I.D.F. From this point a multiple of the lines on a terminal per station basis is carried to the multiple banke of the connectors serving the stations on that line, thue providing meane for establishing connections for incoming calls. At the I.D.F. the line is also cross-connected to the vertical side whence it is cabled to the primary line switch.

When the receiver is removed from the hook at the calling station, a circuit is cloeed from battery at line relay "A" through the contacts on cutoff magnet "B" and over the subscriber's line to supervisory ground at relay "S". This energizes relay "A" which, in operating, completes a path from open main battery supply through the contact of relay E, the winding of peg count relay D and the 45-ohm

winding of magnet "B" to supervisory ground. Relay D is energized and cloees the circuit through the winding of a peg count meter. Magnet "B" is also energized and causes both the plunger and the "BCO" armature to operate. The operation of the plunger actuates the four paire of springs in the line switch bank. The subscriber's line is extended through two of the pairs of line switch bank contacts to a first selector, and pulse relay *L[a] is energized by current flowing over the subscriber's line. The closing of the contacte at relay "L" energizes relay "R", the contacts of which, in closing, place ground potential on the release wire. A path is thus closed through the 1200-ohm winding of magnet *B[H] and the bank contacts to ground. The 1200-ohm winding holds both the plunger and the "BCO" armature in the operated position.

When the 45-ohm winding of "B" actuated the "BCO" armature the cutoff contacts were broken, thus opening the circuit through the winding of relay "A". Relay "A" is of the slow-release type, however, and the circuit through the 45-ohm winding of magnet "B" is kept closed for a short interval of time after the cutoff contacts are opened. This is to permit relays "L" and "R" to place ground on the 1200-ohm winding of magnet "B" before the circuit through the 45-ohm winding is broken, for although the 1200-ohm winding will maintain the plunger in an operated position, it will not cause it to plunge from a non-operated position.

With the bank contacts closed the release wire is connected over the private wire to the connector private bank terminals corresponding to the stations on the line. When relay "R" operates, therefore, the connector terminals are grounded, establishing the "test busy" condition.

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# STEP-BY-STEP MACHINE SWITCHING SYSTEM

## Subscriber's Line Circuit
## With Plunger Type Primary Line Switch, without Secondary Line Switch

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Draftsman
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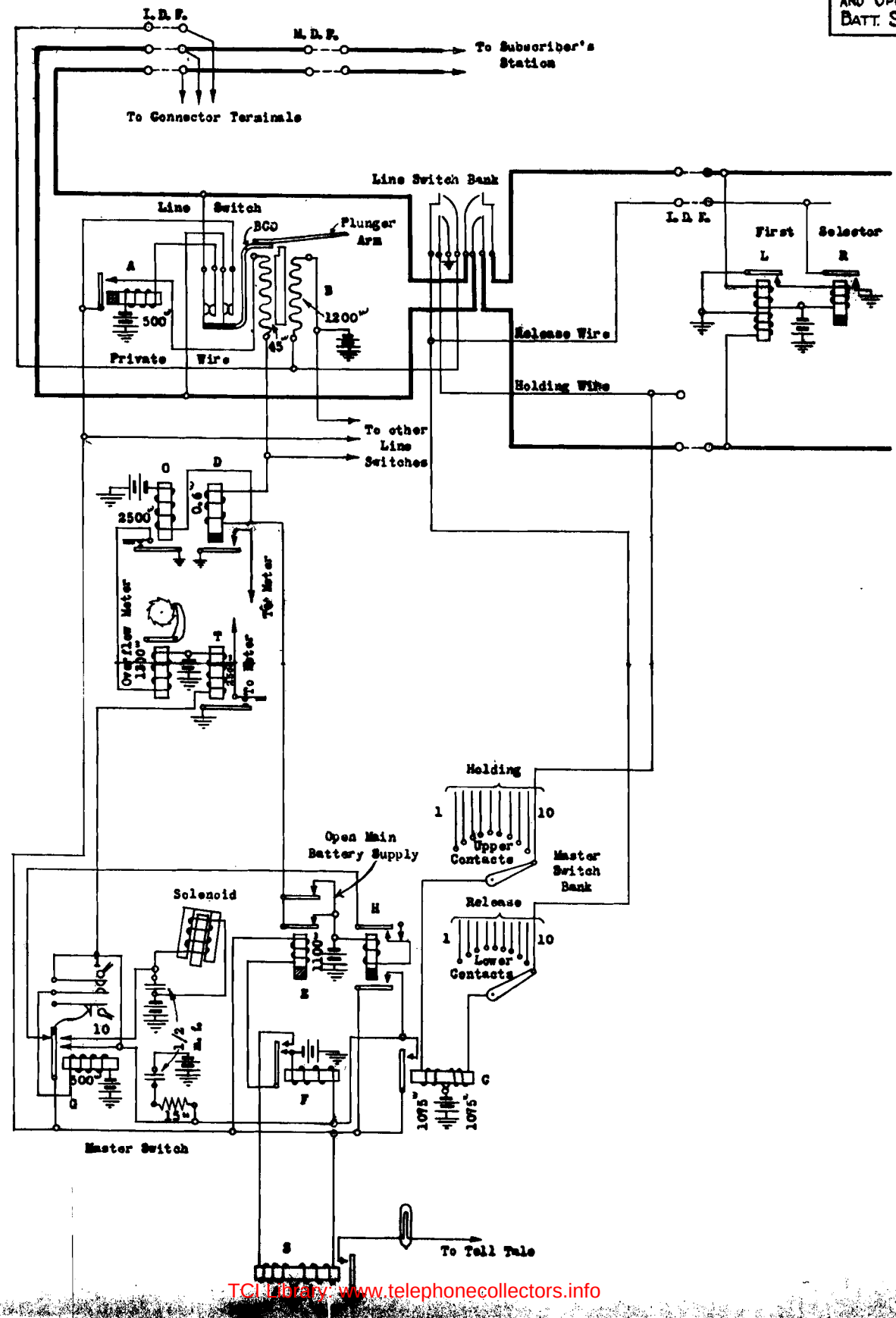
May 1, 1922
Issue 2
Winding of C Rel. and Open Main Batt. Sur changed



The operation of the lfne switch bank contacts and the operation of relay "R" place ground potential on the upper and lower maeter ewitch bank contacts corresponding to the particular trunk seized by the calling line. These contacts are connected through the maeter ewitch wipers to the windings of start relay "C" which is energized when the contacts are grounded. The contacte of relay "C", in closing, complete a path from battery at locking magnet "F" through relay "S" to ground. Magnet "F", which controls the locking arm of the master ewitch, energizes and disengages the arm from the locking segment; the latter then rotates under the influence of the main spring and carries with it the maeter ewitch wipers to the next pair of bank contacte. If these are aleo grounded, relay "C" and magnet "F" will remain energized and the rotary motion of the master switch will be continued. When the wiper reaches a pair of ungrounded contacts, however, relay "C" and magnet "F" release, and the locking arm engages the locking segment and arrests its motion.

When magnet "F" energizes its contaote complete a path from battery at relay "F" through the open main relay "E" to supervisory ground. Open main battery is supplied through the contacts of relay "E", so that when magnet "F" and relay "E" are energized, open main battery is cut off, thus preventing the operation of the line switches while the master switch is in motion.

When the master switch wipers reach the bank contacts for trunk No. 1, tripping arm "1" closes the contacts on the guarding or tripping springs so that when the next line switch plunges the closing of the contacts at relay *C$^{U}$ completes a path from battery at tripping relay "G" to supervisory ground. When relay *G$^{H}$ ener-

gizes it locks itself up mechanically by means of the latch on the tripping spring. The closing of the contacts at relay "G" completes a path from battery at tha solenoid to supervisory ground, energizing the solenoid and rotating the master switch back tc trunk No. 10. Due to relay "G" being locked up during this return movement, magnet "F" and relay "E" are aleo kept operated, thue permitting the locking segment to rotate and keeping the open main battery eupply circuit broken.

When the master switch reaches trunk No. 10, tripping arm "10" strikes the latch spring and releases the armature of relsy "G", thus deenergizing the solenoid. Magnet "F" and relay "E" will also be released if the master switch bank contacts for trunk No. 10 are not grounded, and the master ewitch will stop at trunk Mo. 10. If, however, the contacts for trunk No. 10 are grounded, magnet "F" and relay "E" will remain energized through the operation of relay "C" and the master ewitch will again start to rotate in the direction of trunk No. 1 as described before.

If, when the master switch reaches trunk No. 10, this trunk is found busy, there is a possibility that magnet "F" may be released momentarily after the armature of relay "G" is unlatched and before relay "C" can operate. In order to prevent a line switch from plunging into the busy No. 10 trunk in such a case, relay "E" is made of the slow releasing type and thus keepe the open main battery supply cut off during the momentary release of magnet

During the building up of the connection through the varicus selectors tc the connector, the ground on the releaee wire, which holds the line switch operated, comes successively from the

selectors and finally, on calls local to the originating office, fram the connector, or on interoffice calls, from the repeater. When tht connector or repeater is released at the termination of the call the ground is removed from the releaee wire, magnet "B" is deenergized allowing the plunger to restore, and ground is removed from the master switch bank contacts.

On a call incoming to the line, ground potential is placed on the private terminal at the connector and a circuit is completed through the 1200-ohm winding of magnet *Bn, which operatea the "BCO" armature and clears the line of relay "A". The switch will not extend its line to a firet selector, however, since the current through the 1200-ohm winding is insufficient to caueo the plunger to operate.

On calls to an operator it is neceseary in some cases for the operator to know what class of line is calling, as for example, in the case of a call to a toll recorder from a line which is Eenied toll service. To provide this feature a "class of service" tone is applied at the primary line switch by oonnecting it to the battery side of the 1200-ohm winding of magnet "B". When the operator answers, the tone is induced on the talking pair of her telephone set circuit, and the tone is removed by the operation of a key.

It will be noted that ground potential for the operating circuits of the different relaya and magnets on the line and master switches is eupplied in most cases through the supervisory relay 8. In the normal course of operation the magnets and relays receiving ground through S are held in the operated position for only brief intervals of time, and the continued energizing of relay S for several seconds is indicative of trouble in the circuits or of an

all-busy sub-group of trunks. Relay S is therefore associated with an auxiliary circuit containing a slow acting relay, and an auxiliary visual signal and audible alarm are operated whenever relay S is held up for more than a predetermined number of seconds.

Where trunks from primary line switches run directly to first selectors, the holding wires are carried to the I.D.F., but it is not necessary to extend them to the selectors. The purpoee of employing these fourth wires and carrying them to the I.D.F. is to permit the use of the same circuit and wiring arrangements at the primary line and master switches as are employed where the trunks lead to secondary line switches, (see Section 2b), and aleo to facilitate the introduction of secondary line switches at a later date should this be found desirable. For similar reasons, all primary master switches are wired for and equipped with a pick-up relay H. This relay is used only where the trunks lead to secondary line switches, and its functione are described in Section 2b.

The line relay battery supply for each division of 25 line switches is furnished through a three ampere fuse. A three ampere fuse is also provided in the battery supply lesd for each master switch.

Metering Relays. With each subgroup of primary line switches there will be provided, when specified, relay and meter equipment for obtaining the following record:

1. The approximate total number of calls originated in a primary line switch subgroup, with the exception of those calls which are abandoned before the calling line is extended to a first selector.

When specified, relay and meter equipment will aleo be provided for each primary line switch subgroup to obtain either one of the following records:

2. The approximate nunber of times that all of the trunke in a primary subgroup become busy.

3. The approximate number of delayed calle and rrong connections due to all of the trunks in a primary eubgroup being buey.

Referring to drawing No. 807-1, relay D and its associated peg count meter are used to obtain the record referred to under "1". If the master switch is not in notion, the closing of the contacts at relay A in response to an originating call causes relay D to operate from the open main battery supply. If the master switch is in motion when the call is initiated, the open main battery supply is broken at relay E, and relay D will not be energized since it will not operate in series with the 2500-ohm winding of relay O. Relay D will operate, however, as eoon as the master switch finds an idle trunk, provided the subscriber has not in the mean time abandoned the call. nelay D is made slow relcasing to eneure the positive operation of the register.

Relay T and its asaociated "trunks-busy" rneter are used to obtain the record referred to under "2". Relay T is energized over a path to supervisory groundwhenever relay C or relay G operates, and remains energized as long as the master switch is in motion. The contact spring at relay T, howecer, is weighted and acts like a pendulum when the armature of the relay impinges against it. As a result the contacts are intermittently opened and closed during a brief interval after the reloy is energized, and it is not until the

vibration of the spring las subsided that the contact becomes oufficiently positive to enable the register to operate. Relay T is so adjusted that the elapsed time between its operation and the operation of the register is somewhat greater than the time required for the master switch to pass through one complete cycle of its motion.

Relay O and its associated register, marked "overflow meter" on the drawing, are ueed to obtain the record raferred to under "3". If a call is originated while the master ewitch is in motion, relay O will be energized over a path from battery at realy O, through the winding of relay D, the 45-ohm winding of magnet B and the contacte at relay A to supervisory ground. Relay O, however, is provided with a pendulum type contact spring, as previously described in oonnection with relay T, which delays the operation of the associated meter. The relay is so adjusted that the elapsed time between its operation and the operaticn of the meter, is equal to the average normal interval between the removal of a receiver from its hook and the transmission of the first dial pulse, and with thia adjustment the meter will register approximately the sum of the number of times that the subscribers delay dialing because of an abeence of dial tone and the number of failures to establish the proper connection due to a subscriber commencing to dial before his line has been extended to a first selector.

## Subscriber's Line Circuit with Plunger Type Primary and Secondary Line Switches:

Drawing No. 807-2 shows the circuit for a subscriber's line provided with primary and secondary line switchee of the plunger type and employing primary and secondary master switches of the solenoid type. The essential functions of the circuit and the method of wiring it at the frames are the same as described under Division III, Section 2a.

Upon the removal of the receiver from its hook, relay A is actuated and the BCO armature and plunger at magnet E are operated as described under Division III, Section 2a. The following circuit conditions are established when the primary line switch bank contacts are closed by the plunger:

1. The tip and ring of the calling line are extended to the secondary line switch.

2. Qround potential is placed on the primary master switch bank contactacorresponding to the trunk seized, causing the master switch to rotate to the next idle trunk.

3. Ground potential is placed on the holding aire of the trunk.

4. The 1200 ohm winding of magnet E is connected to the release wire of the trunk.

The ground on the holding wire cloaes a path from battery at supervieory relay U, through the contacts at relays V and N, the 18-ohm and 3400-ohm windings of relay H, the contacts at

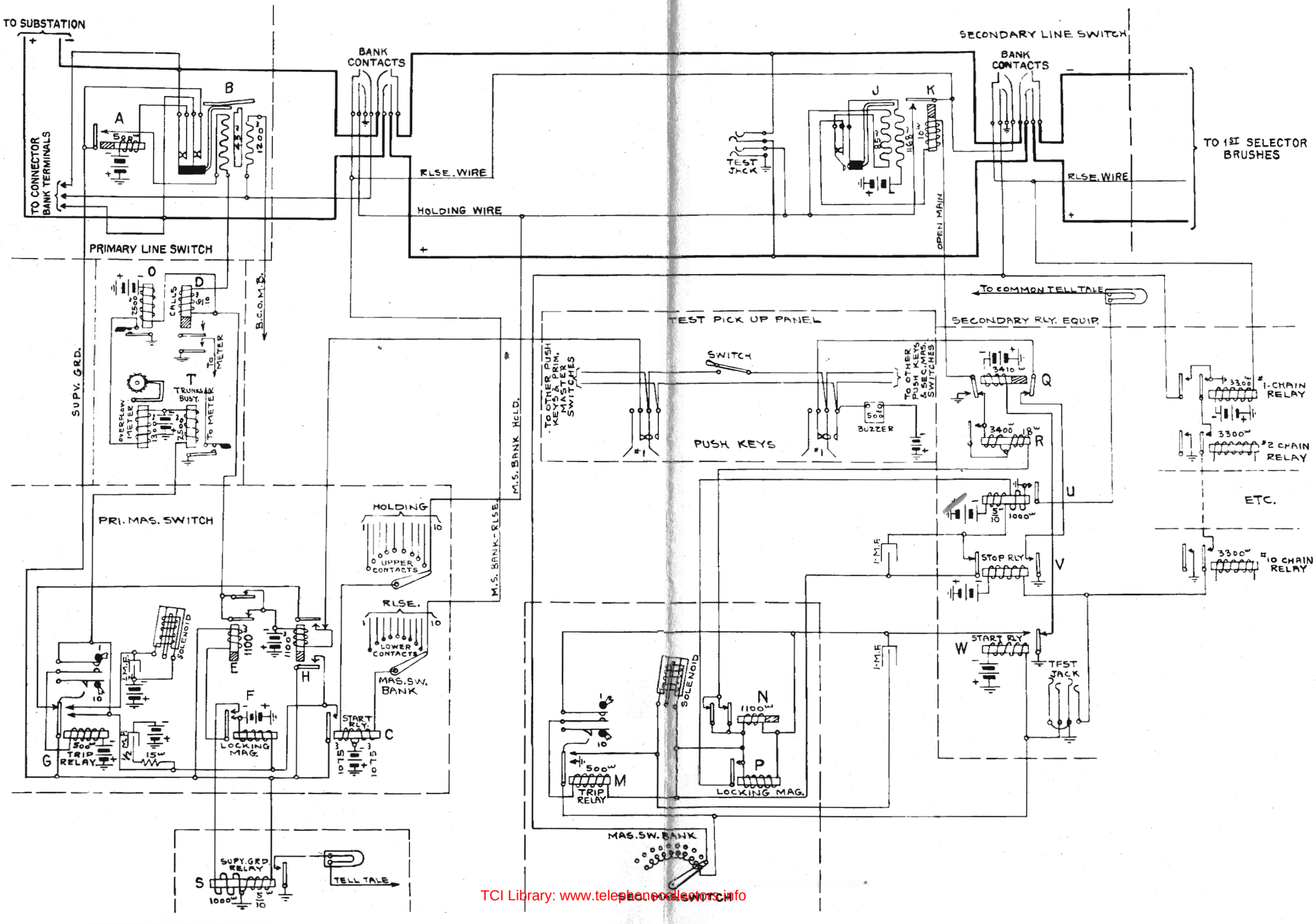
relay Q, the winding of relay K and the contacts and 85-ohm winding of magnet J to ground. Relay R is energized, short circuits its 3400-ohm winding, and then relay K and magnet J are also energized. The closing of the contacts at relay K places the holding wire ground on the release wire, thus completing a path through the 1200-ohm winding of magnet B, holding the primary switch plunger operated until the release wire is grounded from the first selector.

The energizing of magnet J through its 85-ohm winding operates its associated plunger and contacts. The plunger is held in the operated position by the 85-ohm and 1168-ohm coils of magnet J which are placed in series by the action of the contacts at magnet J. The closing of the secondary line switch bank contacts extends the subscriber's line and the release wire to the first selector. The operation of the pulse and release relays at the first selector, as described under Section 2a, places ground on the release wire, thus holding the primary line switch plunger operated after the release of relay K due to the actuation of the contacts at magnet J.

When the secondary switch plunges, a path is completed from battery at start relay W through the secondary maater switch wipers and contacts to ground at the secondary line switch bank contacts. Relay W energizes and a circuit is completed from battery at relay U through the contact at relay V and the windings of relays N and P in parallel to ground at relay Y. Relays N and P

STEP-BY-STEP MACHINE SWITCHING SYSTEM

Subscriber's Line Circuit with Plunger Type
Primary and Secondary Line Switches



are energized, the operation of relay P releasing the locking segment of the master switch and the operation of relay N breaking the open main battery supply circuit to the secondary line switches.

The energizing of relay W, which starts the secondary master switch hunting for an idle trunk, at the same time breaks the circuit through the winding of relay Q. If the master switch hunts past several consecutively numbered busy trunks, relay W will hold up for an appreciable length of time, and relay Q will release and place ground instead of battery potential on the open main feed to the secondary switches. This placee ground on the holding wires of all idle trunks incoming to this particular secondary sub-group and on their master switch bank oontnote at the primary switches, ao that if there are any primary master switches directing their plungers toward any of the idle trunks leading to this particular secondary sub-group, the master switches will be moved to the next idle trunk in order to divert traffic for the time being to other secondary sub-groups. The number of consecutively numbered busy trunks over whioh the secondary master switch must hunt before this action, known as the "kick-off", takes place, depends on hon quickly relay Q releases after relay W has been energized. This factor may be varied by altering the adjustment of relay Q.

When the secondary master switch wiper reaches an ungrounded terminal, relay W releases which, in turn, releases relays N and P and energizes relay Q. This stops the master switch at the idle

trunk and removes the ground on the open main supply, replacing it with battery potential.

When the eecondary master switch wipers reach the terminals for trunk No. 1, the guarding spring contacts are closed by tripping arm "1", and when the next secondary line switch plunges, the operation of relay W causes relays M, N and P to energize. Relay M locks up mechanically and closes a circuit through the solenoid which rotates the master switch back to trunk No. 10. Relay M is then unletched by tripping arm "10", the solenoid is deenergized and the master switch will remain at trunk No. 10 if this trunk is idle, or if not, will start to hunt for the next idle one in the manner described above.

With the release wire of each trunk leading to a first selector there is associated a chain relay which is energized whenever its trunk becomee buey. When all of the trunks in a sub-group of ten become buey, a path is closed from battery at stop relay V through the chain relay contacts to ground at the chain relay for trunk No. 1. Relay V energizes and opens the battery supply to relay P so that the secondary maeter switch cannot continue to oscillate while all of its trunks remain buey. Ai soon as a trunk is freed, however, the chain circuit is broken, relay V releases and the master switch starts to hunt in the usual manner for the idle trunk.

In this connection it may be noted that the primary master switch circuit is arranged ao that when all ten of the trunks in a sub-group from primary to secondary line switches become busy, the primary master switch continues to oscillate until a trunk is

released. As may be eeen from the discussion given under Division IV, Sections 1 and 2a, the "all-trunks-busy" condition should not occur frequently at primary boards, whereas this condition is of more common occurrence at secondary boarde. As a result, the primary master switch circuit current drain and the wear on the primary maeter switches due to all-buey primary sub-groups is not excessive with the arrangement employed, while at eecondary boarde it has been possible to reduce materially the current drain and the wear on the master switches by avoiding, as described above, a continual oscillation during the "all-trunks-busy" period.

When all except one of a eub-group of trunke from a secondary board to first selectors are busy, the master switch wiper is on the ungrounded terminal of the idle trunk and relay W is in the released position. When this trunk is seized, relaye V and W are operated, but relay Q, being slow-releasing, is not de-energized immediately and for an instant the ground at the contacte of relay V ie placed on the contact of pick-up relay H through the contacts of relay Q and the test pick-up keys and knife switch. This ground is placed on the H relays of all primary master switches in the particular regular, combined or partial group concerned (see Div. IV, Sectione 2a and 2c), and the following action takes place at all of these primary master switches: Relay H is energized, cuts off the ground coming from relay V and locke itself up by completing a path through its own contacts and those of relay G to supervisory ground. Relay H also closes a circuit from battery at relay F to supervisory ground. Relay F energizes and the master switch is

rotated to trunk No. 1. The guarding spring contacte aro then closed and the path through relay G is completed to ground by way of the contacta at relay H. Relay G energizes, completes the circuits through the solenoid and through relays P and E, and releaaea relay H. The maeter switch ie thue rotated back to trunk No. 10, whereupon relay G is unlatched and the switch remains at trunk No. 10 or commences to eeek an idle trunk in the usual manner.

Thie sweeping movement of all the primary maeter switches which takee place when the trunk sub-group of an associated secondary master switch becomes all-busy is known ae the "pick-up". The need for the "pick-up" feature may be seen by considering the following typical case: Refer to drawing No. 807-11 in Div. IV, Sec. 2a. A subscriber, whoee line ewitch is in sub-group A, initiatee a call, and his line is switched to the trunk leading to secondary switch sub-group f, and then is connected over one of the trunks in sub-groupe f' to a first eelector. The call is completed, the partiee hang up, and the primary line ewitch plunger reetores, but, as in practically all cases, is not immediately engaged by its maeter ewitch bar. Assume that before the master switch rotates past this plunger and picks it up, the same subscriber initiates another call. His line will be extended over the trunk ueed on the first call to eecondary switch sub-group f. In the interval between the termination of the first call and the origination of the second one, however, secondary trunk sub-group f' may have become all-busy due to traffic having been routed through it from other primary sub-groups of switches, and on the second call

the building up of the connection between the calling subscriber and a firet selector would, in such a caee, be obstructed at secondary sub-group f'.

In order to prevent such a condition, as soon as any aecondary sub-group of trunks, such as f', becomes all-busy, the "pick-up" takes place, and all primary master switches associated with the all-busy secondary sub-group are rotated as described previously, picking up all released but unengaged plungers. A plunger under the control of its master switch oannot plunge into a trunk leading to an all-busy secondary sub-group, because as soon as secondary trunk sub-group f', for example, becomes all-busy, all of the idle trunks incoming to aecondary switch sub-group f are made to test busy at their respective primary sub-groups, so that the primary master switches will hunt past them. This is accomplished as follows:

When all trunka in a secondary sub-group become busy, the secondary master switch, as described above, remains opposite the last trunk made busy, the master switch bank contact of which is grounded in the usual manner. Relay W is thus held operated and when relay Q releases, ground potential is placed on the open main supply which, in turn, places ground on the holding wires of all trunks terminating at the particular secondary line switch group in quastion. The primary master switch bank contacts of these trunks are thus grounded so that the trunks will test busy at the primary boards. The relations between this circuit arrangement, the

"pick-up" feature and the trunking scheme ueed between primary and secondary line switch sub-groupe are discussed under Division IV, Section 2a.

In order that the pick-up may take place at all of the primary master switches in a group when any one of the associated secondary subgroups of trunks becomes all-busy, the pick-up leads from all of the H and Q relays in a group are connected together. A continued ground on any one of these leads, however, will oauee the pick-up to take place repeatedly and will prevent any of the subscribers' lines involved from reaching a first selector until the ground is removed. To expedite the work of locating and removing such a ground, the pick-up leads are oonnected together through a series of test keys and a knife switch, which are mounted at a test pick-up panel at the primary line switchboards. If a pick-up lead becomes grounded, the knife switch is opened to determine whether the ground is on a primary or a secondary lead, and then the primary or secondary test keys are operated to locate the trouble. A separate test key is provided for each pick-up lead, and the circuit is so arranged that when a key is operated the corresponding pick-up lead is disconnected from the other pick-up leads, and the latter are connected to battery through a buzzer. Therefore, if a ground exists, the buzzer will sound when the key for an ungrounded lead is operated, but will not sound when the key for the grounded lead is operated.

At the termination of a call the ground on the release wire is removed when the connector or repeater releases, as described under Div. III, Section 2a. The removal of this ground re-

releases magnet B, thus restoring the primary line switch plunger, and removes ground from the lower master switch bank contact. When the primary line switch bank contacts open, ground is removed from the upper primary master switch bank contact and from the holding wire. Magnet J then releases, the secondary line switch plunger restores and ground is removed from the secondary master switch bank contacts.

The operation of the metering relays and registers associated with the primary line switches is the same as described under Div. III, Section 2a.

**Subscriber's Line Circuit with Plunger Type Line Switches. Arranged for Message Register Service:**

Drawing No. 807-3 shows a subscriber's line circuit provided with plunger type line switches and solenoid type master switches and arranged for message register service.

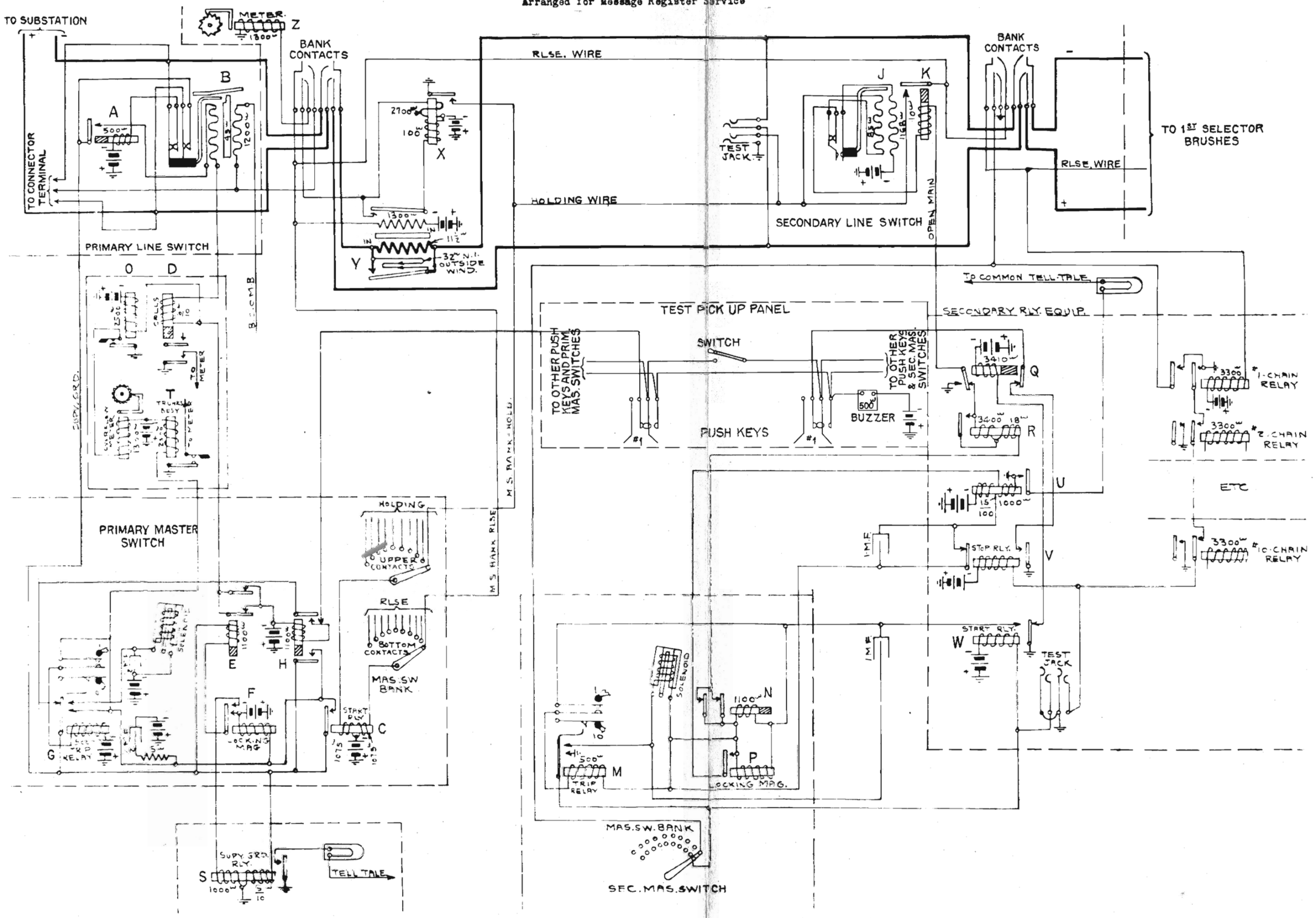
When a call is initiated the primary line switch plunges in the usual manner and the primary line switch bank contacts, in closing, complete a path from battery at relay X through its B?— ohm winding and through the winding of register Z to ground, Relay X operates but register Z does not, oming to the 2,700-ohm resistance in series with it. The closing of the contacts at relay X places ground on the holding wire, causing the primary master switch to rotate and the secondary line switch to plunge.

When ground potential is plaoed on the release wire through the operation of relay K a path is completed from battery at relay Y through its 1300-ohm winding to the release wire ground, and this closed path is maintained after relay K releases by ground coming successively from the selectors and the connector or repeater as the connection is built up, The current through the 1,300-ohm ninding of relay Y, however, does not cause the Operation of this relay.

When the subscriber's line is extended to the first selector, current is sent out over the line from battery at pulse relay A (Dwg. No. 8074) and as the connection is built up the subscriber's line current is furnished in turn through the pulse relays at the different selectors and finally through a relay

# STEP-BY-STEP MACHINE SWITCHING SYSTEM

Subscriber's Line Circuit with Plunger
Type Line Switches
Arranged for Message Register Service



at the connector if the call is local to the originating office or by the repeater in the caee of an inter-office call. The current flowing over the subscriber's loop passes through the 11-1/2-ohm winding of relay Y but in such a direction as to set up a magneto-motive force opposing that created by the current through the 1,300-ohm winding, and relay Y is not operated.

Whether or not register Z will operate when the called party answers depends on the circuit arrangement employed at the connector, As described in Division III, under the sections covering connector circuits, connectors used to serve lines calls to which are charged for, are arranged to reverse the direction of the current through the calling party's loop when the called party answers, the reversal being effected through the medium of the repeater in the case of an interoffice call. Where incoming service to a line is free, this line is served by connectors that do not reverse the current through the calling subscriber's loop when the called party answers. Similarly, on a call from a message rate line to an operator, completed to her position from a selector level, no current reversal takes place when the operator answers.

If, when the called party answers, the current through the calling party's loop is reversed, the direction of the magneto-motive force groduced by the current through the 11-1/2 ohm winding of relay Y is also reversed and the combined forces set up by the currents through the 11-1/2-ohm and 1,300-ohm coils operate relay Y,

The contacts of relay Y, in closing, shunt out its 11-1/2-ohm winding, thus balancing the talking pair, and preventing relay Y from releasing if the currant is again reversed. The relay is held operated by the current through its 1,300-ohm winding. The operation of relay Y also completes a path from battery through the 100-ohm winding of relay X and the register Z to ground. The 100-ohm and 2,700-ohm windinge of relay X in parallel with one another and in series with register Z permit the latter to operate.

If, when the called party answers, the current through the calling party's loop is not reversed, the contacts of relay Y are not closed and consequently register Z is not operated. The conversation is held through the 11-1/2-ohm winding of relay Y in parallel with its 32-ohm non-induotive winding.

**Regular Selector Circuit:**

The functions of this circuit are—

(1) To respond to the series of pulses from the dial so as to step the brushes up to the required level and around to an idle trunk in this level if there be any.

(2) If there be no idle trunk in that level to send back a suitable tone to the subscriber.

(3) If an idle trunk is available to connect the subscriber's line to that trunk and to clear the line of bridged apparatus.

(4) To provide for the release of the selector at the termination of the call.

The following circuit description is applicable to all regular selectors, whether first, second, third or fourth in the train, except that first selectors are provided with a dial tone as described hereinafter. The circuit description also applies to selectors, other than toll selectors, used for handling special service calls. The special circuits required for toll selectors, test distributor selectors and the like are described under separate headings.

The selector circuit is shown on Drawing No. 807-4. When the selector is seized pulse relay "A" is operated through a circuit from battery at relay "A", through the contacts at relay "D", through the line switches, over the subscriber's loop and through the contacts of springe J to ground. The Operation of relay "A" cloees a path from main battery supply through a lew resistance supervisory relay (not shown), through the winding of release relay "B" and the contaots of relaye "A" and "D" to ground at relay "D". This operates relay "B", which places ground potential on the release wire and holds

the line switches and the preceding selectors, if any, in the operated position.

At the first break of the pulse springs at the dial, the subscriber's loop is momentarily opened and pulse relay *An is released, but release relay "B", being slow releasing, remains operated, so that for an instant a path is completed from battery at vertical magnet "F", through series relay "C", the contaote of relays "B", "A", and *Dn to ground at relay "D". Magnet "F" is energized, moving the selector shaft and brushes up one step, and the off-normal springe "ON" are closed. Relay "C" is also energized an4 its contacts close a path from battery at interrupter relay "E", through the oontacte on springa "ON" and the contacts on relay "C" to ground at relay "B". Relay "E" is energized, and locks itself up through eprings "ON", the contacts of rotary magnet "G", end the contacts of relays "E" and "D" to ground at relay "D".

An instant later the pulse springs at the dial close again and relay *An operates, thus breaking the circuit through magnet "F" and relay "C". Magnet "F" releases preparatory to moving the ehaft up another step if required. If the oloeing of the dial pulse springs is only momentary, relay "C", bring slow releasing, will not restore and at the next break of the pulse contacts relay "A" will again release and magnet "F" will move the shaft up another step. Thie action is continued during the return movement of the dial, relay "A" intermittently operating and deenergizing, magnet "F" actuating the shaft at each break of

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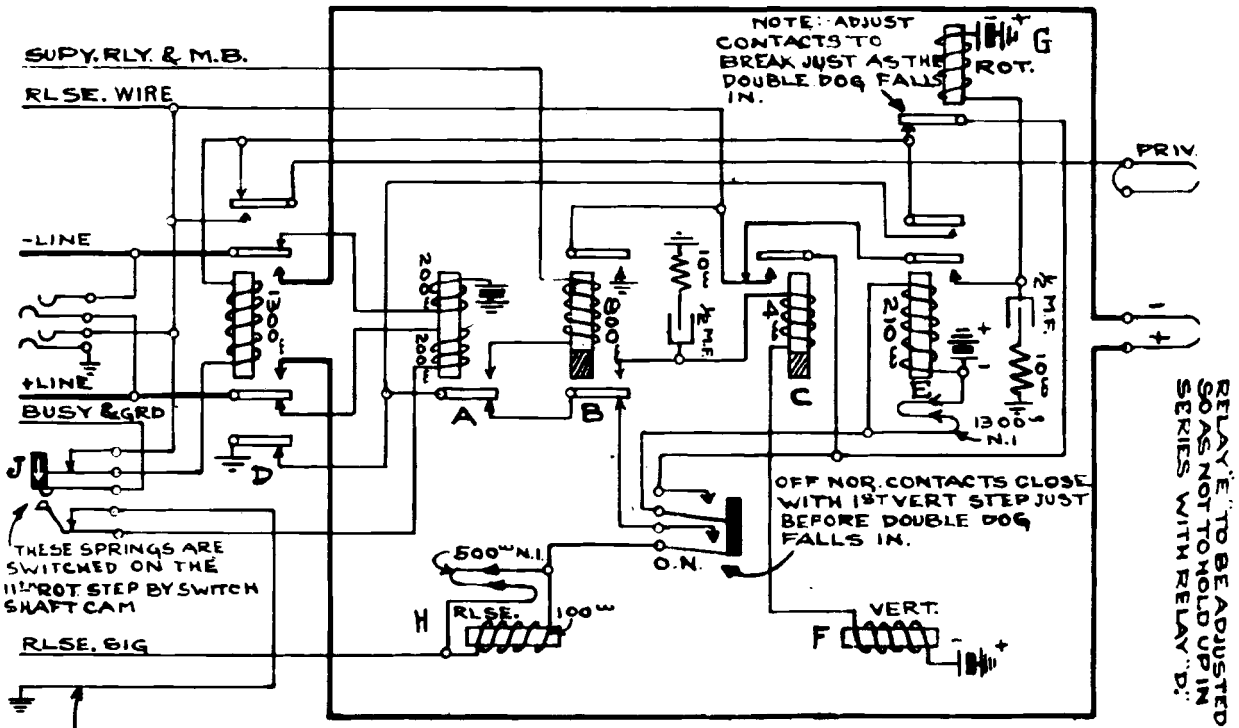
# STEP BY STEP MACHINE SWITCHING SYSTEM

## Regular Selector Circuit




NOTE: For dial tone on first selectors this lead is carried to ground through an induction coil.

the dial pulse contacts and relays "B", "C" and "E" remaining energizdd.

If the dial pulse contacta remain closed for more than an instant, however, as will be the case when the dial has returned to normal, relay "A" is held operated for a sufficient length of time to permit relay "C" to release. The release of relay "C" does not deenergize relay "E", however, since the latter is locked up as described above. When relay "C" releases a path is completed from battery at rotary magnet "G" through the contacts at relays "E", "C", and "B" to ground at relay "B". Magnet "G" is energized and rotates the brushes to the first set of terminals in the level to which they have been raised. Magnet "G", in operating, also opens its contacta, breaking the circuit over which relay "E" is locked up and relay "E" releases. Relay "E" in releasing breaks the circuit through relay "G" and the latter restores.

The action which now takes place depends on whether or not the private terminal to which the private wiper has been rotated is grounded.

Assume first that the brushes have been rotated to an idle trunk. The relesse wire to the private terminal of this trunk will be open. A path may be traced from battery at relay "E", through springs "ON", the contacts of magnet "G", the winding of relay "D", the contacta on springs "J" and tha contacts of relay "B" to ground at relay "B". Relay "D" operates but relay "E" remains unoperated due to the 1300-ohm resistance of relay "D" in series with it. The contacts of relay "D" in closing extend

the talking pair through to the brushes and to the trunk selected, and also break the circuit through the winding of relay "A" which in restoring releases relay "B". Relay "B", by virtue of its slow release feature, keeps the releese wire grounded until the release relay at the next selector, or at the repeater or connector, has time to operate. The operation of the release relay at the next switch sends ground back over the release wire to the private wipers, and this ground is in tarn placed on the release wire leading to the preceding switch through the contacts of relay "D", thus holding relay "D" and the preceding switches in the operated position.

When the contacts on springs "ON" were closed at the first vertical movement of the aelector shaft the release magnet "H" would have been operated and the shaft restored to normal at the first subsequent release of relay "A" were it not for the faot that relay "B" is held operated continuously until its release, which is caused by the operation of relay @D$^{U}$. When relay "B" releases it is still necessary to keep the circuit through magnet "H" open and this is accomplished by the opening of the release circuit contacts at relay "D".

If the first set of terminals to which the selector brushes have been rotnted are the terminals of a trunk which has been made busy at some other aelector, the private terminal of the set will be grounded, In this case a path may be traced from battery at relay "E", through springs "ON", the contacts of magnet "G" and the contacts of relay "D" to ground at the private wiper,

Relay "E" operates and magnet "G" is again energized over a circuit passing through the contacts of relaye "E", "C", and "B" to ground at relay "B". Relay "D" remains unoperated since one-side of its winding is grounded on the releaae wire through springs "J", while the other side of its winding is grounded at the private wiper through its own contacts. The operation of magnet "G" rotates the shaft and brushes to the next set of terminals and also releases relay "E" which in restoring deenergizes magnet "G" as before. This cycle of operations is repeated until the private wiper reaches an ungrounded terminal, when relay "E" will remain deenergized, stopping the rotation of the brushes, and relay "D" will operate, as described befora,

If all of the trunks in the level are busy, the brushes, after having reached the 10th set of terminals, are rotated one step further, whereupon springs "J" are actuated by a cam on the selector shaft. The operation of springs "J" removes the regular ground from the winding of relay "A", replacing it with another ground upon which is superimposed a busy-back tone which is thus made audible to the calling subecriber. When the shaft is in the 11th rotary position the private wiper lead is open and in order to prevent the operation of relay "D" the circuit through its winding is broken at springa "J". It is necessary to keep relay "D" deenergized and relaya "A" and "B" operated in order to transmit the busy-back tone to the subscriber.

When the calling party reotores the receiver at the

termination of the call the ground is removed from the release wire and relay "D" releases, This completes a circuit through release magnet "H", the contacts of springs "ON", the contacts at relays "B", "A", and "D" to ground at relay "D". Magnet "H" energizes and operates the double-dog, permitting the selector shaft to restore to normal position.

Dial Tone:

Aa mentioned under Division II, Section 3-c, a distinctive tone known as a dial tone is applied to a calling line as soon as it has seized a first selector, in order to notify the subscriber that he may proceed with the dialing. On first selectors, therefore, the winding of the pulse relay is carried to a ground upon which the dial tone is superimposed by means of an induction coil, as noted on Drawing No, 807-4. When the selector is seized thia tone, being in series with the line, becomes audible to the subscriber. If the selector finds an idle trunk, the dial tone is removed by the operation of relay "D", or, in oase no idle trunk is found, by the operation of springs "J".

**Repeater Circuit for One-Way Inter-Office Trunks:**

Drawing No, 807-5 shows the circuit of the repeater used in one-way inter-office trunks for reducing the number of wires in the trunk from three to two, for repeating the dfal pulses to the switches ahead and for providing the proper automatic supervisory features over the two-wire trunk. It is also advantageous to supply transmitter current to the calling party from the repeater.

When the calling party's line is extended to the repeater, current flows from battery at pulse relay "A" through the contacts of relay "D", over the subscriber's loop to ground at relay "A". The latter energizes and relay "B" is operated through the contacts of relay "A" to ground.

The closing of the contacts at relay "B" plaoes ground potential on the release wire, thus holding the switches behind in the operated position. The operation of relay "B" also completes a path from battery at relay "F" through ita 1,900-ohm winding to ground at relay "B", but relay "F" is not operated over this circuit.

The operation of relay "B" furthermore closes a bridge across the trunk leading to the switch ahead, the bridged path passing through the contacts of relay "C", the 60-ohm winding of relay "F", the contacts of relay "D" and the 250-ohm winding of relay "E". This permits the pulse and release relays at the switch ahead to operate in the usual manner and also causes relay "E" to operate, the contacts of which are in a chain relay circuit uaed for indicating when all of a sub-group of outgoing trunks are busy.

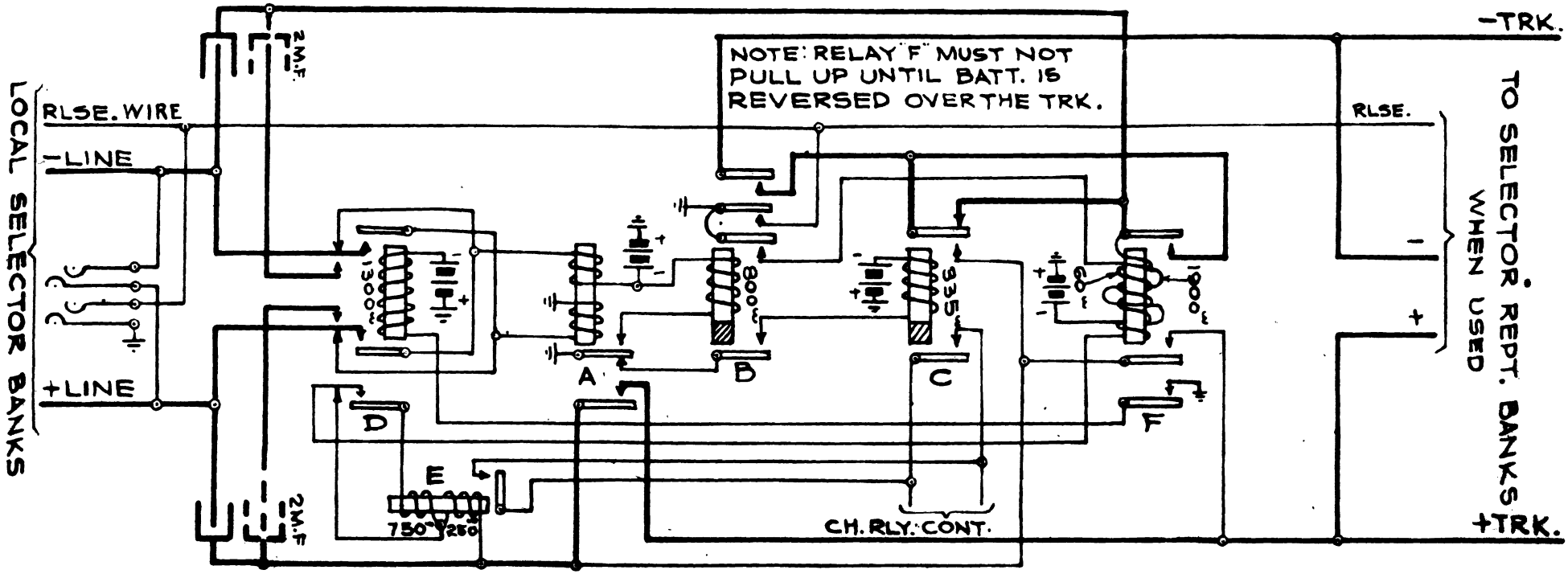
The cloaing of the bridged path through relay "F" doea not cause this relay to opcrate, as the currents in the two windings are in opposition.

At the first momentary opening of the calling subscriber's loop circuit at the dial, relay "A" releases and causes the Operation of relay "C" through the contacts of relay "B" which remains energized. The actuation of the contacts at relay "C" opens the bridged path through the windings of relay "F" and "E" and completes a path from one side of the trunk to the armature of relay "A". Since the latter has released the bridge across the trunk is broken and the pulse relay at the switch ahead is released, An instant later, when the dial pulse contacts are momentarily cloaed, relay "A" energizes, but relay "C", being slow releasing, remains operated. The bridge acroes the trunk is thus cloaed through the contacts of relay "C" and "A". In this way the contacts of relay "A", in responding to the dial pulses, intermittingly open and cloae the trunk bridge and therefore repeat the pulses to the next switch. During the return movement of the dial, the chain relay circuit for the trunk is held closed by the contacts at relay "C" instead of by those at relay "E". When the dial returns to normal position, relay "A" is held operated for a sufficient length of time to permit relay "C" to releose, thus re-establishing the trunk bridge through relays "F" and "E".

All subsequent series of pulses from the dial nre repeated successively to the switches ahead in the same manner. The operation

# STEP BY STEP MACHINE SWITCHING SYSTEM

## Repeater Circuit for One-Way Interoffice Trunke



ef the repeater then depends on whether or not the battery supply to the repeater from the switches ahead is reversed when the called party answers, as discussed under Division III, Section 2-c. If the battery is reversed, the current through the 60-ohm winding of relay "F" will be reversed and will assist that passing through its 1,900-ohm winding, and relay "F" will be operated. The closing of the contacts at relay "F" places ground potential on the winding of relay "D" which, in operating, reverses the transmitter battery on the trunk leading to the switches behind and to the calling station.

When specified, the condensers shown dotted on the drawing are provided, and are so wired as to be placed in multiple with the regular condensera when relay "D" operates, in order to reduce the transmission loss through the circuit. The circuit is arranged in such a manner that the extra condensers are not connected during the dialing period in order that at Che time of the break of the dial pulse springs the condenrer charge and discharge will not be so great as to prevent the release of relay "A".

The operation of relay "D" also changes the path of the bridge circuit across the trunk by placing the 750-ohm winding of relay "E" in series with its 250-ohm winding. This increases the impedance of the bridged path to voice currents and decreases the transmission loss due to the bridge.

The closing of the contacts at relay "F", besides operating relay "D", plnoes a shunt around the pulse contacts of relay "A"

and also around the bridge circuit contacts of relay "C". This is to insure that the circuit to the switch ahead will not be interrupted in case relay "A" is de-energized by a discharge from the condensers at the time battery is reversed or by a movement of the calling subscriber's dial after the called party has answered.

If, when the called party answers, the battery to the repeater from the switches ahead does not reverse, the currents through the 60-ohm and 1900-ohm windings of relay "F" will remain in opposition and relay "F" will not operate. Relay "D" will therefore not be operated and the 750-ohm coil of relay "E" will not be introduced into the bridge acroes the trunk. The extra condensers, if installed, will also not be utilized on suoh a connection.

When the calling party restores the receiver, the line is opened and relay "A" releases, whereupon relays "B" and "F" restore. The release of relay "B" removes ground potential from tbe release wire, thus restoring the switches behind the repeater, and also breaks the bridge circuit, releasing the relays at the switches ahead.

**Local Regular Connector Circuit for Individual or Selective Party Line Service. Arranged to Release Connector After Both Parties Have Hung Up.**

The term "local regular connector" signifies one used for completing connections, other than toll connections, to individual and party line stations only.

The connector circuit is shown on Drawing No. 807-55.

The functions of the circuit are:

1. To respond to the first series of dial pulses which the connector receives so as to step the brushes up to the proper level.

2. To respond to the second series of dial pulses which the connector receives so as to step the brushee around to the terminale corresponding to the subscriber's station being called.

3. If the line on which the desired station is located is idle, to connect the calling party's line to the called party's terminale, tb apply ringing current to the latter and to give an audible ringing signal to the calling subscriber.

4. To cut off the ringing current when the called party answers.

5. To furnish talking battery to the called subscriber, and on connections local to the originating office to furnieh talking battery to the calling subscriber.

6. To reverse the current over the calling party's line ahen the called party answers in order to operate the message register equipment, if any, associated with the callicg line, or, on calls from an operator, to provide supervision at the operator's position.

7. If the desired station is busy to avoid making a connection to it ond to return a busy-back signal to the calling party.

8. To release the connector as soon as the last party to hang up has restored his receiver.

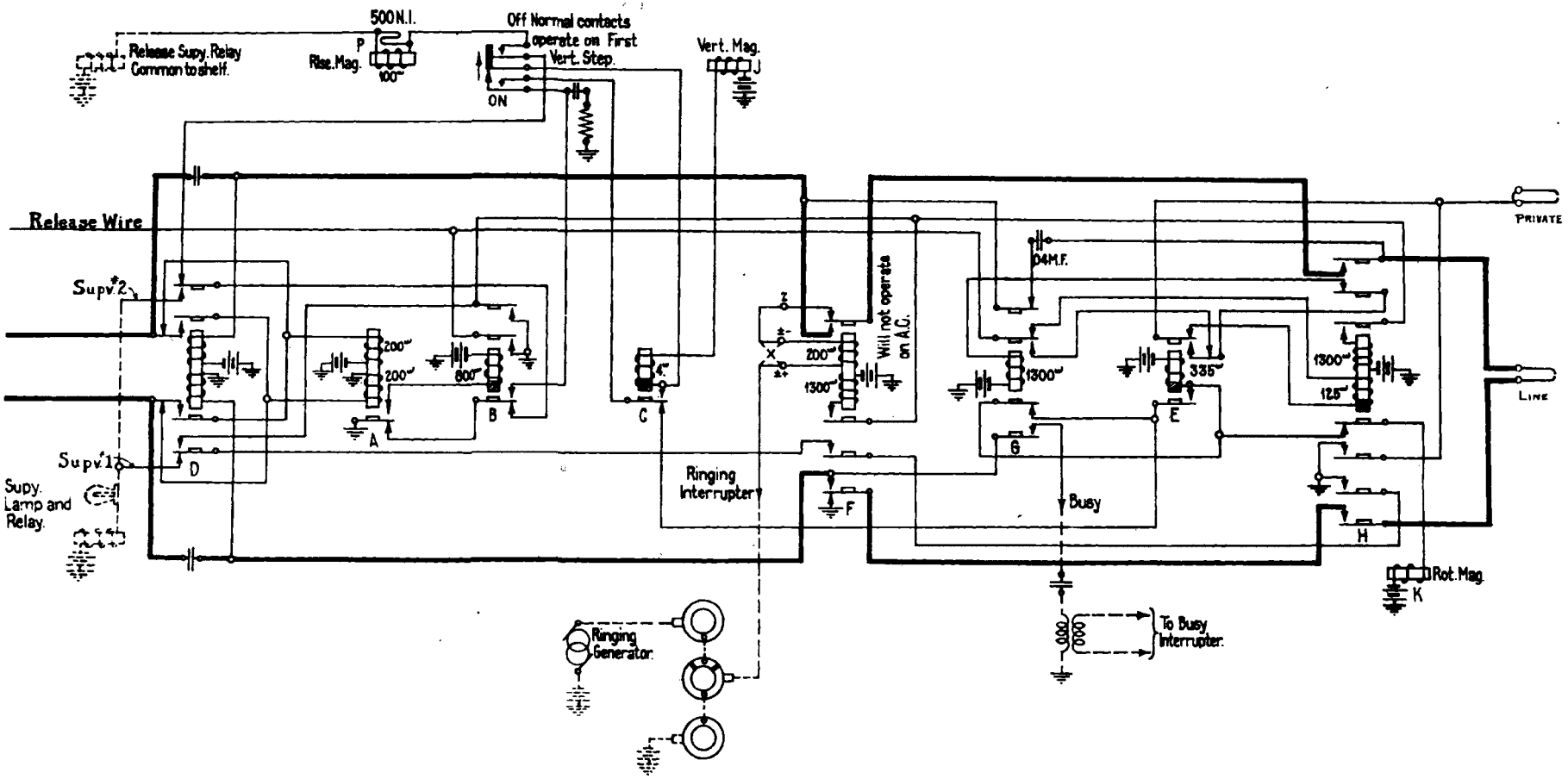
When the connector is seized, relay A is operated through a oirouit from battery relay A, through the contacts of relay D, through the preceding switches and over the subscriber's loop to ground at relay A. The operation of relay A causes relay B to energize, the contacte of which, in closing, places ground potential on the release wire of the trunk incoming to the connector thus holding the preceding switches in the operated potaition, and preventing the connector from being seized by other selectors.

At the first interruption of the dial pulse springe, pulse relay A is momentarily released, but slow releasing relay B does not restore and for an instant a path is completed from battery at vertical magnet J, through the winding of relay C, the contacts on off-normal springs ON and the contacts of relays B and A to ground at relay A. Magnet J is energized and moves the connector brushes up one step. The shaft in moving upward permits springs ON to operate. Relay C is also energized and locke itself up through its own contacte, through the operated off-normal springs and through the contacts of relays B and A to ground at relay A.

At the following momentary closing of the dial pulse springs relay A operstes and de-energizes magnet J, but slow releasing relay C remains operated, At the next opening of the dial pulse contacts, relay A in restoring again causes magnet J to operate. Thus, during the return movement of the dial for the first series of pulses to the connector, relay A responds to the pulses and causes magnet J to actuate the shaft the required number of times, while relays B and C remain operated.

STEP-BY-STEP MACHINE SWITCHING SYSTEM

Local Regular Connector Circuit for Individual or Selective Party Line Service



When the dial has returned to normal position relay A remains energized long enough to permit relay C to release. The release of relay C breaks the path through magnet J, springs ON having been operated. Relay C, in releasing, also completes a path from battery at rotary magnet K, through the contacts of relays H, G and C, through springe ON and the contacts of relay B to the open contacts of relay A, so that at the first interruption of the dial pulse contacts in the next series of pulses relay A, in restoring, completes this circuit to ground and causes magnet K to energize. Magnet K rotates the brushes to the first set of terminale in the level to which they have been raised. Relay 'A, in releasing, also completes a path from battery at relay E through the contacts of relays G and C, through springs ON and the contacts of relays B and A to ground at relay A. Thia causes relay E to energize.

At the following momentary closing of the dial pulse springe relay A operates and de-energizes the magnet K, but slow releasing relay E remains operated. At the next opening of the dial pulse contacte relay A, in restoring, again causes magnet K to operate. Thus, during the return movement of the dial for the second series of pulses to the connector, ralay A responds to the pulses and causee magnet K to step the brushes around to the required set of terminals, while relays B and E remain operated and relay C remains unoperated.

The private wipers in rotating to the called terminals are likely to pass over private terminals that are busy. As

explained later, a busy private terminal is at ground potential, and when the private wiper passes over euoh a terminal relay G will be energized over a circuit from battery at relay G through the contacts of relays H and E to the private wiper ground. The oirouit over which magnet K ogsratea, however, is carried through contacts on relay G (the reason for this is given later under the heading "Called Line Found Busy"). It is therefore necessary to short-circuit these contacte on relay G during the rotary motion in order that the circuit through magnet K will not be broken as the brushes pass over busy terminals. These contacts are short-circuited by the contacts on relay E.

Called Line Found Idle. After the dial returns to normal position relay A remains operated and therefore relay E restores. The called line being idle, the private terminal of the called station is at battery potential, being oonnected through the I.D.F. to one side of the BCO winding of the line switch on the called line, the other side of the BCO winding being oonnected to battery. A circuit is therefore completed from battery at the line switch through the BCO winding, over the private lead and wipers, through the contacts of relay E, ths 125 ohm winding of relay B and the contacts of relays G and B to ground at relay B. Relay H is energized and looke itself up over the circuit from battery at relay H, through the oontactr of relays H and B to ground at relay B.

The operation of relay H establishes the following circuit conditions:

1. The talking pair is closed from relay F to the line wipers.

2. Ground potential is placed on the private wipers and therefore on the BCO winding at the aalled party's line switch, thue operating the BCO armature and preventing the line switch from plunging when the called party answers. Thie private wiper ground is placed, through the private multiple, on the correspondicg private terminals of all other connectors serving the same hundssd stations, thue establishing the "test-busy" condition at the other connectors.

3. The circuit over which magnet K operates is broken so that the switch will not be rotated further if the calling party should dial again.

4. The path from the winding of relay G to the oontacts of relay E is broken. If the calling subscriber should move hie dial during conversation and momentarily break the line circuit, relay E would energize over the usual path to ground at relay A. If the circuit through relay G were not broken at the contacts of relay H, relay G would then be energized through the contacts of relay E to the private wiper ground and when relay E restored after the momentary line interruption, relay G wouid lock up through the make-before-break contacts of relay E and through the contacte of relays G and B to ground at relay B. This would apply the busy-back tone to the line.

When relay H operates superimposed ringing potential and battery are applied alternately through the 200-ohm winding and the contacts of relay F and through the contaotr of relay H to the upper line wiper of the connector. The ringing current is seht out either over the tip or over the ring of the line, as required, by a suitable cross-connection or bunching block arrange-

ment at the I.D.F., as described under Division V "Cabling and Wiring". To complete the ringing circuit the lower line wiper is connected through the contacts of relays H and F to ground at relay F.

It may be noted that tripping relay B requires direct current for its operation and that thereforo battery is placed in series with the generator for all kinds of ringing. A special superimposed battery is required, however, only where four-party selective service is given, as in present manual practice.

From the above it may be seen that in so far as ringing is ooncerned, a given connector, having the circuit shown on Drawing 807-55, may serve individual line and also any kind of party line stations with the exception of stations requiring a two-ring code on four-party semi-selective lines. An additional limitation is that on four-party lines, statione requiring positive superimposed current and stations requiring negative superimposed aurrent cannot be served by the same connector. Further information regarding ringing circuits is given in Division VII on "Power Plants."

While the called party's bell is being rung a part of the high frequency components of the ringing current is ahunted through the .04 Y.B. oondeneer and through the contacts of relay G to one side of the calling line; it then passes over the calling line and produces the audible ringing signal at the called party's station.

When the called party answers relay P is tripped by the ringing battery. Relay B, in operating, removes the ringing from the line and closes the talking path between the calling and called parties. A path is also completed from battery at relay B, through its 1300-ohm winding end its own contacts and through the contacts

of relay B to ground at relay B, and relay F locks up.

When the called party answers a circuit is completed from battery at selay D, through the contacts on relays F and H and over the called party's line to ground at relay D and the latter energizes. The current flowing over this path is the transmitter current for the called party. Relay D, being bridged across the line during conversation, is designed to act in the capacity of a retardation coil and presents a high impedance to voice ourrente.

The contacts of relay D, in operating, reverse the battery eupply from relay A to the trunk incoming to the connector. In the caae of a oall local to the originating office, the battery supply from relay A provides the transmitter current for the calling party so that relay A, like relay D, is aleo designed to act as a retardation ooil. On such a oall the battery reversal tbat takes place when relay D operates actuates directly the message register equipment, if any, associated with the calling line. In the caae of an interoffice connection the battery current from relay A passes through the repeater circuit, and on euch a connection the battery reversal operates the message register equipment, if any, through the medium of the repeater. On callb from an operator the reverse current feature may be utilized to provide supervision at the operator's position.

In addition, relay D, in operating, establishes the following circuit conditions:

1. The release circuit, through releaoe magnet P and the off-normal springs, is opened so as to prevent the releaee of the connector until the called party de-energizes relay D by hanging up his receiver.

2. A path is completed from battery, through a supervisory circuft over the lead marked "Supv. #2@to the open contacte of relay B. If, after the connection is completed, the calling party restores his receiver and the called party does not, the No, 2 eupervisory circuit is completed through the contacts of relaye B and A to ground at relay A. This circuit will frequently be closed, but usually only for an inetant, after the termination of a conversation, and the supervisory circuit is arranged to give an audible and visual alarm in case the circuit is cloeed for more than a pre-determined number of seconds.

3. The parallel paths from battery at relay B through its 1300-ohm winding, and from battery at relay H through its 1300 ohm winding, are completed through the contacts of relays D, F and H to ground at relay H. This circuit is known as the "relay D multiple circuit" and the need for it is pointed out below under "Release When Calling Party Hange Up First."

When relay D is In the releaeed position and relays F and H are in the operated position, a circuit is closed from battery through a supervisory circuit over the lead marked "Supv. #1" and through the contacts of relaye D, F and H to ground at relay H. This path will be closed in case of premature tripping of relay F, or in case the calling party at the end of conversation fails to hang up by the time the called party hae reetored his receiver (since relays B and H remain operated as long as relay B remains operated). The eupervisory circuit is arranged to give an audible and visual alarm after a predetermined number of seconds.

Release When Calling Party Hangs Up First. As soon as the calling party restores his receiver, relay A releases, opening the circuit to the winding of relay B, but the latter does not immediately de-energize. For an instant a path is completed from battery at relay E, through the contacts of relays G and C, off-normal springs ON and the contacts of relays B and A to ground at relay A. Relay E energizes and removes from the release wire the ground which was placed on it from the contacts of relay H, through the contacte of relay E, the 125 ohm winding of relay H and the contacts of relay G. Relay B soon restores and removes its ground also from the release wire. Relay B in restoring, opens the circuit through the winding of relay E but the latter, being elow releasing, does not immediately de-energize and the release wire becomes ungrounded, thus restoring the preceding switches. Relay E soon de-energizes and again places the private wiper ground on the release wire through the 125-ohm winding of relay H and the contacts of relay G, thus preventing a selector from seizing this connector until the called psrty hangs up.

When the calling party restores his receiver the No. 2 supervisory circuit is completed, as described previously.

The release of relays A and B partially closes the release circuit through release magnet P, but this circuit is not completed until the called party hangs up and de-energizes relay D. The principle object of maintaining the connection at the connector between the time that the calling party hangs up and the time that the called party hangs up, is to prevent the plunging of the called party's line switch during this interval, thus avoiding, in the

office ae a whole, a considerable amount of unnecessary line switch and master switch operation and the useless temporary appropriation of secondary line sritches and first selectors.

In o'rder to prevent the line switch from plunging, however, it is necessary to maintain the private wiper ground continuously until the called party hangs up, thus preventing the BCO armature from restoring. To accomplish this it is necessary to make special provision for keeping relay H operated continuously, for otherwise when relay B releases, relay H would release and the grounds to the private wipers from relaye H and B would be removed. The special provision made for keeping relay H operated is the "relay D multiple circuit", referred to previously, relay H finding ground through the contacts of relays D, B and H. The multiple circuit also keepe relay F operated.

When the called party restores his receiver, relay D releases and oompletee the releaee circuit from battery, through a release signal circuit, releaee magnet P, off-normal springs ON and the contacts of relaye D, B, and A to ground at relay A. Magnet P actuates the double dog, permitting the shaft to return to normal, whereupon the off-normal springs are restored snd the release circuit is opened. The release signal circuit is arranged to give a visual and audible signal if the releaee circuit remains cloeed for mors than a pre-determined number of seconds due to the switch falling to restore completely or to improperly adjusted off-normal springs.

The release of relay D also opens the multiple circuit, allowing relays F and H to restore.

Release When Called Party Hangs Up First. When the callsd party restorea his receiver, relay D releases and closes the release circuft as far as the open contaots of relay B and the entire connectfon remains estabiiehed.

As soon as the called party restores his receiver the No. 1 supervisory circuit is completed, as described previously.

When the calling party hangs up relay A releases, causing the release of relay B. The latter, in restoring, completes the release circuit and the connector restores to normal. With relay D in the restored position, the release of relay B de-energizes relays B and H, and with both relays B and X restored, ground potential is removed from the incoming release wire, thus restoring the preceding switches and making the connector available for another call.

Called Line Found Busy. If the called line is in use on an originating call, the private terminal of the called station is grounded from the release wire in the train of switches used to complete the originating call. If the called line is in use on an incoming call, the private terminal of the called station is grounded, through the private multiple wiring, from the contacts on the H relay of the connector uaed to establish the incoming connection.

After the dial returns to normal, slow releasing relay E holde up long enough to permit relay G to operate over a circuit through the contacts of relays H and E to the private terminal ground.

When relay E de-energizes, a path is completed from battery at relay G, through the contacts of relay H, the make-before-break contacts of relay E and the contacts of relays G and B to ground at relay B, and relay G locks up. Relay H remains unoperated; the connector is therefore prevented from establishing connection to the busy line.

The contacts of relay G, in operating, establish the following circuit conditions:

1. The busy-back tone is applied to the calling subscriber's line.

2. The circuit to magnet K is opened so that if the subscriber dials again the connector will not be rotated further.

3. The circuit through the .04 M.F. condenser, connecting one side of the calling line to the upper line wiper, is opened to prevent the busy back-tone or any noise on the calling party's line from being transmitted to the line over which the called party is talking.

4. The circuit to the 125-ohm winding of relay H is opened to prevent relay H from operating and establishing the ringing condition if the called line is freed before the calling party hangs up.

When the calling party restores his receiver the release of the connector is effected in the manner described previously. The release of relay B permits relay G to restore.

# AMOUNT AND ARRANGEMENT OF EQUIPMENT

## Primary Line Switches.

One primary line switch is required for each working subscriber's line in the office. In general, one primary line switch is associated with each private branch exchange trunk, but if the traffic to and from a P.B.X. is such as to warrant the use of one-way trunks, it may be advisable to terminate the trunks handling the traffic from the P.B.X. directly on first selectors, especially if the busy hour for these trunks is coincident with the busy hour for the central office. In addition, spare line switches amounting to about 5% of the number of working switches are installed in order to facilitate the work of distributing the lines over the various sub-groups for equalizing the sub-group loads.

It may be advisable in some cases to combine switches for flat rate and for message rate service into the same sub-group, especially where a small number of message rate lines are involved or where it is expected that the message rate service will not grow rapidly.

In order to handle traffic from coin box stations the circuits of the trunks leading from a primary line switch sub-group containing coin box lines are so arranged that a dial-

ing path from the station to a first selector is not established until the tip side of the line is grounded by the deposit of a coin, Coin box lines, therefore, cannot be combined into the same sub-group with lines of any other clane.

Where it is found desirable to place switches for flat rate lines in the eame sub-group with switches for message rate lines, it will be necessary to provide a compensating resistance in each flat rate line circuit at the point corresponding to the place where the register appears in a message rate line circuit. Moreover, each trunk from a sub-group w— taining message rate lines requires two relays used in connection with tho opsration of the register, whereas trunks from a sub-group containing flat rate lines only do not require these relays. Before combining message rate lines and flat rate lines, therefore, the saving to be obtained by combining should be balanced against the cost of the compensating resistances and the cost of that proportion of the message register trunk relays chargeable to the flat rate lines.

Size of Sub-Groups. The number of primary line switches that should be placed in a sub-group (i.e. the number of switches that should have access to a sub-group of trunks to secondary line switches or to firet selectors) depends on four factors

as follows:

1. The number of trunks in the sub-group.
2. The percentage of originating calls which it is permissible to have delayed due to an all-buay sub-group of trunkn,
3. The number of calls originated by the lines in the eub-group during the busy hour.
4. The average holding time for the calls originated by the lines in the sub-group.

There is a relation between the calling rate and holding time of the lines loading a sub-group of trunks and the average number of simultaneously buay trunks in that sub-group during the busy hour. Thie relation is expressed by the formula -

$$A = \frac{C \times H}{3600}, \text{ or } C = \frac{3600 \times A}{H}$$

where A equals the average number of simultaneously busy trunks in the sub-group during the busy hour, C equals the total number of calls originated in the busy hour in the sub-group of switches, and H equals the average holding time in seconds for the calls originated by the lines in ths sub-group.

There is also a relation between the average number of simultaneously busy trunks in a sub-group during the busy hour (A} and the number of trunks required in that sub-group to provide adequatsly for the traffic to br carried. This relation, covering such cases as are commonly encountered in machine switching systems, is given in the accompanying "Average and Average Plus Deviation" Tables. Values for

tho average number of simultaneously bury trunks are given in Tables A and B, and the number of trunks required is given in the "Average Plus Deviation" column .

In determining the number of primary line switches required to load properly a trunk sub-group of known size the value of C is obtained from the above formula, A being obtained from Table "A" and H from the traffic data. Then:

$$N = \frac{1.05\ C}{L},$$

where N equals the number of primary line awitchee per sub-group, and L equals the average buey hour calls per line obtained from the traffic data. The faotor 1.05 provides the 5% spare switches in accordance with the previous discussion.

Since the traffic handling capacity per trunk increases as the size of the trunk sub-group increases, it is in general desirable to use 10-trunk sub-groups, this being the largest sub-group obtainable with the plunger type line switch. Ten-trunk sub-groups minimize the total number of trunks to the secondary line switches or to the first selectors and therefore minimize *the* number of secondary line switches or first selectors required, although other considerations, pointed out latar, may make it more economical on the whole to employ 9-trunk or even 8-trunk sub-groups.

After having formed as many primary sub-groups as poesible, a few lines will ueually remain which are insufficient in number to provide a proper load for an additional sub-group of trunks, Such linee may be formed into a partial sub-group, or, if they are few in number, may be evenly distributed over tha sub-groups already formed. If the latter procedure materially increases the load on the sub-groups a partial sub-group ehould be formed instead. To calculate the number of trunks necessary to handle the traffic from the partial sub-group, determine the value of A from the formula previously given (the number of switches in the partial sub-group and therefore the value of C being known). "A" is then found in Table "A", interpolating if necessary, and the number of trunks necessary ie found opposite in the "Average Plus Deviation" column.

If the number of switches per sub-group of ten trunks happens to be such as to result in a material waste of space and bank equipment, it may be found desirablr to reduce the number of switches per sub-group in order to obtain a more economical equipment layout. Any material reduction in the number of switches per sub-group is accompanied by a suitable reduction in the number of trunks per sub-group, As may be seen from Table "A", however, the efficiency per trunk of a 10-trunk sub-

group is 1.20 times the efficiency per trunk of an 8-trunk sub-group, end is about 1.09 times the efficiency per trunk of a 9-trunk sub-group, so that more total trunks from primary line switchboards and more total secondary line switches (or first selectors) are required to handle a given amount of traffic where 8-trunk or 9-trunk instead of 10-trunk sub-groups are employed. These factore should be balanced against any space and equipment savings that may be effected by the use of sub-groups of reduced size.

While in general the number of switches in a sub-group ehould be eufficient to load fully ite sub-group of trunkr, there will probably be cases where it will be found economical to operate the trunk sub-groups at a somewhat leer or greater than normal load in order to effect material savings in space and equipment. For example, nhere the number of switches, including spares, per sub-group of ten trunke would normally be 52, it would doubtless prove economical to place but 50 switches in a sub-group, thus increasing the average number of switches per line switchboard from about 139 to 200. In this case the number of trunks per sub-groups would remain ten, since 50 switches would overload a 9-trunk sub-group.

Primary Maater Switches.

One primary master switch is provided for each sub-group of primary line switches, and is mounted ae described in Division II, Section 3b.

# TABLES SHOWING AVERAGE AND AVERAGE PLUS DEVIATION

| Average + Deviation | AVERAGE Table A | AVERAGE Table B | Average + Deviation | AVERAGE Table A | AVERAGE Table B |
|---|---|---|---|---|---|
| 1 | .001 | .010 | 26 | 13.03 | 15.62 |
| 2 | .045 | .149 | 27 | 13.74 | 16.40 |
| 3 | .191 | .436 | 28 | 14.44 | 17.18 |
| 4 | .429 | .823 | 29 | 15.15 | 17.96 |
| 5 | .739 | 1.28 | 30 | 15.87 | 18.74 |
| 6 | 1.11 | 1.79 | 31 | 16.59 | 19.53 |
| 7 | 1.52 | 2.33 | 32 | 17.32 | 20.32 |
| 8 | 1.97 | 2.91 | 33 | 18.05 | 21.12 |
| 9 | 2.46 | 3.51 | 34 | 18.78 | 21.92 |
| 10 | 2.96 | 4.13 | 35 | 19.52 | 22.72 |
| 11 | 3.49 | 4.77 | 36 | 20.26 | 23.53 |
| 12 | 4.04 | 5.43 | 37 | 21.01 | 24.33 |
| 13 | 4.61 | 6.10 | 38 | 21.76 | 25.14 |
| 14 | 5.20 | 6.78 | 39 | 22.51 | 25.96 |
| 15 | 5.79 | 7.48 | 40 | 23.25 | 26.77 |
| 16 | 6.41 | 8.18 | 41 | 24.02 | 27.59 |
| 17 | 7.03 | 8.90 | 42 | 24.78 | 28.41 |
| 18 | 7.66 | 9.62 | 43 | 25.54 | 29.23 |
| 19 | 8.31 | 10.35 | 44 | 26.30 | 30.05 |
| 20 | 8.96 | 11.08 | 45 | 27.08 | 30.88 |
| 21 | 9.62 | 11.83 | 46 | 27.85 | 31.71 |
| 22 | 10.29 | 12.57 | 47 | 28.62 | 32.53 |
| 23 | 10.97 | 13.33 | 48 | 29.40 | 33.37 |
| 24 | 11.65 | 14.09 | 49 | 30.18 | 34.20 |
| 25 | 12.34 | 14.85 | 50 | 30.96 | 35.03 |

## TABLES SHOWING AVERAGE AND AVERAGE PLUS DEVIATION
(Continued)

| Average + Deviation | AVERAGE Table A | Table B | Average + Deviation | AVERAGE Table A | Table B |
|---|---|---|---|---|---|
| 51 | 31.74 | 35.87 | 76 | 51.88 | 57.20 |
| 52 | 32.53 | 36.71 | 77 | 52.71 | 58.07 |
| 53 | 33.32 | 37.55 | 78 | 53.53 | 58.94 |
| 54 | 34.10 | 38.39 | 79 | 54.35 | 59.80 |
| 55 | 34.90 | 39.23 | 80 | 55.18 | 60.67 |
| 56 | 35.69 | 40.07 | 81 | 56.01 | 61.54 |
| 57 | 36.48 | 40.92 | 82 | 56.84 | 62.41 |
| 58 | 37.28 | 41.77 | 83 | 57.67 | 63.29 |
| 59 | 38.08 | 42.61 | 84 | 58.50 | 64.16 |
| 60 | 38.88 | 43.46 | 85 | 59.33 | 65.03 |
| 61 | 39.68 | 44.31 | 86 | 60.17 | 65.91 |
| 62 | 40.48 | 45.16 | 87 | 61.00 | 66.78 |
| 63 | 41.29 | 46.02 | 88 | 61.84 | 67.66 |
| 64 | 42.10 | 46.87 | 89 | 62.67 | 68.54 |
| 65 | 42.90 | 47.73 | 90 | 63.51 | 69.41 |
| 66 | 43.71 | 48.58 | 91 | 64.35 | 70.29 |
| 67 | 44.52 | 49.44 | 92 | 65.18 | 71.17 |
| 68 | 45.34 | 50.30 | 93 | 66.02 | 72.05 |
| 69 | 46.15 | 51.16 | 94 | 66.86 | 72.93 |
| 70 | 46.96 | 52.02 | 95 | 67.70 | 73.81 |
| 71 | 47.78 | 52.88 | 96 | 68.55 | 74.69 |
| 72 | 48.60 | 53.74 | 97 | 69.39 | 75.57 |
| 73 | 49.42 | 54.60 | 98 | 70.23 | 76.45 |
| 74 | 50.24 | 55.47 | 99 | 71.08 | 77.33 |
| 75 | 51.06 | 56.33 | 100 | 71.92 | 78.22 |

Secondary Line Switches - Regular Groups.

The purpose of using secondary line switches is to reduce the number of first selectors required to handle a given amount of traffic. The secondary switches are enabled to accomplish this through the medium of a special trunking system between the primary and secondary switches, the trunking being such as to give any particular primary line switch access to a large number of first selectors (maximum of 100) instead of access to only a small number of first selectors (maximum of 10).

The secondary line switches, like primary line switches, are arranged in sub-groups, each sub-group providing the proper load for its sub-group of trunks leading to first selectors. The discussion in this section is confined to those cases where a number of primary line switch sub-groups (usually from 20 to 30) are associated by the trunking system with ten secondary line switch sub-groups, and through them with 100 first selectors. This is the most common arrangement, and accordingly the 100 first selectors, together with their associated primary and secondary sub-groups, are known collectively as a "regular" group.

The association between ten sub-groups of secondary switches and their corresponding sub-groups of primary switches is shown for a typical case on drawing 807-11. Lines marked A

to T inclusive represent 20 sub-groups of primary line switches. Lines A' to T' inclusive represent 20 sub-groups of 10 trunkr each leading to the secondary switches. Lines a to j inclusive represent 10 sub-groups of secondary switches, and lines a' to j' represent 10 sub-groups of 10 trunks each leading to 100 first selectors. The 100 selectors are arranged in 10 groups, each group being half of a shelf. The half-shelves are denoted by the letters k to t inclusive.

Each of the sub-groups of trunkr $A^t$ to $T^c$ is distributed over the secondary sub-groups a to j; that is, the 10 trunks in sach of the sub-groups $A^t$ to $T^1$ go to ten different secondary sub-groups, as shown for sub-group $A^1$. Each primary line switch is thus provided with a path to each of the secondary sub-groups and therefore to each of the 100 selectors.

If all of the trunks in a recondary sub-group, such as f', become busy due to 10 calls having been routed through thie sub-group from primary sub-groups K to T, for example, it becomes necessary to prevent a call originating in any of the primary sub-groups A to J from being routed to sub-group f', from which there would be no free path to a selector. The circuits are accordingly so arranged that when all trunks in a secondary sub-group become busy, all idle trunks incoming to the corresponding sub-group of secondary switches are made to test busy at their respective primary sub-groups, as described

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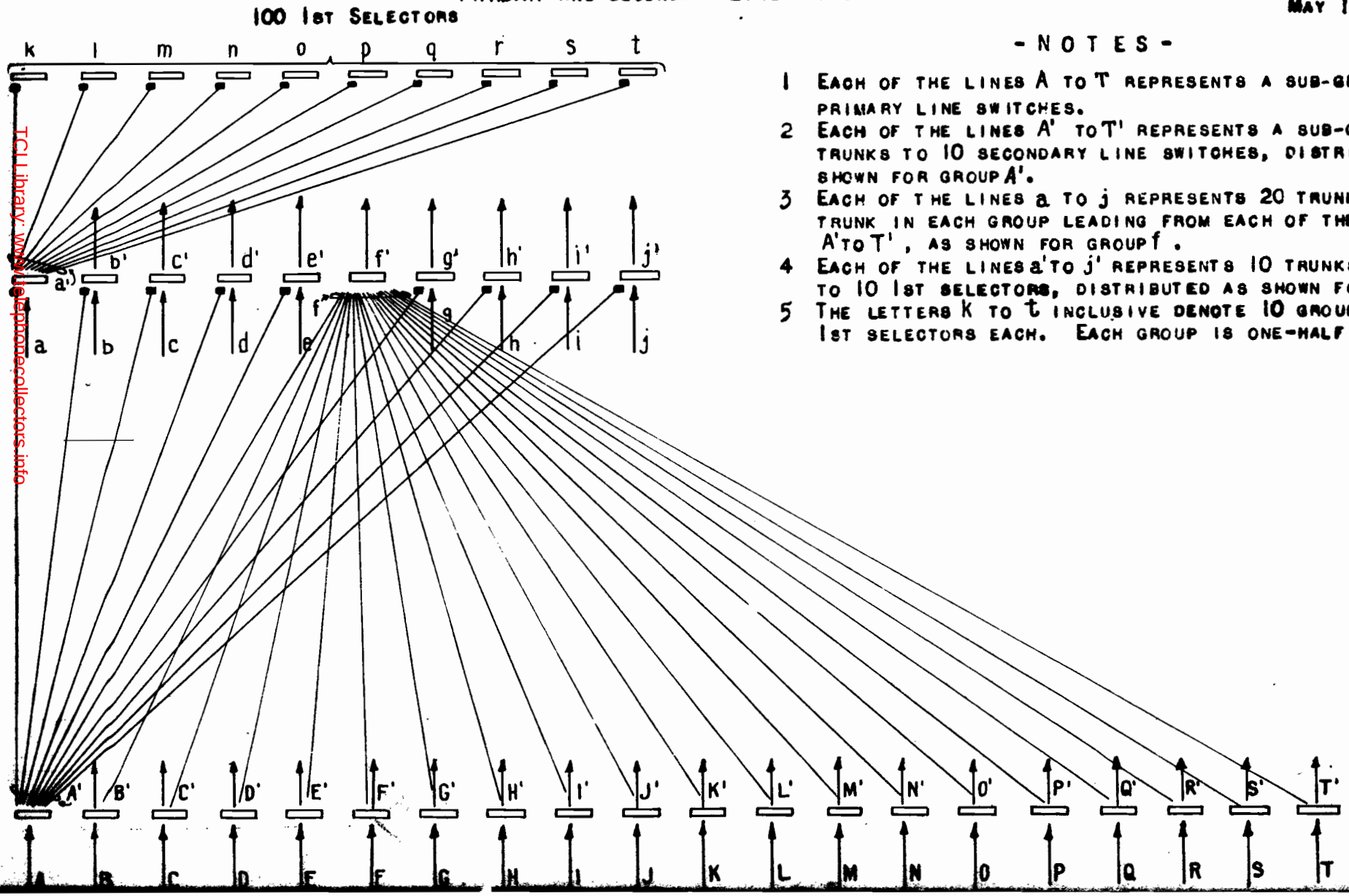
# STEP-BY-STEP MACHINE SWITCHING SYSTEM

## Schematic Diagram Showing Relation between Primary and Secondary Line Switches and First Selectors






## - NOTES -

1. Each of the lines A to T represents a sub-group of primary line switches.
2. Each of the lines A' to T' represents a sub-group of 10 trunks to 10 secondary line switches, distributed as shown for group A'.
3. Each of the lines a to j represents 20 trunks, one trunk in each group leading from each of the groups A' to T', as shown for group f.
4. Each of the lines a' to j' represents 10 trunks leading to 10 1st selectors, distributed as shown for group a'.
5. The letters k to t inclusive denote 10 groups of ten 1st selectors each. Each group is one-half of a shelf.

in Division III, Section 2b. A trunk made busy in this way is referred to as an "artificially" busy trunk.

Since there is only one path between a given primary and a given sscondary sub-group, it follows that if this trunk is seized by one of the switches in the primary sub-group, all idle switches in that primary sub-group are denied access to any of the idle selectors associated with the given secondary sub-group. The 100 trunks leading to the selectors do not, therefore, constitute a true 100 trunk group with respect to the primary switches, since every idle selector in the 100 is not at all times accessible to every idle primary line switch.

With the scheme of busying ths trunks "artificially", as just described, the building up of a connection from a primary switch to a seleotor cannot be obstructed at the secondary sub-groups, and the only time that a given primary line switch can be prevented from reaching a selector is when all 10 of the trunks serving that primary switch are busy, either artificially or directly from originating traffic. The traffic handling capacity of the 100 first selectors may therefore be considered as being measured by the traffic handling capacity of the trunks between the primary and secondary sub-groups, and this capacity is affected by the fact that the trunks may be made busy "artificially" as well

as directly from originating traffic,

In order that the trunks between the primary and the secondary sub-groups, (and therefore the 100 trunke to selectors) may handle the maximum amount of traffic, it is neceasary to minimize the number of "artificially" busied trunks under any given load condition, which means that the traffic should be divided as evenly as poseible among the different eecondary sub-groups. It is apparent, however, that absolutely uniform distribution of traffic among the secondary sub-groups can only be approximated, and that as the number of busy selectors in the group of 100 becomes large it is practically certain that eome one of the secondary sub-groups of trunks will become all-busy due to uneven distribution of the traffic.

When all of the trunks in a given secondary sub-group, such as f', become busy, a circuit feature, described under Division III, Section 2 b, as the "pick-up", is brought into play and by the use of a proper cross-connection scheme hetween the primary and secondary line switches, advantage is taken of the "pick-up" to help distribute the traffic evenly over the remaining available secondary sub-groups. When the "pick-up" takes place, the master switches for all the primary sub-groups A to T are swept back to their respective Yo, 10 trunke, and the majority of them will usually re-

main directed toward the different No, 10 trunks, while a fewer number of them will be rotated to their respective No, 9 trunks, still fewer to their respective No, 8 trunks, etc, The cross-connection scheme is therefore so arranged that the various No, 10 trunke at the different primary sub-groups will be. evenly distributed over the different eecondary sub-groups, the various No, 9 trunks will Se evenly distributed over the different secondary sub-groups, etc., and the traffic originating after the "pick-up" is evenly distributed over the remaining available secondary sub-groups as far as it is practicable to do so, The chance that another secondary sub-group of trunks will become all-busy, producing more "artificially" busied trunks, is therefore minimized.

Despite the traffic distribution obtained through the uee of the "pick-up" feature in conjunction with this cross-connection scheme, the larger the number of busy selectors in the group of 100 the greater will be the likelihood of an increased number of "artificially" busy trunks and the less will be the traffic handling capacity of the primary-secondary trunks.

At present it is thought that if the amount of traffic to be handled by the 100 first aelectore is limited to that which a normal group of 85 trunke would be expected to carry, it will be satisfactory to determine the number of trunki required between the primary and secondary line switches

as previously described in Division IV, Section 1a, using Table A.

Although the above discussion has been based on the use of 10-trunk primary sub-groups, it is applicable in its essential points to cases where the primary sub-groups consist of only 8 or 9 trunks each. In such cases, the trunking system used between primary and secondary line switches is such that a number of primary sub-groups is associated with 10 secondary sub-groups and through them with 100 first selectors, thus forming a "regular" group as previously described. By the use of suitable cross-connection schemes, given later, it is expected that where 8-trunk or 9-trunk primary sub-groups are used the same efficiency will be obtained from a group of 100 first selectors as where 10-trunk primary sub-groups are employed; that is, in all regular groups the trunks to the 100 first selectors are regarded as equivalent to an 85-trunk group working at normal efficiency, whether there are 8, 9 or 10 trunks per primary sub-group.

Number of Primary Sub-groups per Regular Group.

From Table "A" it is seen that an 85-trunk group (to which the trunks to the 100 selectors are assumed to be equivalent) can handle an average of 59.3 simultaneous calls in the buey hour. The number of primary switch sub-groups that should be included in each regular group is determined as followe: The value of A, determined from the formula $A = \frac{C \times H}{3600}$, is calculated for each primary eub-group. The number of primary sub-groups to be placed in the regular group is then regulated so that the sum of the A's in the regular group equals approximately 59.3, If the value of A for each of the primary sub-groups is the same, the number of primary sub-groups per regular group equals $\frac{59.3}{A}$.

If the number of primary line switches in each sub-group can with economy be so adjusted that the primary trunk sub-groups are fully loaded, but not overloaded, A will equal 2.96, 2.45 and 1.97 for 10-trunk, '9-trunk and 8-trunk sub-groups respectively. The number of primary eub-groups per regular group will then be:

$\frac{59.3}{2.96} = 20$, where 10-trunk primary eub-groups are used;

$\frac{59.3}{2\ 45} = 24$, where 9-trunk primary sub-groups are ueed;

$\frac{59.3}{1.97} = 30$, where 8-trunk primary sub-groups are used.

Since one primary master switch is required for each primary sub-group, the number of primary master switches will

be the same as the number of primary sub-groups.

Number of Secondary Line Switches per Sub-Group.

To determine the number of secondary line switches per sub-group, the total number of working primary trunke per regular group is first calculated. This number, which will be called "S", will dopend on the number of primary sub-groups per regular group and on the number of working trunks in each primary sub-group. Since each working trunk terminates at a secondary line switch, the total number of secondary line switches per regular group also equals 8, The average number of secondary line switches per sub-group therefore equals $\frac{S}{10}$, If S is evenly divisible by 10 each secondary eub-group will contain the same number of switches. If S is not evenly divisible by 10, the number of switches in eone of the secondary sub-groups will be greater by one than in the others; this however does not materially affect ths efficiency of the trunking system.

In cases where the primary trunk sub-groups are fully loaded, but not overloaded, the total number of secondary line switches per regular group will, in accordanae with the previous discussion, be ae follows:

20 x 10 = 200, where 10-trunk primary sub-groups are used;

24 x 9 = 216, where 9-trunk primary sub-groups are used;

30 x 8 = 240, where 8-trunk primary sub-groups are used.

Coneequently, in such cases the average number of secondary line switches per sub-group will be 20.0, 21.6 and 24.0 where 10, 9 and 8-trunk primary sub-groups respectively are employed.

Since one aecondary maeter switch ie required for each secondary sub-grau?, the number of secondary master switches per regular group is 10.

Croes-Connecting Scheme for Trunks Between Primary and Secondary Line Switches in a Regular Group.

In order to permit of a uniform method of cabling the trunks between primary and secondary line switches and at the same time to secure the relatione between the primary nnd secondary sub-groups which have previoualy been described, an I.D.F. is employed upon which jumper connections are mada between the cables coming from the primary line switches and thoee leading to the secondary line switches.

Ae described later in Division IV, Section 2d, a separate group of first eelectors is provided for handling traffic from coin-box linee operated on a machine switching basis, and if euch traffic is routed to the eelectore through secondary line switches, the latter are also kept in a group separate from the other aecondary switches in the office. Trunks to secondary line switches handling coin-box traffic are therefore considered separately in applying the cross-connection schemes described in this sec-

tion and in Section 2c.

The cross-connections at the trunk I.D.F. for a regular group are made in accordance with Table I. In this table the figures from 1 to 10 in column "A" are the numbers of the first 10 primary sub-groupe in a regular group; the figures 1 to 10 in the horizontal row at the top indicate the numbers of the trunke in the different primary sub-groups. The other figures in the table are the numbers of the secondary line switch sub-groupe to which the corresponding primary trunks are croee-connected. Bor example, the table shows that trunk No. 8 in primary eub-group No. 6 is cross-connected to secondary sub-group No. 4. In order to make the table more general in its application no attempt hae been made to number the primary and eecondary sub-groups in accordance with the standard numbering scheme outlined later in Division IV. The table supposes the primary sub-groups and the eecondary sub-groups in a regular group to be numbered from 1 up.

Primary, Sheet 4

## TABLE I.

### Primary-Secondary Line Switch Cross-connecting Scheme.

### For Regular or Partial Groups.

Trunk Numbers

| A | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |
|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |
| 2 | 2 | 4 | 6 | 8 | 10 | 1 | 3 | 5 | 7 | 9 |
| 3 | 3 | 6 | 9 | 1 | 4 | 7 | 10 | 2 | 5 | 8 |
| 4 | 4 | 8 | 1 | 5 | 9 | 2 | 6 | 10 | 3 | 7 |
| 5 | 5 | 10 | 4 | 9 | 3 | 8 | 2 | 7 | 1 | 6 |
| 6 | 6 | 1 | 7 | 2 | 8 | 3 | 9 | 4 | 10 | 5 |
| 7 | 7 | 3 | 10 | 6 | 2 | 9 | 5 | 1 | 8 | 4 |
| 8 | 8 | 5 | 2 | 10 | 7 | 4 | 1 | 9 | 6 | 3 |
| 9 | 9 | 7 | 5 | 3 | 1 | 10 | 8 | 6 | 4 | 2 |
| 10 | 10 | 9 | 8 | 7 | 6 | 5 | 4 | 3 | 2 | 1 |

The trunks in those primary subgroups which are higher in number than 10 are also cross-connected in accordance with the table, the table being repeated in whole or in part as many times as necessary. Bor instance, if there are 25 primary sub-groups in a regular group, the whole table is repeated for primary sub-groups Nos, 11 to 20 inclusive, and the upper half of the table is again repeated for the primary sub-groups Nos, 21 to 25 inclusive.

If tho primary eub-groups contain only 9 trunke each, tha corresponding figures in the column headed "5" ars disregarded; that is, the corresponding No, 5 trunke are not cross-connected but are made büey at the I.D.F., as described under Div. V, "Cabling and Wiring". If the primary sub-groups contain ohly 8 trunks each, the corresponding figures in the columns headed "5" and "7" are disregarded, the corresponding No. 5 and No, 7 trunks bsing made busy instead of being cross- connected.

The table indioates the secondary switch sub-group, but not the particular switch in that sub-group, to which a particular primary trunk is cross-connected. The numbers of the particular secondary switches to which the different primary trunks are connected are determined as follows: Starting with the lowest numbered primary sub-group, each working trunk is

connected to the No. 1 secondary line switch in the proper secondary sub-group as indicated by the table; each succeeding primary sub-group is then cross-connected in consecutive order, each working trunk being connected to the proper secondary sub-group and in that sub-group to the lowest numbered switch to which no connection has yet been made.

Partial and Combined Groups.

Sections 2a and 2b in Div. IV have been confined to a discussion of regular groups, a regular group comprising 100 first selectore and their associated primary and secondary switches. In general, however, the total number of first selectors handling traffic other than coin box traffic from secondary line switches, or the total number handling coin box traffic from eecondary line switches, will not be an even multiple of 100, There are two methods that may be used in cross-connecting between the primary and eecondary line switches associated with thoee selectors which remain after as many regular groups ae possible have been formed, The remaining selectors may be formed into a separate group, called a "partial" group, or they may be amalgamated with one of the regular groups to form a "combined" group, For example, if the total number of firet selectore involved is 666, they may be arranged into six regular groups and one partial group of 66, or into five regular groups and one combined group of 165.

Partial Group Plan.

Due to the selectors in a partial group being arranged in a group of less than 100, their efficiency is somewhat less than that of the selectors in a regular group,

If P be the number of firet selectore required for the partial group, the efficiency of the trunke to the seleotore is considered to be equivalent to that of a normal group of 0,85 P trunks.

The number of firet selectors required for the partial group is therefore determined ae follows: The value of A for each primary sub-group included in the partial group is calculated. The sum of tho various A's, which will be called $A_p$, equals the total average simultaneous busy hour calls for the partial group. The size of the trunk group for which the correeponding value in Table A is is then found, interpolating if necessary. The number *of* trunks in the group thus found, divided by 0,85, gives the number of first selectorr required for the partial group,

Where the partial group plan is used, the primary line switches remaining after all of the regular groups have been formed are cross-connected in the usual manner to 10 sub-groups of esoondary switches in accordance with Table I, Due to the fact that there are not enough of these remaining primary switches to furnieh a full load for 100 selectors, the number of sub-groups of euch remaining switches will be less than the number normally associated with 10 eecondary sub-groups and consequently the number of secondary line switches per sub-group will be lese than normal,

As far as possible the same number of firet selectors is connected to each of the 10 secondary sub-groups; that is, if the total number of selectors in the partial group is 76, each of 6 of the eecondary sub-groups will serve 8 first selectors and each of the other 4 eecondary sub-groups will serve 7 first selectors. Ordinarily, however, the theoretical number of selectors required for the partial group is increased or decreased to the nearest even multiple of ten; that is, if the calculations show that 78 selectors are required, 80 would usually be specified, each secondary sub-group serving eight selectors.

It will be seen that if an addition is made to an office where the partial group plan has been followed, and the additional primary and eecondary line switches and first selectors can be included in the partial group without increasing tho size of thr latter beyond that of a regular group, no re-arrangement *of* the cross-connections between ths primary and secondary line switches is necessary, the new switches merely being cross-connected in aocordance with Table I, If the addition is so large as to increase the size of the partial group beyond that of a regular group, the partial group may be completed (formed into a regular group), and a new partial group started, without necessitating any re-arrangement of existing crose-oonneations, If the formation of a

new partial group is not economical, however, the existing partial group together with the additional switches may be formed into a combined group and this will necessitate new cross-connections for the majority of the switches involved in the combined group,

Where this plan is employed all of the selectors in the combined group are considered as working at the same efficiency as those in the regular groups. The number of first selectors required for the combined group is therefore determined as follows: The value of A for each primary switch subgroup included in ths combined group is aalculated, The sum of the various A's, which will be called $A_c$, equals the total average simultaneous busy hour calls for the combined group. The total number of selectors required for the combined group then equale $\frac{A_c}{59.3} \times 100 = 1.69\ A_c$.

If 1.69 $A_c$ is evenly divisible by 10, the number of secondary sub-groups in the combined group will equal $\frac{1.69\ A_c}{10}$ or 0,169 A, If 1.69 A, is not evenly divisible by 10, the number of secondary sub-groups in the combined group will equal the intergral part of the quotient $\frac{1.69\ A_c}{10}$, increased by 1.

The average number of secondary line switches per sub-group is determined by dividing the total number of working primary trunks in the combined group by the number of secondory sub-groups in the combined group. The average number of eecondary line switches per sub-group will be approximately the eame as for regular groups, that is, about 20, 21.6 and '24 fbr 10, 9 and 8-trunk primary sub-groups respectively.

Where the combined group plan is used all of the primary line switches that would form a partial group, if the partial group plan had been followed, together with the primary line switches In the last of the regular groups, are cross-connected in accordance with one of the Tables Nos. II to VII. These tables are prepared for combined groups ranging in size from 11 to 16 secondary sub-groups per group, In general, where a combined group would contain more than 16 secondary sub-groups, the partial group plan should be ueed.

Tables Nos. II to VII are ueed in the same manner as Table No. I, They are prepared on the basis of 10-trunk primary sub-groups, but like Table No, 1 are also applicable where the primary sub-groups contain only 8 or 9 trunks each. The number of the particular seoondary switch in a sub-group to which a given primary trunk is connected is determined in the eame manner as described in connection with Table No. I.

As far as poeeible the same number of first selectore ie connected to each of the aecondary sub-groups in the combined group, as explained in connection with partial groups.

It will be noted that the chief advantage of the combined group plan as compared with the partial group plan is that the former effects a saving in first selectors. On the other hand, its principal disadvantage is that a combined group cannot grow as additions to the office are made without re-arranging the existing cross-connections between the primary and necondary line ewitchee in the combined group, In general, where a partial group, if uaed, would be small and would remain so for a considerable period of time, the saving effected by reducing the necessary number of selectors through the use of a combined group will more than compensate for the cost of re-arranging croee-connectione when making an addition. Convereely, where a partial group, if ueed, would be large, or where it would become large in a comparatively short time, it will generally be found economical to employ the partial group plan.

Offices Having Lese Than One Regular Group.

In offices where the number of firet selectore required to handle the traffic, other than coin box traffic, from the secondary line switches is greater than 70 but less

than 100 initially, the croes-connections between the primary and secondary line switches are made ae previously described for a partial group, and 10 secondary switch eub-groupe are installed. It is thought that where the number of first selectors required is less than 70 the uee of secondury line switches will not in general be justified, and in such cases the trunks from the primary line switches are run directly to the firot selectors, and are cross-connected as described in Division IV, Section 3d.

## TABLE II

### Primary-Secondary Line Switch Cross-Connecting Scheme

### For Combined Groups Having from 101 to 110 Selectors.

**Trunk Numbers**

| A | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |
|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 1 | 2 | 3 | 4 | 5 | 11 | 7 | 8 | 9 | 10 |
| 2 | 2 | 4 | 6 | 11 | 10 | 1 | 3 | 5 | 7 | 9 |
| 3 | 3 | 6 | 11 | 1 | 4 | 7 | 10 | 2 | 5 | 8 |
| 4 | 4 | 8 | 1 | 5 | 9 | 2 | 6 | 10 | 11 | 7 |
| 5 | 5 | 11 | 4 | 9 | 3 | 8 | 2 | 7 | 1 | 6 |
| 6 | 6 | 1 | 7 | 2 | 8 | 3 | 9 | 11 | 10 | 5 |
| 7 | 7 | 3 | 10 | 6 | 2 | 9 | 11 | 1 | 8 | 4 |
| 8 | 8 | 5 | 2 | 10 | 11 | 4 | 1 | 9 | 6 | 3 |
| 9 | 9 | 7 | 5 | 3 | 1 | 10 | 8 | 6 | 4 | 11 |
| 10 | 10 | 9 | 8 | 7 | 6 | 5 | 4 | 3 | 2 | 1 |
| 11 | 11 | 10 | 9 | 8 | 7 | 6 | 5 | 4 | 3 | 2 |

## TABLE III

### Primary-Secondary Line Switch Cross-Connecting Scheme

### For Combined Groups Having from 111 to 120 Selectors.

Trunk Numbers

| A | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |
|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |
| 2 | 2 | 4 | 6 | 8 | 10 | 12 | 1 | 3 | 5 | 7 |
| 3 | 3 | 6 | 9 | 12 | 2 | 5 | 8 | 11 | 1 | 4 |
| 4 | 4 | 8 | 12 | 3 | 7 | 11 | 2 | 6 | 10 | 1 |
| 5 | 5 | 10 | 2 | 7 | 12 | 4 | 9 | 1 | 6 | 11 |
| 6 | 6 | 12 | 5 | 11 | 4 | 10 | 3 | 9 | 2 | 8 |
| 7 | 7 | 1 | 8 | 2 | 9 | 3 | 10 | 4 | 11 | 5 |
| 8 | 8 | 3 | 11 | 6 | 1 | 9 | 4 | 12 | 7 | 2 |
| 9 | 9 | 5 | 1 | 10 | 6 | 2 | 11 | 7 | 3 | 12 |
| 10 | 10 | 7 | 4 | 1 | 11 | 8 | 5 | 2 | 12 | 9 |
| 11 | 11 | 9 | 7 | 5 | 3 | 1 | 12 | 10 | 8 | 6 |
| 12 | 12 | 11 | 10 | 9 | 8 | 7 | 6 | 5 | 4 | 3 |

## TABLE IV.

## Primary-Secondary Line Switch Cross-Connecting Scheme For Combined Groups Having from 121 to 130 Selectors.

Trunk Numbers

| A | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |
|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |
| 2 | 2 | 4 | 6 | 8 | 10 | 12 | 1 | 13 | 5 | 7 |
| 3 | 3 | 6 | 9 | 12 | 2 | 13 | 8 | 11 | 1 | 4 |
| 4 | 4 | 8 | 12 | 3 | 7 | 11 | 2 | 6 | 10 | 13 |
| 5 | 5 | 10 | 2 | 13 | 12 | 4 | 9 | 1 | 6 | 11 |
| 6 | 6 | 12 | 5 | 11 | 4 | 10 | 3 | 9 | 13 | 8 |
| 7 | 7 | 1 | 13 | 2 | 9 | 3 | 10 | 4 | 11 | 5 |
| 8 | 8 | 3 | 11 | 6 | 1 | 9 | 13 | 12 | 7 | 2 |
| 9 | 9 | 5 | 1 | 10 | 13 | 2 | 11 | 7 | 3 | 12 |
| 10 | 10 | 9 | 8 | 7 | 6 | 5 | 4 | 3 | 2 | 1 |
| 11 | 11 | 13 | 7 | 5 | 3 | 1 | 12 | 10 | 8 | 6 |
| 12 | 12 | 11 | 10 | 9 | 8 | 7 | 6 | 5 | 4 | 3 |
| 13 | 13 | 7 | 4 | 1 | 11 | 8 | 5 | 2 | 12 | 9 |

## TABLE V

## Primary-Secondary Line Switch Cross-connecting Scheme For Combined Groups Having from 131 to 140 Selectors.

Trunk Numbers

| A | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |
|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |
| 2 | 2 | 4 | 14 | 8 | 10 | 12 | 1 | 13 | 5 | 7 |
| 3 | 3 | 6 | 9 | 12 | 2 | 13 | 8 | 11 | 1 | 4 |
| 4 | 4 | 8 | 12 | 3 | 14 | 11 | 2 | 6 | 10 | 13 |
| 5 | 5 | 10 | 2 | 13 | 12 | 4 | 14 | 1 | 6 | 11 |
| 6 | 6 | 12 | 5 | 11 | 4 | 10 | 3 | 9 | 13 | 14 |
| 7 | 7 | 1 | 13 | 2 | 9 | 3 | 10 | 14 | 11 | 5 |
| 8 | 8 | 14 | 11 | 6 | 1 | 9 | 13 | 12 | 7 | 2 |
| 9 | 9 | 5 | 1 | 10 | 13 | 14 | 11 | 7 | 3 | 12 |
| 10 | 10 | 9 | 8 | 7 | 6 | 5 | 4 | 3 | 2 | 1 |
| 11 | 11 | 13 | 7 | 14 | 3 | 1 | 12 | 10 | 8 | 6 |
| 12 | 12 | 11 | 10 | 9 | 8 | 7 | 6 | 5 | 4 | 3 |
| 13 | 13 | 7 | 4 | 1 | 11 | 8 | 5 | 2 | 14 | 9 |
| 14 | 14 | 3 | 6 | 5 | 7 | 2 | 9 | 4 | 12 | 8 |

# TABLE VI.

## Primary-Secondary Line Switch Cross-connecting Scheme

## For Combined Groups Having from 141 to 150 Selectors.

### Trunk Numbers

| A | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |
|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |
| 2 | 2 | 4 | 6 | 8 | 10 | 12 | 14 | 9 | 1 | 3 |
| 3 | 3 | 6 | 9 | 12 | 15 | 1 | 4 | 7 | 10 | 13 |
| 4 | 4 | 8 | 14 | 13 | 3 | 7 | 11 | 15 | 2 | 6 |
| 5 | 5 | 10 | 15 | 3 | 8 | 13 | 1 | 6 | 11 | 7 |
| 6 | 6 | 12 | 1 | 7 | 13 | 2 | 8 | 14 | 3 | 9 |
| 7 | 7 | 14 | 4 | 11 | 1 | 8 | 15 | 5 | 12 | 2 |
| 8 | 8 | 1 | 7 | 15 | 6 | 14 | 5 | 13 | 4 | 12 |
| 9 | 9 | 15 | 10 | 2 | 11 | 3 | 12 | 4 | 13 | 5 |
| 10 | 10 | 3 | 13 | 6 | 14 | 11 | 2 | 12 | 5 | 15 |
| 11 | 11 | 5 | 12 | 10 | 4 | 15 | 9 | 3 | 14 | 8 |
| 12 | 12 | 7 | 2 | 14 | 9 | 4 | 10 | 11 | 6 | 1 |
| 13 | 13 | 9 | 5 | 1 | 12 | 10 | 6 | 2 | 15 | 11 |
| 14 | 14 | 11 | 8 | 5 | 2 | 9 | 13 | 10 | 7 | 4 |
| 15 | 15 | 13 | 11 | 9 | 7 | 5 | 3 | 1 | 8 | 14 |

## TABLE VII

## Primary-Secondary Line Switch-Cross-connecting Scheme For Combined Groups Having from 151 to 160 Seleotore.

Trunk Numbers

| A | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |
|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |
| 2 | 2 | 4 | 6 | 8 | 10 | 12 | 14 | 16 | 1 | 3 |
| 3 | 3 | 6 | 9 | 12 | 15 | 1 | 4 | 7 | 10 | 13 |
| 4 | 4 | 8 | 12 | 16 | 3 | 7 | 11 | 15 | 2 | 6 |
| 5 | 5 | 10 | 15 | 3 | 8 | 13 | 1 | 6 | 11 | 16 |
| 6 | 6 | 12 | 1 | 7 | 13 | 2 | 8 | 14 | 3 | 9 |
| 7 | 7 | 14 | 4 | 11 | 1 | 8 | 15 | 5 | 12 | 2 |
| 8 | 8 | 16 | 7 | 15 | 6 | 14 | 5 | 13 | 4 | 12 |
| 9 | 9 | 1 | 10 | 2 | 11 | 3 | 12 | 4 | 13 | 5 |
| 10 | 10 | 3 | 13 | 6 | 16 | 9 | 2 | 12 | 5 | 15 |
| 11 | 11 | 5 | 16 | 10 | 4 | 15 | 9 | 3 | 14 | 8 |
| 12 | 12 | 7 | 2 | 14 | 9 | 4 | 16 | 11 | 6 | 1 |
| 13 | 13 | 9 | 5 | 1 | 14 | 10 | 6 | 2 | 15 | 11 |
| 14 | 14 | 11 | 8 | 5 | 2 | 16 | 13 | 10 | 7 | 4 |
| 15 | 15 | 13 | 11 | 9 | 7 | 5 | 3 | 1 | 16 | 14 |
| 16 | 16 | 15 | 14 | 13 | 12 | 11 | 10 | 9 | 8 | 7 |

Trunke to First Seleotors Handling Coin Box Traffic,

It is advantageous from an operating etandpoint to carry traffic from coin box lines to the Zero and A-B operators over trunk groups which are separate from thoro handling traffit from flat rate or message rate lines. Consequently, the cross connections between line switches and the first selectors in an office serving coin box linee should be so arranged that the first selectors handling coin box traffic will not handle traffic from any other class of lines; in other words, primary line switch sub-groups serving coin box lines ehould not be placed in the same regular, combined or partial group with primary line switch sub-groups serving flat rate or message rate lines.

It is thought that in most step-by-step offices serving coin box lines, the number of such lines will be insufficient to warrant the ure of secondary line switches for handling their traffic and tho trunks from their primary line switches will ordinarily be cross connected directly to first selectors. In euch cases cross connections are made in accordanoe with the method given later in Division IV, Section 3d, under "Offices Where Secondary Line Switches are not Installed".

If in any offioe there is a sufficient number of coin box lines to justify the use of secondary line switches for handling their traffic, a separate group (partial, regular or combined) is formed for this purpose in the usual manner.

Birst Selectors.

Regular Selectors (Excluding Toll Selectors.)

Where secondary line switches are not employed, one first selector is provided for each working trunk from the primary line switches. Where secondary line switches are used, one first selector is provided for each working trunk from the secondary line switches. In general, trunks for completing connections to the subscribers from the special operators' positions, other than toll poeitione, are also terminated at first eeleotora.

Selector Multiple.

First selector banke are multipled together in the shop in groups of five or ten, and the eelectore in each euch group are termed a "selector division". Either two 10-selector divisions or one 10-selector and two 5-selactor divisions are placed on a shelf at the selector boards. Where three divisions are mounted on a shelf, the 10-selector division is looated at the power end of the board. The multiple wiring of the line and private banks for each division is extended to the flat type terminals mounted across one end of the selector board. Ae explained later, the terminal strips and the associated wiring and cabling are so arranged that the wiring for any given level of a selector division can be multipled with the wiring for the correeponding level of the other division or divisions on the same ahelf, and alao with the wiring for the corresponding level of as many more divieions on otber shelves as may be neceaeary.

The number of trunks on any given level available to one division of selectors is limited to ten, and this sub-group of ten trunke is multipled at the terminal strips through as many divisions of eelectors as are required to give the trunke a proper load. If the total number of trunks necessery to carry the traffic over the given level is greater than ten, other sub-groups of ten trunke each are employed, each additional sub-group bsing multipled through as many additional divieions of eelectora as are necessary.

Terminal Strip Arrangement.

An assembly of a number of flat type terminal strips on a set of mounting pins is known as a terminal "pile-up". Across the terminal end of the seleotor board, and within the vertical space corresponding to the distance between adjacent shelves, eix pile-upe of terminals are mounted. Thus there are thirty-six pile-upe across the end of the standard selector board. The three upper pile-ups in each set of six are ueed for terminating all of the bank wiring from the corresponding shelf of 20 eelectore located on one aide of the board, and the three lower pile-ups in eaoh set of six are ueed for terminating all of the bank wiring from the correaponding shelf of 20 selectore located on the other aide of the board. The upper three pile-upe in a set of six are usually ueed for terminating the wiring from the shelf on the right-hand eide of the board, facing its terminal end, and this eide of the board is therefore known as the "high" eide as distinguished from the opposite or "low" side.

Of the upper three pile-ups in a set of six, the top ona is used for terminating the private conductore coming from all levels of the corresponding shelf of selectore; the middle pile-up is ueed for terminating the tip and ring conductors coming from the even numbered levels of those selectors, and the lowest pile-up is used for terminating the tip and ring conductorß coming from the odd numbered levels. The lower three pile-upa in a set of eix bear the same relation to the corresponding shelf of selectors on the other side of the board.

As shown schematically on Drawings Nos. 807-57 and 807-65, under Division V, Section 5a, one flat type terminal strip is required in each pile-up for terminating the bank wiring from each division of selectore on the shelf to which the pile-up corresponds. Rach pile-up will therefore contain either two or three flat type strips for terminating the division bank wiring. In addition, aach pile-up will inolude one or more flat type strips on which are terminated the outgoing cables leading to the brushes of second selectors, or the multiple cable leading to other pile-ups by means of which multiple connection is made to selector divisions an other shelves. The pike-ups will also frequently include other strips that are required to obtain the "multiple slip", "multiple reversal" or "graded multiple" features, which are explained later.

A cable running between two pile-ups both of which are located at the same selector board is known as a "short multiple"

cable. A cable running from a pile-up on one board to a pile-up on another Soard is known as a "long multiple" cable.

Grouping of First Selector Divisions.

The number of first selectore to be placed in one sub-group, that is, the number required to provide a proper load for a sub-group of ten trunks to eecond selectors, depends on the efficiency of the trunk groupe leading to the first selectors and on the proportion of the total traffic incoming to the firat selectore which is routed over the particular level being considered.

In general at least two divisions of selectors are required to form a eub-group. The choice as to the relative location on the selector boards of the different divisions of selectors in a sub-group is a matter that is governed principally by cabling considerations. Since the bank wiring from the different eelector divisions on the same shelf is terminated in the same set of three pile-ups, no switchboard cable is required to multiple such divisions together; they are multipled either by pinching together and soldering the corresponding lugs, or, in certain cases described later, the multipling is accomplished by means of standard local forms inserted in the pile-ups. For this reason, and for the eake of regularity in arrangement, where selector sub-groups contain 20 selectors each, the divisions are in general so multipled that each shelf of selectors constitutes a

selector sub-group.

Where the 20 selectore on a given shelf, as for example, the top ahelf on the high aide, are insufficient to provide a full load for a sub-group of trunks to aecond selectore, it is the practice to multiple that shelf with some, or, if necessary, all of the divisions on the top shelf on the low side of the same board, If these 40 selectors do not afford sufficient load for the sub-group of trunka, some or all of the divisions on the shelf next to the top on the high eidq of the board are also multipled with them. If these 60 selectors do not fully load the trunk sub-group, eome or all of the divisions on the shelf next to the top on the low side of the board are then incorporated in the sub-group. In this way, selector sub-groups of any desired size are built up by alternately including the shelves on each side of the board while progressing downward, and then if necessary, continuing from the top of the next selector board until the required number of divisions are included in the sub-group,

If, in thus forming a sub-group, all of the selector divisions on the last shelf to be included are not required for that sub-group, it is customary to start the next sub-group for the level in question with the selectors remaining on that shelf

and then to complete the next sub-group in the usual manner.

Multiple Slip and Multiple Reversal.

Assume that the No. 1 trunk in a sub-group of trunks to eecond selectors appears at the first terminal of its level at each of the first selectore through which it is multipled; that the No, 2 trunk appears at the second terminal at each of the first selectors, etc. Since all of the selectors will hunt over their terminale in order, from one to eero, and since each selector will etop on the first one that doee not teet busy, it is clear that the No, 1 trunk will receive mos traffic than any of the othere in the eub-group; that the No. 2 trunk will be the next busiest one, and that the No. 10 trunk will be used only when the sub-group is handling its peak loads. It is also apparent that due to the low numbered trunks and therefore the low numbered selector terminals being the busiest ones, the selectore will, on the average, have to rotate further in finding an idle trunk than would be the case if an arrangement were effected whereby each terminal in the level had the same chance of being made busy,

Ono arrangement that is used to distribute the traffic among the trunks in a sub-group and to minimize the average hunting period of the selectore is known as "multiple slip", and consists of so multipling the trunks that trunk No. 10, for ex-

ample, appearing at the tenth terminal of its level throughout one divieion of eelectors, will appear at the ninth terminal throughout a second divieion, at the eighth terminal throughout a third division, etc. Similarly, every other trunk in the sub-group, in passing from one divieion to the next, is "slipped" one terminal, or in passing from a division where it appeare at the first terminal is connected at the next divieion to the tenth terminal,

This scheme is shown on drawing No. 807-67, figure 1, for the case where there are 100 selectors (ten divisions of ten each) in the eeleotor sub-group. If each of the ten divisions routee approximately the same amount of traffic over the given level, each of the trunks will be utilized to about the same extent, and equal use will be made of the second selectors upon which the trunks terminate; this is advantageous from a maintenance point of view. Moreover, since each terminal in the given level hae an equal chance of being made busy, the average hunting period at the first selectors is minimized, which reduces the wear on the selector mechanisms and alao reduces the chance that one or more pulsee in the next digit to be dialed will be lost during the hunting period, resulting in a failure to establish the proper connection.

Drawing No. 807-67, figure 2, shows multiple slip applied in the case of a sub-group of trunks multipled through

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# STEP BY STEP MACHINE SWITCHING SYSTEM

SCHEMATIC DIAGRAM SHOWING THE MANNER IN WHICH A SUBGROUP OF TRUNKS IS MULTIPLED THROUGH ITS SELECTORS, USING MULTIPLE SLIP OR MULTIPLE REVERSAL.

807-67
INFORMATION
ENGINEER Emm
DRAFTSMAN A F
MAY 1, 1920

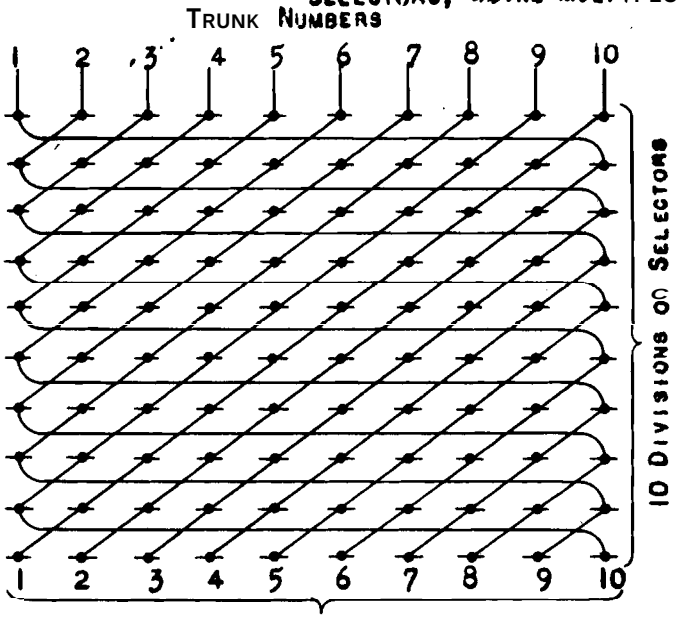


FIG. 1
MULTIPLE SLIP

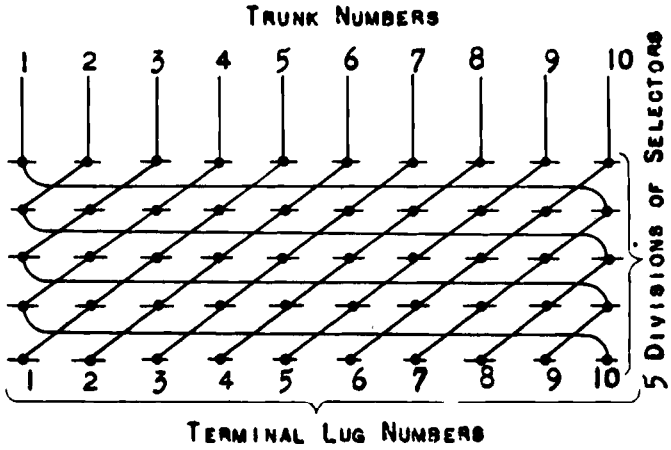


FIG. 2
MULTIPLE SLIP

NOTE: THE TEN LINES IN EACH HORIZONTAL ROW REPRESENT THE TEN SETS OF TERMINAL LUGS TO WHICH THE WIRING FOR THE GIVEN LEVEL FROM ONE DIVISION OF SELECTORS IS CONNECTED. THE DIFFERENT NUMBERED SELECTOR TERMINALS ARE CONNECTED THROUGH THE BANK WIRING TO CORRESPONDINGLY NUMBERED TERMINAL LUGS.

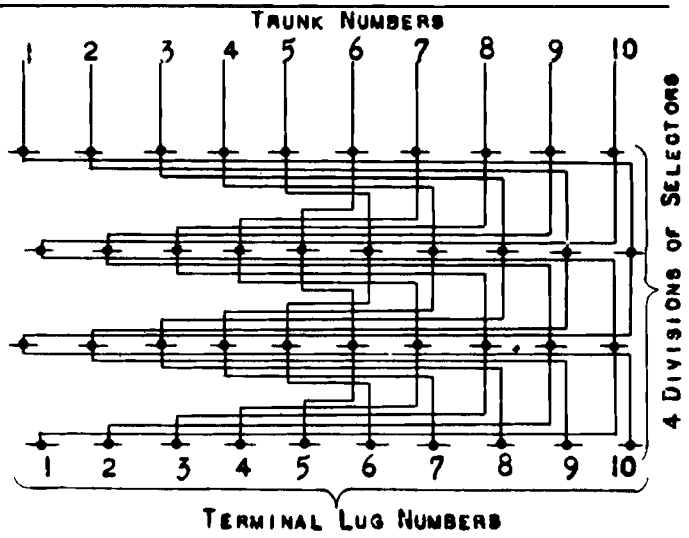


FIG. 3
MULTIPLE REVERSAL

fifty eelectore (five diviaione), It will be seen that in this case trunk No, 8, appearing at terminale Nos. 1,2,3,4 and 6 in the different divisions, will probably carry more traffic than any of the othere, while trunk No, 10, appearing at terminale Nos. 6,7,8,9, and 10, will probably carry less traffic than any of the othere, although the inequality in the traffic distribution among the trunks is less than would have obtained if multiple slip had not been used. This inequality could be further reduced by inserting multiple slip between the selectors of a division or by slipping more than one terminal between divisione, Both schemes, however, are open to the objections that they would introduce additional wiring standards and maintenance difficulties and would increase the individual engineering required on esch job, and it is thought that the advantages obtained would not be compensating.

Where the number of selectors in a sub-group is small, (forty or less), the gain that would be effected by the use of multiple slip would alao be small, and in such cases another arrangement, known as "multiple reversal", is used. This consists in reversing the wiring between certain selector divisions so that a trunk connected to terminal No. 1 throughout one or more divisions will be connected to terminal No, 10 throughout the other divisione of the eub-group, a trunk con-

nected to terminal No, 2 throughout one or more divisions will be connected to terminal No, 9 throughout the other divisions of the sub-group, etc, This arrangement is ehom for a typical case in Drawing No. 807-67, figure 3, The effect of multiple reversal is similar to that of multiple slip.

Where it is desired to introduce multiple slip or reversal between divisions on the same shelf, the terminal strips at which the division bank cables are terminated are connected together through a local cable called a "hairpin form". Each end of this form is soldered to a flat type terminal strip. The form is inserted in the pile-up, and is connected to the flat type terminal strips of the two divieione which are to be multipled together. The hairpin form is of two general types, ono being so made up as to introduce multiple slip between the divisione, the other being formed to give multiple reversal between the divisions.

Ae noted previously, the private conductora for all levels from the different divisions on a given shelf are terminated in the same pile-up, and consequently only one local form is used for introducing multiple elip or multiple reversal (ae the case may be) in the private conductore for all levele between such divisions. It is therefore thc practice to employ either multiple elip or multiple reversal for sll levels between

divisions on the same shelf; that is, if multiple elip, for example, is introduced for one level, multiple slip is used on all levels; otherwise an excessively large number of standard hairpin forme would be neoeseary to afford various combinations of slip and reversal for the different levels.

These remarks also apply to the use of tha elip and reversal between divisions on different shelves. In this case the slip or reversal is introduced in the short or long multiple cables and since the private conductors terminated in one pile-up aro multipled to those in another pile-up through only one cable, it is desirable to use either the slip or the revereal on all levels.

In determining whether multiple elip or multiple reversal should be ueed in any particular caee, and in determining in what manner the slip or reversal should be introduced, it is recommended that in general the practice outlined below be followed:

If the eelector sub-groups for all levels each contain fifty or more selectors, multiple elip is used and is introduced between each division of ten eelectore,

If any one of the eelector sub-groups for the different levels containe less than fifty selectors, multiple

reversal is used. The reversal should be introduced in such a way that the bank wiring of one-half of the selectors in each sub-group is revereed with reepect to the bank wiring in the other half, For the sake of uniformity, this is accomplished or approximated in all cases by inserting the reversal between the firet ten and the last ten selectors on each shelf, (provided of course that all of the selectors on a shelf are in the same sub-group ), and by inserting it between such divisions on different shelves as are to be multipled together.

Number of Regular Selectors per Sub-Group.

The eelectore handling traffic from flat and message rate lines are considered as forming a separate class from those handling traffic from the special operators' positions, since the trunk groups leading to the latter class of selectors are ordinarily of a different size, and consequently work at a different efficiency, from those leading to the selectors in the former class. The size of the selector sub-groups for handling special service calls should therefore be figured separately. The selectore handling coin-box traffic, if any, will in general form an additional claes that should be considered separately.

As previously explained, in offices serving coin box lines, separate groups of trunks for coin box traffic are provided to the zero and A-B operatore, so that in such offices the selectore handling coin box traffic should be kept in a separate group when forming eelector sub-groups for the zero level, and also when forming sub-groups for the first level where the codo 112 is used for reaching the A-B operators; that is, when considering these levels, selectors handling coin box traffic are not multipled with any other selectors.

In calculating the number of first selectors per sub-group, Table B in the "Average and Average Plus Deviation Tables" is employed. From this table it will be seen that for a 10-trunk sub-group the value for the average number of simul-

taneously busy trunks in the buey hour is 4.13.

The total number of calls originated in the office during the busy hour and the total number of oalls to the different points correeponding to the different first selector levels are obtained from the traffic data. From this data is determined the percentagee of the total calle incoming to the firet eelectore routed to each of the ten levels during the buey hour,

The value of A in the formula $A = \frac{C \times H}{3600}$ is then determined, where C is the total number of calle originated during the buey hour by the class of lines being considered. "A" is then multiplied by the various percentages representing the relative amounts of traffic routed to the different first selector levels, and the results give the average number of calls of the class concerned that will be in progress simultaneously over the different first selector levels during the buey hour, For any given level, this quantity will be called $A_r$.

Of this average number of calls ($A_r$), the number that will be furnished by each firet selector will be $\frac{A_r}{T}$, where T is the total number of first selectors in the claae, If R is the number of first selectore through which a ten-trunk sub-groups should be multipled, then $R = \frac{4.13}{\frac{A_r}{T}}$, or $R = \frac{4.13\ T}{A_r}$.

As previously explained, selector sub-groups are built up to the required size by multipling together the required number of eelector divisions. Each division, however, contains either five or ten selectors, so that the number of eelectore per sub-group will be some even multiple of five or ten. Since R will, in general, not be an even multiple of five or ten, it will ueually be necessary to increaee or decrease the number of selectors per sub-group somewhat above or below the theoretical value. The extent to which it is permissible to vary the value of R (without unduly overloading or underloading the trunk sub-groups) will frequently be a matter of judgment resting with the engineers most familiar with the nature of the traffic data being used. It is thought that in general, however, the following practice will be found satisfactory:

Where R is 15 or 16, and in some cases where R is 17, each sub-group will contain 18 selectors; where R is 19, 20 or 21, and in some cases where R is 18 or 22, each sub-group will contain 20 selectors. Where R is 24, 25, 26 or 27, and in some cases where R is 23, each eub-group will contain 25 selectore. In those instances where R is 17, 18, 22 or 23, and it is thought that the above practice would unduly overload or underload the trunk sub-groups, the method described later under

"Graded Multiple" may be used.

Where R is from 28 to 32 inclusive, each sub-group will contain 30 selectors, and where R is from 33 to 37 inclusive, each sub-group will contain 35 selectors.

Where R is greater than 37, R is increased or decreased to the nearest even multiple of 10, except as noted below. If R lies midway between two numbers each of which is an even multiple of 10, whether R is decreased or increased should be determined by the engineer for the particular installation involved.

It will be seen that in order to obtain selector eub-groups of the proper size, it is necessary in some cases to install divisions oontaining five selectors each, while in other cases ten selector divisions only are necessary. If five selector divisione are installed in order to obtain the desired sub-grouping for any one level, it will usually be desirable to take advantage of this fact in regulating the size of the sub-groups for other levels; that is, if R = 55 for a particular level, the number of selectors per eub-group for this level may be made 55, instead of 50 or 60, if some other level requires the use of five eelector divisions.

In a 4-digit system, it is thought that the number of first selectors per sub-group for all levels will frequently be large enough to avoid the necessity of employing five eelector divisions, whereas in a 5-digit system the number of first selectore per sub-group on Che level reserved for local traffic will in general be small and may require the use of five eelector divisions. In any case, all first selectar divisions will be of the ten selector size, unless five selector divisions are specified.

Combined and Partial Sub-Groups.

The quotient obtained by dividing the total number of first selectors of a given class by the number of selectors per sub-group will, in general, not be a whole number. The selectors represented by the fractional part of this quotient may be formed into a partial selector sub-group with a correspondingly smaller trunk sub-group to second selectors, or if feasible they may be multipled with some of the selectors of another class, forming a combined relector sub-group sufficient in size to provide a proper load for 10 trunks to second eelectors. For efficiency reasons, combined selector sub-groups are used wherever possible.

It may be noted that where a partial sub-group is employed, each selector loading the partial eub-group is pro-

vided with ten working terminals in the given level. Each terminal which would normally correspond to an unused trunk is multipled to a terminal correeponding to a working trunk, thus reducing the average trunk-hunting time,

In determining the number of trunks required for a partial sub-group, the relation $A_p = \frac{A_r \times R_p}{T}$ is used, where $A_r$ is the average number of calls that are in progress simultaneously, during the busy hour, over the level being considered, where $R_p$ is the number of selectors in the partial sub-group, and where T is the total number of first selectors in the class. $A_p$ is the average number of calls to be carried simultaneously over the partial sub-group of trunks during the buiy hour, The nearest value to $A_p$ in Table "B" is found, and the correeponding value in the "average plus deviation" column is the number of trunke required in the partial sub-group,

In determining the number of selectors required in a combined eub-group, those selectors to which the selectors of another class are to be multipled are first considered as though they were to forn a partial sub-group, and the value of $A_p$ is determined as just explained; then $(4.13-A_p)$ is the average number of simultaneous busy hour calle to be added to

the 10-trunk sub-group by multipling that sub-group through a number of selectors of the other class. The number of selectors of the other class necessary to furnish this load is given by the expression $\frac{(4.13-A_p)\ T}{A_r}$ where T nnd $A_r$ are the values applying to the class of selectors being used to complete the combined sub-group.

Graded Multiple.

Ar previously noted, where the number of eelectore that should be included in a sub-group is 17, 18, 22 or 23, it may be found inadvisable to increase or decrease this number to the neareet even multiple of five, and in such cases a special scheme of trunk multipli ng known ae "graded multiple" may be used.

Graded multiple is a scheme for associating a sub-group of trunka from first to second selectore with several divisions of firet selectors in euch a way that some of the trunke, called common trunks, are multipled throughout all of the first eelectore involved, while each of the other trunks, called individual trunke, is multipled through only a part of the eelectore, The total number of trunke in a graded multiple sub-group is eome even multiple of ten, but the number of these which are "common" and the number which are "individual" depends on the particular form of graded multiple being considered.

Drawing No. 807-68 ehowe schematically the form of graded multiple which is used where 17 firet selectors would provide a proper load for a sub-group of 10 trunks, In this case, a graded multiple sub-group of 30 trunke is associated with 50 eelectore, It will be noted that the five trunke

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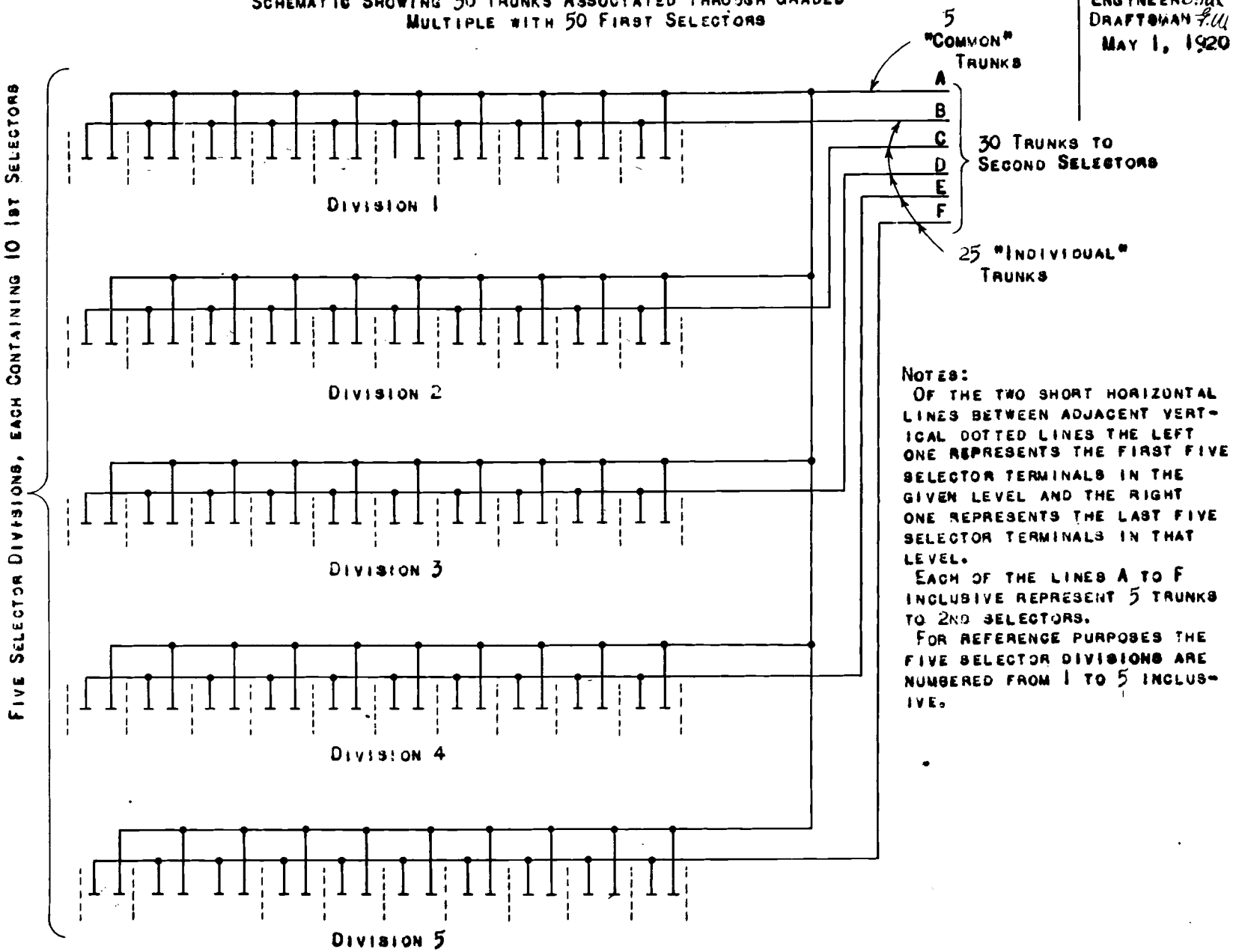
# STEP-BY-STEP MACHINE SWITCHING SYSTEM

## Schematic Showing 30 Trunks Associated through Graded Multiple with 50 First Selectors




Notes:

Of the two short horizontal lines between adjacent vertical dotted lines the left one represents the first five selector terminals in the given level and the right one represents the last five selector terminals in that level.

Each of the lines A to F inclusive represent 5 trunks to 2nd selectors.

For reference purposes the five selector divisions are numbered from 1 to 5 inclusive.

represented by line "A" are multipled throughout all of the fifty selectors. These are the common trunke and appear in each division at the last five terminals of the given level. The five trunks represented by line B are multipled through Division No. 1 only. These are individual trunke and appear at the first five terminale of the given level, Similarly the lines C, D, E and F represent four more sets of five individual trunke each, appearing in their respective divisions at tho first five terminale of the given level,

From an examination of Drawing No, 807-68 it will be seen that if the traffic over the 30 trunke hae been eo distributed that all of the common trunks represented by line "A" and all of the individual trunks represented by line "B", for example, have been made busy and the next call happens to be routed to one of the idle selectors in Division No. 1, the call will be delayed even though there may be one or more idle trunks among the individual ones represented by lines C, D, B and B, The 30 trunks do not, therefore, constitute a true 30 trunk group with respect to the 60 selectors which they serve.

It is at present estimated that the busy hour load to be carried by the sub-group of 30 trunks should be regulated to equal ths load which three sub-groups of 10 trunke each could carry on the basis provided by Table B. The form of

graded multiple shown on Dwg. No. 807-68 may therefore be used, as previously stated, where 17 selectors would provide a proper load for a sub-group of 10 trunks, since in that case three 10-trunk sub-groups, to whioh the graded multiple sub-group is assumed to be equivalent, oould carry the traffio from 81 selectors.

The following table shows the four different forme of graded multiple used for trunking between first and second selectors:

| A | B | C | D | E | F |
|---|---|---|---|---|---|
| 17 | 50 | 30 | 25 | 5 | 3 |
| 18 | 70 | 40 | 35 | 5 | 4 |
| 22 | 110 | 50 | 44 | 6 | 5 |
| 23 | 160 | 70 | 64 | 6 | 7 |

The numbers in Column A indicate the number of selectorr that aould be required to provide a proper load for a sub-group of 10 trunks.
The corresponding numbers in Columns B and C show respectively the number of selecton with which the graded multiple sub-group is associated, and the total number of trunks in the graded multiple sub-group.
The corresponding numbers in Columns D and E show respectively the total number of individual and the total number of common trunks in the graded multiple sub-group.
The corresponding numbers in Column F show the number of regular 10-trunk sub-groups to which the graded multiple sub-group is regarded as oquivalent with respect to traffic handling capacity,

The relative location on the selector boards of the different divisions included in a graded multiple sub-group is determined by the same considerations as those governing the multipling of selectors when forming regular sub-groups, ae previously described.

As shown in Division V, "Cabling and Wiring", one or more extra flat type terminal strips are required in each terminal pile-up in order to obtain the multipling arrangements inherent to the graded multiple scheme.

In multipling, together selector divisions that are located on the same shelf, no multiple slip or reversal is introduced into the common trunks. To do this would require a large number of additional types of hairpin forms to care for the different kinds of graded multiple and for time different levels on which graded multiple might be used. Whether multiple slip or multiple reversal should be used on the other levels is determined as previously described, disregarding the level or levels to which the graded multiple scheme is applied.

The short and long multiple cables used where graded multiple is employed, however, are necessarily special in the senee that they must be specially formed out to their flat type terminal stripa, This is necessary in order that on the level or levels where graded multiple is used, the terminals corre-

sponding to the common trunks from the shelves to be multipled can be connected together without eome of the common trunks from one shelf being connected to some of the individual trunks from another shelf. This would result if standsrd multiple cables were used, since these are formed out to give either multiple reversal or multiple elip over the ten trunks of each level.

Since multiple cablee are of necessity formed specially to care for graded multiple, advantage is taken of this faot to insert multiple elip or revereal in the common trunks in order to equalize the load over them as fsr as practicable. Where the graded multiple sub-group includee 50 or 70 selectors, multiple reversal is inserted in the common trunks, whereas if the graded multiple sub-group includes 110 or 160 selectors, multiple elip is inserted instead. The slip or reversal is introduced between each shelf of selectors in the graded multiple sub-group. Whether the multiple cables should be formed out to give multiple slip or multiple reversal on the other levels is determined ae previously described.

It is not expected that there will be any cases where the traffic over the firet or over the zero levels of first selectors will be such as to require the uee of graded multiple for these levels. In general, therefore, selectors

handling traffic from flat rate and message rate lines and those handling coin box traffic may be included in the same graded multiple sub-group. Selectors handling trsffic from the special operators' positions may alro be included in the same graded multiple sub-group with those handling traffic from flat rate, message rate and coin box lines if this is found deairable.

Due to the relatively large number of selectors in a graded multiple sub-group a considerable number of selectors may remain after as many graded multiple sub-groups as possible have been formed for the level being considered. The remaining selectors are formed in the usual manner into regular sub-groups and, if necessary, into a partial or combined sub-group as previously described.

Cross Connections In Trunks To Regular Selectors.

It is to be noted that in applying the cross connection schemes outlined below, the trunks to selectors handling calls from coin box stations should be considered separately in order that traffic from coin box stations to the zero or A-B operators' positions may be handled over a separate group of trunks.

Offices Where Secondary Line Switches Are Not Installed.

By means of appropriate cross connections at the line I.D.F., the subscribers' lines may be so distributed among the different line switch sub-groups that each sub-group of trunks to first selectors will be properly loaded, but it would be difficult to do this and also distribute the lines in such a manner that each sub-group of trunks would be carrying its peak load at the same time. Since the peaks in the different sub-groups will in general occur at different times, it is desirable to relate the primary trunk sub-groups with the different selector sub-groups so that approximately the same number of trunks from each of the several primary sub-groups will be terminated at each selector sub-group. By this means the peak loads in the trunk sub-groups from first to second selectors are reduced and the chance that a call will be delayed due to an all-busy sub-

group of trunks to second selectors is correspondingly reduced.

In some offices all of the primary trunk sub-groups will not be of the same size and therefore will not work at the same efficiency. An additional advantage, therefore, in associating the primary trunk eub-groups and the first selector sub-groups as described above is that any difference which may exist in the efficiency of the primary trunks doce not have to be taken into account in forming the selector sub-groups, all of which may be made af the same size for any given level.

In order to preserve a regular cabling arrangement between the primary line switches and the selector boards, and at the same time to permit of the association between primary trunk sub-groupr and selector sub-groups just described, jumper connections in the trunks between the line switches and selectors are made at an I.D.F.

The cross connections are made in accordance with the plan outlined below. It should be noted that the arbitrary numbering schemes referred to are used only ar a means for facilitating the description of the plan, and ars not to be taken as the standard mothod for numbering line switch and selector equipment in an office.

The half-shelves of selectors serving the class or classes of lines being considered are arbitrarily numbered from

"1" up. The half-shelf nearest the terminal strips on the highest shelf involved on the high side of the first selector board is numbered "1" and the other half of that shelf is numbered "2". The numbering is continued in this manner by progressing downward on the high side of the board until all of the half-shelves on that side that are to be numbered have been included. The numbering is continued in the same manner on tbe low side of the board, progressing downward, and is then continued for the half-shelves on the next board if there be more than one.

The ten selectors in each half-shelf are also arbitrarily numbered from 1 to 10, the numbering progressing toward the power end of the board.

All of the working trunks from the primary line switches for the class or classes of linee in question are also arbitrarily numbered from 1 up, beginning at the No, 1 trunk in the first sub-group and continuing up to the number corresponding to the highest numbered half-shelf of selectors, and then repeating as many times as are necessary to cover all of the working trunks.

In running the cross-connections, the first Ho, 1 primary trunk is connected to the No. 1 selector Sn the No, 1

half-shelf, the second No. 1 trunk is connected to the No. 2 selector in the No. 1 half-shelf, etc., until all No. 1 trunks have been connected to the different selectors in the No. 1 half-shelf. Then the first No. 2 trunk is connected to the No. 1 selector in the No. 2 half-shelf, the eecqnd No. 2 trunk is connected to the No. 2 selector in the No. 2 half-shelf, etc., until all No. 2 trunke have been connected to the various selectore in the No. 2 half-shelf. Thie scheme in continued until all of the working trunke have been cross-connected.

Offices Where Secondary Line Switches Are Installed.

In such officee the different regular groups and the combined or partial group will not in general carry their respective peak loads at the same time. In order to minimize the chance thut a call will be delayed due to an all-busy sub-group of trunks from first to second selectors, therefore, it is desirable to relate the various sub-groups of trunks from secondary line switches with the different eelector sub-groups in auch a manner that approximately the same number of trunks from each of the regular groups and fron the combined or par-tial group will be terminated at each selector sub-group.

In order to permit of regular cabling arrangements snd at the same time to obtain the desired relation between the secondary trunk sub-groups and the first selector sub-groups,

cross connections are introduced in the trunks between the secondary line switches and the first selectors.

The half-shelves of selectors serving the class or classes of lines being considered, and the selectors on each half-shelf, are arbitrarily numbered as previously described under "Offices Where Secondary Line Switches Are Not Installed". The working trunks from the secondary line switches for the class or classes of lines in question are arbitrarily numbered in the same manner as the trunks from primary line switches in offices where secondary line switches are not installed. The cross connections are then made in accordance with the plan previously outlined under "Offices Where Secondary Line Switches Are Not Installed."

**First Selectors.**

**Toll Selectors.** Because of the differences between local and toll requirements in regard to operating methods and transmission features, separate trains of selectors are employed for establishing toll connectiona between the toll board and the mechanical subscribers. In a single-office district it is the customary practice to terminate each working switching trunk from the toll board at a toll first selector, although in eome cases it may be found economical to terminate such trunks at toll aecond selectors.

In offices serving coin box lines, the switching trunks over which connections to coin box stations are made are terminated at toll selectors which are equipped with double private banks, as on trunk-hunting aonnectors, and four-wire circuits are used between these selectors and the toll second selectors. The fourth brush on each coin-box toll first selector is multipled to the bank contacts of a special switch which IS reached by the toll operator over a coin-box operating trunk and which enables her to control ths application of coin collect or return current to the coin-box lines. In forming toll first selector sub-groupe the coin-box toll

first selectore may be multipled with the other toll first eelectors if desired.

Selector Multiple. Like regular first selectors, toll first selectors, (other than coin box toll first selectors), are multipled together in the ehop in divisions of five or ten, and twenty selectors in either two or three divisions are mounted in the regular manner on a shelf at the standard selector board. The division bank wiring is carried, as previously described for regular eelectore, to terminal strips at one end of the bosrd where the divisions may be multipled together as required.

The terminal strip arrangement for the four-wire trunke from coin box toll first selectore is essentially the same as that required for other first selectors, the only difference being that extra flat type terminal strips are required in the orivate conductor pile-ups for the termination of the division wiring and the cabling used in connection with the fourth conductors. The number of flat type terminal etripi that would be required in euch private conductor pile-up where four-wire trunks are used would, however, exceed the capacity of the standard assembling pins if three divisions of selectors were mounted on a shelf, so that ooin-box toll first selectors will be furnished only in 10-selector divisions.

Toll first selectors are not multipled with regular first selectors and fgr this reason the former are usually grouped together on a separate selector board, The toll firrt selector board may, however, be used for mounting other selectorr, such as toll second selectors, special or auxiliary selectors, etc., if such an arrangement is found to be economical in the utilization of frame and floor space.

Toll first selectors are mounted on opposite and on adjacent shelves at the selector board, thir relative location permitting the selector divisions to be formed into sub-groups in accordance with the method described in Division IV, Section 3-a, under "Grouping of First Selector Divisions."

Multiple slip or multiple reversal is used in multipling toll first selectors, and is inserted between divisions ar described in connection with regular first selectors in Section 3a.

Number of Selectors Per Sub-Group.

The number of toll first selectors required to provide a proper load for a sub-group of ten trunks to toll second selectors is determined in the same general way as described for regular first selectors in Section 3-b. The relation $R = \frac{4.13\ T}{\Delta}$

is employed, where R is the number of toll first selectors per sub-group, T is the total number of toll first selectors concerned and $A_r$ is the average number of calls in progress simultaneously during the busy hour over the level being considered. The value of $A_r$ is calculated from the traffic data used in connection with the formula $A = \frac{C \times H}{3600}$.

In order to adapt tha multipling scheme to the standard equipment arrangements, the theoretical number of toll first selectors per sub-group (R) is increased or decreased to the nearest even multiple of five or ten aa previously described for regular first selectors, although the use of five-selector divisione will not ordinarily be necessary to obtain an economical multipling arrangement.

Due to the necessity of keeping the toll selectore in a separate train, no opportunity is afforded to combine the trunks to toll second eelectore with the trunks from regular first to regular eecond selectors, After as many toll sub-groups as possible have been formed for a particular level, the remaining toll selectors are formed into a partial sub-group. The number of trunks required for the partial sub-group is determined as described in Section 3-b, the relation $4 = \frac{A_r \times R_p}{T}$ being employed in conjunction with Table B.

Second Selectors - Four-Digit System.

Regular, Special and Toll Selectors. Each working trunk from the regular first selectors, with tho exception of thoee from the firet and zero levels, is terminated at a regular second selector, the trunks from the zero level being carried to jacks at the zero operators' positions, and those from the first level being terminated at special seoond eelectore,

Each working trunk from the toll firet selectors is terminated at a toll second selector.

In a single office district, assuming a 4-digit system, regular and toll second selectors are divided into groups, a group consisting of all of the regular and toll selectors which handle traffic from a given level at the firet selcctors. There will be as many groups of regular and toll second selectors as there are working levels (exclusive of the zero and first levels) at the first selectors, The special second selectors constitute one or more additional groups. In offices serving coin box lines and where the h-B operators are reached by the code 112, the special second selectore used for handling ooin box traffic are kept in a group separate from the other special second seleotorr in order that ooin box calls may be routed to the A-B operators over a separate group of trunks. In general selector divisions in the same group may be multipled together, whereas it is not

permissible to multiple together divisions that are in different groups.

All of the regular second selectors in a given group should, as far as possible, be located together on the same selector board in order to permit a sub-group of trunks to connectors to be multipled as described in Section 3-a under "Grouping of First Selector Divisions." The toll second selectors in a group should be located together in a similar manner. In general, it is desirable to make provision on this basis for the growth of any group of second selectors corresponding to a particular thousand subscribers' terminals which, in the initial period, are but partially equipped. It may also be desirable to allow for the growth of second selector groups if increases in the calling rate or holding time are expected, although the advisability of doing this will depend largely on such factors as the floor plan layout, the number of additional selectors required for growth and the time that it is estimated will elapse before the additional equipment will be installed.

For cabling reasons the ten trunks in a sub-group from first selectors are terminated on a half-shelf at the second selector board; that is, they are terminated at either the

first ten or the last ten selectors on a shelf. Bor the same reasons the trunks of partial sub-groups are terminated at seeond selectors all of which are located on the same half-shelf. Bor example, a six-trunk partial sub-group would be terminated at the first six selectors on a half-ehelf, the other four selector positions being provided with banke but not being equipped with selectors.

Selector Multiple.

Regular and Special Second Seleotors.. Like first selectors, regular and special eecond eelectors are usually multipled together in divisions of ten, but are furnished in divisions of five if required, and twenty selectors are mounted in the regular manner on a ahelf at the etandard selector board. The multiple wiring for each division is carried to flat type terminal strips mounted across one end of the selector board and the terminale are arranged in the same manner as previously described in connection with firet selectors. The relative location on a board of the different divieions of selectors in a sub-group is the same as described for first selectors in Section 3-a under "Grouping of First Selector Divisions."

Toll Second Selectors. Toll eecond selectors are usually multipled together in divisions of ten, but are furnished in divisions of five if required, and ten selectora are mounted on

a shelf, The toll second selectors in a 4-digit system are termed "transmission" selectorc; that ia, the subscriber's battery supply on a toll call is furnished through a repeating coil which is associated with the toll eecond selector. It is not feasible to mount the repeating coil on the selector base, but by mounting ten of the selectors on one-half of a shelf and the ten corresponding repeating coils, together with certain other associated apparatus, on the other half of the same shelf, it is possible to mount, wire and test out this equipment in the shop, and it is thought that this arrangement possesses sufficient advantage to warrant a departure from the ueual method of arranging the selectors on the boards. In order to minimize the length of the division bank cablee, the selectore are mounted on the half-shelf nearer the terminal end of the board.

The transmission selectors are provided nith double private banke, and four-wire trunks are used between these selectors and the connectors. The multiple wiring for each division is carried in the usual manner to flat type terminal strips at the end of the selector board, and the arrangement of the terminale ie substantially the same as for coin box toll first selectors. The relative location on a board of the different divisions of selectors in a sub-group is in general the same as for regular second selectore,

The number of second selectors required to provide a proper load for a sub-group of ten trunke to connectore will usually be large, and it is thought that in the majority of cases multiple slip will be found satisfactory as a means of distributing the load over the trunke of the sub-groups and of reducing the rotary action of the selectors, although multiple reversal will be provided if required, The slip or reversal is ineerted in the multipling as previously described in connection with first selectors,

Number of Selectors per Sub-group.

The size of regular, toll, or special second selector sub-groups is determined in the same general way as described for first eelectors in Section 3b, using the relation $R = \frac{4.13\ T}{A_r}$. The number of trunks required for a partial sub-group ie also determined as described in Section 3b, using the relation $A_p = \frac{A_r \times R_p}{T}$. Combined local and toll sub-groups may be used as explained later.

In determining in what manner and to what extent the theoretical size of a second selector sub-group should be increased or decreased to conform to equipment limitations, the practice outlined in connection with first selectors should in general be followed.

Combined Local and Toll Sub-groups.

In a 4-digit system a given level at a group of regular eecond selectors handles the local traffic incoming to a

maximum of but 100 terminale and therefore the total number of trunks required per level, which is the number of local connoctore required per 100 terminals, is usually small, varying from about 6 or 7 as a minimum to perhape 15 as a maximum for a regular group of 100 terminals. (A regular group of 100 terminals is one which doce not include P.B.X. trunks). It is also apparent that except where the total number of trunks required per level is just ten, a partial sub-group of trunks will result and this partial sub-group may be small and relatively inefficient. In such cases, therefore, the total number of trunks and conneotore required to handle the local traffic to the group of 100 terminals may be increased by a considerable percentage over the number that would be necessary if the use of small partial sub-groupe could be avoided. It will be found economical in eome cases, therefore, to combine a partial sub-group of trunks from a group of regular second selectors with the trunks from the corresponding level of the toll second selectors in the same group, The toll trunks required to serve 100 terminale are seldom sufficient in number to form in themselves an efficient sub-group, but by combining them with a partial sub-group from the regular selectors a larger partial sub-group or a full sub-group of

ten trunks may be obtained and the added expense incident to the use of partial sub-groups may be largely eliminated,

The scheme of combining local and toll partial sub-groups in this way is applicable, however, only to those levels serving regular groupe of 100 terminals. The connoctore at which euch combined groupe are terminated, called "combination" connectors, must of course handle both local and toll traffic and are therefore designed to include the circuit features of both local and toll connectors. As a result, combination connectore require more apparatus than either of the other two types and it so happens that conbination connectors also arranged for trunk hunting (for use in connection with groups containing private branch exchange trunks) would require more relays than could be mounted on the standard connector baee, To avoid equipment complications, therefore, combination trunk-hunting connectors are not for the present to be used.

In determining what multipling arrangement ohould be used for the regular and toll second selectors, the following general plan is followed: The number of regular second selectors required to provide a proper load for a sub-group of ten trunks is determined in the usual manner. If this number is

greater than the total number of regular second selectors in the group concerned, a partial sub-group results if the combined local and toll eub-group plan is not ueed, and the number of trunks required for the partial eub-group is determined ae previously explained. If there are more regular second seloctore than are required to furnish a full load for ten trunke, the exceee selectors form a partial sub-group if the combined sub-group plan is not used, and the number of trunke required to handle their traffic is determined in the ueual manner. Similiarly, the number of toll trunke that would be required in a separate partial sub-group to carry the toll traffic to the particular 100 terminals being considered is then determined. Assume that the average number of simultaneous calle to be carried in the buey hour by the partial sub-group from the regular selectors is $A_p$, and that the average number to be carried by the partial sub-group from the toll selectors is $A_t$. If $(A_p + A_t)$ is less than or equal to 4.13, the two partial sub-groups may be combined into a partial or a full sub-group. The value, in Table B, which is nearest to the sum $(A_p + A_t)$ is then found, and the number of trunks and combination connectore required in the combined sub-group, or combined partial sub-group, is found opposite in the "Average Plue Deviation[a] column. If $(A_p + A_t)$ exceeds 4.13, the *two* partial sub-groupr may be formed into one combined sub-

group of ten trunks with one partial sub-group still remaining. The value of ($A_p + A_t - 4.13$) is then found in Table B, and the number of trunks required in the partial sub-group is given opposite in the "Average Plus Deviation" column. In cases where a ten trunk eub-group and also a partial sub-group would be required for local traffic, the combined sub-group, if used, ehould in general be so arranged that it will carry all of tha toll traffic in order to avoid the use of toll connectore as well ae both local and combination connectore,

Combination connectore are somewhat mors expansive than local or toll connectore, and their extra cost should be balanced in each case against the saving resulting from any reduction in the necessary number of trunks and connectors effected by the uee of the combined sub-group plan, but it is thought that in general the uee of this plan will be justified if it results in the saving of one or more connectors per hundred terminale, In some instances the traffic conditions may be such that no reduction in the number of connectors can be effected by following the combined sub-group plan, and in auch cases the local and toll partial sub-groupe ars kept separate,

Becauee of circuit requirements the combination connector is provided with two separate sets of jack springs,

one set for terminating the 3-wire trunk coming from the regular selectors and another eet for terminating *the* 4-wire trunk coming from the toll selectors. In other words, the regular and the toll partial sub-groups of trunks forming a combined sub-group are in effect multipled together at the connectors by using separate eete of selector-connector cablee for the regular and toll partial sub-groups, instead of employing the ueual method of multipling betwesn the selector board terminal strips.

## Second Selectors—Five-Digit System.

**Regular, Special and Toll Selectors.** The level or levels at tho firet selectors over which traffic local to the originating office is routed are termed the local levels and each working trunk from theee levels, except the zero and first levels, is terminated at a regular second selector known ae a local second selector. The trunks from the zero and first levels are carried to jacks at the zero operators' positions and to special second selectore reepectively.

Each working trunk coming from another office, other than the toll office, is terminated at a regular seoond selector known as an incoming second selector.

Each working switching trunk from the toll board is, in general, terminated at a toll eecond selector, although in some cases it may be found satisfactory to terminate such trunks at toll third selectors. In offices serving coin box linse, the switching trunks over which connections to coin box stations are made are terminated at toll eelectors which are provided with double private banke, and the trunk from these selectors are four-wire circuits, as described in connection with coin-box toll first selectors in Section 3e. In forming the toll seoond selector sub-groups the coin box

toll eecond selectors may be multipled with the other toll second selectors if desired.

In aome cases the trunks from the manual board used for completing connections to mechanical subscribers may economically be terminated at eecond eelectors inetead of at ffrst selectors.

In a multi-offica district, assuming a five-digit system, regular eecond selectors are divided into classes as in the case of first selectore, the local selectors constituting one class and ths incoming selectors forming another class. There may be still another class comprising the eelectors at which the trunks from the special operators' positione are terminated. The distinction between these classes lies in the difference in efficiencies of the trunk groups incoming to them, which makes it neceesary to consider each class separately in calculating the size of selector sub-groups.

The regular aecond seleétors, the toll second selectors and the special second selectors constitute three separate groups and in arranging the multipling each group is kept separate. In offices serving coin box lines a eeparate group of coin box special eecond aelectora may be required, as

previously explained in Section 4a.

For the sake of simplifying the cabling to the second eelectore and to simplify and economize in the multiple cabling between their terminal strips, the local second selectore and the incoming selectors are segregated so that ae far as practicable all, or at least a majority, of the selectors on a given board will be of the same claee and so that the different boards mounting eelectore of the same claee will be located adjacent to one another, If there are any eecond selectors handling traffic directly froa the special operators' positions, euch eelectora are ueually few in number and are located either with the local or with the incoming selectors, depending on the layout of the offioe,

In general, it is desirable to make provision on the basis of segregated classes for increases in the number of local second selectors required as the office grows, and for increases in the number of incoming selectors required ae the treffic incoming to the office becomee greater, although the extent to which euch provision should be made will of course depend on euch factors as the floor plan layout und on the estimated nature and amount of growth in the area concerned,

Since the toll eecond selectore are not multipled with the regular second selectors, the former are usually grouped together on a separate selector board, As explained under Section 3e in connection with toll first selectore, however, economies may sometimes be effected by utilizing tho toll selector board for mounting other selector equipment.

For cabling reasone the ten trunke in a sub-group from first to local second selectors are all terminated on a half-ehelf at the second selector board, and the trunks of a partial sub-groups are terminated .at local eecond selectors all of which are located on the same half-shelf.

In a multi-office district the sizes of the varioue trunk groups leading to the incoming eecond selectors at a given office will in general not be the same and their trunk efficiencies will differ aocordingly, For example, trunke from a manual office or trunks coming from another machine ewitching office through outgoing trunk secondary switches may be in groups of large size and of comparatively high efficiency, whereas trunke which come from a machine switching office and which are not carried through outgoing trunk secondary switches will in general be in small sub-groups and their efficiency will be correepondingly small. In order to

avoid the necessity of taking into account euch differences in trunk efficiency when calculating the number of incoming second selectors required to provide a proper load for a sub-group of trunks, the main frame cross-connections in the incoming trunks are utilized to distribute the trunks over the selector shelves in euch a way that as far as possible each sub-group of trunks from the incoming second selectors will carry a proportionate amount of traffic from each of the various groups of incoming trunks.

The extent to which the ideal distribution can be attained will in general be limited to some extent by the method used in obtaining peg count records of the interoffice traffic where auch records are obtained at the incoming office. This method consists of associating a release relay, through which the current for the operation of the release magnets is supplied, with each shelf or half-shelf of selectors, and of connecting a register with each release relay so that when a selector is restored to normal at the termination of a oall the operation of the corresponding release relay will cause the associated register to soore. This method of obtaining peg counts is used for trunks incoming from a manual office, and may also be ueed for trunks incoming from another machine

switching office, although methode whereby the counte may be obtained at the outgoing end of trunke from machine switching offices are being considered.

From the foregoing it will be seen that for the preeent the incoming trunke should be cross connected eo that all incoming selectore on a shelf or on a half-shelf will be in the same incoming group , and so that ae far as possible the eame number of eecond selectore inanygiven incoming group will be üeed to load each sub-group of trunke to third selectore,

Selector Multiple. The regular, toll and special aecond selectore, with the exception of coin box toll aecond selectore, are multipled together in divisions of five or ten, and are mounted in the regular manner on a ehclf at the standard eelector board, The multiple wiring for each division is carried to flat type terminal strips and the latter are arranged as previously described for firet selectors. Coin box toll eecond eelectore are furnished in 10-selector divisions only, and their terminal arrangement ie the same ae previously described for coin box toll first eelectore, The relative location on a selector board of the different diviaione of selectora in a sub-group is the same ae described for first

selectors in Section 3a under "Grouping of First Selector Divisions."

Multiple slip or multiple reversal is used in multipling second selectors in a 5-digit system as previouely described in connection with first selectors.

Number of Selectors Per Sub-Group.

The number of eecond aelectors required to provide a proper load for a sub-group of ten trunke, and the number of trunks required for a partial eub-group, are determined as previously described for firet selectors, each group or clase of eecond selectors being considered separately.

It ehould be noted that for efficiency reaone partial sub-groups of local and incoming selectors should, if feasible, be formed into combined sub-groups, thue reducing the number of regular third selectors required. Such partial sub-groups may also be combined with partial sub-groups of second eelectore handling traffic from the speoial operators' poeitions, The number of selectore required for a combined sub-group is determined as described in connection with firet selectors in Section 3b.

In determining whether five-selector divisions ehould be used to obtain economical multipling arrangements

at second selectore, the practice outlined in connection with first selectore should, in general, be followed, Although five-selector divisions may sometimes be required for incoming or toll aecond selectors, it is thought that there will be very few if any cases where the smaller divisions will be needed for the local selectors,

Third Selectore

Regular. Special and Toll Selectors. Each working trunk from the local and incoming eecond selectore is terminated, in a 5-digit system, at a regular third eelector. Each working trunk from the first level at epecial eecond selectors is terminated at a special third selector. As previously noted the switching trunks from the toll board may be terminated at toll third eelectore, although usually they are terminated at toll second selectore and the trunks from the latter are terminated at toll third eelectore,

As in the case of second selectors in a 4-digit system, regular and toll third selectors are divided into groups, a group consisting of all the regular and toll selectore handling traffic from a given level at the second eelectors. The epecial third eelectors constitute one or more additional groups. In offices serving coin-box lines and where the A-B operatore are reached by the code 112, the eecond level at the special third selectors handling traffic from the coin-box linee is not multipled with the second level at the other epecial third selectors, thus permitting the uee of a separate trunk group for coin-box traffic to the A-B operatore,

All of the regular third eelectors in a group should, as far as poseible, be located together on the same seleotor

board in order to permit the sub-groups of trunks to connectors to be multipled together as described for first selectors in Section 3a under "Grouping of First Selector Divisions", and the toll third selectors in a group should be located together in a similar manner. Provision for the growth of the groupe should be made as mentioned in connection with eecond selectors in Section 4a.

All of the trunks in a sub-group or in a partial sub-group to third selectore are terminated on the same half-shelf to simplify the cabling.

Selector Multiple.

Regular and Special Selectors. Regular and special third selectora are furnished in division of five or ten, although it is expected that satisfactory multipling arrangements may be obtained in nerrly all cases without the use of five-selector divisions. The multiple wiring for each division is carried to flat type terminal strips mounted across one end of the selector board, and the terminale are arranged as previously described in connection with first selectors. The relative location on a board of the different divisions of selectore in a sub-group is the same as described for first selectors in Section 3a under "Grouping ofFirst Selector Divisions".

Toll Selectors. Toll third selectors are available in either five-selector or ten-selector divisions, al-

though it is thought there will be but few cases where five-selector divisions will be required. In a 5-digit system the toll third selectore are the "transmission" selectors, and ten of them, together with the associated repeating coil equipment, are mounted on a shelf at the eelector boards, as described in connection with toll second aelectore in Section 4a. The multiple wiring for each division is carried to flat type terminal strips at the end of the selector board, the strips being arranged to care for the four-wire trunke to connectors. The relative location on a board of the different divisions of selectora in a sub-group is in general the same as for regular third selectore,

Multiple slip or multiple reversal is inserted in the multipling between third selector divisions as previously deacribed in connection with second selectore in Section 4a.

Number of Selectora per Sub-group.

The number of regular, toll or special third selectore required to provide a proper load for a sub-group of ten trunks, nnd the number of trunke required for a partial sub-group, are determined as described in connection with first selectors in Section 3b. The theoretical number of selectors per sub-group is increased or decreased to oonform to equipment

limitations as previously dascribed.

When coneidering levele serving regular groups of 100 subscribers' terminals, partial sub-groups of trunke from regular third selectors may be combined with partial sub-groups from toll third oelectoro in some cases to reduce the number of trunks and connectors required, The resulting combined sub-groups or combined partial sub-groupe are terminated at combination connectore, The conditions under which the combined sub-group plan will prove cconomical are in general the same as described in corinection with eecond selectors in Section 4a under "Combined Local and Toll Sub-groups".

Connectors .

In a 4-digit system, one connector is provided for each working trunk from the regular and toll second selectors, and in a 5-digit system one connector is provided for each working trunk from the regular and toll third oclectore, a trunk from the regular selectors combined with a trunk from the toll selcctore being considered as one trunk. In general, one test connector is also provided for each group cf 100 subscribers' terminals for the purposes deecribed later.

All of tbe connectors serving a given group of 100 terminals constitute a connector group, Groups of 100 terminals and the connector groups serving them are classified as "regular" and as "trunk-hunting" groups. A regular connector group serves only individual and party-line stations, together with their cxtensicn stations, whereas a trunk-hunting connector group serves P.B.X. trunks and consecutive linee and also other individual lines if desired. Regular connector groups may contain regular local and regular toll connectors, regular local and combination connectors, or combination connectors only. Trunk-hunting connector groups will include trunk-hunting local and trunk-hunting toll connectors.

Connector Multiple and Terminal Strip Arrangement. Connector banks are multipled together in divisions of five or eleven. As deecribed in Divisicn II, Section 3q, three standard types

of connector boards are available, mounting five, eleven or sixteen connectors per shelf. One connector division is mounted per shelf except On boarde providing for sixteen oonnectore per shelf, where one eleven-connector division and one five-connector division are placed on a shelf,

The multiple wiring of the line and private banks for each connector division is extended to standard A.T.& T.Co's type terminal stripe, which are mounted horizontally, one above the other, on the sides of the connector board near one end, Five 3-point or five 4-point terminal stripe are provided for each shelf of connectore, each strip providing terminals for the wiring from two oonnector levels. The 4-point stripe are used for trunk-hunting connector groups, trunk-hunting connectors being equipped with double private banks. The terminal strips provide means for making connection between the division bank wiring and the cables leading to the line I.D.F., and aleo provide means for multipling together connector divisions located on different shelves where this is found desirable.

Test Connectore, The test connector is so arranged that it will establish connection to a set of terminals even though they teet busy, and thus provides means for routine teeting by the

maintenance forces and also enables the operating department to verify buey reports. The test connectors are reached from the wire chief's desk and from the special operators' positions through test distributor ewitchee or through teet distributor selectors and teet distributor switches, which enable the wire chief or operators to eelect the desired teet connector by dialing the number of the hundreds group which that connector serves.

Arrangement of Connectore In order to preserve a regular numbering scheme at the connector boards it is desirable to place, as far as practicable, all connectors in the same group on the same shelf, although in the caee of trunk-hunting connectors it may be found desirable from floor plan conaiderationa to mount the connectoro for a hundred terminals on two separate boards and in some caeee on two or more ehelvce at the second boerd,

In an office where the number of connectors (exclusive of the teet connector) per regular group does not exceed ten, connector boarde providing capacity for eleven connectore per shelf are ueed for the regular groups. The number of connectors per trunk-hunting group will usually exceed ten, and in euch an office ten of the connectore in each

trunk-hunting group are mounted on a shelf at one of the regular connector boarda and the excess trunk-hunting connectors are mounted on a separate or "overflow" board, If the total nwnber of trunk-hunting connectore per group does not exceed 15, the connectore in excess of 10 are mounted at a board providing capacity for five connectors per shelf. If the total number of trunk-hunting connectors per group is greater than 15, the connectors in excese of 10 may be mounted on two or more shelves at a bonrd providing for five connectore per shelf, or they may be mounted on one or more shelves at a board providing for eleven connectore per shelf. The type of "overflow" board to be used will depend on the number of trunk-hunting connectore in the group, the nwnber of such groups in the office and on the floor plan layout.

In an office where the number of connectors (exclusive of the test connector) per regular group exceeds 10 but does not exceed 15, connector boarde providing capacity for sixteen connectors per shelf are ueed for the regular groups. If the number of connectors per trunk-hunting group exceeds 15 in such an office, 15 of the connectore in each trunk-hunting

group are mounted on a shelf at one of the regular connector boards, and the excess trunk-hunting connectora are mounted on one or more shelves at an overflow board providing capacity for five, eleven or sixteen connectors per shelf.

Where a connector group is divided between two boards, each connector is fused at its own board. Since the two boards may be separated by a considerable distance, the practice of fusing each connector at its own board saves an appreciable amount of power wiring in some cases.

Grouping of Subscribers' Terminals.

In addition to the segregation of subscribers' lines into regular and trunk-hunting groups as previously described, certain limitations as to what lines may be included in the same group of 100 terminals are imposed by the type of ringing required on the lines, since all connectors in a given group will apply the same type of ringing current to all terminals in that group.

Connector groupe wired for main battery superimposed ringing, as described *in* Division III, Section 2f, are usually used to serve the individual and two-party lines, and may also serve the one-ring stations on four-party semi-selective lines. The terminals in such groupa may include both tip and ring side stations, since the ringing current is eent

out over the proper side of the line by appropriate wiring at the I.D.F., as described in Division Y.

Separate connector groups are required for the two-ring stations on four-party semi-eelective linea. The connector circuits in euch groups are arranged to insure that when ringing starts the bells will receive the complete two-ring code. Individual lines and two-party lines may also be included in two-ring groups in so far as this may be found desirable.

In offices serving four-party selective lines, the odd-numbered hundreds groupe are provided with positive superimposed ringing and the even-numbered hundreds groups are provided with negative superimposed ringing. Either negative or positive superimposed groups may be used to serve individual or two-party lines. As in the case of main battery superimposed groups, the negative or positive superimposed current is sent out over the tip or ring side of the line as required by means of proper wiring arrangements at the I.D.F.

Official lines, to which free service from coin-box or message register lines is to be given, are placed in a separate group and are served by conneotore which do not reverse the battery over the calling subscriber's line when the called party answers.

Private Branch Exchange Groups of More Than Ten Trunks.

The trunk-hunting connector is not at present arranged to hunt over more than tho tcn terminals in any one level, In view of this the listed number of a P.B.X. should if possible be so chosen that the connector terminal for the listed number, together with the higher numbered and zero terminals in the level concerned will provide for a sufficient number of P.B.X. trunks to care for the present demand and, in general, for expected growth. If, however, the number of trunke handling traffic to a P.B.X. switchboard exceeds ten, the connector group is divided into two or more sub-groupe with rcapect to the P.B.X. level in question.

Where a group of 100 terminals comprises one or more P.B.X. groups each including more than ten trunks, the connectora required for the 100 terminals are usually large in number and are mounted on two or more shelves at the connector boarda, If more than 10 but not more than 20 trunks are needed in a P.B.X. group, the level concerned is divided into two sub-groups of ten trunks each. Each eub-group is multipled through approximately the same number of connectors,

using ehort multiple cabling between shelves where necessary. One sub-group of ten trunke is cabled to the line I.D.F., terminating there at the regular terminal etrip on the horizontal side. The other sub-group of ten trunks is cabled eeparätely to the I.D.F., is terminated there at an extra terminal etrip on the horizontal side, and the regular and extra strips are connected together by a tie cable, The tie cable connects each trunk in one of the sub-groups to the correspondingly numbered trunk in the other sub-group. If eleven P.B.X. trunks are required, the tie connection is cut between the two trunks, cne in each sub-group, which appear at each of their connsctors at the first terminal in the level concerned. In this way nine trunks are multipled through the entire group of connectors, and two trunke are multipled through only one sub-group of connectore. This arrangement is one form of graded multiple and provides two "individual" and nine "common" trunks to the P.B.X. Additional cabling is required between the extra I.D.F. terminals and an extra set of terminals mounted on *the* horizontal side of the M.D.F. in order tc provide connection between the "individual" trunk terminating at the extra I.D.F. etrip and the outeide cable leading to the P.B.X. If more than eleven trunke are required in

the P.B.X. group additional tie connections at the I.D.F. are cut, resulting in more "individual" and fewer "common" trunks.

If more than 20 but not more than 30 trunks are needed in a P.B.X. group, the connector multiple for the level concerned is divided into three 10-trunk sub-groupe, each being multipled through approximately the same number of connectors arid each being cabled separately to the line I.D.F.. Two extra sets of I.D.F. and M.D.F. terminals, together with the requisite tie cabling, ure provided, and the required number of P.B.X. trunke is obtained in the manner previously deacribed.

## Numbering of Central Office Equipment

**Line Switch Equipment.**

Switchboards for mounting primary or secondary line switches and those for mounting outgoing trunk secondary switches are built in units, each unit providing capacity for 200 switches. Each side of a unit, called a "bay", provides capacity for 100 switches. The switches in a bay are arranged in four divisions, each division affording capacity for 25 switches. Provision is made for mounting a master switch immediately above each division. The divisions and master switches in a bay are assigned the letters "A", "B", "C" and "D" as shown on Drawings Nos. 807-69 and 807-70.

Primary Line Switch Equipment. Each primary line switch bay is assigned a number prefixed by the letter "L". The bays in an office are assigned consecutive numbers from "1" up, except as noted below in connection with lines or rows of switchboards arranged for growth. Odd numbers are assigned in order to the bays on one side of each line of switchboard, disregarding aisle spaces if any, and even numbers are assigned in order to the bays on the other side of each line, the two bays of any one unit Wir~assigned consecutive numbers. In general, the lowest numbered bays in a line or row will be those nearest the line intermediate distributing frame. Where space is reserved to provide for the growth of a line or row, the bays should be numbered initially so that in the ultimate the numbering in each line will be consecutive as just described.

line switches in each bay are numbered from "0" to "99"

as shown on Drawing No. 807-69. Each line switch number appears opposite its switch on a designation strip mounted on the master switch bar. In addition, each primary line switch is provided with a designation card upon which is placed the multiple number or numbers to which the line switch is cross-connected at the line I.D.F.

Each subgroup of trunks from the primary line switches is identified by the letter of the primary master switch with which it is associated and by the number of the bay in which that master switch is mounted. A card is provided above the line switches showing for each primary line switch subgroup the number of the secondary line switch subgroup and the number of the secondary switch in that subgroup, or the number of the first selector bay and the number of the selector position in that bay, to which each of the working trunks in the primary subgroup is cross-connected.

Secondary Line Switch Equipment. Secondary line switchboard bays are numbered the same as primary bays except that each number is prefixed by &* letter "S" instead of the letter "L".

The secondary line switches in each division are numbered from "1" to "25" SB shown $B Drawing No. 807-70. The line switch numbers are placed opposite their respective switches on a designation strip mounted on the master switch bar. In addition, each secondary line switch is provided with a designation card upon which is placed the number of the associated primary trunk and the number of the primary subgroup including that trunk.

Each subgroup of trunks from the secondary line switches is identified by the letter of the secondary master switch with

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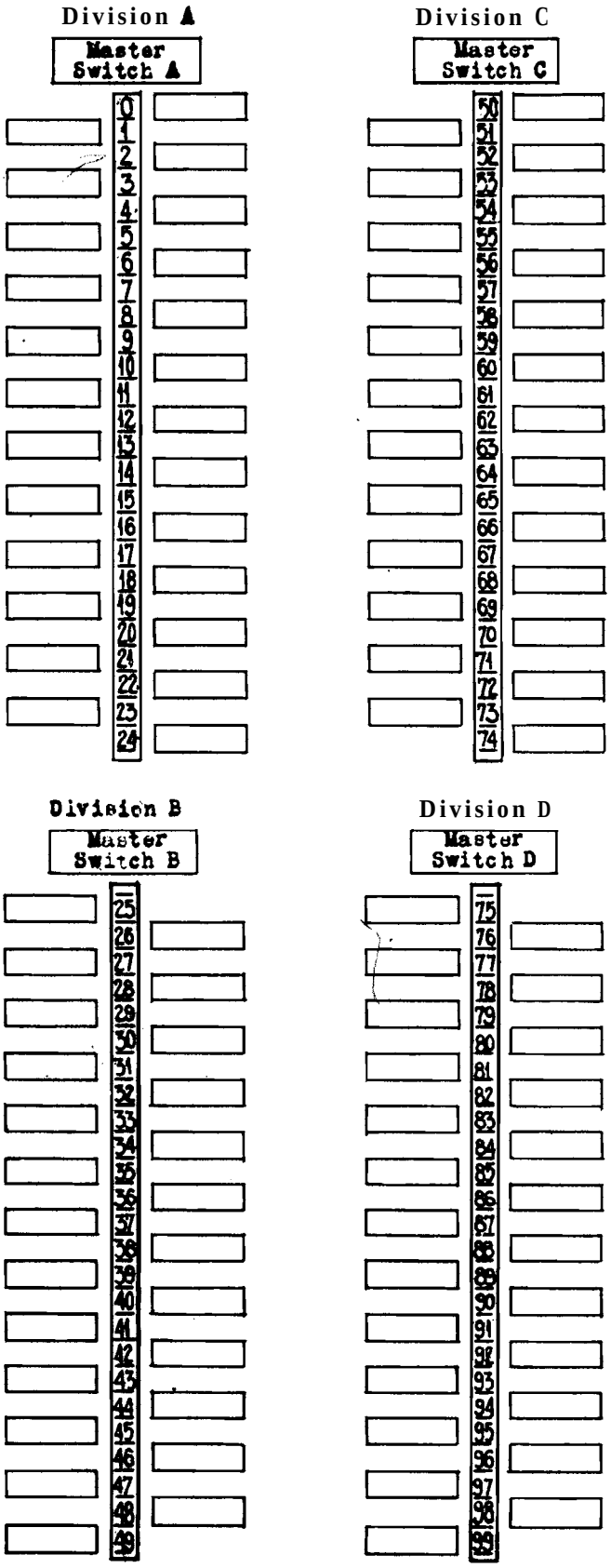
Information
Engineer Emm
Draftsman
Aug. 1, 1920
Issue 1.
Numbering
changed. Emm
MAY 1, 1922
Issue 2.

# STEP BY STEP MACHINE SWITCHING SYSTEM

## Numbering of Primary Line Switches



A. T. & T. Co.

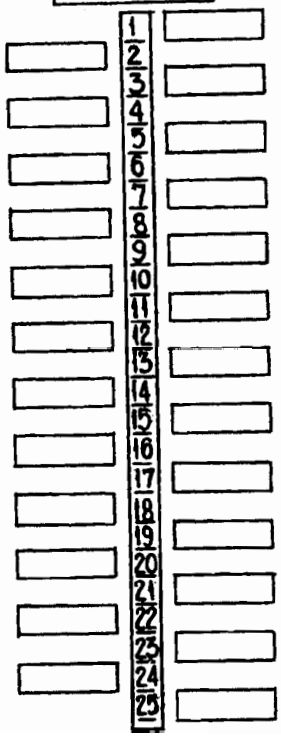
Dept. of Oper. & Eng.

807 - 70
Information Engineer EMM
Draftsman
Aug. 1, 1920.
Issue 1.
Numbering changed. EMM
MAY 1922
Issue 2.

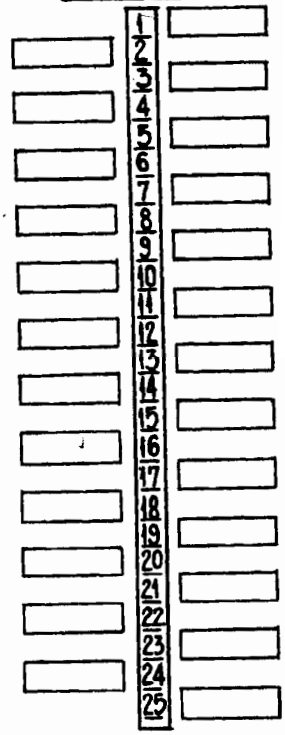
# STEP BY STEP MACHINE SWITCHING SYSTEM

## Numbering of Secondary Line Switches and Outgoing Trunk Secondary Switches

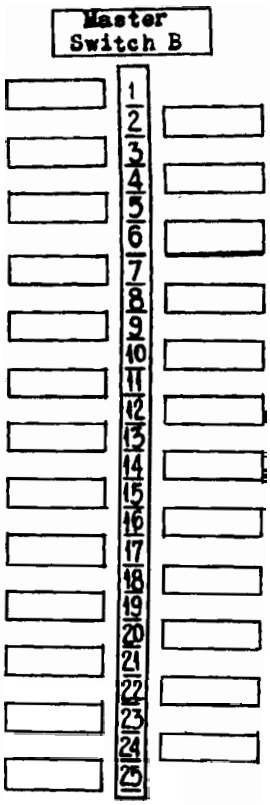
Division A



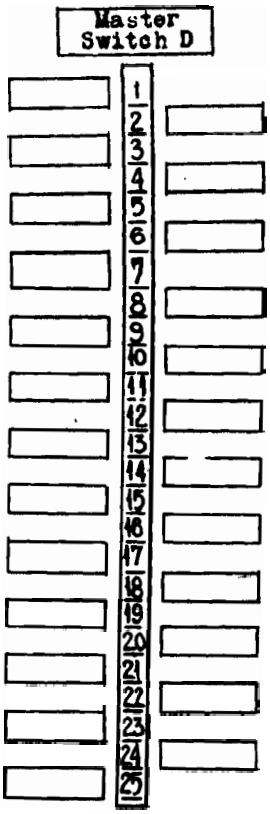

Division C




Division B




Division D



which it is associated and by the number of the bay in which that master switch is mounted. For each subgroup (division) of secondary line switches a card is provided showing the number of the first selector bay and the number of the selector position in that bay to which each of the working trunks in the secondary subgroup is cross-connected.

Outgoing Trunk Secondary Switch Equipment. Outgoing trunk secondary bays are numbered the same as primary bays except that each number is prefixed by the letter "T" instead of the letter "L".

The switches in each division are numbered from "1" to "25" as shown on Drawing No. 807-70, the numbers being placed opposite their respective switches on a designation strip mounted an the W-ter switch bar.

In addition, each outgoing trunk secondary switch is provided with a designation card which shows the number of the associated trunk and also shows at what set of pile-ups that trunk terminates at the first selector boards. The pile-ups are identified W-the letters of the shelf to which they correspond and by the number of the bay in which that shelf is located.

Each subgroup of trunks from the outgoing trunk secondary switches is identified by the letter of the outgoing trunk secondary master switch with which it is associated and by the number of the bay in which that master switch is mounted. A card is provided each subgroup (division) of outgoing trunk secondary switches, showing the number of the repeater bay and the number of the repeater in that bay to which each of the working trunks, in the outgoing trunk secondary subgroup is cross-connected.

Selector Equipment.

Boards for mounting regular, special and toll selectors are built in units, each unit providing capacity for 240 selectors. Each side of a unit, called a "bay", provides capacity for 120 selectors. A bay contains six shelves, each shelf providing capacity for 20 selectors. The various bays used for mounting regular first selectors are numbered consecutively from "101" up, those used for regular second selectors from "201" up and those used for regular third selectors from "301" up. The bays used for mounting special or toll selectors are numbered consecutively from "601" up. The bays in any given hundreds series are numbered in consecutive order progressing in the direction of growth of the boards concerned. Where both bays at a given board are in the same hundreds series they are assigned consecutive numbers.

The half-shelves of selectors in each bay are assigned the letters "A" to "L" inclusive, as shown in Figure 1, Drawing No. 807-76. This figure shows the relative location of the different half-shelves when facing the selector bay. Each shelf is known by the two letters assigned to its half-shelves; e.g. shelf "AB".

Each division of selectors is assigned the letter of the half-shelf on which Pt is located. Where two five-selector divisions and a ten-selector division are mounted on a shelf the two five-selector divisions are mounted on the half-shelf nearer the terminal end of the board. In order to distinguish between the two five-selector divisions, the half-shelf letter, which is common to both divisions, is suffixed by the letter "x" for the left-hand division

and is suffixed by the letter "y" for the right-hand division facing the selector bay, as shown in Figures 2 and 3, Drawing No. 807-76.

The selector positions are assigned numbers from "1" to "120" in each bay as shown in Figure 1, Drawing No. 807-76, and each selector is provided with a designation card upon which the number of the corresponding selector position is placed. The repeating coil equipment associated with a toll transmission selector is assigned the same number as the selector to which it corresponds.

At each first selector the designation card also shows the number of the associated primary or secondary trunk, and the number of the primary or secondsry subgroup including that trunk.

Bor each selector at which a trunk incoming from another machine switching office is terminated the designation card shows, in addition to the selector position number, the name of tha outgoing office, the number of the repeater associated with the trunk at the outgoing office and the number of the bay in which that repeater is located. For each selector at which a trunk from a manual office or from special service positions is terminated the designation card shows, in addition to the selector position number, the name of the originating office and the number of the trunk at that office.

A card is mounted between each selector shelf and the terminal end of the board, and shows for each division of selectors on the corresponding shelf where each outgoing trunk is terminated. For a trunk leading to a selector the card shows the number of the selector bay and the number of the selector position in that bay at which the trunk is terminated. For a trunk leading to a connector the card shows the number of the oonnector bay, the number of the shelf in that bay

and the number of the connector on that shelf at which the trunk terminates.

Where a trunk leads to another office through an outgoing trunk secondary switch the card shows the number of the outgoing trunk secondary subgroup and the number of the outgoing trunk secondary switch in that subgroup to which the trunk is cross-connected.

Where a trunk leads to another office without passing through an outgoing trunk secondary switch the card shows the number of the repeater bay and the number of the repeater in that bay to which the trunk is cross-connected.

Repeater Equipment.

Boards for mounting repeaters are built in units, each unit providing capacity for 320 repeater bases. Bach side of a unit, called a "bay", gravides capacity for 160 repeater bases. A bay contains eight shelves, each shelf providing capacity for 20 repeater bases. Repeaters are usually mounted one per base but certain types *may* be mounted two Per base.

Zach repeater bay is assigned a number prefixed by the letter "R". The bays in an office are numbered consecutively from "1" up. The bays are numbered in consecutive order in the direction of growth as described in connection with selector boards.

The repeaters in each bay are numbered consecutively from "1" up, the numbering progressing from left to right on each shelf and from the top shelf down ae shown in Figure 4, Drawing No. 807-76.

If two repeaters are mounted on the same base they are assigned consecutive numbers.

The repeater number is placed on a designation card mounted

Numbering of Selectore and Repeaters and Designations for Selector Shelves

| | | | | |
|---|---|---|---|---|
| 1 | A | B | 20 | Shelf AB |
| 21 | C | D | 40 | Shelf CD |
| 41 | E | F | 60 | Shelf EF |
| 61 | G | H | 80 | Shelf GH |
| 81 | I | J | 100 | Shelf IJ |
| 101 | K | L | 120 | Shelf KL |

Fig. 1

Showing Selector Position Numbering, and Shelf and Division Designations in a Bay where there are no 5-Selector Divisions

| | | | |
|---|---|---|---|
| | A | Bx | By |
| | C | Dx | Dy |
| | E | Fx | Fy |
| | G | Hx | Hy |
| | I | Jx | Jy |
| | K | Lx | Ly |

Terminal End of Board

Fig. 3

Showing Divieicn Deeignatione for a "Low-Side" Bay where 5-Selector Divisions are Inetalled on each Shelf

| | | |
|---|---|---|
| Ax | Ay | B |
| Cx | Cy | D |
| Ex | Ey | F |
| Gx | Gy | H |
| Ix | Iy | J |
| Kx | Ky | L |

Terminal End of Board

Fig. 2

Showing Division Designations for a "High-Side" Bay where 5-Selector Divisions are Installed on each Shelf

| | |
|---|---|
| 1 | 20 |
| 21 | 40 |
| 41 | 60 |
| 61 | 80 |
| 81 | 100 |
| 101 | 120 |
| 121 | 160 |
| 161 | 200 |

Fig. 4

Showing Repeater Numbering in a Bay where the Repeaters are Mounted Two per Baee on the Two Lower Shelves

on the repeater base. For a repeater associated with a trunk to a machine switching office this card also shows the name of the incoming office, and the number of the selector bay and the number of the seleator poeition in that bay at which the trunk terminates. For a repeater associated with a trunk to a manual office the designation card shows, in addition to the repeater number, the name of the manual office, and the number of tne panel and jack at which the trunk terminates, or the number of the switchboard position at which it terminates together with the number of the trunk in the position.

Connector Equipment.

Boards for mounting connectors are built in units, each unit providing capacity for 50, 110 or 160 oonneators. lach side of a unit, called a "bay", provides capacity for 25, 55 or 80 connectors. A bay contains five shelves, each shelf providing capacity for 5, 11 or 16 connsctore,

lach bay is assigned a number prefixed by the letter "C". The various bays in an office are assigned consecutive numbers from "1" up, except as noted below in connection with lines or rows of connector boards arranged for growth. The bays in a given line or row are numbered in order, progressing in the direction of growth of the line or row. Odd numbers are assigned in order to the bays on one side of each line, disregarding aisle spaces if any, and even numbers are assigned in order to the bays on the other side of each line, the two bays of any ona unit being assigned consecutive numbers. In general, the lowest numbered bays in a line or row are those nearest

the line intermediate distributing frame. Where space is reserved to provide for the growth of a line or row, the bays should be numbered initially so that in the ultimate the numbering in each line will be consecutive as just described.

A shelf of connectors is designated by the hundreds number of the group of terminals which are served by the connectors on that shelf. The shelves in a bay are numbered consecutively from the top down, the numbering being continued from the bottom shelf of one bay to the top shelf of the bay which is next higher in number, as shown for a typical case in Figure 1, Drawing No. 807-77. Where a group of connectors is divided among two or more shelves in the same bay, the shelves are distinguished by adding a literal suffix to the hundreds number; e.g. shelf 21-A, 21-B, 21-C, etc.

The connectors (excluding the test connector) on a shelf are numbered consecutively from "1" up, the No. 1 connector on each shelf being at that end of the board which is farthest from the connector board terminal strips, as shown in Figure 2, Drawing No. 807-77. The test connector is located at the extreme end of the shelf next to the No. 1 connector. Each connector is provided with a designation card showing its number, the card for a test connector being marked "TEST". A card, mounted between the fuse panel and the terminal strips for each shelf, shows the number of the primary line switch bay and the number of the line switch in that bay to which each of the working terminals in the corresponding connector group is cross-connected.

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# STEP-BY-STEP MACHINE SWITCHING SYSTEM

## Numbering of Connector Equipment

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Information
Engineering
Draftsman
Aug. 1, 1920

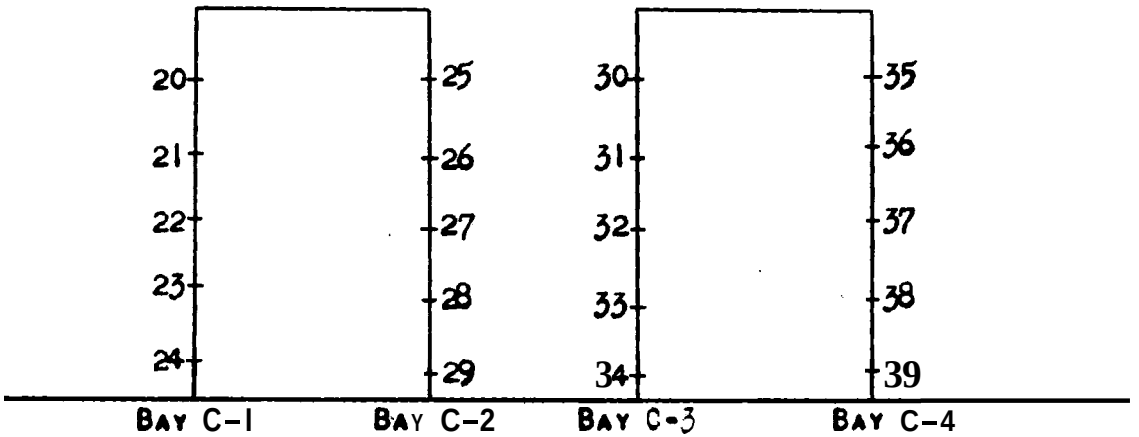



Fig. 1
Typical Numbering of Connector Bays and Shelves

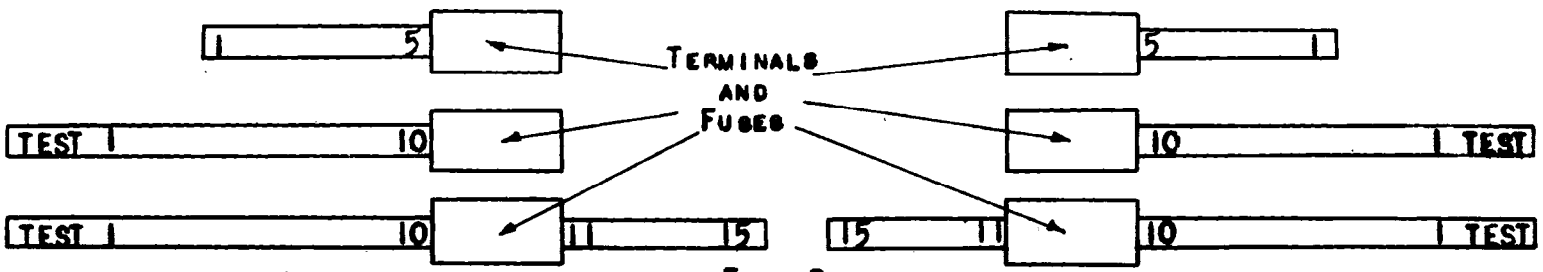



Fig. 2
Numbering of Connectors on a Shelf

# CABLING AND WIRING

## General

The cabling for a typical office in a single office district is shown schematically in drawing No. 807-66. Drawings No. 807-45, No. 807-46, show schematically the cabling of an office in a multi-office district. Drawings Nos. 807-66 and 807-46 show a common intermediate distributing frame for cross-connecting subscribers' lines and the trunks from the primary and secondary line switchboards.

Drawing No. 807-45 shows a separate trunk intermediate distributing frame. The common intermediate distributing frame makes a more desirable arrangement and should be used except where a substantial saving in switchboard cables can be obtained by using a separate trunk intermediate distributing frame. With a common intermediate distributing frame it is possible to connect certain lines directly to first selectors without going through line switches as is explained in Div. IV, by cross-connections op the intermediate distributing frame.

In some cases floor plan considerations may make it desirable to provide tao trunk intermediate distributing frames, one for cross-connecting the trunks from the primary to the secondary line switches, and one for cross-connecting the trunks, from the secondary line switches to first selectors.

Photographs Nos. 10 and 28 show two views of cable runs in an existing installation.

### Switchboard Cables:

Cables used with step-by-step equipment will be the Western Electric Company's standard switchboard cables, using

enameled wires. Where no special precautions against moisture need be taken, Western Electric Company's standard cable of the No. 5000 type will be used. Where special moisture conditions are aet, Western Slectric Company's moistureproof cables of the No. 1000 type will be used. In determining where moistureproof cables are required the same considerations hold as in manual practice.

Hand-formed Cablee:

The hand-formed cables betseen the line switch, selector, or connector banks and the terminal assembly will be made up of moistureproof wire (double cotton covered enameled wire) in all cases in order to have but one manufacturing standard. The wiring running fron bank to bank, is aadc up of loose wires not formed up into a cable and is not subject to moisture trouble. This wiring will be made up of tinned, single silk and single cotton covered conductors.

Cross-connecting Jumpers:

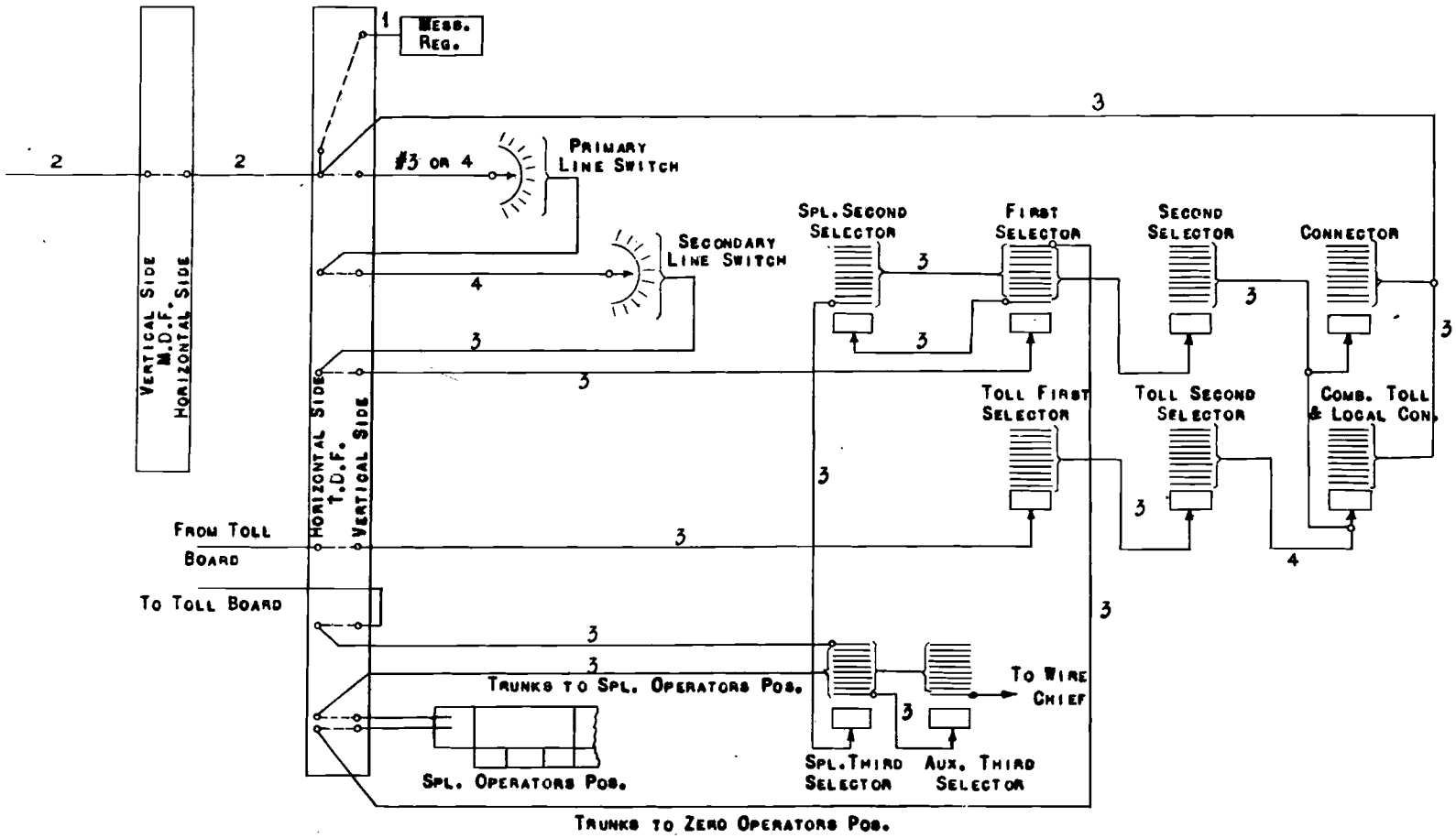
For distributing frame cross-connecting wires the present standards used in manual practice will be provided and the same consideration will govern their use. For cross-connecting the trunke from the primary line switches to the secondary line switches a four-conductor jumper wire will be used.

Cable Racks:

For the most part the cable racks are supported directly on the frameworks of the various boards and are not hung from the ceiling except where necessary to support extra long runs between boards.

# MACHINE SWITCHING SYSTEM

## STEP BY STEP TYPE EQUIPMENT
## CABLING SCHEMATIC DIAGRAM FOR OFFICE IN SINGLE OFFICE DISTRICT




NOTE: THE NUMERALS INDICATE THE NUMBER OF CONDUCTORS PER CIRCUIT.
*FOUR CONDUCTORS FOR MESSAGE REGISTER LINES.
THREE CONDUCTORS FOR ALL OTHER LINES.

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ENGINEERING DEPARTMENT

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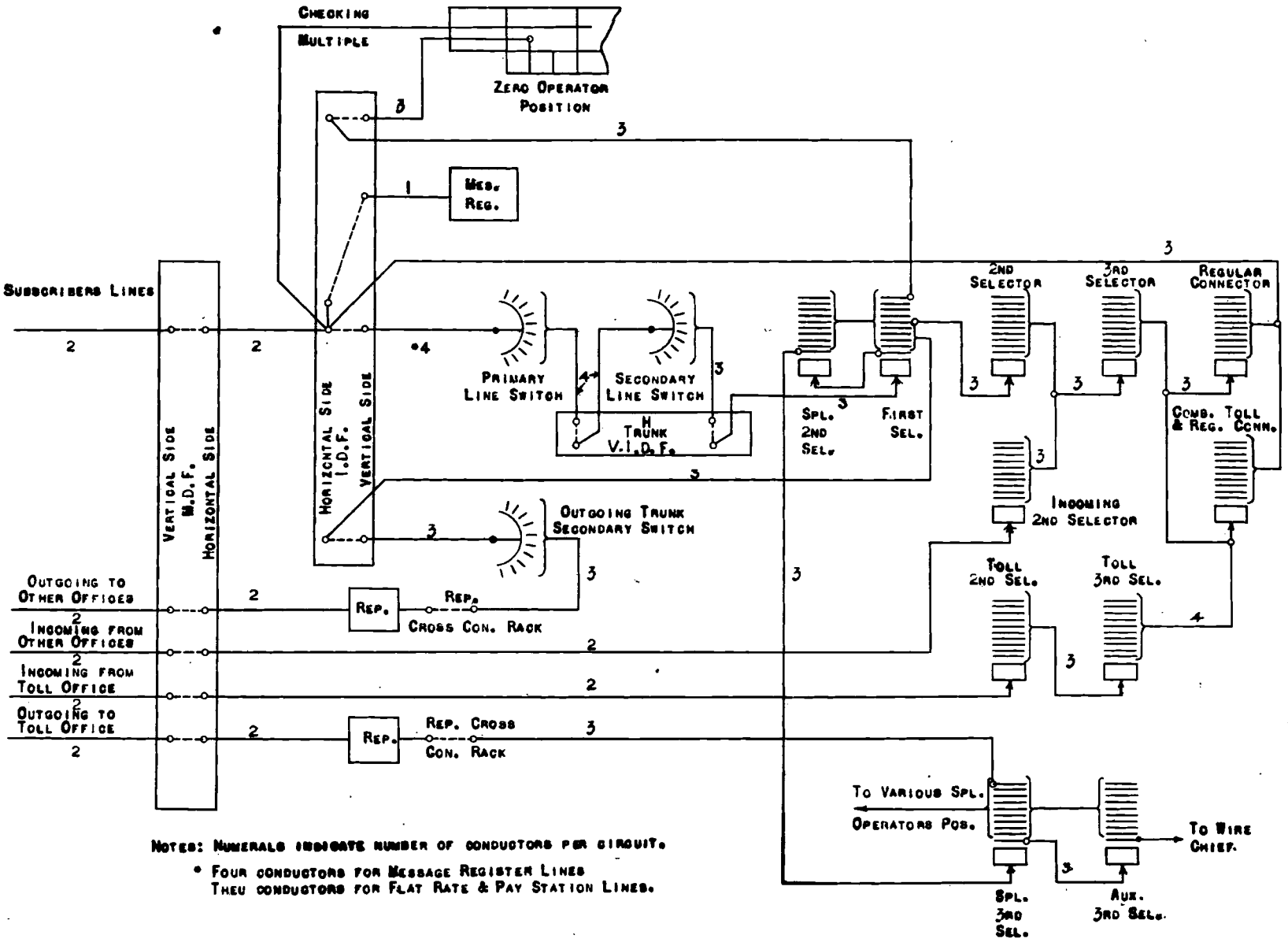
JAN. 7, 1920

# MACHINE SWITCHING EQUIPMENT

## STEP BY STEP TYPE EQUIPMENT
## CABLING SCHEMATIC DIAGRAM
## SHOWING SEPARATE TRUNK INTERMEDIATE DISTRIBUTING FRAMES
## MULTI-OFFICE DISTRICT




NOTES: NUMERALS INDICATE NUMBER OF CONDUCTORS PER CIRCUIT.

* FOUR CONDUCTORS FOR MESSAGE REGISTER LINES
THEU CONDUCTORS FOR FLAT RATE & PAY STATION LINES.

American Telephone & Telegraph Co.
Engineering Department

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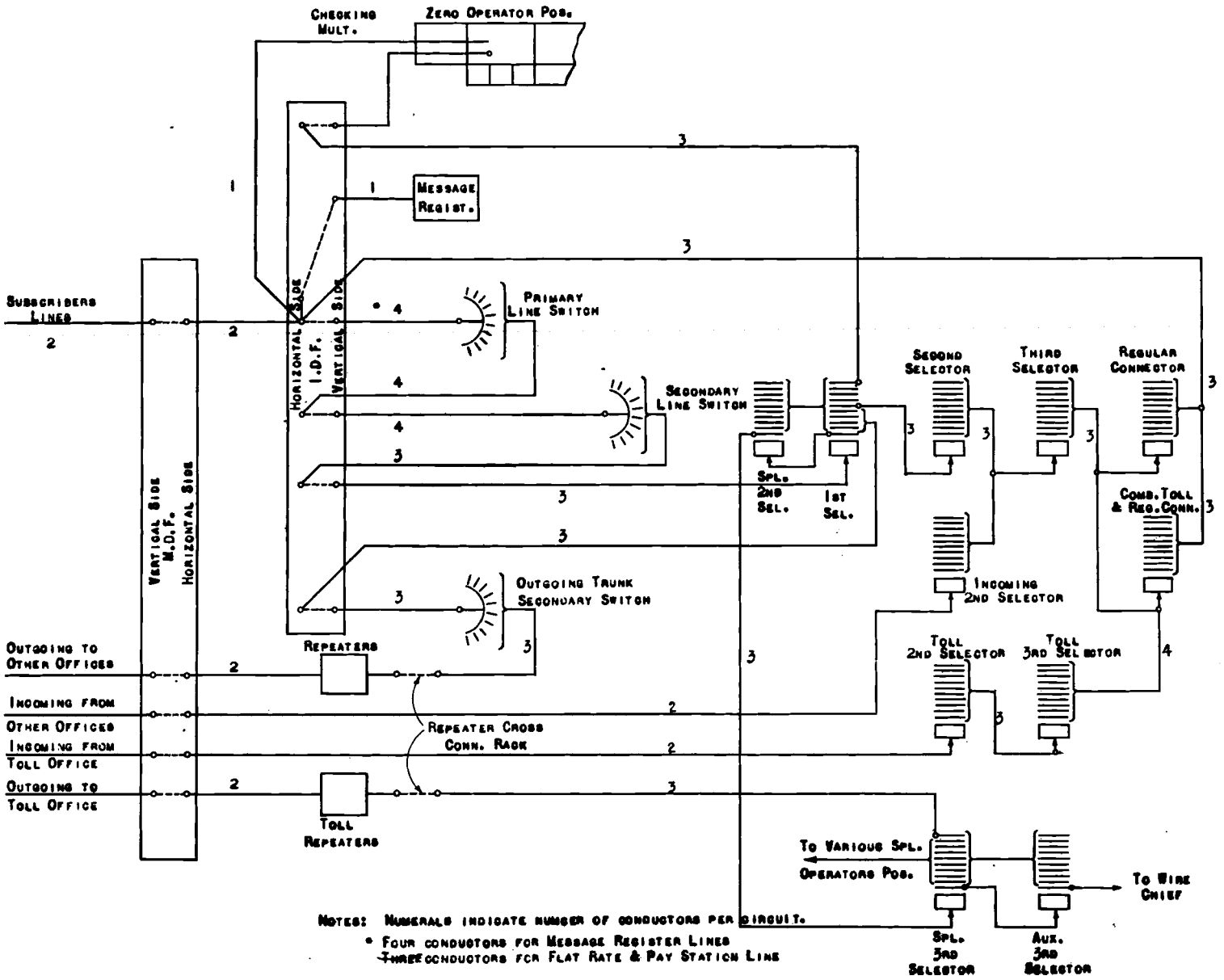
Engineer
Draftsman
Checked by

Jan. 8, 1920

# Machine Switching System

Step by Step Type Equipment
Cabling Schematic Diagram
Showing Cross Connections made on Line Intermediate
Distributing Frame
Multi-Office District




Notes: Numerals indicate number of conductors per circuit.
* Four conductors for Message Register Lines
~~Three~~ conductors for Flat Rate & Pay Station Line

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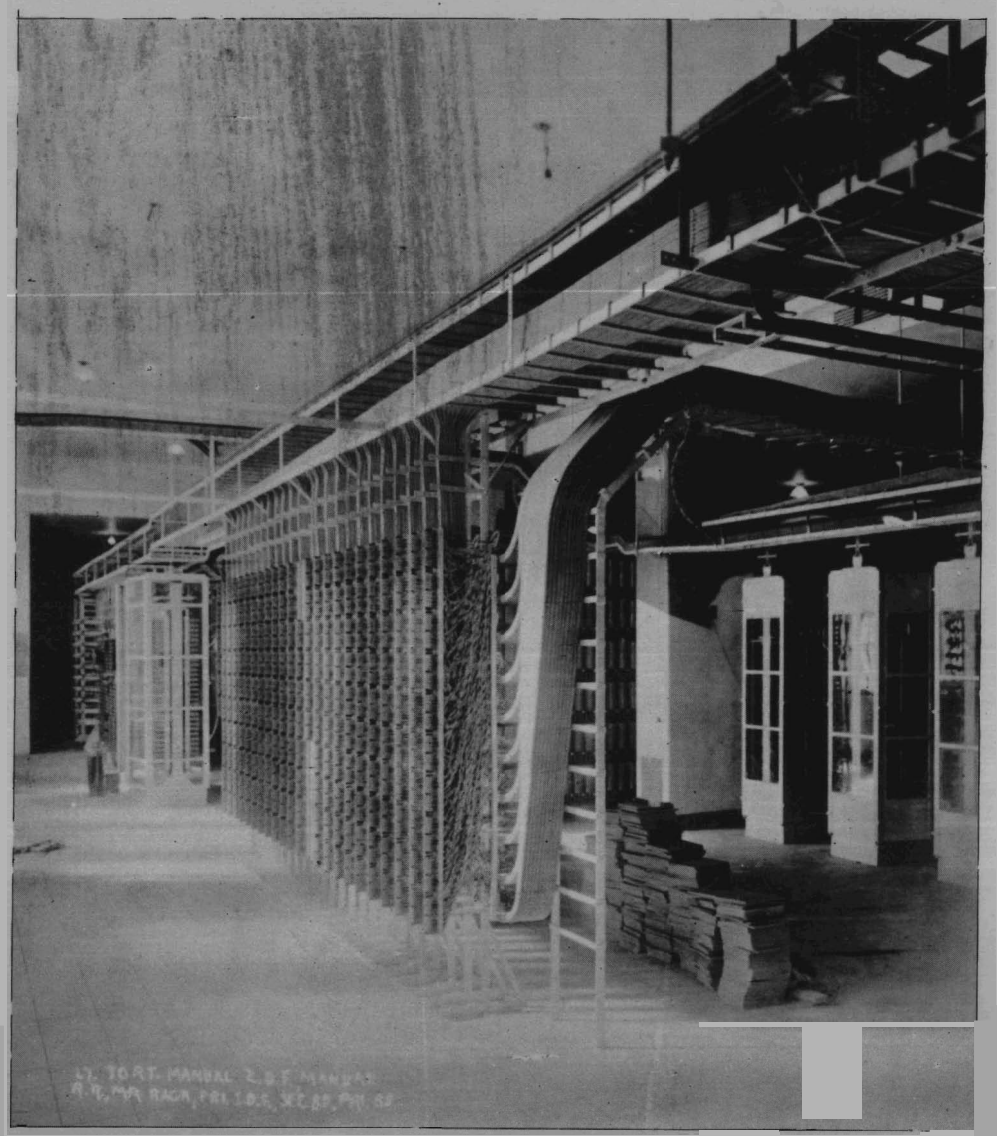
STEP BY STEP MACHINE SWITCHING SYSTEM

Trunk I.D.F. Cable Runs

No. 10

May 1, 1920.



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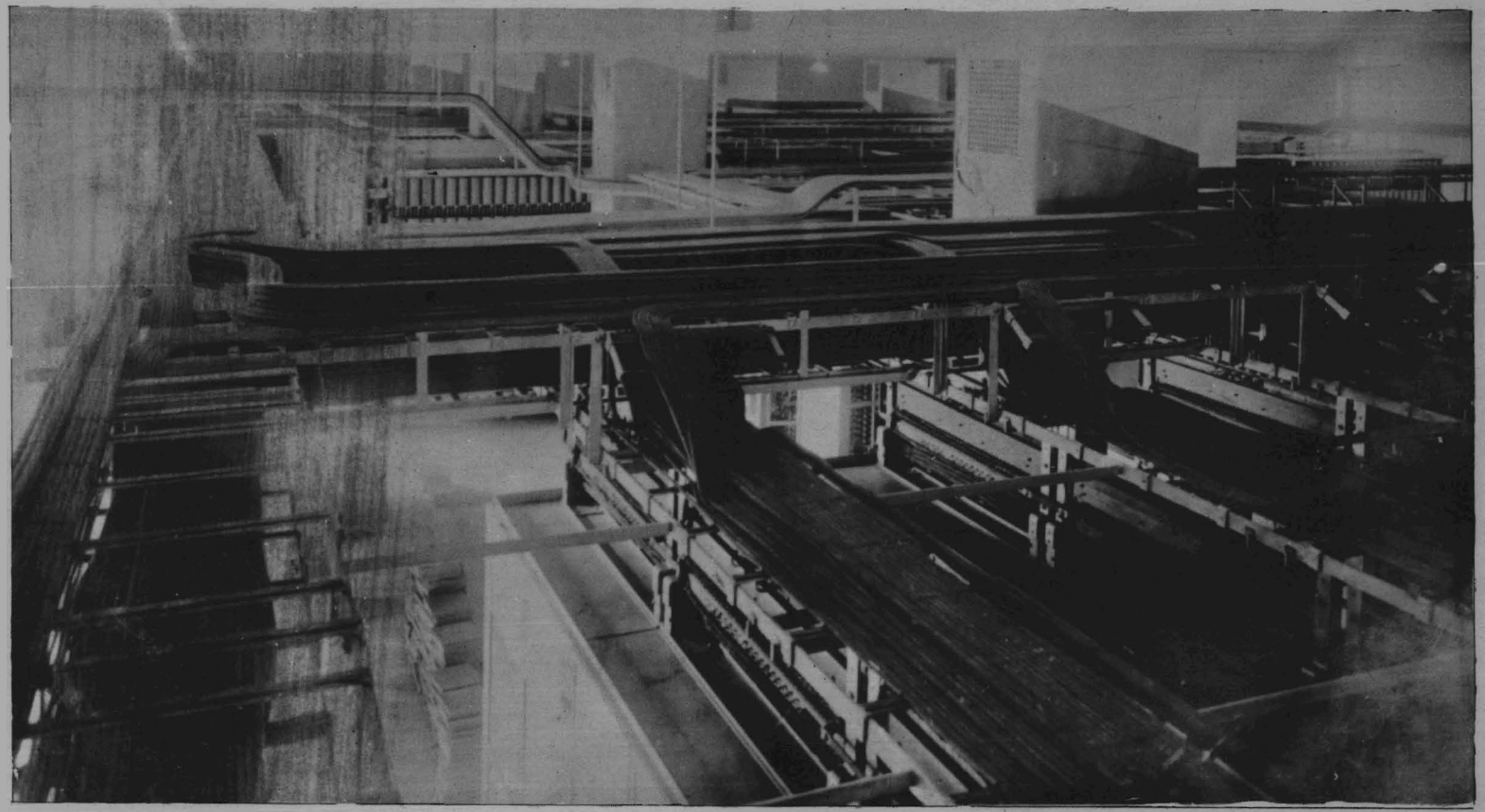
STEP BY STEP MACHINE SWITCHING SYSTEM

No. 28

May 1, 1920

Cable Runs over Primary Line Switchboards



# SUBSCRIBERS' LINE CIRCUIT

## Individual Flat Rate Lines.

Figure 1 of Drawing No. 807-98 shows the cabling and wiring arrangement of an individual flat rate line provided with checking multiple. The line from the subscriber's station is terminated on protectors on the vertical side of the M.D.F., is cross-connected to the horizontal side, and is cabled to the horizontal side of the I.D.F. From the horizontal side of the I.D.F., the line is cabled to a terminal strip mounted on the connector board. Fron that point, the line is connected to the connector banks by means of local wiring.

The subscriber's line is also cross-connected to the vertical side of the I.D.F. and is cabled to flat type terminal strips at the top of the line switchboard. Local wiring connects these terminals to the line switch. A multiple of the private conductor extends from the horizontal side of the I.D.F. to the checking multiple et the machine switching *A" board. Where checking multiple is not installed, the cabling arrangement is the same as that shown in Figure 1, except that *the* checking multiple lead ia omittad.

As described in Division IV, trunk-hunting connectora are provided with four-wire banks and the two pri-

vate conductors of each P.B.X. line, except the last line of a P.B.X. group, are straoped together. These straps are installed at the terminal strips at the connector boards, as indicated on Drawing No. 807-98, and only three wires per circuit are carried to the I.D.F.

It was formerly the practice to carry both private conductors of each circuit to the I.D.F. and to install the necessary strapping at that point. With this arrangement, only one strap per circuit was required, even when the connectors of a group were located on more than one shelf. With the arrangemeat shown on Drawing No. 807-98, it will be necessary in some casea when the connectors of a group are located on more than one shelf to install more than one strap per circuit, and this will have the effect of slightly increasing the cost of making P.B.X. trunk group changes. It is thoupht, however, that this increaee will be more than offset by the saving in cabling resulting from the use of three-wire instead of four-wire circuits to the I.D.B.

Individual Message Register Lines.

In step-by-step offices where message regiater service is rendered, the most economical scheme for wiring and cabling the message register leads depends in general on the percentage of message register lines which may be

expected in the ultimate. Although this also applies in the case of manual offices, an additional factor to be considered in step-by-step offices serving P.B.X. lines is that part of the subscribers' multiple is definitely associated with the regular connector groups while the remainder is definitely associated with the trunk-hunting connector groupe; that is, the P.B.X. lines, and as a general rule the non-P.B.X. lines, are not assigned indiscriminately. It follows, therefore, that where message register service is to be given for lines in both the regular and trunk-hunting connector groups, the most desirable message register cabling and wiring arrangement for the lines in the trunk-hunting connector groups may or may not be the most desirable arrangement for the lines in the regular connector groups. It also follows that if message register service for the lines in the trunk-hunting connector groupe is to be rendered, but that no message register provision need be made for lines in the regular connector groupe, substantial savings may be effected by eliminating all message register terminal equipment and wiring on the lines associated with the regular connectors.

The particular message register wiring plan that should be used in any given case should therefore be determined by considering the lines in the trunk-

hunting connector groups as forming one class, and the lines in the regular connector groups as forming another class, and by then apglying the limits, which are given later in this section, separately to each of these two general classes of lines.

Figure 2 of Drawing No, 807-98 shows one of the methods of oabling and wiring a line in a regular conneotor group, where the line is equipped with both checking multiple and a message register. It is ooneidered standard to use the method of oabling and wiring shown in this figure in offices where it is estimated that in the ultimate the number of message register lines in the regular connector groupa will not exceed 100. It is expected that there will be but little occasion for using this scheme of oabling for lines in the trunk-hunting connector gronps, since in the majority of oases where P.B.X. message register service is rendered, the P.B.X. message register lines will probably constitute a fairly high percentage of the total number of P.B.X. lines in the office.

The message register requires a fourth conductor between the vertical side of the I.D.F. and the terminal assembly on the line switchboard. This fourth conductor, together with the tip, ring and private oonduotore of the line, are cross-connected to an extra four-point terminal strip on the horizontal side of the frame. From this

terminal strip, the message register conductor is cabled to the message regieter rack and the tip, ring and private conductors are cross-connected to the regular subscriber's terminals on the horizontal side of the I.D.F. The gurpoae of this method of wiring is to permit the use of three-point terminal strips on the horizontal side of the I.D.F. for all lines in the regular connector groups, at the same time providing a flexible arrangement whereby any of these lines may be grovided with a message register.

Figure 3 of Drawing No. 807-98 shows one method of wiring and cabling a line in either a trunk-hunting or regular connector group, where the line is equipped with both checking multiple and a message register. It is considered standard to use the method of cabling shown in thir figure for trunk-hunting connector groups and also for regular connector groups where it is estimated that in the ultimate the total number of message register lines in the class being considered will be less than 25 percent. of the total number of lines in that class. (In the case of regular connector groups having not more than 100 message register lines in the ultimate, the plan shown in Figure 2 is employed as previously described.) With the method shown in Figure 3, the message register conductor, together with the tip, ring and private conductore of the line, are cross-connected to the hori-

zontal side of the I.D.F. in the regular way. At the horizontal side, the message register eonduetor is strapped to an adjacent punching on the same block and is cross-connected to a separate message register terminal on the vertical side. The purpose of the extra punching on the horizontal side is to avoid soldering the two message register cross-connections to one punching. The message register conductor 4s cabled from the separate message register terminal on the vertical side of the I.D.F. to the message register rack.

Figure 4 of Drawing No. 807-98 shows another method of wiring and cabling a line equipped with bath checking multiple and a message register. It is considered standard to use the method of cabling shown in this figure for lines in the trunk-hunting connector groups, and also for lines In the regular connector aroups, where it is estimated that in the ultimate the number of message register lines of the class being considered will be more than 25 percent. but less than 100 percent. of the lines of that class. The method shown in Figure 4 differs from that shown in Figure 3 in that the message register conductor on the horizontal side of the I.D.F. is cabled to a separate message register terminal on the same side of the frame, and from the latter terminal is cross-connected to a separate message register terminal an the

vertical eide.

The arrangement of the terminal stripe used for the additional meseage register terminals on the H.I.D.F. and for the message register terminals on the V.I.D.F. is the same as described in Specifications No. 3634, "Standard Intermediate Distributing Frames." The special sleeve terminal referred to in the Specifications corresponds to the extra message regiater terminal on the H.I.D.F.

The arrangement shown in Figure 4, ae compared with that shown in Figure 3, possesses the advantages that it reduces the ahances of disconnecting the message register unintentionally when changing line switch cross-connectiona and also, in some casee, permits the use of shorter message register jumper wires.

Figure 5 of Drawing No. 807-98 shows still another method s· wiring and cabling a line equipped with both checking multiple and a message register. It is considered standard to use this arrangement for lines in the trunk-hunting connector groups, and also for linee in the regular connector groups, where it is estimated that in the ultimate approximately all of the lines of the class being coneidered will be of the message regiater type. When practically all lines of a class are of this type, there is but comparatively little advantage in introducing a cross-connection between the regiater and the line

multiple terminal, and in such cases therefore the registers are cabled directly to the connector multiple on the horizontal side of tha I.D.F., as shown in Figure 5.

Lines Terminated Directly on Pirat Selectors.

As mentioned in Division IV, it may be desireble under some conditions to terminate a subscriber's line directly on a first selector rather than on a primary line switch. In this case, the first selector differs slightly from a regular first selector for circuit reasons.

The cabling and wiring arrangement employed where a flat rate line is terminated directly on a first selector is similar to that shown on Drawing No, 807-98, Figura, 1.

Where the trunk I.D.F. (on which the cross-connections in the trunks to the regular first selectors are made) is separate from the line I.D.F., the tip, ring and private leads from the V.I.D.F. are carried in a single cable to the horizontal side of the trunk I.D.F. and there are cross-connected to the vertical side. From that point, the tip, ring and private leads are carried in a single cable M the jacks of the first selector. The aabling between the line I.D.F. and the first selector is taken through the trunk I.D.F. in order that the selector may later be used as a regular selector if desired.

Where the trunk I.D.F. is combined with the line I.D.F., the tip, ring and private leads from the vertical side are carried in a single cable directly to the jacks of the first selector.

The cabling and wiring arrangements employed at the I.D.F. where a message register line ia terminated directly on a first selector are in general the same as those shown on Drawing No. 807-98 except that the tip, ring and private conductors are carried in a single cable to the first selector in the same manner as described in connection with a flat rate line terminated directly on a first selector. The message register conductor ia carried in a separate cable.

Two-Party Lines.

Drawing No. 807-99 shows the cabling and airing arrangements for two-party flat rate lines, and also for two-party message rate lines terminated on answering jacka.

Figure 1 shows the cabling and wiring arrangement for a two-party flat rate line provided with checking multiple where the double cross-connection method is used at the I.D.F. It is considered standard to use thie method where it is estimated tbat the number of two-party lines in the ultimate will not exceed ten per cent. of the total number of lines in the office.

Pigure 2 shows the cabling end wiring arrange-

ment for a two-party flat rate line provided with checking multiple where six-point terminal stripa are provided on the vertiual side of the I.D.F. The interchange of tip and ring conductors between the two stations on the line is made by straps on the six-point terminal strip. This method obviates the two prinoipal disadvantages of the double cross-connection scheme, namely, the termination of two sets of jumpers at the same set of terminals and the necessity for exercising special precaution in running the cross-connection to insure the proper interchange of tip and ring oonduotors.

It is considered standard to provide aix-point terminal atrips on the vertical side of the I.D.F. for all flat rate subscribers' lines where it is estimated that the number of two-party lines in the ultimate will constitute ten percent. or more of the total number of lines.

Figure 3 shows the standard cabling and wiring arrangement Ior a two-party ressage rate llne equipped with checking multiple. As noted in Division I, there is no circuit available at the present tim. for handling the originating traffio of message rate party lines on a mechanical basis in a step-by-step office. For such lines, the outgoing traffio is handled on a ranual basis and the incoming trafflo on a machine switching basis.

The arrangement shown in Figure 3 is similar to that shown in Figure 1 with the exception of the terminal strip and cabling on the vertical side of the I.D.F. The cabling to the answering jack and to the relay rack is terminated at a five-point terminal strip on the V.I.D.F.

The general arrangement described in connection with Figure 2 has not been standardized for two-party message rate lines since in cases where such lines are served by a step-by-step office, their number will ordinarily be small. Furthermore, that arrangement would require the installation of eight-point terminal strips on the vertical side of the I.D.F. and the use of snoh terminal strips would be somewhat objeotionable from a cost and maintenance standpoint.

A general study has been made to determine whether bunching blocks should be employed for two-party lines. It is estimated that there would be very few if any cases where the use of bunching blocks for two-party lines would be justified, and as a result the use of these blocks for such lines haa not been standardized.

Four-Party Lines.

Drawing No. 807-100 shows the cabling and wiring arrangements for four-party flat rate and four-party message rate lines. As previously noted, the originating traffic on message rate party lines is handled manually

and the incoming traffic mechanically.

Figure 1 shows the standard cabling and wiring arrangement provided where a four-psrty flat rate line is aired for checking multiple and where the regular interframe cabling for one of the stations is used for the line circuit.

Figure 2 shows the atandard cabling and wiring arrangement provided where a four-party flat rate line is wired for checking multiple and where an extra cable pair ia carried from the bunching blook on the I.D.F. to a terminal strip on the horizontal side of the M.D.F. and from that point, cross-connected to the subscriber's line. With this arrangement, the line is cabled from the horizontal side of the M.D.F. to the line switch side of the I.D.F. instead of the connector multiple side. It is, therefore, unnecessary to rearrange the cross-connections in case Station No. 1 is disconnected, as would be necessary with the arrangement shown in Figure 1.

Figure 3 shows the standard cabling and wiring arrangement provided where a four-party message rate line is wired for checking multiple and where the regular interframe cabling for one of the stations is used for the line circuit.

Figure 4 shows the atandard cabling and wiring

arrangement provided where a four-party message rate line is wired for checking multiple and where an extra cable pair is carried fron the bunching block on the I.D.F. to a terminal strip on the horizontal side cf the M.D.F., as described in connection with Figure 2.

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Dept. of
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# STEP-BY-STEP MACHINE SWITCHING SYSTEM

Subscribers' Line Cabling and Jumper Wiring.
Individual Lines, Including P.B.X. Trunk Lines.

807-98
Information
Engineer-
Draftsman- but
Checked by-
May 1, 1922

## CABLING AND WIRING ARRANGEMENT FOR FLAT RATE LINES

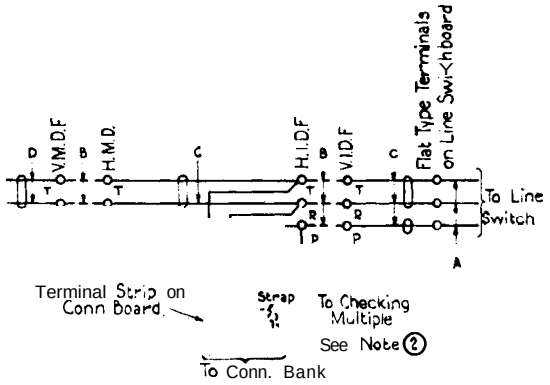


Fig. 1

## NOTES

(1) When checking multiple is not installed checking multiple lead from P terminal is omitted

(2) Where cabling is provided for P.B.X. trunk lines, this wiring and terminal are provided, the strap being omitted on the last line of each P.B.X. group.

(3) Where flat rate lines are terminated on message register line switches, the cabling and wiring arrangement is the same as for a message register line, the message register being replaced by a compensating resistance

A - Local Wiring
B - Jumper Wiring
C - Cable
D - Outside Cable

## CABLING AND WIRING ARRANGEMENTS FOR MESSAGE REGISTER LINES

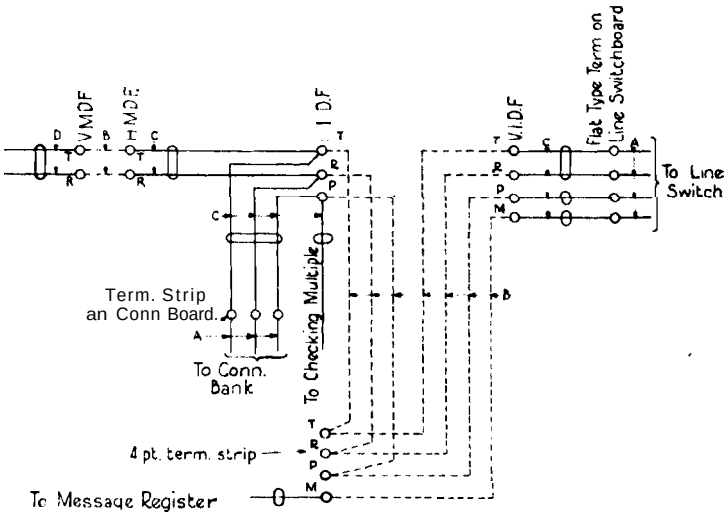


Fig. 2

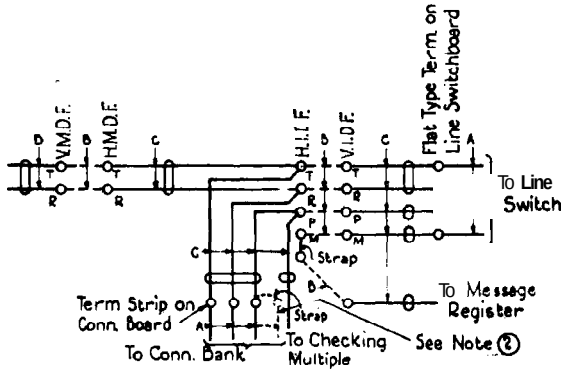


Fig. 3

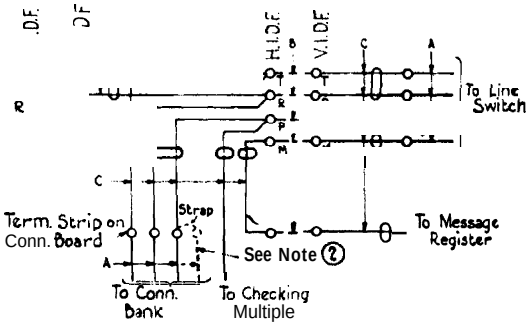


Fig. 4

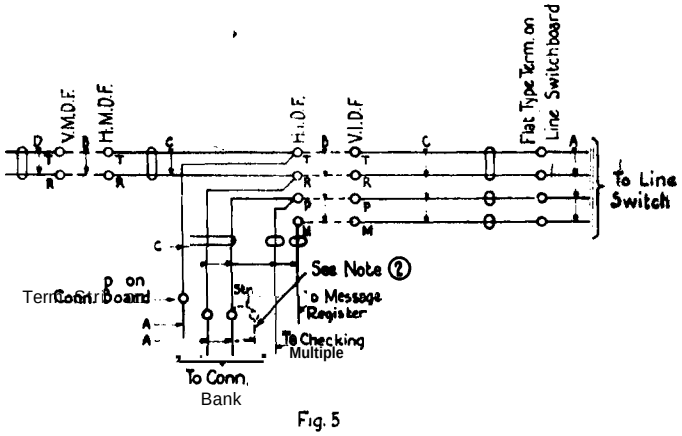


Fig. 5

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# STEP BY STEP MACHINE SWITCHING SYSTEM

Subscribers Line Cabling and Jumper Wiring.
Two-Party Flat Rate and Two-Party Message Rate Lines

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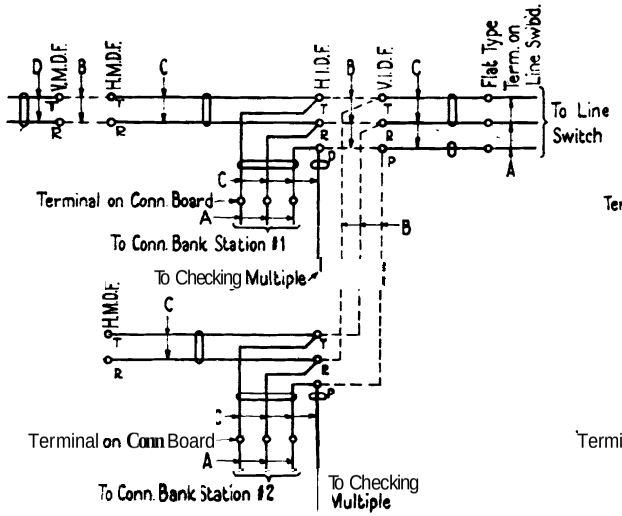
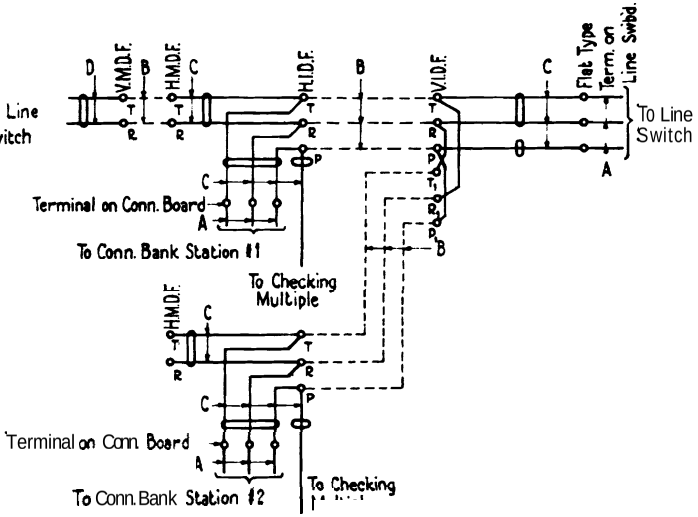
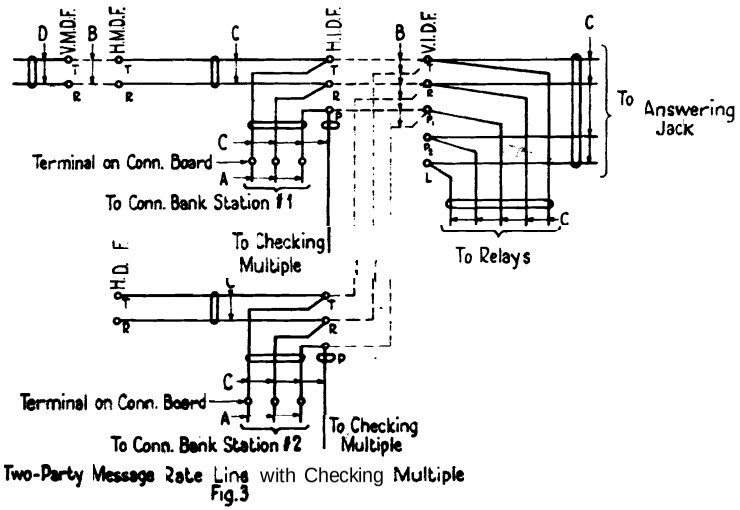
May 1, 1922




Two-Party Flat Rate Line with Checking Multiple. Double Cross Connection Method
Fig.1




Two-Party Rat Rate Line with Checking Multiple. Six-Point Terminal Strip Method
Fig.2




Two-Party Message Rate Line with Checking Multiple
Fig.3

## -NOTES-

1- When Checking Multiple is not installed, the Checking Multiple Lead from the P terminal s omitted.

2- In case service to Station H is discontinued, it is necessary to transfer and reverse the main frame jumper in order to give service to Station #2

A- Local Wiring
B- Jumper Wiring

D- Outside Cable

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# STEP BY STEP MACHINE SWITCHING SYSTEM

Subscribers Line Cabling and Jumper Wiring
Four-Party Flat Rate and Four-Party Message Rate Lines

**807-100**
Information

Engineer
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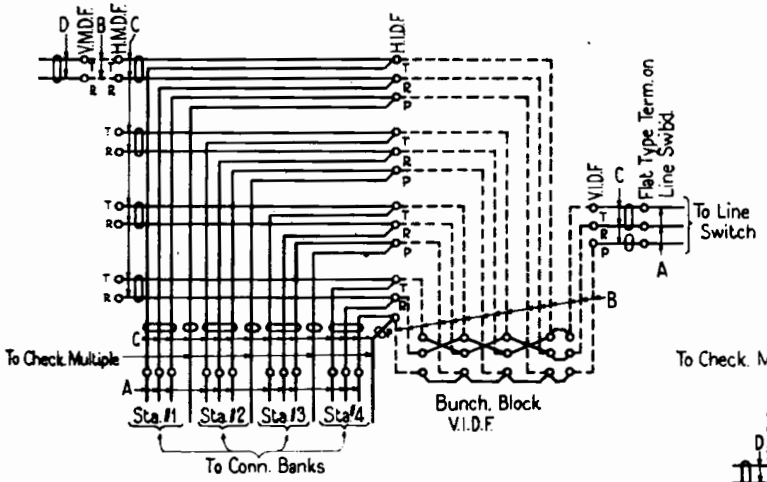
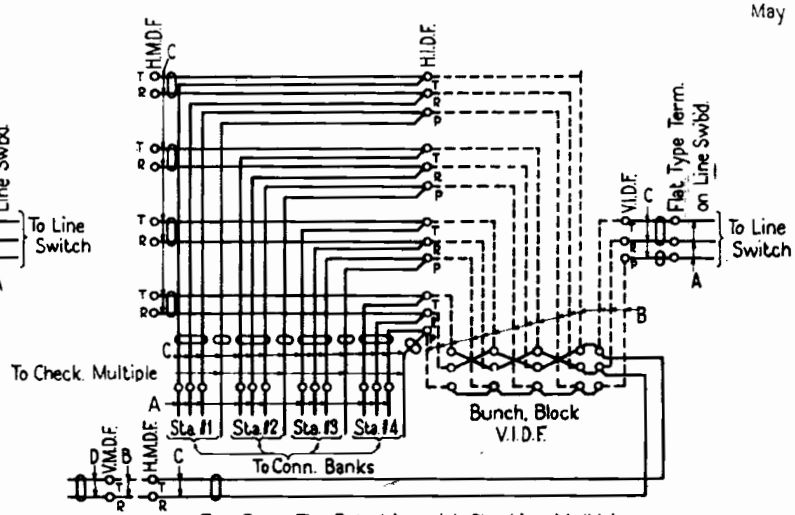
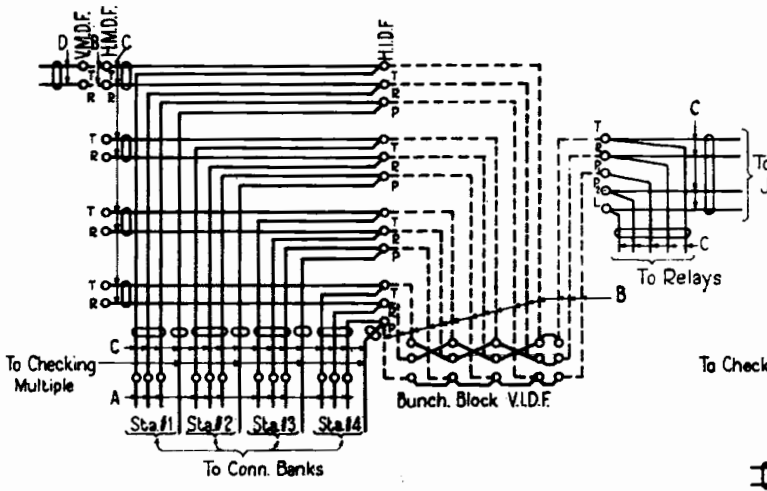
Checked by
May 1, 1922.



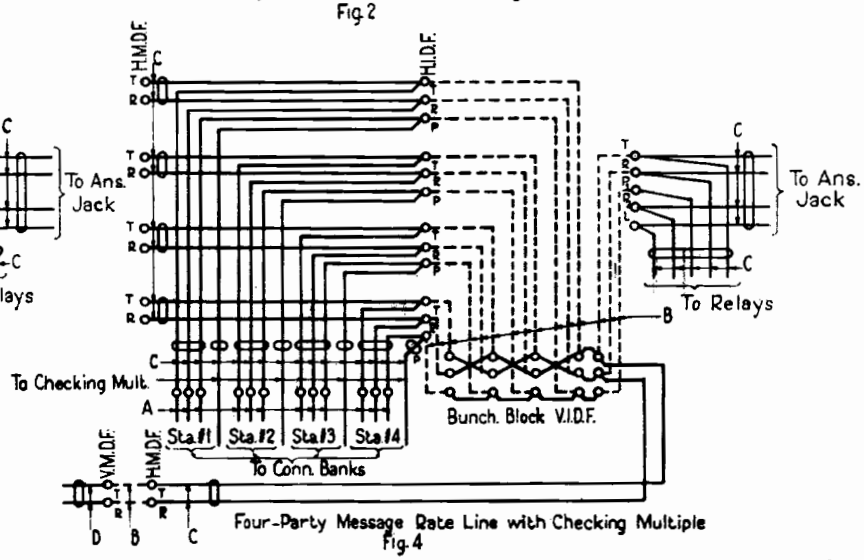

Four-Party Flat Rate Line with Checking Multiple
Fig. 1




Four-Party Flat Rate Line with Checking Multiple
Fig. 2




Four-Party Message Rate Line with Checking Multiple
Fig. 3




Four-Party Message Rate Line with Checking Multiple
Fig. 4

## -NOTES-

When Checking Multiple is not installed the Checking Multiple lead from the P terminal is omitted.

2 Bunching block consists of a six-point terminal strip having a capacity for eight four-party lines.

3 In Figs 1 and 3, if service to Station #1 is discontinued and there are other parties on the line, the main frame jumper is transferred and if necessary, reversed.

A- Local Wiring
B- Jumper Wiring
C- Cable
D- Outside Cable

# Terminal Assembly on Line Switchboards

## Primary Line Switchboards:

Drawing No. 807-56 shows typical terminal assemblies on a primary line switchboard. Fig. 1 shows terminal assembly where 10 trunke are multipled through 100 line switches. Fig. 2 shows terminal assembly where 10 trunke are multipled through 75 line switches. Fig. 3 shows terminal assembly where 10 trunks are multipled through 50 line switches. Fig. 4 is a wiring diagram showing the connections to the terminals.

The battery aide of the B.C.O. coils of the line switchea are wired to terminale in the next to the bottom strip, Fig. 1, and are multipled tnrough two other stripa by means of strap wires as indicated. The battery lead from the fuse panel is multipled through all the terminals in the bottom strip. Four additional terminal strips are provided through each of which a separate battery lead may be multipled, each lead having a distinctive tone superimposed upon it, If no tone is wanted upon a particular line the terminal of that line in the next to the bottom etrip is bent down and soldered to the baftery terminal beneath it. If tone No. 1 is wanted a terminal carrying battery and tone No. 1 is eoldered to one of the multiple terminals of that line. In this way the current supply to the B.C.O. coil of any line switch may nave no tone superimposed upon it or it may have any one of four tones as required to indicate the class of service of the particular line.

## Secondary Line Switchboürds:

Drawing No, 807-64 shows a tvpical terminal assembly for a bay of secondary line switches. It is similar to the terminal as-

sembly on the primary line switchboards except that provision is made for four cables of outgoing trunks, one for each division of switches and no provision is made for superimposing tones on the B.C.C. windings of the line switches.

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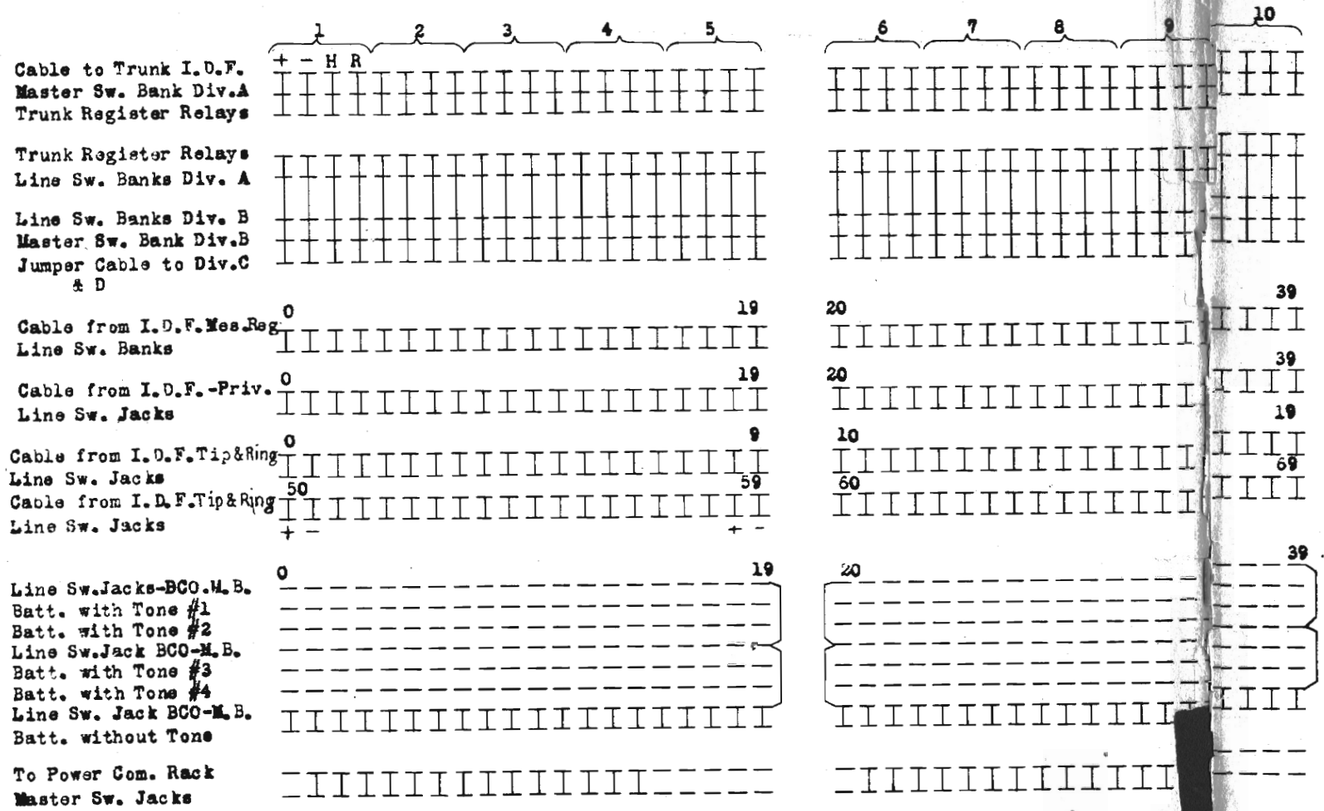
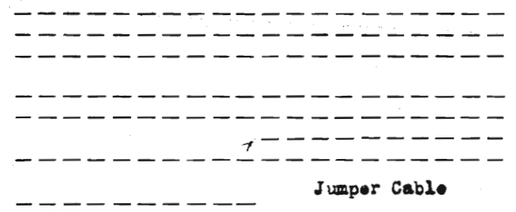


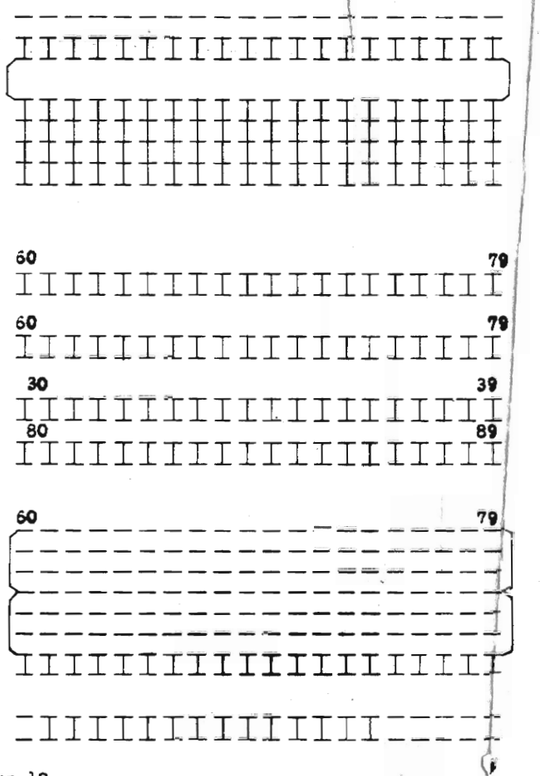
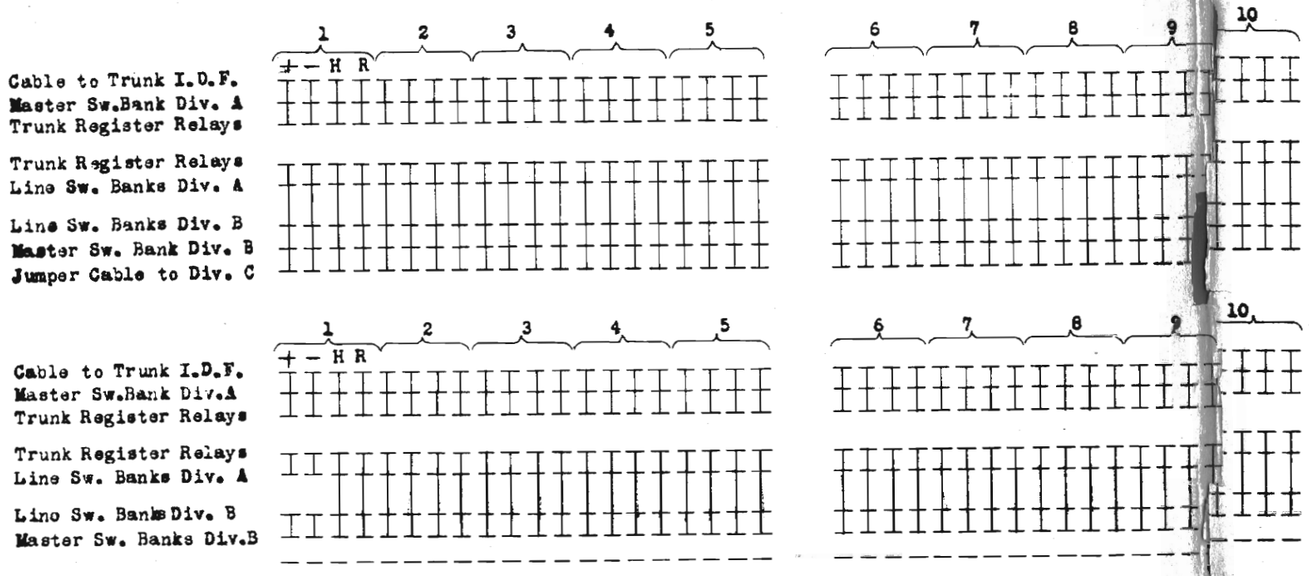




Fig. 1 Terminal Assembly Arranged for Multipling 10 Trunks through 100 Line Switches



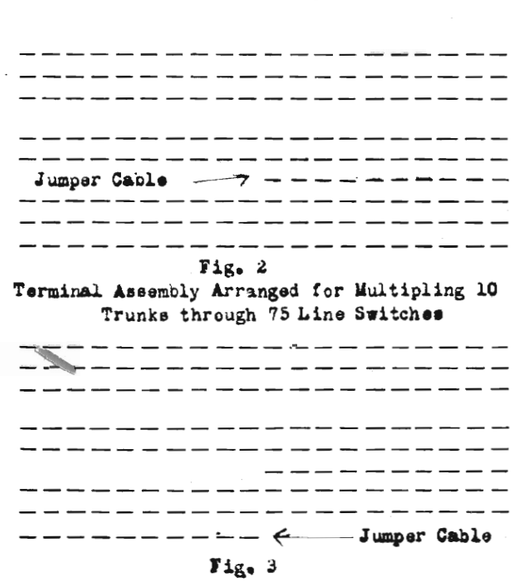




Fig. 2
Terminal Assembly Arranged for Multipling 10 Trunks through 75 Line Switches

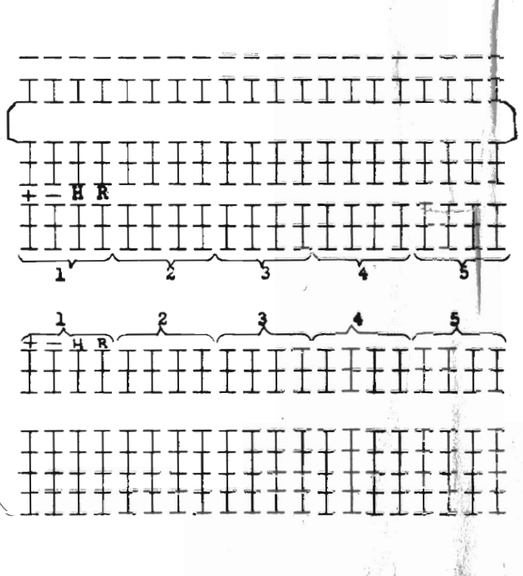
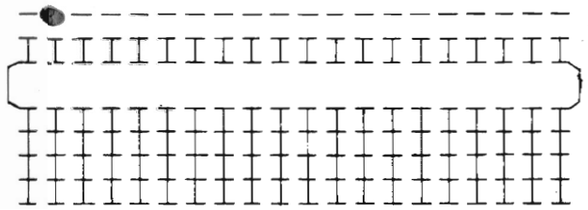


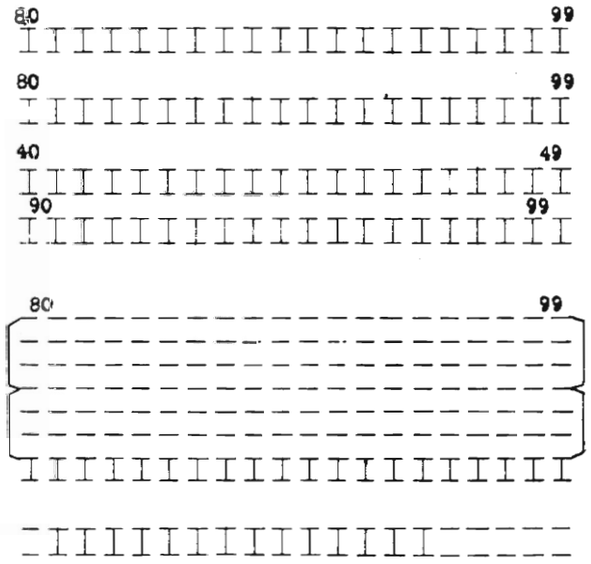

Fig. 3
Terminal Assembly Arranged for Multipling 10 Trunks through 50 Line Switches

Terminal Assembly for
Primary Line Switch Boards



Master Sw. Bank Div. C
Wired for Trunk Reg.
Relays but not equipped

Line Sw. Banks Div. C
Jumper Cable to Divs. A & B
Line Sw. Banks Div. D
Master Sw. Bank Div. D




From Line
I.D.F.

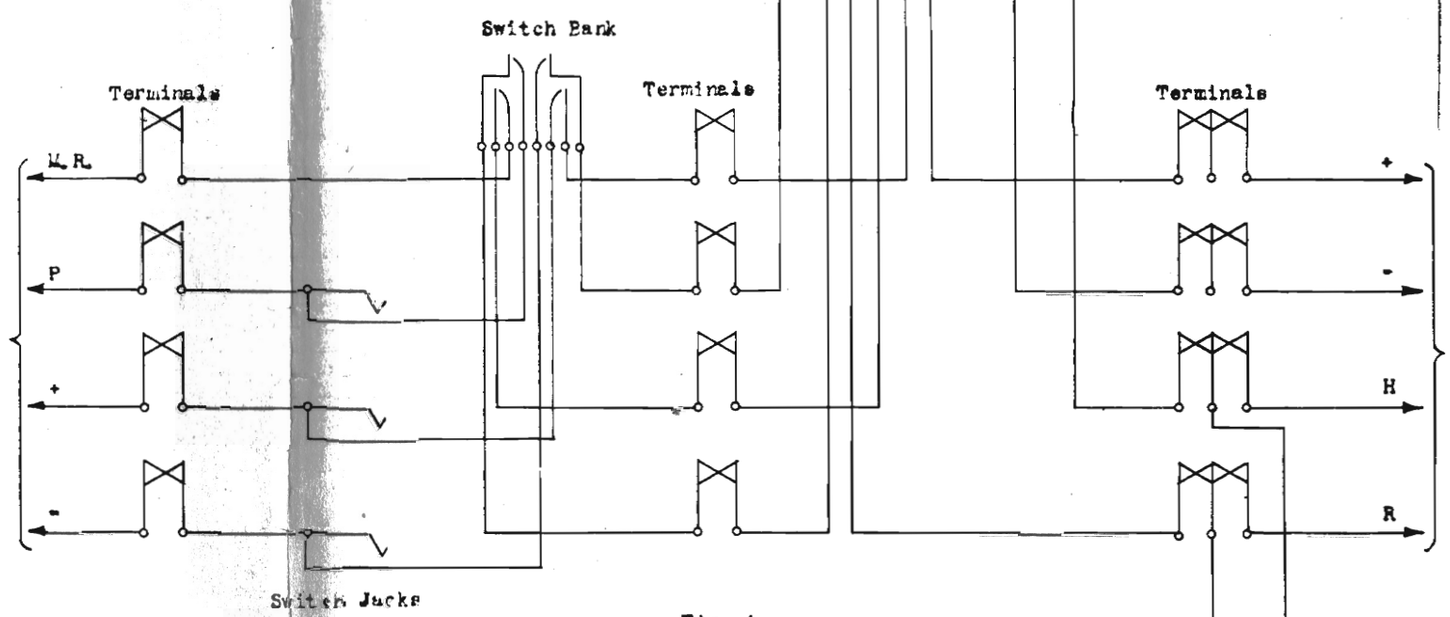
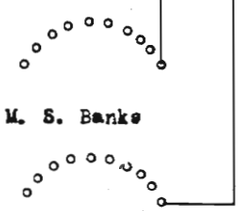
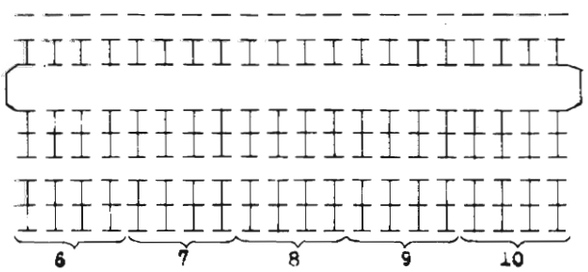


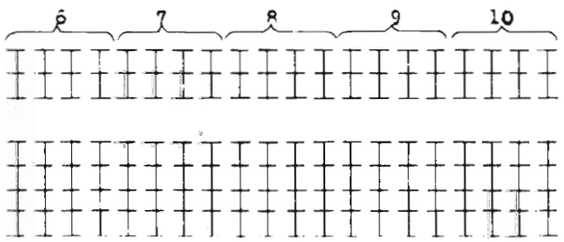

Fig. 4
Wiring Diagram
of
Terminal Assembly




Master Sw. Bank - Div. C
Wired for Trunk Reg. Relays
but not equipped

Line Sw. Banks - Div. C
Jumper Cable to Div. A & B
Line Sw. Bank Div. D
Master Sw. Bank Div. D
To Term. Assy. next bay




Cable to Trunk I.D.F.
Master Sw. Bank Div. C
Trunk Reg. Relays

Trunk Reg. Relays
Line Switch Banks Div. C

Line Switch Banks Div. D
Master Sw. Banks Div. D

## Trunks from Primary Line Switches to Secondary Line Switches

Trunks from the primary line switchboards to secondary line switchboards are cabled through an intermediate distributing frame in order that the trunks from each subgroup of primary line switches can be distributed over several subgroups of secondary switches, as described in Division IV, Section 2. The four-conductor trunks are cabled ten trunks per cable from the terminal assembly of the primary line switchboards to terminal strips on the horizontal side of the intermediate distributing frame. Each terminal block has capacity for 20 trunks or two cables.

Trunks from the intermediate distributing frame to the secondary line switchboards are cabled from terminals on the vertical side of the intermediate distributing frame to the terminal assembly on the secondary line switchboards. Each bay of secondary line switches has a capacity for 100 switches. Four 51-pair cables are run to each bay. Each cable carries the tip, ring, holding and release conductors for the 25 switches of one division.

Terminal strips with 20 sets of terminals per strip are provided at the vertical side of the intermediate distributing frame. Accordingly, five strips are required for the four cables running to one bay of secondary line switches.

## Trunks from the Secondary Line Switches to First Selectors

The trunks from the secondary line switches to the first selectors are carried through an intermediate distributing frame in order that the trunks from any one subgroup of secondary line switches can be terminated in different half-shelves of first selectors, as described in Division IV, Section 3.

The trunks from the secondary line switches are wired in a hand-formed cable from the switch banks to the terminal assembly mounted above the switchboard as shown in drawing No. 807-64. Cables carrying 10 trunks with 3 conductors each extend from this terminal assembly to terminals on the horizontal side of the intermediate distributing frame, each strip having capacity for 20 trunks or 2 cables. They are cross-connected to terminal strips on the vertical side where cables to the first selectors are terminated, 20 trunks per strip. The cables from the distributing frame to the first selectors terminate at the selector end directly on selector jacks, each cable serving 10 selectors on one half-shelf.

Where the trunks from the primary line switchboards run directly to first selectors they are cabled from the terminal assembly on the primary line switchboards, 10 trunks per cable, 4 conductors per trunk, the same as though secondary switches were used, to the horizontal side of the intermediate distributing frame. This provides for adding secondary line switches later should it prove desirable to do so. They are cross-connected by means of 3-wire jumper connectors to the terminals on the vertical side whence they are cabled, to the first selectors as described in the preceding paragraph.

## Trunks From First Selectors to Second Selectors

### Selector Board Terminal Assembly.

As explained in Division IV, the 20 selectors on one shelf are usually arranged in two divisions of 10 each. The selector banks of each division of 10 selectors are multipled together and the 100 trunks, 10 for each of the 10 levels, are brought out to the terminal assembly, as indicated in Drawing No. 807-57. This is shown in detail for one division of selectors in Drawing No. 807-58. One terminal strip has a capacity for 100 terminals and as each trunk has three conductors, 100 trunks from one division require 300 terminals or three strips. All the private conductors of the 100 trunks are connected to the top strip from left to right in the following order; trunks 1 to 10 first level, trunks 1 to 10 second level, etc. The second strip carries the tip and ring conductors for the 50 trunks of the even numbered levels, and the third strip the tip and ring conductors of the five odd numbered levels.

Photograph No. 29 shows the bank wiring of a division of ten selectors and the local cable connecting the last bank to the three flat type terminal strips.

Each of these three strips is placed on a separate mounting, each mounting carrying the terminals for 20 selectors. This is indicated in Drawing No. 807-57. Each mounting carries, in addition to the terminals of the bank wiring, terminals of cables leading to terminals on another shelf or to selectors mounted on another board.

In some cases, where it is desirable to multiple 15, 25 or 35 selectors together to furnish the proper load for 10 trunks, the arrangement shown in Drawing 807-65 may be used. The 20 selectors on one shelf are multipled in 3 divisions instead of 2. The division nearest the terminal assembly, contains 5 selectors, the next division 5 selectors, and the last division 10 selectors. The 100 trunks, from each division are brought out to separate terminal strips in the terminal assembly as shown.

Terminal Assembly Diagram.

Diagrams showing the arrangement of terminals in the terminal assembly, usually show the private conductors only. Where all 10 trunks from each level in a division of selectors are carried in one cable, terminal assembly diagrams can be still further simplified by representing the 10 terminals of the trunks from each level by a single line. Figure 1 of Drawing 807-59 is a diagram for one shelf of selectors. Each of the 10 horizontal lines in the second row from the top represent the 10 private terminals of the 10 trunks from one level of the first division of selectors on the shelf shown. The third row represents the private terminals of the trunks from the second division of selectors on that shelf. Figure 2 shows in detail the same arrangement as that shown in Figure 1. The top row of terminals is used to terminate the cables outgoing from this board. The 10 trunks from each level are run in one cable. The diagram as shown is for a first selector board and the cable carrying the trunks from the first level terminates at special second selectors, the cable carrying the trunks from the second level terminates on local second selectors, the cable from the fourth level terminates on inter-office repeaters, etc.

In some cases, where it is desirable to multiple 15, 25 or 35 selectors together to furnish the proper load for 10 trunks, the arrangement shown in Drawing 807-65 may be used. The 20 selectors on one shelf are multipled in 3 divisions instead of 2. The division nearest the terminal assembly, contains 5 selectors, the next division 5 selectors, and the last division 10 selectors. The 100 trunks, from each division are brought out to separate terminal strips in the terminal assembly as shown.

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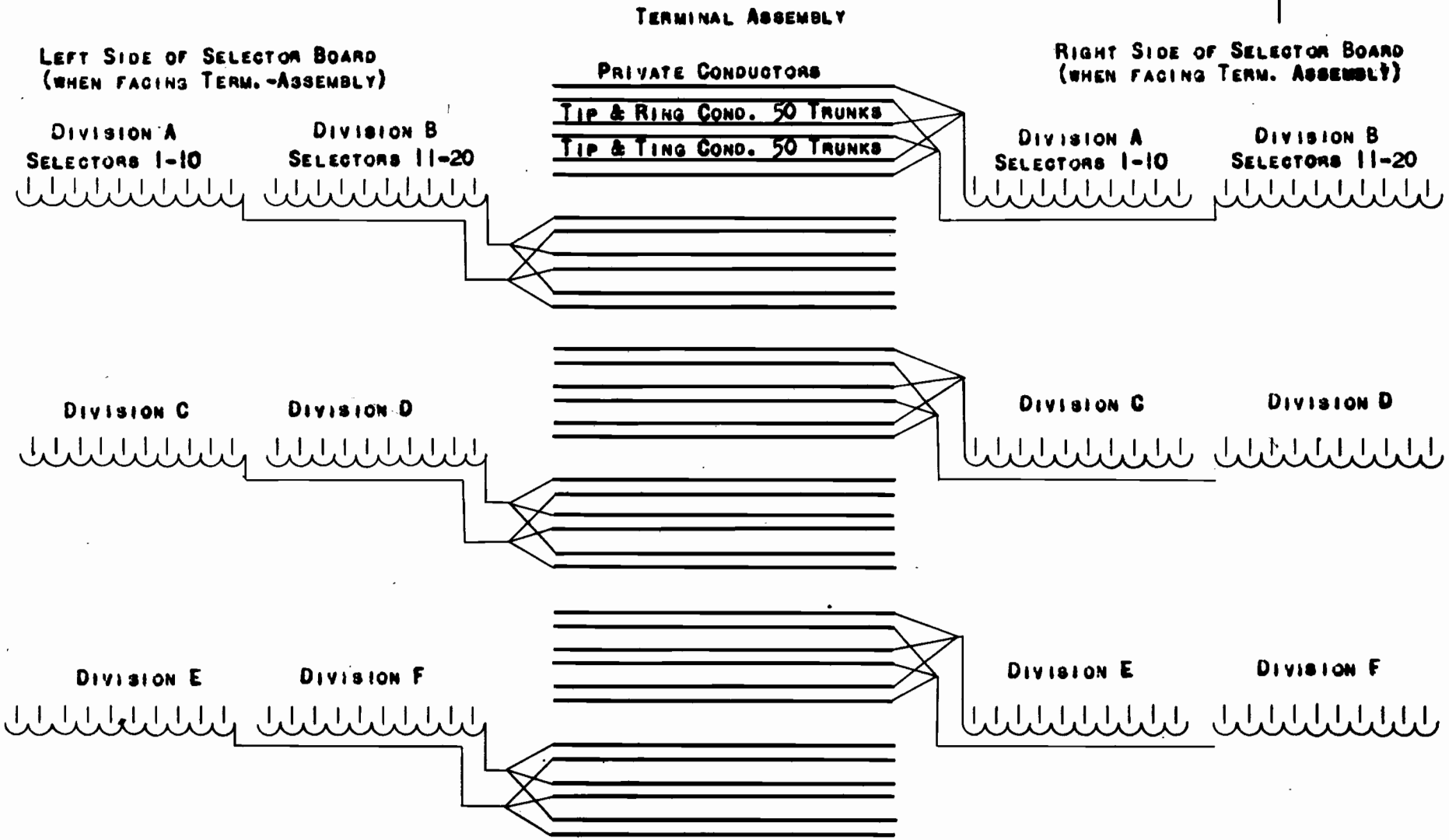
ENGINEER
DRAFTSMAN
CHECKED BY
DEC. 22, 1919

ISSUE 1.

# STEP-BY-STEP MACHINE SWITCHING SYSTEM

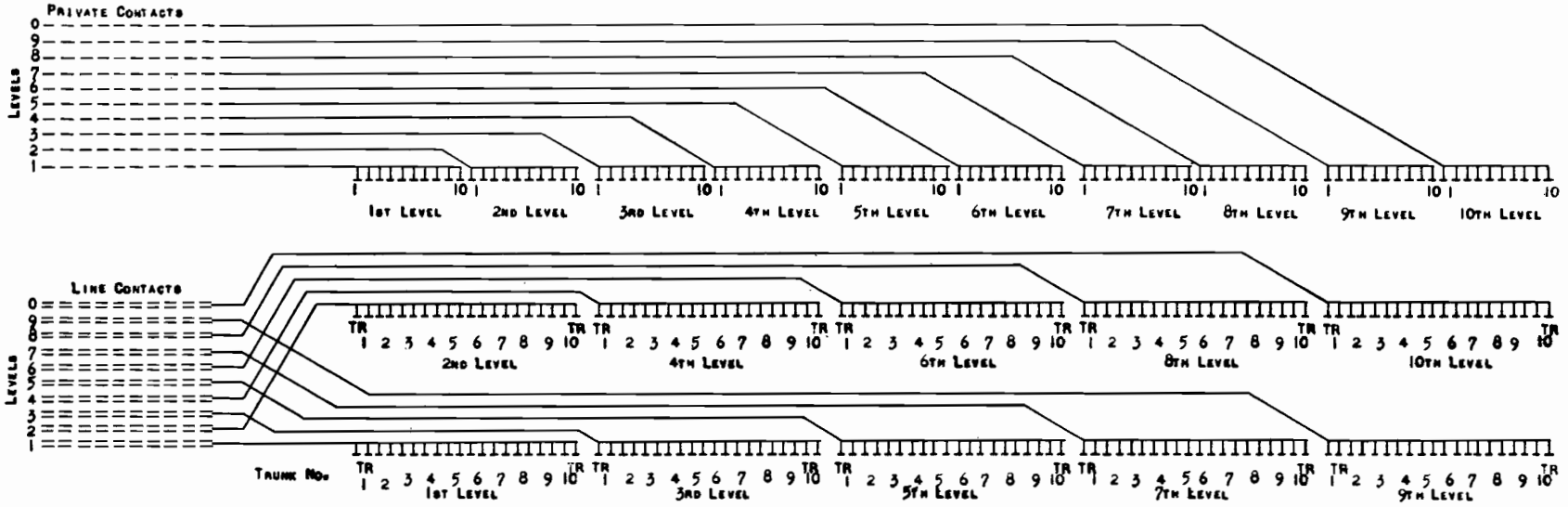
## TERMINAL ASSEMBLY ON SELECTOR BOARD
## SHOWING WIRING FROM SELECTOR BANKS TO TERMINAL ASSEMBLY
## SELECTORS MULTIPLEDIN TWO DIVISIONS



STEP-BY-STEP MACHINE SWITCHING SYSTEM

TERMINAL ASSEMBLY ON SELECTOR BOARD
DETAILED ARRANGEMENT OF SELECTOR BANK TERMINALS

BANK OF LAST SELECTOR ON SHELF

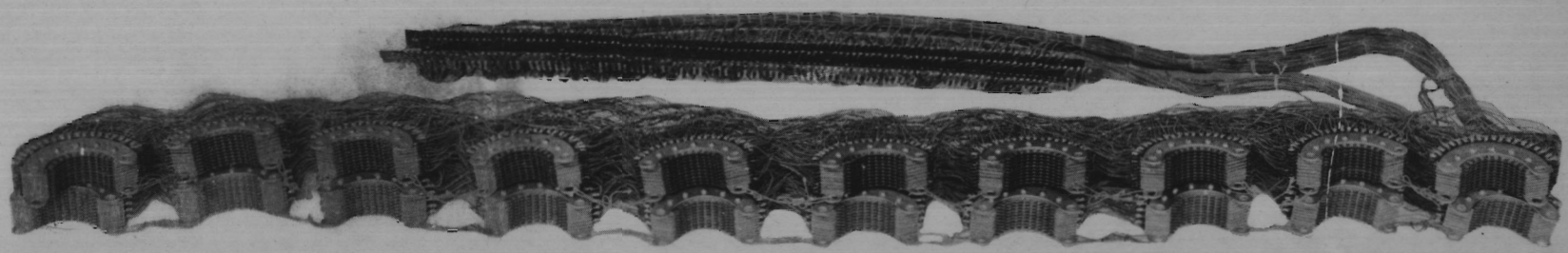


A. T. & T. Co.
Eng. Dept.

# STEP-BY-STEP MACHINE SWITCHING SYSTEM

## The Banks, Bank Wiring, Terminal Strips and Connecting Cable for a Division of Selectors

Photograph No. 29
May 1, 1920



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ENGINEER
DRAFTSMAN
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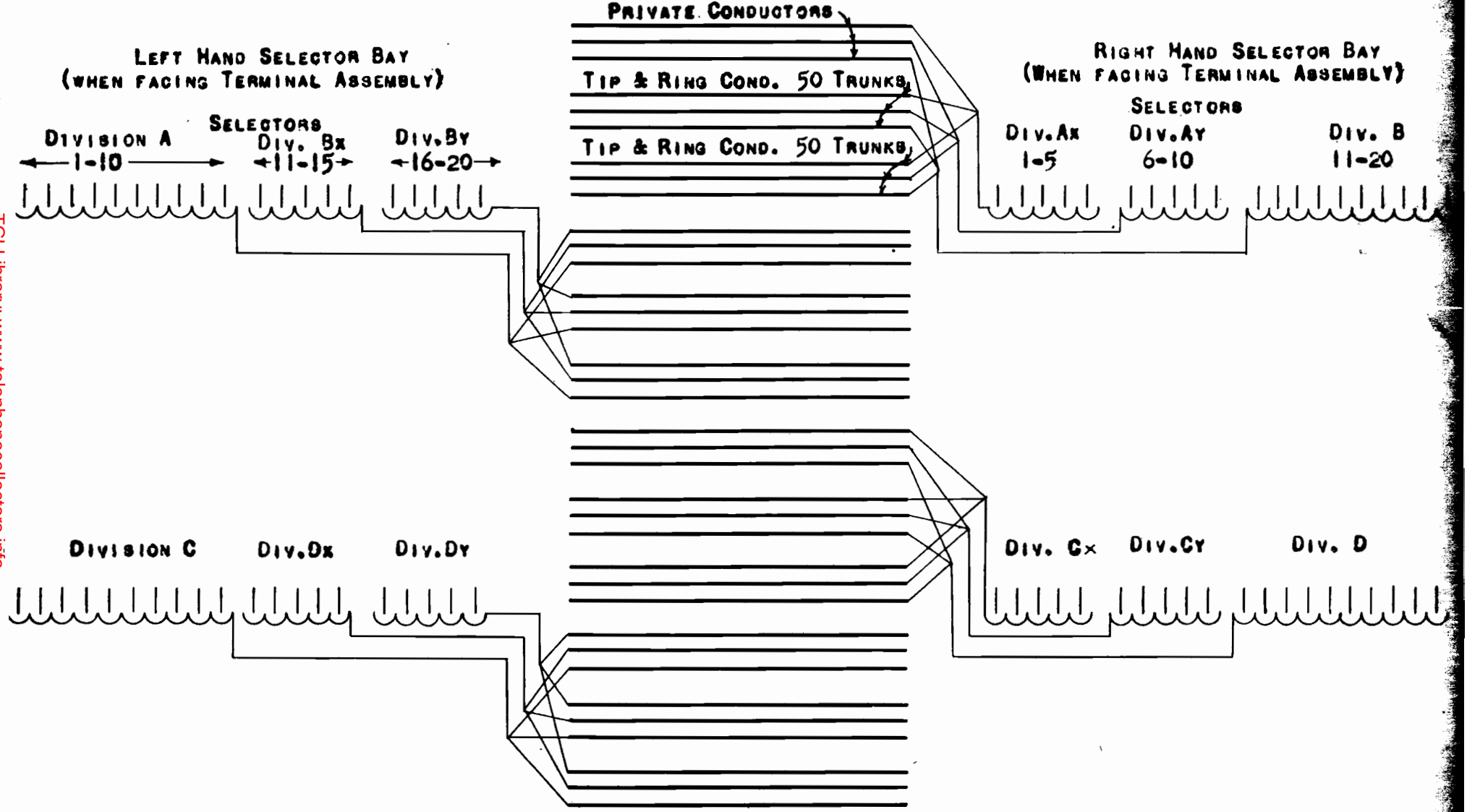
DEC. 22,
ISSUE 1.

# STEP-BY-STEP MACHINE SWITCHING SYSTEM

## TERMINAL ASSEMBLY ON SELECTOR BOARDS
## SELECTORS MULTIPLED IN THREE DIVISIONS

### TERMINAL ASSEMBLY



American Telephone & Telegraph Co.
Engineering Department

# Step-by-Step Machine Switching System

## Terminal Assembly Diagram
## Selector Board

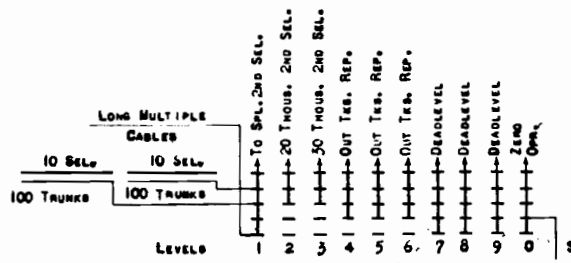



Fig. 1

Symbols

- Indicates that all five terminals are soldered together
- Indicates that top four terminals are soldered together.
- Bottom terminal not soldered

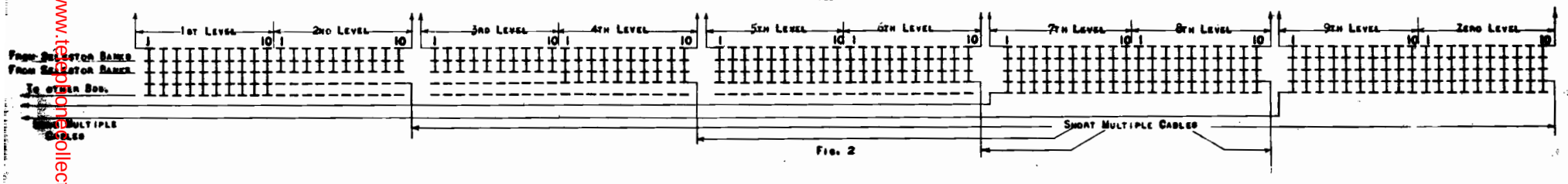



Fig. 2

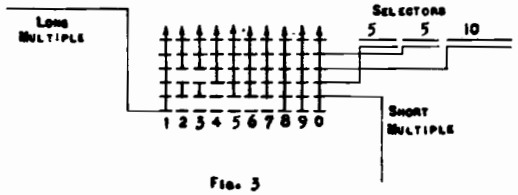



Fig. 3

1st Level 10 trunks multipled through 20 selectors on this shelf, through other selectors on next shelf, and still others on another board.
2nd & 3rd levels multipled through 20 selectors on this shelf.
4th, 5th & 6th levels " " 20 " " " " and to others on next shelf below.
7th, 8th, 9th & 0 " same as 1st level.

Figure 3 shows a diagram in which the selectors on a shelf are multipled in 3 divisions. Trunks from each division terminate on separate terminal strips as indicated.

Multipling of Selectors.

As explained in Div. IV, the number of first selectors through which 10 trunks are multipled is in general different for each level. Drawing No. 807-60 is the complete assembly diagram for a board of first selectors where the selectors on each shelf are multipled in 3 divisions as indicated. This diagram shows how the sub-group of trunks for the various levels are multipled through different number of selector divisions. In this diagram, as in figure 1, drawing No. 807-59, the 10 terminals of the trunks from each level of a division of selectors are represented by a single horizontal line and only the terminals of the private conductors are indicated. The following table, based upon this diagram, shows the selectors through which the trunks from each level are multipled.

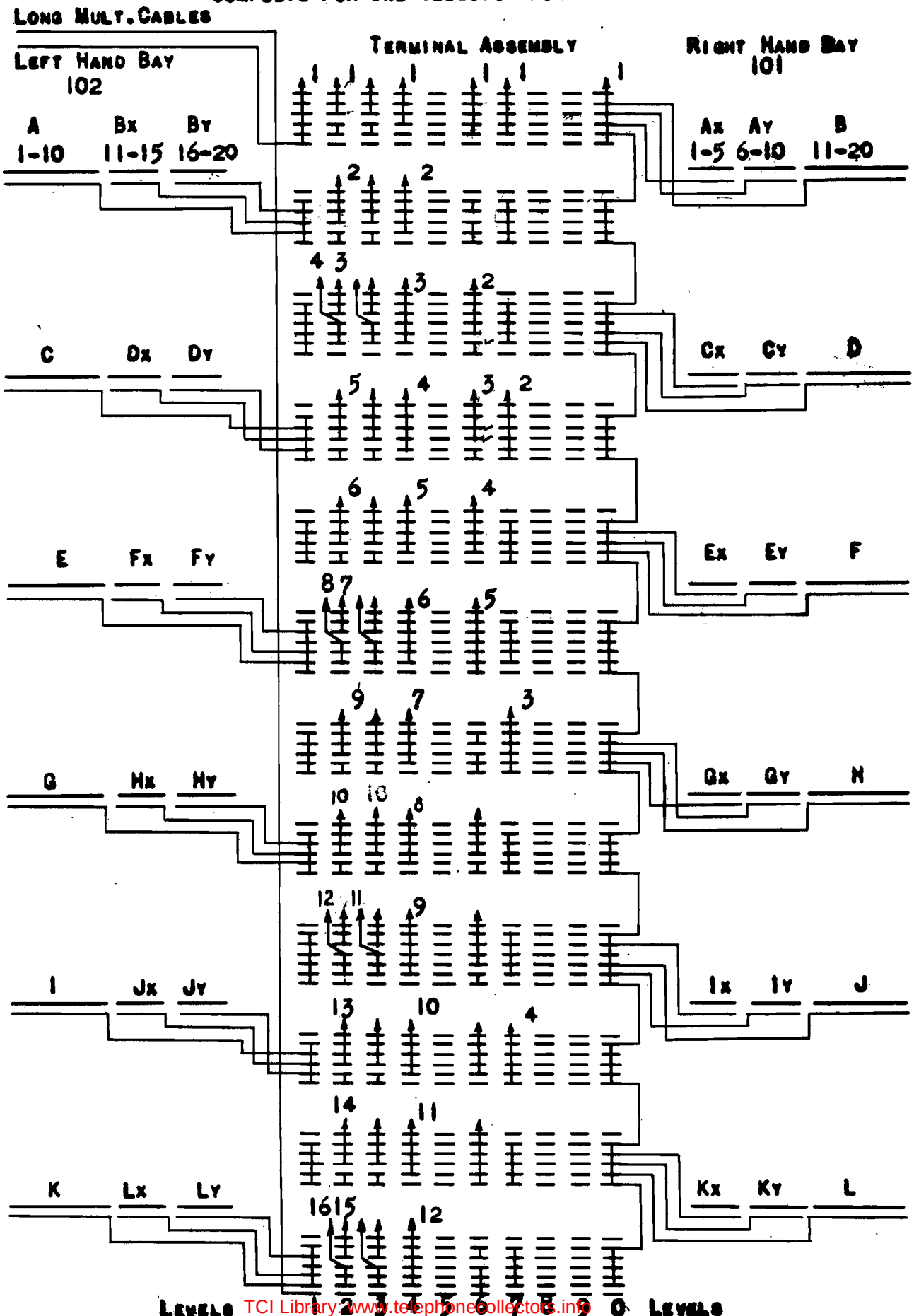
| Levels | Cable Number | Selectors in Sub-group Bay | Divisions | Total No. |
|---|---|---|---|---|
| 2nd | 1 | 101 | Ay & B | 15 |
| | 2 | 101 | Ax | |
| | | 102 | Bx & By | 15 |
| | 3 | 102 | A | |
| | | 101 | Cx | 15 |
| | 4 | 101 | Cy & D | 15 |
| | 5 | 102 | C & Dx | 15 |
| | 6 | 102 | Dy | |
| | | 101 | Ex & Ey | 15 |
| | 7 | 101 | F | |
| | | 102 | Fy | 15 |
| | 8 | 102 | E & Fx | 15 |

| Levels | Cable Number | Selectors in Sub-group Bay | Divisions | Total No. |
|---|---|---|---|---|
| 4th | 1 | 101 | A & B | 20 |
| | 2 | 102 | A & B | 20 |
| | 3 | 101 | C & D | 20 |
| | 4 | 102 | C & D | 20 |
| 6th | 1 | 101<br>102 | Ay & B<br>By | 25 |
| | 2 | 102<br>101 | A & Bx<br>Cx & Cy | 25 |
| | 3 | 101<br>102 | D<br>C & Dx | 25 |
| | 4 | 102<br>101 | Dy<br>E & F | 25 |
| 7th | 1 | 101<br>102<br>101 | A & B<br>A & B<br>C & D | 60 |
| | 2 | 102<br>101<br>102 | C & D<br>E & F<br>E & F | 60 |
| | 3 | 101<br>102<br>101 | G & H<br>G & H<br>I & J | 60 |
| 1st & 10th | 1 | All selectors on both bays and others on next board | | |

For example, the ten trunks carried in cable No. 1 second level, are multipled through the 15 selectors of divisions Ay & B, Bay 101. The trunks carried in cable No. 2 are multipled through the 5 selectors of division Ax, Bay 101, and ten selectors in division Bx & By, Bay 102. It will be seen that each sub-group of trunks from the second level are multipled through 15 selectors; each sub-group of trunks from the fourth level are multipled through 20 selectors; etc.

# STEP BY STEP MACHINE SWITCHING SYSTEM

## TERMINAL ASSEMBLY DIAGRAM
## COMPLETE FOR ONE SELECTOR BOARD



Where it is necessary to use graded multiple, as explained in Div. IV, Sec. 3 c of these notes, the selectors are multipled together as shown on the terminal assembly diagrams on Drawing No. 807-61. It should be noted that these diagrams differ from that shown on Drawing No. 807-59 in that but one level is shown and the terminals of each trunk from this level are indicated. Such diagrams, called "Level Details", are necessary where all ten trunks from a given level are not multipled through the same selectors.

Figure "1" shows a case where 30 trunks are associated with 50 selectors. The first 5 trunks from each division of 10 selectors are individual to that division. The remaining 5 trunks are common to all 50 selectors. Each cable to second selectors carries 10 trunks. The first cable carries the 5 individual trunks from the first division of 10 selectors and the 5 common trunks. The remaining two cables each carry 10 individual trunks as indicated.

Figure "3" shows the case where 50 trunks are associated with 110 selectors. Here the first 4 trunks are individual to each group of 10 selectors and the remaining 6 are common to all 110 selectors.

Multiple Slip and Multiple Reversal.

Where it is desired to slip or reverse the multiple between the first 10 and the last 10 selectors on a shelf, two extra terminal strips, wired together through a hairpin form, introducing the desired slip or reversal are inserted between the terminal strips for the bank wiring from the two half shelves. The terminals

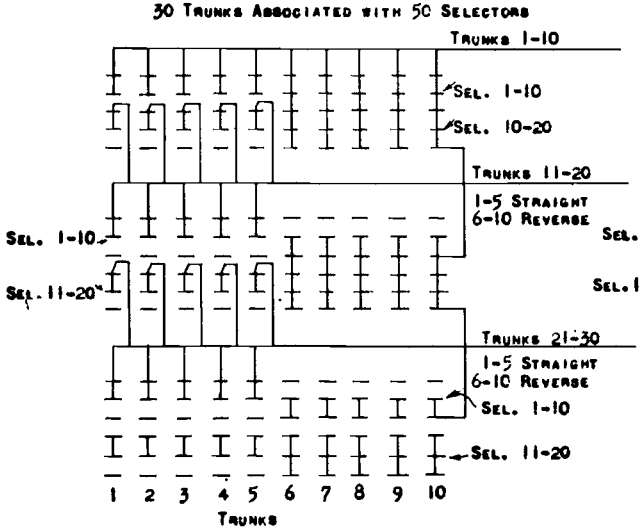
of one of these extra strips are soldered to the terminals of one halfshelf, and the terminals of the other extra strip are soldered to the terminals of the other halfshelf. This is indicated in Drawing No. 807-62, Figure 1 and 2.

These hairpin forms are made up and connected to their terminal strips in the factory and are inserted in the terminal assembly as required.

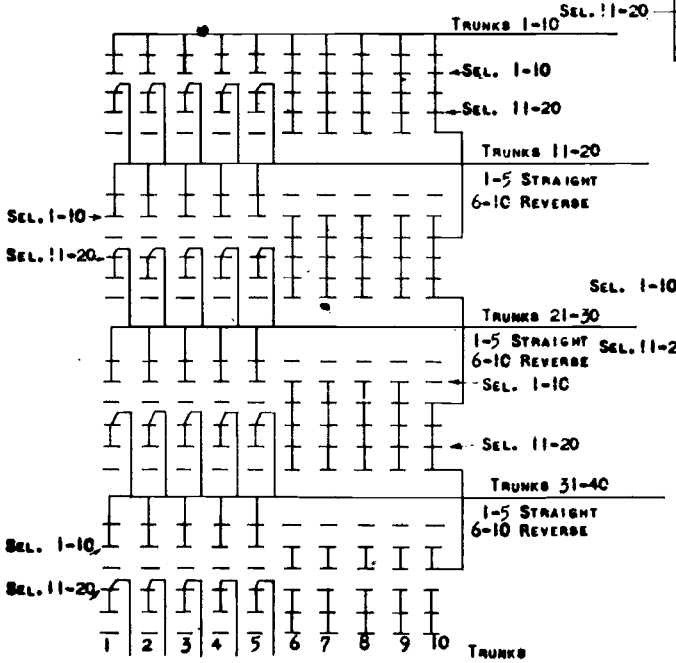
Where a slip or reversal is to be made between selector divisions on different shelves, it is accomplished by slipping or reversing the conductors in the multiple cables.

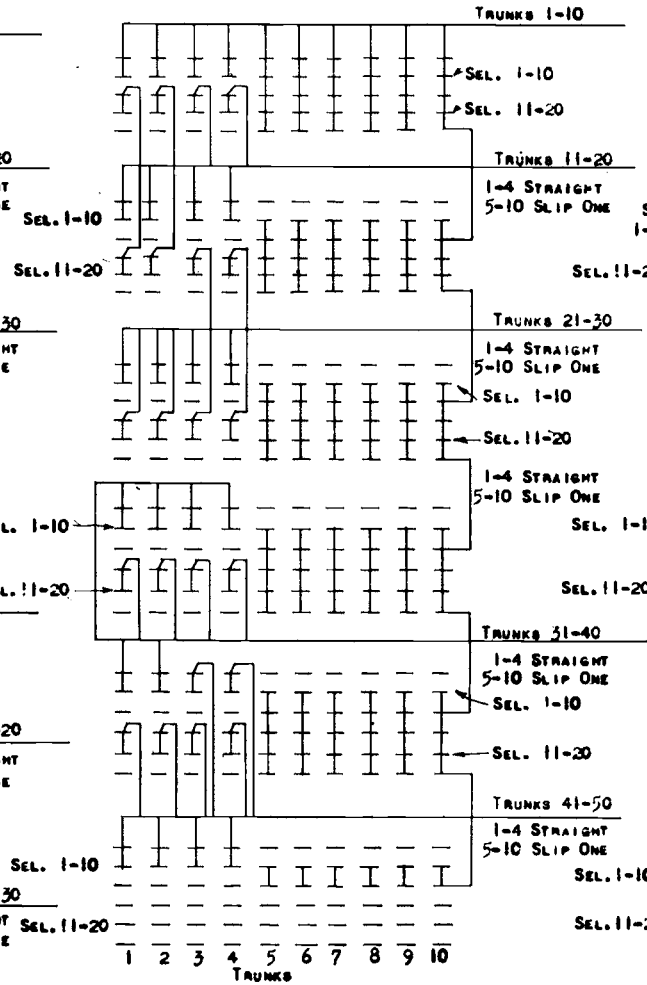
Figure "3" of Drawing No. 807-62 shows the symbols used in assembly diagrams to denote multiple slip or reversal. The cross indicates a slip or a reversal by means of the hairpin form. Where a slip or a reversal is made in the multiple cable a note to that effect is added.

30 TRUNKS ASSOCIATED WITH 50 SELECTORS




40 TRUNKS MULTIPLED THROUGH
70 SELECTORS
FIG. 2




50 TRUNKS ASSOCIATED
110 SELECTORS
FIG. 3

70 TRUNKS ASSOCIATED WITH 160 SELECTORS

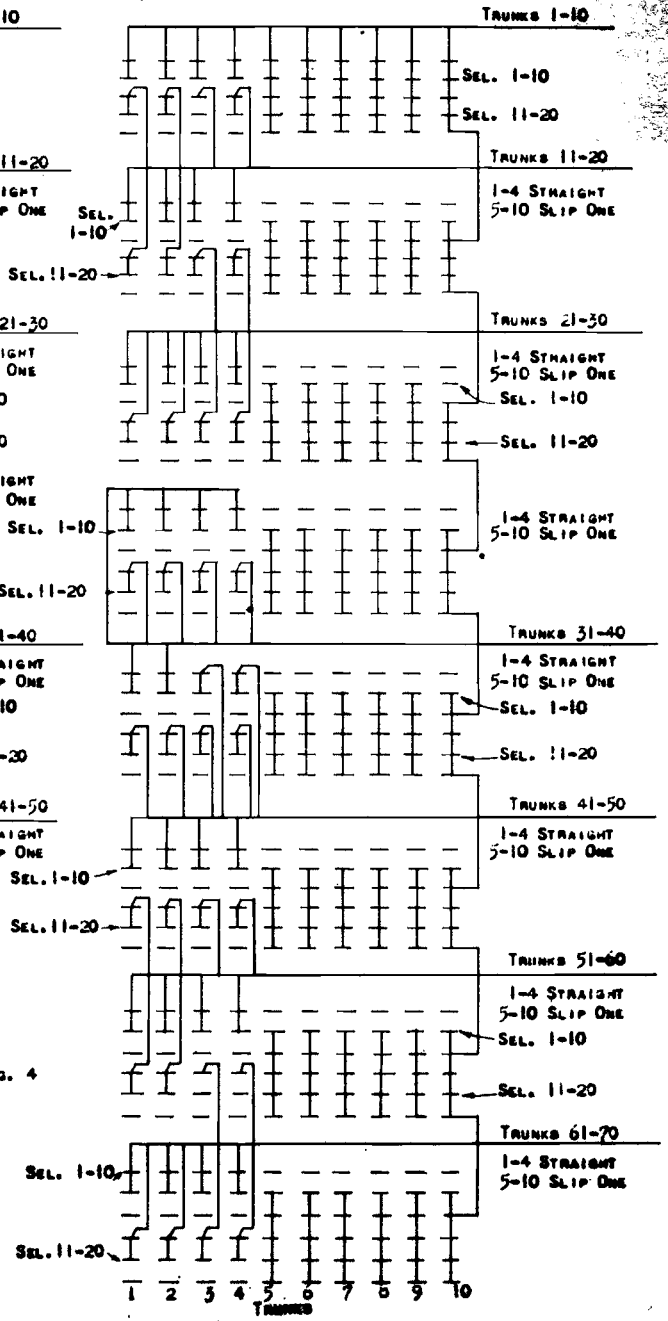



FIG. 4

# STEP-BY-STEP MACHINE SWITCHING SYSTEM

## MULTIPLE SLIP AND REVERSAL

### TRUNKS-ONE LEVEL

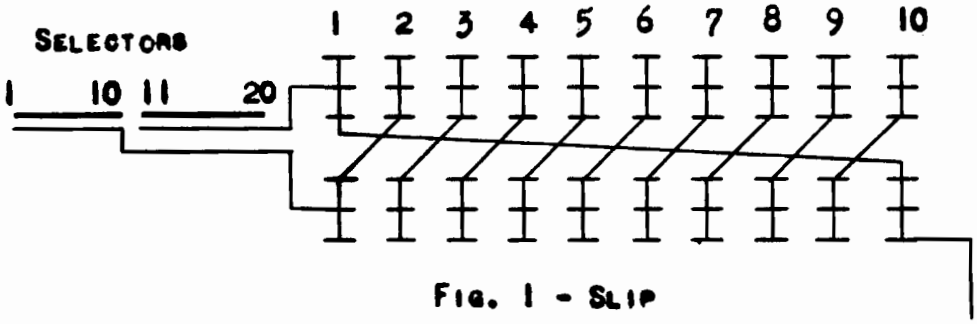



FIG. 1 - SLIP

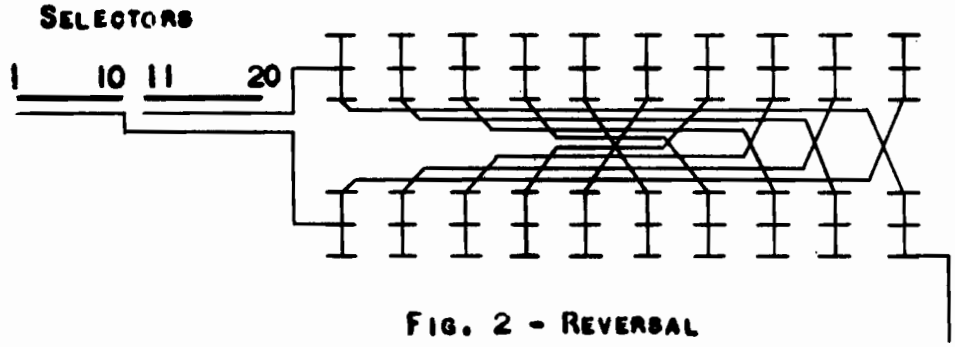



FIG. 2 - REVERSAL

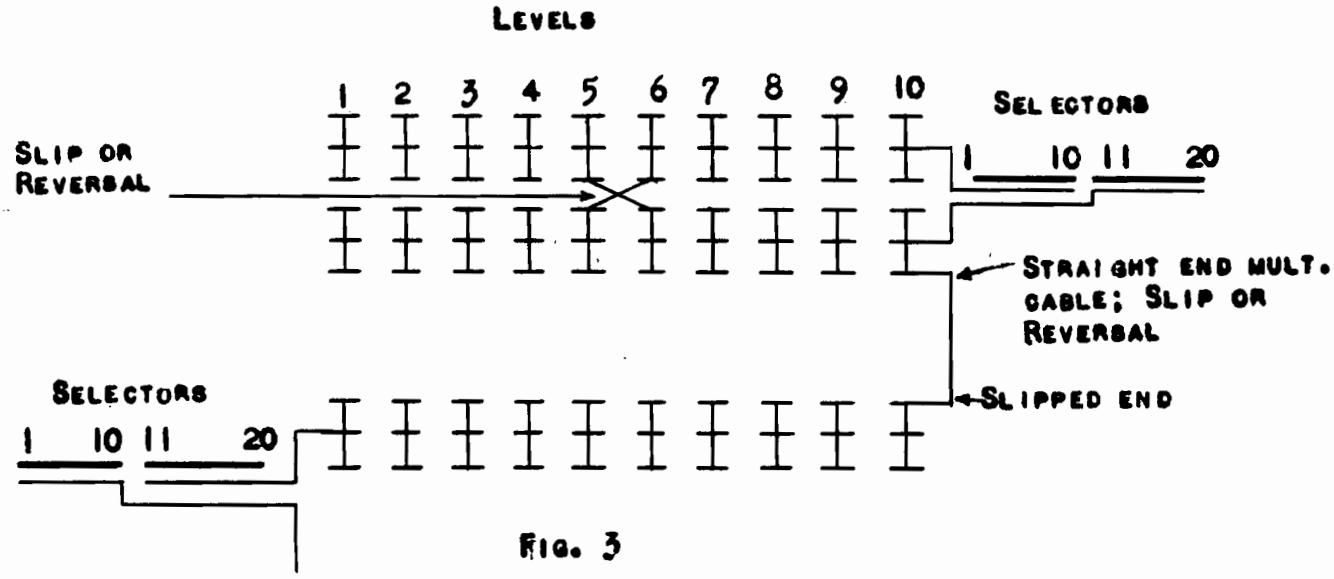



FIG. 3

Outgoing Trunks.

Drawing No. 807-63 shows the cabling for outgoing trunks. Figure 1 shows a trunk without outgoing trunk secondary switches. As explained in the preceding section, the trunks from the banks of the first selectors are wired to terminals in the terminal assembly at the end of each selector board. From the terminal assembly the outgoing trunks are cabled, ten trunks per cable to the vertical side of a cross-connecting frame at the end of the repeater board. The terminals on the horizontal side of this cross-connecting frame are wired permanently to the various repeater jacks in the repeater board. By proper cross-connection, any trunk can be connected to any repeater. This cross-connecting frame is provided so that the repeater shelves may be filled up, and still have repeaters on trunks going to a particular office located together. That is, it is not necessary to leave space for growth between groups of repeaters. From the repeater jacks the outgoing trunks are cabled directly to the horizontal side of the main distributing frame, 20 trunks per cable, 2 conductors per trunk.

Figure 2 of Drawing No. 807-63 shows an outgoing trunk carried through an outgoing trunk secondary switch. Cables with 10 trunks each are carried from the terminal assembly on the first selector boards to the horizontal side of an intermediate distributing frame and cross-connected to the vertical side. From the vertical side of the intermediate distributing frame the outgoing trunks are cabled to the terminal assembly on the outgoing trunk secondary switchboards. This IDF cross-connection permits

the distribution of the trunks over the sub-groups of outgoing trunk secondary switches as described in Division IV. This frame may be the line intermediate distributing frame, or one of the trunk distributing frames, depending upon the floor plan layout. The trunks from the banks of the secondary switches are wired to the terminal assembly mounted above the switchboard and from there, cabled to the repeater cross-connection frame, ten trunks per cable.

# STEP-BY-STEP MACHINE SWITCHING SYSTEM

## CABLING OF OUTGOING TRUNKS

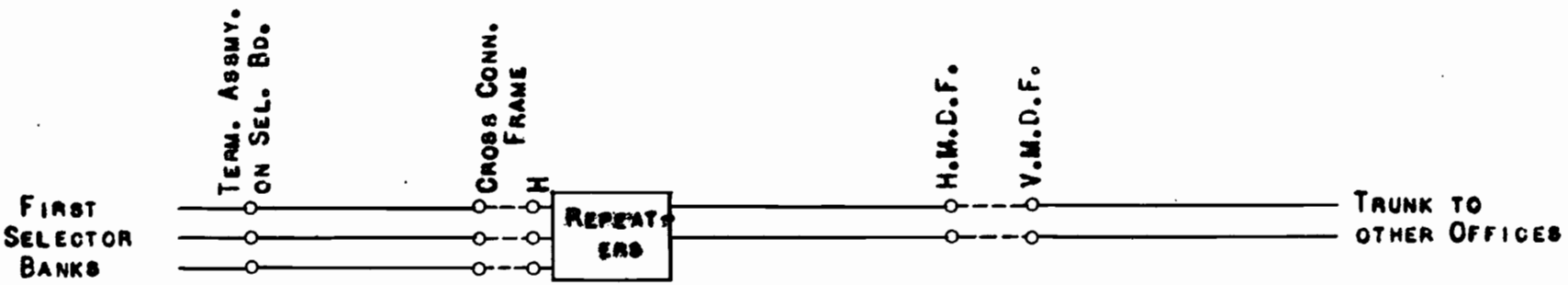



FIG. 1

OUTGOING TRUNKS WHEN OUTGOING SECONDARY SWITCHES ARE NOT USED

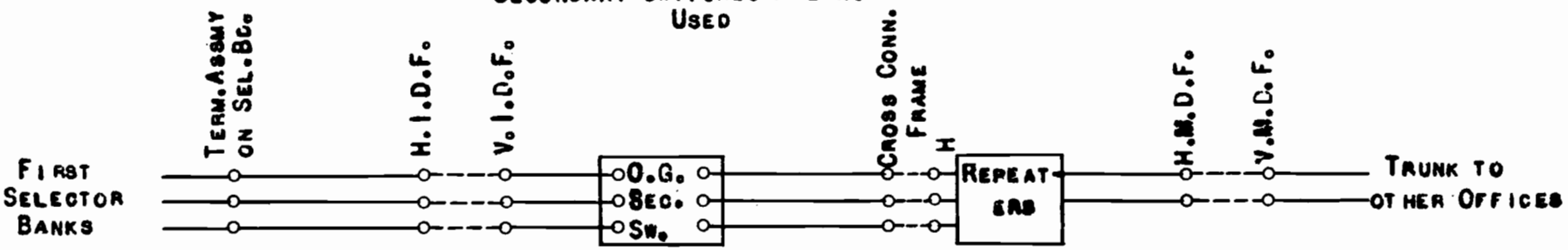



FIG. 2

OUTGOING TRUNK WHEN OUTGOING SECONDARY SWITCHES ARE USED

Incoming Trunks.

Trunks incoming from other offices terminate on the vertical side of the main distributing frame, are cross-connected to the horizontal side and cabled to incoming selectors as indicated in drawing No. 807-45. These cables terminate directly upon the selector jacks, two cables per shelf of 20 selectors. Any desired grouping of incoming selectors in the selectors' bays can be accomplished by proper cross-connections at the main distributing frame.

Trunks from Second Selectors to Third Selectors.

The cables carrying the trunks from the second selectors to third selectors run from the terminal assembly on the second selector boards to selector jacks on the third selector boards. Each cable carries ten trunks and two cables terminate on each shelf of third selectors.

Trunks from Third Selectors to Connectors.

The trunks from the third selectors to the connectors are cabled from the terminal assembly on the selector boards to jacks on the connector shelves. In general the connectors serving 100 terminals are located on one shelf. Cabling is provided to care for the capacity of the shelves. Thus where connector boards have capacity for 15 connectors per shelf, cabling would be provided for 15 even though but 12 connectors were equipped. Trunks to local connectors are always cabled ten trunks per cable. Where connector boards having a capacity of 16 connectors per shelf are used, the ten trunks to the first ten connectors, not counting the test connector, are run in one cable; the five trunks to the five remaining connectors together with the trunks to the five connectors directly beneath on the next shelf, are run in a second cable. On the bottom shelf the conductors for five trunks are dead-ended.

Combination local and toll connectors have trunks from local third selectors and toll third selectors. Separate jack springs are provided for terminating these trunks. Trunks from toll third selectors to toll or combination connectors are cabled five or ten trunks per cable depending upon whether the ultimate number of toll connectors per group of 100 terminals is five or more. These trunks are four conductor trunks.

## Trunks From Connectors To The Intermediate Distributing Frame.

Trunks from regular connectors to the intermediate distributing frame are cabled from the terminal strips at the connector boards to the horizontal side of the intermediate distributing frame- 20 trunks per cable, 3 conductors per trunk. Trunks from the trunk hunting connectors are four-wire trunks - tip, ring and two private conductors. The two private conductors are strapped together at the terminal blocks on the horizontal side of the intermediate distributing frame. They are cabled 20 trunks per cable.

When connectors serving the same group of 100 terminals are located in different connector bays as is often the case with trunk hunting connectors, the method of cabling to the intermediate distributing frame should be specified. Drawing No. 807-75, Figure 1 shows the method proposed for use where no provision need be made for more than 10 trunks to any P.B.X. Separate sets of cables are run from each bay to the same terminals on the horizontal side of the intermediate distributing frame. If the connectors serving the same group of 100 terminals are located on more than one shelf in the overflow board, the various shelves are multipled together at the connector board terminal strips as indicated.

Figure 2 show the method proposed for use where provision is made for more than 10 trunks but not more than 20 trunks to a P.B.X. Here the total number of connectors serving the group of 100 terminals are divided into two sub-groups. The number of connectors

STEP BY STEP MACHINE SWITCHING SYSTEM

Method of Cabling between Trunk Hunting Connectors and Intermediate Distributing Frame

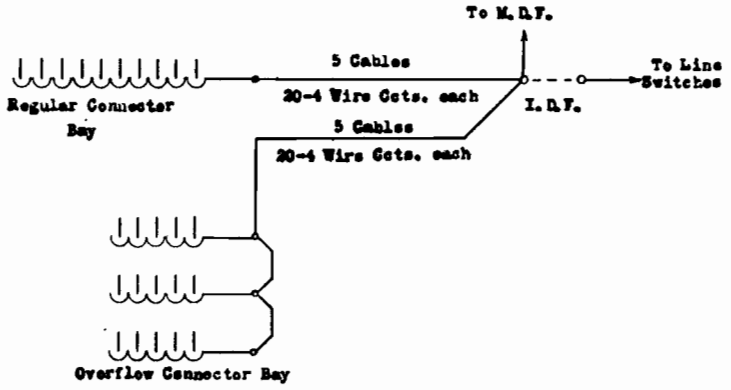



Fig. 1

Method of Cabling where no Provision need be made for more than 10 Trunks to any P.B.X.

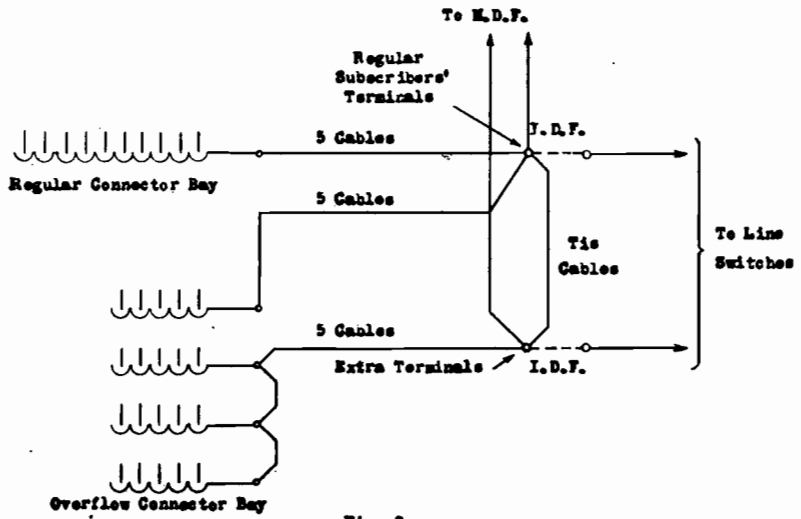



Fig. 2

Method of Cabling where Provision is made for more than 10 trunks but less than 20, to any P.B.X.

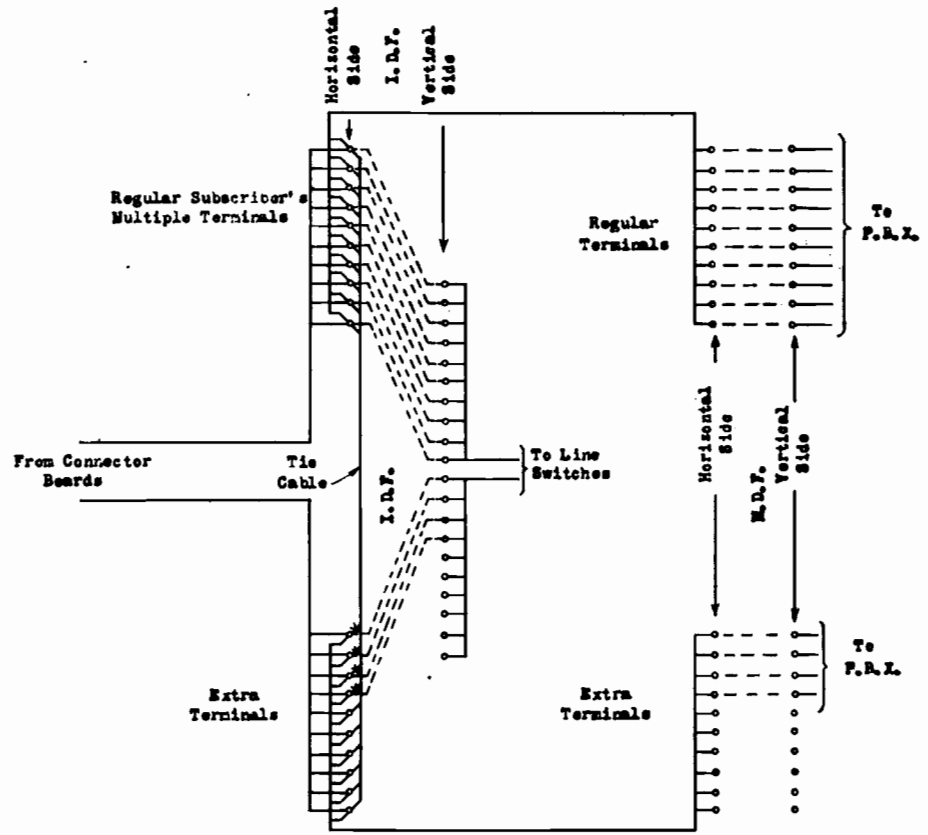



Fig. 2

Method of Providing 14 Trunks to a P.B.X.

Note: "X" indicates conductors of tie cable opened.

in the two sub-groups should be as nearly equal as possible. Trunks from the sub-group containing the connectors mounted on the regular board are cabled to the regular subscriber's multiple terminals on the horizontal side of the intermediate distributing frame. The trunks from the second sub-group are cabled to an extra set of terminals on the same side of the frame. These two sets of terminals are multipled together by means of tie cables. The extra set of terminals are cabled to extra terminals on the horizontal side of the main distributing frame as indicated in Figure 3. If more than 10 trunks are required to a P.B.X., for example 14 trunks, the tie conductors of the first four trunks are opened and the corresponding terminals on the horizontal side of the main distributing frame are cross-connected to the additional trunks to the P.B.X. on the vertical side of the frame. This scheme provides for four individual trunks from each sub-group of connectors and 6 trunks common to both sub-groups. If the additional four trunks are to be two-way trunks, the corresponding terminals on the horizontal side of the intermediate distributing frame are cross-connected to terminals on the vertical side where cables to line switches terminate.

If provision need be made for more than 20 trunks to a P.B.X. the group of connectors serving the group 100 terminals will be divided into three or more sub-groups instead of two and extra sets of terminals are provided on the horizontal side of the intermediate and main distributing frames. These sets of terminals on the horizontal side of the intermediate distributing frame are multipled together by means of the cables.

# BUILDINGS AND FLOOR PLANS

## General.

The type of building required to house step-by-step machine switching equipment is in general the same as that required for panel equipment. General Engineering Circular No. 803, "Fire Prevention and Protection in connection with Construction of Telephone Buildings" applies to buildings for machine switching equipment as well as those for manual equipment.

## Safe Floor Loads.

The safe floor loads assumed in designing buildings for step-by-step equipment are the same as in the case of buildings for panel equipment, and are as follows::

| | | |
|---|---|---|
| Main Frame Room, | 175 | pounds live load per square foot, |
| Switchroom, | 150 | " " " " " " |
| Operating Room, | 150 | " " " " " " |

While these carrying capacities are somewhat greater than are actually required for most of the mechanical switchboards, it is recommended that these figures be used as the basis of design in order to provide flexibility to care for certain other parts of the equipment, such as the I.D.F. and M.D.F., and to care for possible future developments.

Where storage batteries are located on any floor other than the basement, it may be necessary to reenforce the floor supporting them. Such reenforcements will be a more common requirement in step-by-step than in manual offices, since in general the batteries used in step-by-step offices are considerably heavier. The question as to whether reenforcements are necessary should be checked in each case.

Ceiling Heights.

The desirable minimum ceiling height for switchrooms is 13' -0" under the ceiling slab and 12'-6" under beams. While a ceiling somewhat less than 13 feet in height would care for step-by-step equipment as at present designed, it is thought desirable to provide a 13' ceiling in order to care for possible future developments and to provide for greater flexibility in the machine switching plant. No story should have a ceiling height of less than 13'-0" as it may be desirable at some future time to install switches on any floor.

In most cases, the floor plans can be arranged to provide satisfactorily for a long main distributing frame such as would result from limiting the height of the frame to 243 or 263 protectors per vertical (depending on whether the protector side of the frame is away from or toward the wall,) and frames of not more than these heights can be installed on any floor having the ceiling height mentioned above.

Where it is necessary or desirable to install a main frame providing capacity for 303 protectors per vertical, the following ceiling heights are recommended:

(1) Where the protector side of the frame is away from the wall, a minimum of 15'-6" under the ceiling slab and of 15'-0" under the beams.

(2) Where the protector side of the frame is toward the wall, a minimum of 15'-0" under the ceiling slab and of 14'-6" under the beams.

Auxiliary Framing.

The cable runways are supported for the most part directly on the framework of the switchboards and are not hung from the ceiling as in manual practice. The auxiliary framing called for in General Engineering Circular No. 350 "Auxiliary Framing on Terminal Room Ceilings" is therefore not so essential in buildings designed for step-by-step equipment. However, since some supports from the ceiling are in general required to carry extra long spans in the cable runs between boards, and since other supports not required initially may be needed at some future time, it is thought desirable to provide sockets or beam clamps as described in the General Engineering Circular just mentioned.

Cinder Fill.

A two or three inch cinder fill is considered desirable on all equipment floors except on the power room floor,

since such a fill provides a means for concealing a part of the conduit for the lighting and power distributing leads, and avoids difficulties in securing a satisfactory bond between the finished flooring and the structural floor. This fill is not a necessity, however, from an equipment standpoint, since in any case a part of the distributing leads are carried overhead on the framework of the switchboards and all of them can be carried overhead if it is desired to avoid the cinder fill required to cover them.

A floor fill of considerable depth is recommended for the power room unless it is satisfactory to carry the power wiring conduit on the ceiling of the floor below. The conduit should not be run along the ceiling of the battery room, and consequently the floor fill should be provided if the battery room is located directly underneath the power room. The fill should also be provided if the exposure of conduit on the ceiling of the floor below would be objectionable from an appearance standpoint. Where the fill is used, it should be from six to eight inches in depth in order to permit crossing of the conduits.

Floor Plan Arrangements - Aisle Spacing.

Drawing No. 807-71 shows the floor plan dimensions and aisle spacing for the various parts of a step-by-step

machine switching equipment.

Figure 1 shows the floor plan dimensions and the aisle spacings for the primary and secondary line switchboards and the outgoing trunk secondary switchboards. Several units can be placed end to end as indicated, but for maintenance reasons it is thought that a lineup of boards should not exceed approximately thirty-five or forty feet. In order to permit the grouping of switches in adjacent bays under the control of one master switch, it is in general desirable to arrange the line switch units in multiples of three; that is, a lineup of boards should contain 3, 6, 9, or 12 units.

Figure 2 shows the floor plan dimensions and the aisle spacings for selector and repeater boards. These boards have apparatus located across both ends and consequently it is necessary to provide an aisle space on all four sides of each board. The desirable and the minimum aisle widths are indicated, the latter dimensions being bracketed. Where selector and repeater boards are provided with casings, the width of the aisle between the side of the casing and a column should not be less than 2'-1", as the casing is equipped with swinging doors and this clearance is necessary to allow the doors to be opened fully. The dimension of 2'-3" shown on the drawing is the recommended clearance between a column and the side of a board not

equipped with a casing. This clearance permits the later installation of a casing if this should be found desirable.

Figure 3 shows the floor plan dimensions and aisle spacings for connector boards. These boards have no apparatus across the ends, so that several boards may be placed end to end. In general, the length of a lineup should not exceed approximately thirty-five or forty feet. The aisle spacing for connector boards is the same as for selector and repeater boards, as previously described.

The capacities of the various connector boards and their use under different traffic conditions are given in Div. II, Sec. 3q and in Div. IV, Sec. 6. Where the number of connectors required per regular group is ten or less initially, but is expected to exceed ten in the ultimate, boards providing eleven connectors per shelf may be installed for these groups, but in general if this is done space should be provided to permit of the installation of the additional framework necessary to increase the capacity of the boards to sixteen connectors per shelf.

Relative Location of Equipment.

The most desirable location of the various groups of switches from the standpoint of cabling economy may be seen by referring to Drawings Nos. 807-45, 807-46 and 807-66 in Divis-

ion V, Section 1. In general, switches performing like functions should all be associated together in one group as far as possible. Thus, the primary line switches should all be placed in one group, the secondary line switches in another group, the first selectors in another, etc.

The heaviest cable runs are between the M.D.F. and the I.D.F., between the intermediate distributing frame and the line switches and between the intermediate distributing frame and the connector banks. Therefore the line switch and connector groups should be located as near as possible to the intermediate distributing frame, and the M.D.F. and I.D.F. should also be located near one another.

The secondary line switches should be located near the primary line switches. When a trunk distributing frame is used for cross-connecting the trunks between the primary and secondary line switches and between the secondary line switches and first selectors, as shown on Drawing No. 807-45, this frame should be located as near as possible to the primary and secondary line switches. If these cross-connections are made on the line intermediate distributing frame, as shown on Drawing 807-46, the secondary line switches should be located near the line intermediate distributing frame. The question of whether or not separate trunk intermediate distributing frames should be used

depends almost entirely on the floor plan layout and the relative cabling costs. Each case should be considered individually to determine what plan results in the most desirable layout, giving due consideration to questions of cabling economy, flexibility of arrangement, provision for growth in the various groups of boards, and cost of maintenance.

The first selectors should be located fairly close to the distributing frame at which the trunks to these selectors are cross-connected. The second selectors should be located near the first selectors and the third selectors near both the second selectors and connectors. The outgoing trunk repeaters should in general be located between the first selectors and the main distributing frame, and if outgoing trunk secondary switches are used they should be located between the repeaters and the distributing frame at which the trunks to the O.G.T. secondary switches are cross-connected.

The heaviest cable run to the machine switching manual board is that from the intermediate distributing frame. This run should therefore be made as short as practicable, although the exact location of the manual board is not of great importance provided no checking multiple is required. If a checking multiple is installed or if it is expected that a

checking multiple will be needed at some later time, however, it should be borne in mind that a comparatively heavy cable run will be required for this purpose, amounting to 250 20-pair cables for one full unit of 10,000 terminals.

Floor Plan Layout.

In some cases, especially in the smaller single unit offices, it will be practicable to place all of the terminal equipment, power plant and switches on one floor. This arrangement is the most desirable one from a maintenance standpoint. It may often be found desirable, however, where but a partial unit is to be installed initially, to locate the equipment on two floors instead of one, thus permitting the use of a smaller initial building and the extension of the building as the equipment grows.

It will be found desirable in most large installations, such as in an office providing ultimately for two units, to locate the equipment on two floors. Where the equipment is separated in this manner it is desirable both from cabling and maintenance standpoints to group together on one floor all of the switches used in handling originating traffic, such as the primary and secondary line switches, first selectors, outgoing trunk secondary switches, etc., and to locate on the other floor all switches handling terminating traffic, such as the

second and third selectors and connectors. From a cabling viewpoint this is a logical consequence of observing the desirable relative locations of the various groups of switches as described in the previous pages.

In general the space requirements for the originating and incoming equipments will differ somewhat, and where these two groups are located on different floors a fairly close space balance may be obtained by locating the main and intermediate distributing frames, the power plant and the test equipment with one or the other of the groups.

Where the equipment is located on two floors, it usually will make no material difference in cabling costs whether the I.D.F. is located on the floor with the connectors or on the floor with the line switches. In such offices the main frame and I.D.F. are usually located on separate floors and are placed one above the other or nearly so to minimize the interframe cabling. In a multi-office building a main distributing frame and power plant common to the various units should be provided if feasible. It is desirable for maintenance reasons to locate the test desk near the main distributing frame.

Where there is no danger from water it will generally be found economical to locate the batteries in the basement.

This is usually desirable because of the large size of the battery, which, if placed above the basement, might require considerable additional building space and in most cases would also require the battery room floor to be substantially strengthened to carry the heavy load.

As a rule there is no serious objection to locating the charging machines in the basement if there is no danger from water and the space is dry and well ventilated. The separation of the charging machines from the terminal equipment will ordinarily involve some additional maintenance expense; however, in case the power plant is large and the space necessary to accommodate it is available in the basement, it may sometimes prove economical to locate the machines as well as the batteries in the basement despite the greater maintenance charges if this arrangement effects sufficient economies in the cost of the building.

As pointed out in Division VII of these notes the size of the emergency power plant used in step-by-step offices requiring emergency equipment is in general greater than in manual offices, so that usually a greater ceiling height will be required in the gas engine room than would be necessary in a corresponding manual office.

Provision for Growth.

As in manual offices, provision for the growth of the

equipment is required. This problem is somewhat more complicated than in manual offices, however, for in addition to providing space for the growth of the terminal equipment, switchboards and operators' quarters, space should usually be provided for the growth of each of the various groups of switches in order that switches performing like functions may be kept together; that is, each group should be unobstructed in the direction of growth by any other equipment or by any permanent fixtures.

An arrangement that very often proves satisfactory is to start the various groups at or near the front of the building with the direction of growth parallel to the side walls and with the temporary rear wall of the switchroom forming the boundary in the direction of growth. Ordinarily it will not be practicable to care for the growth of all groups in this manner, and a more flexible arrangement may be obtained with certain parts of the equipment if two adjacent groups requiring space for growth are installed so as to grow toward one another rather than in the same direction. Then if either group experiences an unexpectedly large growth that group can expand into the space initially allotted to the other group.

Typical Floor Plans.

Drawings Nos. 807-95, 807-96, 807-97 show a set of floor plans which may be regarded as typical for the average two

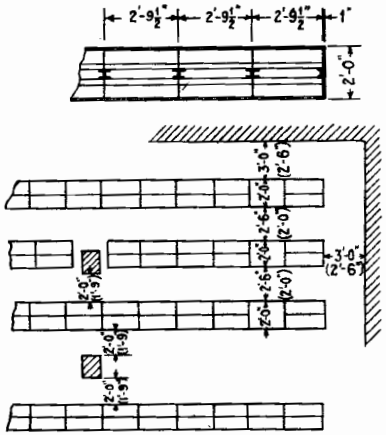
unit office or for the average single unit office in a multi-office district. In general these plans are not intended to apply, however, to a single unit building in which a toll equipment is to be placed, although in some offices of this sort it may be found feasible to arrange the machine switching equipment in approximately the manner shown and to add a third story to the building to care for the toll equipment. The accompanying plans have been drawn up primarily to show what appears to be a desirable layout from the standpoints of maintenance, building and cabling economies, and flexibility to care for growth, and are intended to serve as an illustration of the results obtained by applying to an average office the general principles previously outlined.

# Step by Step Machine Switching System

## Floor Plan Dimensions of Equipment

### Primary & Secondary Line Switchboards and Outgoing Trunk Secondary Sebds.

FIG. 1




| | Total Length | | Total Length |
|---|---|---|---|
| 1 | 2'-11-1/2" | *9 | 25'-3-1/2" |
| 2 | 5'-9" | 10 | 28'-1" |
| 3 | 8'-6-1/2" | 11 | 30'-10-1/2" |
| 4 | 11'-4" | 12 | 33'-8" |
| 5 | 14'-1-1/2" | 13 | 36'-5-1/2" |
| *6 | 16'-11" | 14 | 39'-3" |
| 7 | 19'-8-1/2" | 15 | 43'-0-1/2" |
| 8 | 22'-6" | | |

* Preferred Lengths for Primary Line Switchboards.

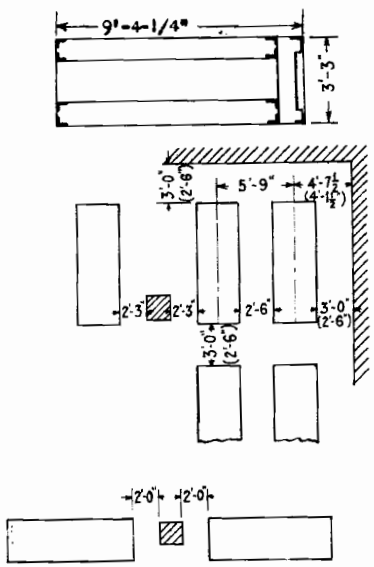
Capacity: Two Bays per Unit
100 Switches per Bay

Height: From floor to top of Casing 7'-4-3/16".

Weight: Fully equipped including Casing - 1030 lbs. per Unit

### Selector & Repeater Boards

FIG. 2



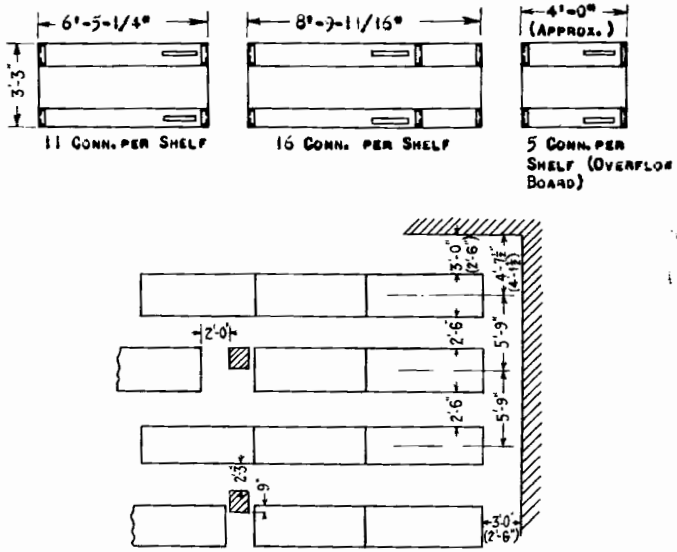

Capacity: Two Bays per Unit
Six Shelves per Bay of Selectors - 20 Selectors per Shelf.
Eight Shelves per Bay of Repeaters - 20 Repeater Bases per Shelf.

Height: From floor to top of Casing, 9'-1-1/2".

Weight: Selector Board fully equipped 5750 lbs.
Casing 270 lbs. additional.
Repeater Board fully equipped 5480 lbs.
Casing 270 lbs. additional.

### Connector Boards

FIG. 3




| | Length | | | |
|---|---|---|---|---|
| | 16 Conn. per Shelf | | 11 Conn. per Shelf | |
| | Without Casing | With Casing | Without Casing | With Casing |
| 1 | 8'-7-11/16" | 8'-11-3/16" | 6'-5-1/4" | 6'-6-3/8" |
| 2 | 17'-6-11/16" | 17'-8-3/16" | 12'-9-13/16" | 12'-11-5/16" |
| 3 | 26'-3-11/16" | 26'-5-3/16" | 19'-2-3/8" | 19'-3-7/8" |
| 4 | 35'-0-11/16" | 35'-2-3/16" | 25'-6-15/16" | 25'-8-7/16" |
| 5 | | | 31'-11-1/2" | 32'-1" |
| 6 | | | 38'-4-1/16" | 38'-5-9/16" |

Capacity: Two Bays per Unit
Five Shelves per Bay
5, 11 or 16 Connectors per Shelf as shown.

Height: From floor to top of Casing, 9'-1-1/2"

Weight: 160 Connector Unit fully equipped - 4104 lbs.
Casing 532 lbs. additional
110 Connector Unit fully equipped - 2830 lbs.
Casing 440 lbs. additional
50 Connector Unit fully equipped - 1290 lbs.
Casing 200 lbs. additional

NOTES:
1. Distance between center lines of adjacent selector, repeater and connector boards is 5'-9" whether or not casings are provided.
2. If casing is provided for selector, repeater or connector boards clear space between side of casing and column must be at least 2'-1".
3. Figures in brackets indicate minimum aisle widths. Other figures indicate desirable aisle widths.

American Telephone & Telegraph Co.
Engineering Department

Engineer
Draftsman
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July 1, 1921

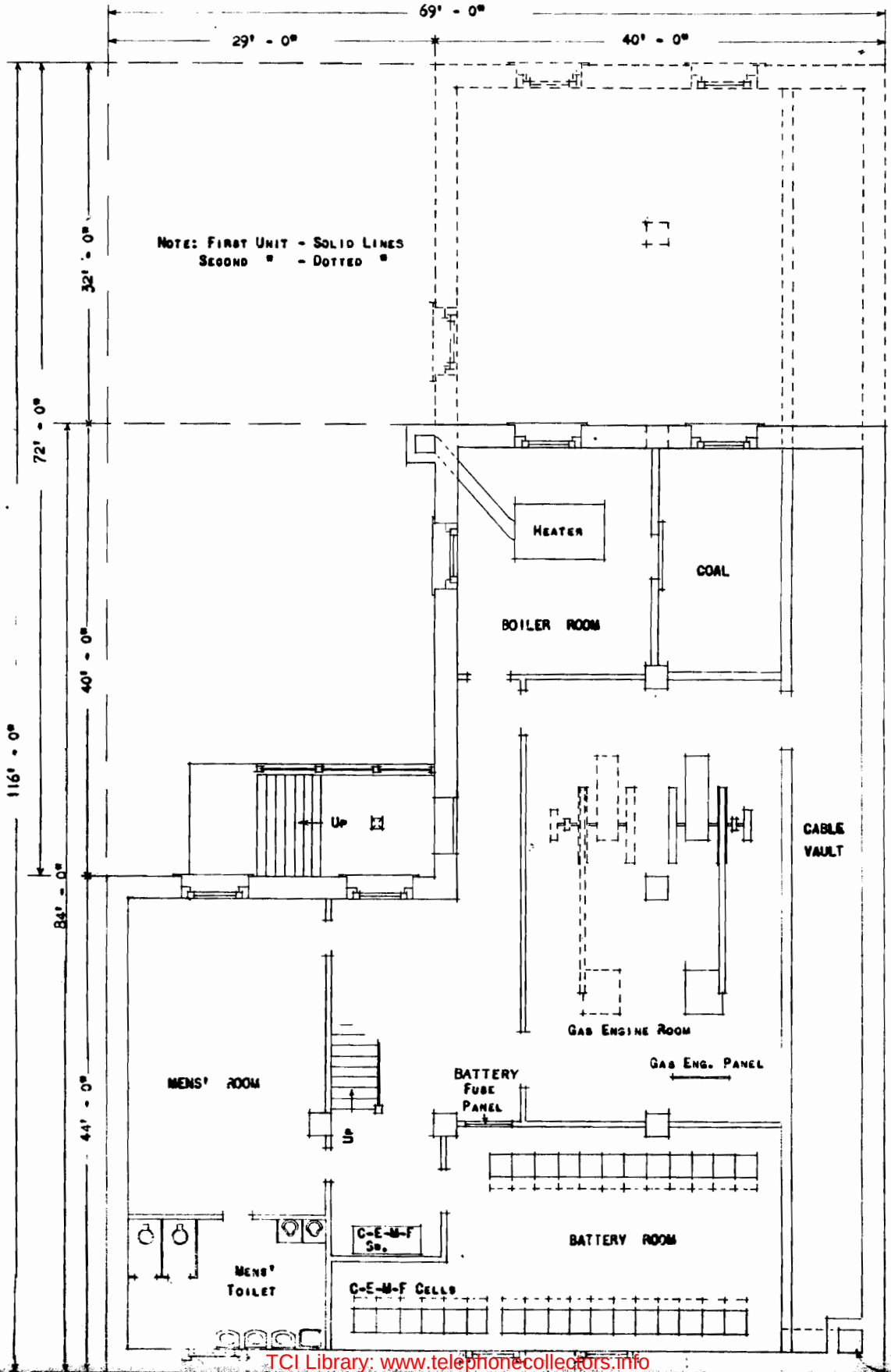
# Step by Step Machine Switching System

## Typical Floor Plan

### Two Unit Office

Scale 1/8" = 1 Ft.

Basement



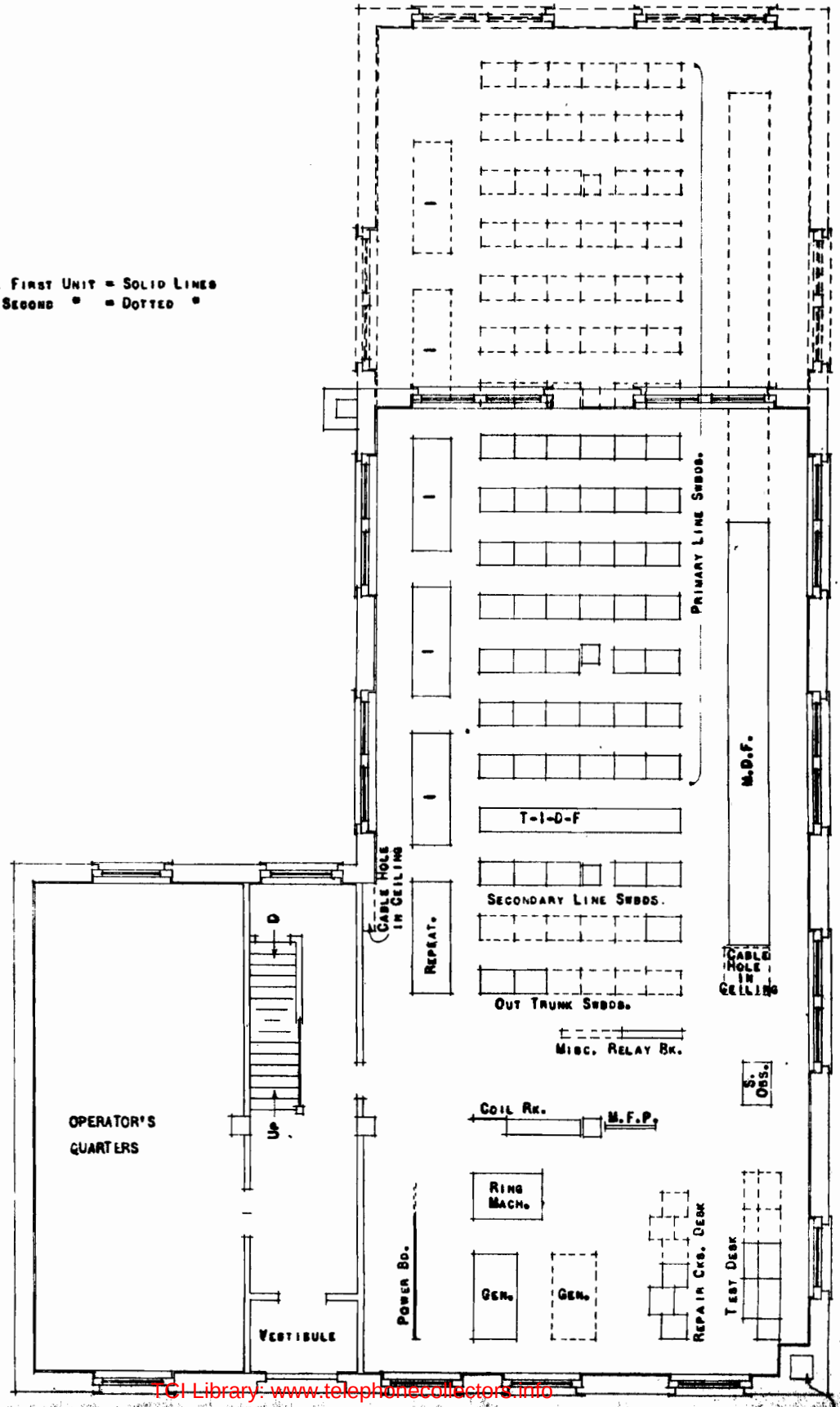
AMERICAN TELEPHONE & TELEGRAPH COMPANY
ENGINEERING DEPARTMENT

# STEP BY STEP MACHINE SWITCHING SYSTEM

## TYPICAL FLOOR PLAN

TWO UNIT OFFICE
SCALE 1/8" = 1 FT.
FIRST FLOOR

NOTE: FIRST UNIT = SOLID LINES
SECOND " = DOTTED "



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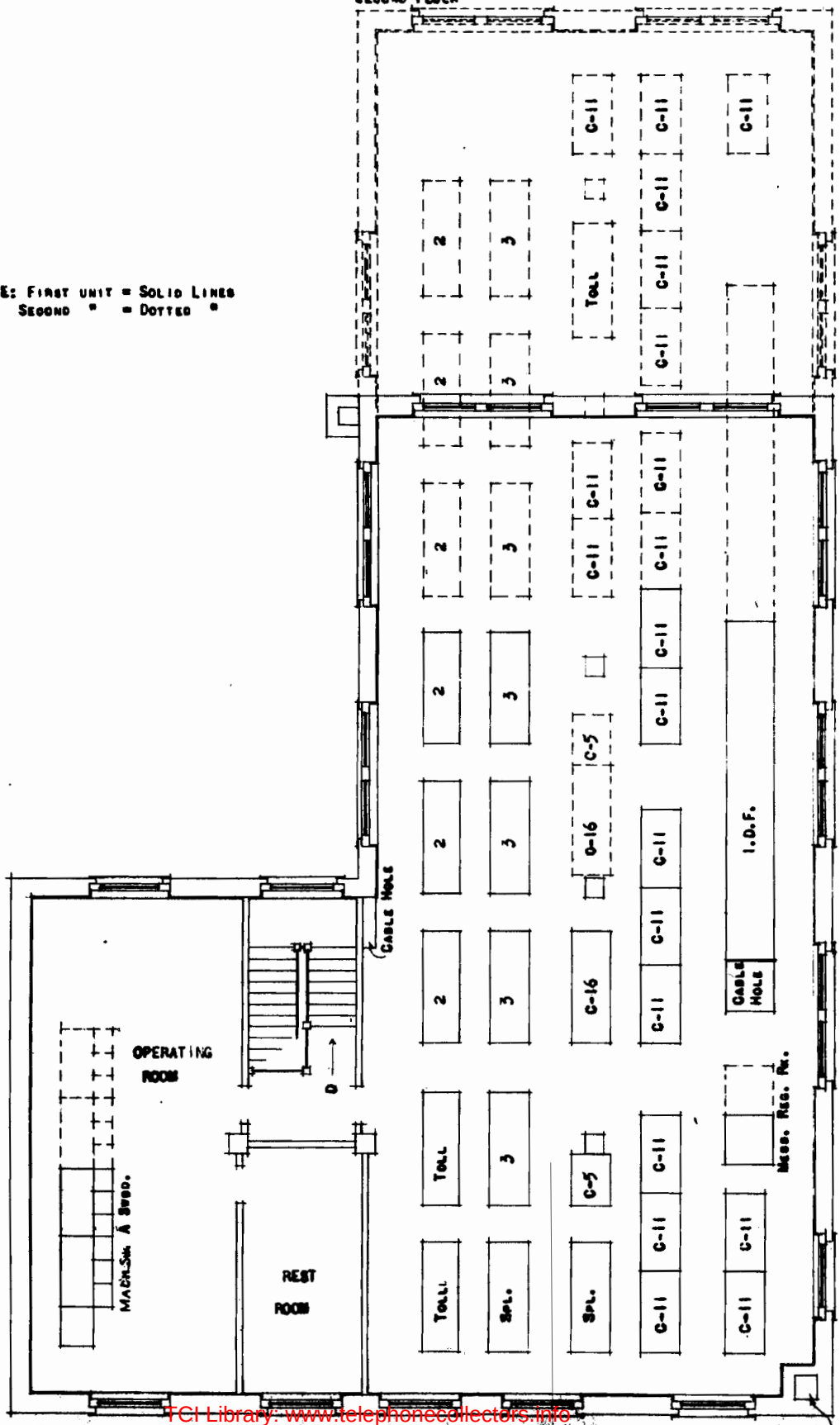
# Step By Step Machine Switching System

## Typical Floor Plan

Two Unit Office
Scale 1/8" = 1 Ft.
Second Floor

NOTE: First unit = Solid Lines
Second " = Dotted "






Bat. Tent

General

Purpose of Machine Switching A Board. The machine switching "A" board is a manually operated switchboard required in connection with a machine switching unit and is used for handling traffic which requires the services of an operator. Although for obvious reasons the use of the machine switching "A" board is ordinarily restricted to that traffic which cannot be completed by the machine switching equipment and to traffic which is being intercepted, any type of call may be handled through this board.

Some forms of traffic such as calls to rural lines, etc., which would ordinarily be handled through a separate rural line or other type of board, may also be handled through the machine switching "A" board where desirable, depending chiefly upon the amount of this type of traffic to be handled and the plant layout in the local area.

Classes of Positions. Two general classes of positions are required in every machine switching "A" board.

(1) Intercepting Positions.

(2) Special Service Positions.

Other classes of positions which may be provided if required are:

(3) Subscribers Positions

(4) Rural Positions.

Official lines terminating at the machine switching "A" board will ordinarily be terminated in front of subscribers or special service positions. Where the entire official P.B.X. is incorporated with the "A" board separate positions may be furnished.

This classification of positions is based on the general functions which must be performed at the "A" board and the various classes differ somewhat as to their equipment. The different classes of positions, however, may be teamed with one another and are frequently combined on the same position. Consequently, in the smaller offices, there may be little or no distinction between the various positions, while in larger offices the distinction will become more marked.

## Equipment Common to all Classes of Positions.

**Outgoing Trunk Multiple.** It will be necessary to provide an outgoing trunk multiple throughout each machine switching "A" board in order to permit the operators to reach subscribers, desks, other positions, etc. This multiple consists of a group of dialing trunks terminated on the jacks of first selectors, dialing trunks to the test distributors or test distributor selectors and several groups of trunks not equipped for dialing.

The dialing trunks to first selectors provide means for the operators to reach subscribers or other terminals reached by dialing, and the trunks to the test distributor equipment are provided to enable the operators to go in over the busy test on a connector terminal in verifying busy conditions and completing cutoffs.

The trunks not equipped for dialing enable the operator to reach connections which are not served on a machine switching basis. These trunks include trunks to:

(1) The various desks such as chief operator, repair clerk and test desk.

(2) Supervisors at the Machine Switching "A" board.

(3) Any office reached by ringdown, automatic or call circuit trunks.

(4) Toll recorder.

(5) Two number toll recorder.

(6) The source of each distinctive tone which may be received by subscribers, such as the dial tone, audible ringing signal, busy back tone and vacant local selector level tone.
In offices where semi-selective party line ringing is furnished, it will be necessary to furnish one trunk for the single ring code and a second trunk for the two ring code.

(7) Other positions, for handling inter-position traffic.

Although the entire outgoing trunk multiple may not be essential to each position, advantages of uniformity and flexibility are gained by extending the multiple throughout the board, while the cost of the multiple is no greater than the cost of terminating each trunk only before the positions where it is required. Consequently the provision of the multiple throughout the entire board is considered standard.

Dial and Method of Dialing. At present the "listening key" method of dialing is used on step-by-step "A" boards, as the dial key method used on the "A" board in manual offices has not yet been adapted for use on the M.S.A. board. Under the listening key plan, when the calling end of a cord circuit equipped for dialing is inserted in the jack of a dialing trunk and the listening key of the cord is operated, the

dial will, when moved off normal, be associated with the cord and locked on to the calling end. The dial will remain locked on the cord until the called party answers or until a dial release key is operated, regardless of the position of the listening key, and while locked on this cord, the dial is not available to any other cord circuit nor will it be affected by the operation of any other listening key.

After dialing has been completed, if the dial has not been released, the calling party will not be able to hear the audible ringing signal, in case the station called is idle or the busy signal in case this station is busy. Furthermore, if the call is intercepted or is to an official line or other free terminal on which supervision is not given, the answer of the called party will not dissociate the dial from the cord and the connection will not be completed. For these reasons, it is considered standard operating practice to operate the dial release key as soon as dialing is completed under all circumstances.

A dial pilot lamp is provided in connection with each dial. This pilot is lighted as soon as the dial is moved off normal after the operation of a listening key, and remains lighted until the dial is released.

Supervisors' Equipment. Supervisors' equipment is provided as in manual practice, each supervisor's division

comprising three switchboard sections. Each supervisor's circuit is terminated in receiver jacks in the lockrail of each section in the division and is multipled to the chief operator's desk.

Each supervisor's division is provided with a supervisor's division lamp, colored red, which is lighted when an operator, another supervisor or the chief operator desires to reach that division and has plugged into the outgoing trunk to that supervisor. Each section in a division is provided with a supervisor's jack and a section lamp, colored white. This lamp is lighted when an operator in that particular section of the division plugs into the supervisor's section jack.

There is a bell associated with each supervisors circuit which rings when either lamp is lighted. Either lamp which may be lighted is extinguished and the bell stops ringing when the supervisor plugs into her receiver jack.

## Equipment Individual to the Different Classes of Positions.

**Special Service Positions.** Special service positions are provided in order to assist subscribers who, for any reason, are unable to complete their calls by dialing the desired number. These positions are reached by dialing "O" and it should be possible to complete any type of call through the special service operator.

The principal functions of the position are:

1. Handling outgoing A-B and two number toll calls.
2. Handling incoming A-B toll calls routed to the "A" board over ringdown or automatic trunks.
3. Handling complaint calls when these calls are handled in the local office.
4. Verifying busy and don't answer conditions reported by subscribers and completing cut offs and delayed calls.
5. Handling outgoing calls on lines denied service for non-payment of bills.
6. Handling calls to and from desks and supervisors.
7. Assisting subscribers who request aid in reaching called stations or who are unfamiliar with the operation of the system.

In addition, special service positions are sometimes called upon

8. To complete calls to toll recorder.
9. To complete calls to rural lines.

In order to perform these various functions, the following incoming trunks should be specified where required.

1. Incoming special service trunks from the zero level of first selectors.

2. Incoming automatic or ringdown "A-B" toll trunks.

3. Answering jacks for machine switching stations denied outward service for non-payment.

4. Answering jacks for trunks from various desks, such as local test, repair clerk and Chief Operator .

5. Answering jacks to care for night service trunks for repair clerk and for No. 17 information desk where this type of desk is provided.

Where coin box service is provided in the local area, separate groups of incoming special service trunks from selectors handling coin box lines may be provided for both the multi-slot coin box lines, and the single slot coin box lines, or a common trunk group may be provided to handle all coin box lines. In the latter case, a multi-slot coin box tone, consisting of a series of single pulses at the rate of five per second from the high frequency tone (460 pps) will be placed on the multi-slot coin box lines to indicate the class of service to the operator. Each of these trunks will be provided with a "tone removal" key by means of which the operator is able to remove the tone after she has determined the class of service given on the station originating the call.

If there are refused toll machine switching stations in the local area, these stations may be routed to the "A"

board over the same group of trunks as stations to which toll service is given. In this case, the refused toll stations will be provided with a two pulse tone to indicate to the operator that toll service is refused. This tone is similar to the multi-slot coin box tone, except that after each two pulses there is a silent interval produced by the omission of three pulses. These trunks will be provided with tone removal keys of the same type as those used on multi-slot coin box trunks.

Cord Circuits. Double ended common battery cord circuits with the calling cord arranged both for dialing and for use with manual trunks are provided at special service positions for completing calls between the answering jacks and the outgoing trunks. These cord circuits are designed to provide flashing recall on the answering cord and busy test on both cords, and are arranged to ring back calling subscribers. This cord circuit may be used with or without coin collect and message register features. If connected to a message register, however, the message register key must be operated before the calling party hangs up in order to make the proper charge.

Where four party full selective service is given both negative and positive superimposed ringing current is available to the answering cords of these cord circuits. The calling cords are provided with straight alternating ringing current of higher potential than the A.C. component of the current used for superimposed ringing. This high potential is provided in order to

ring on magneto rural lines or on A-B toll lines. Where four party semi-selective service is provided, both cords will be provided with straight alternating current ringing.

Where special service positions are arranged for team-work with rural positions handling magneto rural lines universal cords with similar operating features may be provided. These cords are also provided with high potential ringing current for ringing on rural lines.

Where the two number traffic is handled in accordance with the "Toll Board Method" (Method No. 2) Section V. G.E.C. 1076, the special service positions will each be provided with either two or three single ended cords, known as connector terminal cords in addition to the double ended cord circuits ordinarily required. These cords are provided for completing the connection from the two number toll board to the calling party.

Master Ringing Keys. In offices serving lines on a party line basis, it will be necessary to provide a master ringing key with one or more plunger type units in order to direct the ringing to the proper party when ringing back on a party line. In the case of two party or four party semi-selective service, one of these plunger units will be sufficient. When the ring back key of a cord circuit is operated, ringing current will normally be sent to the party or parties on the ring side of the line. When the master key is operated, the ringing current is transferred to the tip side of the line and, when the ring back key is operated, current is sent to the party or parties

on the tip. Code ringing when ringing back on semi-selective lines is controlled from the ring back key.

Where four party full selective service is given, three key units should be provided on the master key. The key unit corresponding to the second party on the line sends negative superimposed current over the tip side of the line; the key unit corresponding to the third party sends positive superimposed current over the ring side and the key unit corresponding to the fourth party sends positive superimposed current over the tip side of the line.

Call Circuit Keys. In multi-office areas in which manual offices are operated, call circuits from the A board to these offices should be provided as in manual practice. Automatic signalling over these call circuits during hours of light load is considered standard and will ordinarily be provided. Ringdown signalling may be used, however, where old call circuits of the ringdown type are already installed, in which case a master call circuit ringing key should be provided in order to ring on uncovered B positions.

Checking Multiple. Where the volume of two number or A-B toll traffic is large, it may be desirable to provide a "checking multiple" as a means of verifying the calling subscribers number on this type of call. This multiple is located in the face of the switchboard and consists of a number of small metallic pins embedded in strips which are similar to multiple jack mountings. One pin is provided for each subscribers terminal in the

machine switching unit and each pin is connected to the correspondingly numbered connector terminal at the I.D.F. Switchboard marking, such as the type of party line ringing, P.B.X. underlining, etc. may be shown on the checking multiple as required. After answering a call, the operator may verify the number given by touching the corresponding pin in the checking multiple with the plug of a "checking" cord, one of which is provided at each position equipped with checking multiple equipment. If the terminal to which this pin is connected is on the line which is calling, the operator will hear a distinctive tone called the checking tone provided she is listening in on the cord which is plugged up to handle the call.

It will be seen that, although the absence of the checking tone shows that the wrong number has been given, assuming the absence of equipment trouble, the presence of the tone is not an absolute indication on a party line that the correct number has been given.

Intercepting Positions. Intercepting positions are provided in order to intercept calls incoming for any station served by the machine switching unit and to handle calls which have been misrouted. These calls include:

1. Calls to vacant connector terminals.
2. Calls routed to vacant local selector levels through directory errors.
3. Calls to vacant toll selector levels.
4. Calls to stations to which the service is being intercepted or temporarily transferred.

5. Calls to stations which are denied incoming service for non-payment of bills.

In order to perform these various functions the following incoming trunk groups are required in addition to the outgoing trunk multiple.

(1) Intercepting trunks from connector terminals. These trunks are used both for intercepting calls to vacant connector terminals and for handling calls to stations to which service is being intercepted for any reason except lines which are plugged up.

(2) Intercepting trunks from vacant local selector levels.

(3) *Intercepting trunks from vacant levels on toll incoming selectors.

(4) Intercepting trunks from vacant levels on toll transmission selectors.

(5) Trouble observation and test trunks.

(6) Trouble intercepting trunks.

(7) Trunks from connector terminals for use by operators or supervisors in the same or another office when it is desired to verify a busy condition or to restore a cut off. Under some conditions direct trunks from manual offices in the same local area to intercepting positions may be provided for handling these calls.

(8) Where the toll board is in the same building one or more trunks to the intercepting position for the use of the toll operator in verifying busies, don't answer complaints etc.

Cord Circuits. Intercepting positions are provided with three single ended intercepting cords which are used for answering call

* On jobs where the toll transmission selector is installed as the incoming selector in the toll train, only one group of intercepting trunks from vacant toll selector levels will be required.

signals received on the intercepting trunks. These cords are equipped with listening keys and flashing keys to enable the intercepting operator to flash in local or toll operators when necessary.

Double ended cord circuits of the same type as those used on special service positions should be specified on intercepting positions where trouble observation and test trunks and trunks for verification requests are terminated and on intercepting positions which are to be teamed with positions on which double ended oords are required. Where these cords are installed on intercepting positions, the master ringing keys, call circuit keys and master call circuit ringing keys, if provided on the other positions should also be installed on the intercepting positions.

Trouble Observation and Test Trunks.
Trouble Intercepting Trunks. In order to intercept calls to and from lines on which trouble exists which cannot be cleared within a reasonable time, it is necessary to provide two groups of trunks. These groups comprise the "trouble intercepting" trunks and the "trouble observation and test" trunks and correspond to the plugging up lines in manual practice. The trouble intercepting trunks are used for intercepting calls to lines which are plugged up and the trouble observation and test trunks are used for intercepting calls originated on the line in trouble and for making tests on the line. Each trouble observation and test trunk is terminated in a jack, lamp and key and each trouble intercepting

trunk is terminated in a jack and lamp in front of an intercepting operator. The other end of each trunk is terminated in a jack at the M.D.F. These jacks are mounted in a jack box and are so arranged that each trouble intercepting trunk jack is adjacent to a trouble observation and test trunk jack. A plugging up cord equipped with a double plug on one end and a shoe on the other is provided to complete the circuit to the subscribers line. When the plugging up cord is plugged into two adjacent jacks and the shoe is inserted in the protectors of the line in trouble, the subscribers line or "outside" circuit is connected to a trouble observation and test trunk and the "inside" circuit, from the connector terminals, is connected to a trouble intercepting trunk.

Testing Equipment. One or more test circuits, each terminating in a single ended cord and a disconnect lamp are extended from the test desk to one of the intercepting positions, together with a call circuit from the test desk which is used for ordering up the cords. This call circuit terminates in a locking key and pilot lamp at the position. When the test man comes in on the call circuit, the call circuit pilot lamp is lighted. The operator answers by operating the call circuit key which extinguishes the lamp and connects her telephone set to the call circuit. The test man then instructs her to plug a test cord into any trouble observation and test trunk he desires. A multiple of this key is provided at an adjacent position for teamwork operation or for operation

during periods when the primary position is uncovered. When the test man releases the test cord the disconnect lamp in front of the machine switching "A" operator is lighted and the operator disconnects.

If there are any lines appearing at the "A" board such as magneto rural lines which are not connected to a connector terminal, or any manually operated trunks or lines appearing at the "A" board, it is considered desirable to test these trunks through the "A" board rather than opening them up at the M.D.F. Consequently if these lines or trunks are not within reach of the test cords ordinarily provided, additional test cords should be installed which are accessible to the lines or trunks in question.

Subscribers Positions. Subscribers positions are furnished where it is necessary or desirable to handle originating calls such as message rate party lines, or coin box lines on a manual basis.

The cord equipment at subscribers positions will be the same as that at special service positions, except that, since no checking multiple is provided, no checking cord will be required. Where subscribers positions are provided they will usually be teamed with the special service positions.

Rural Positions. Rural positions are provided where rural lines are to be handled in the machine switching office. In some cases, these positions are combined with special service positions and are reached by dialing zero. In other cases,

separate positions, reached by dialing the code 116 or the complete rural number are provided, as outlined in G.E.C. 1076.

Where rural lines are operated on a magneto basis, it will be necessary to either provide full universal magneto and common battery cords for positions in front of which the rural lines are terminated or where the number of rural lines is small, to equip each rural line for operation in connection with common battery cords as outlined in G.E.C. 263. In this case, each rural line will be provided with a non-locking push button ringing key in addition to the drop and jack. It is thought that where all of the rural lines may be terminated in front of one position, it will be desirable to equip these lines for operating with common battery cord circuits. Where the lines are multipled in the board or where rural lines appear at more than one position, this will ordinarily not be practicable and universal cords should be specified at those positions in front of which these lines appear.

In offices where rural line service is provided on a common battery basis, divided ringing will be provided on these lines unless otherwise specified. In this case, it will be necessary to provide a master key associated with the calling cords in order to transfer ringing current from the ring side to the tip side of rural lines. This key is of the non-locking plunger type and is similar to the master ring back keys in that it is used only to transfer the ringing connection to the tip

side of the line and not for actual ringing. The ringing code is controlled from the cord circuit ringing key.

Full universal cords are designed either for dialing or for use with manual trunks and present the same general operating features as are provided on common battery cords.

Call Wireless Trunks. Where the rural lines are not multipled through the toll board, call wireless trunks should be provided on one or more of the rural positions for completing incoming toll calls to rural lines. These trunks may be specified for operation with either common battery or magneto rural lines. The circuits are not the same, however, and call wireless trunks specified for operation with one type of rural line will not operate with the other.

Each call wireless trunk is terminated in a lamp and plug in the keyshelf and is provided with a listening key. Ringing is under control of the toll operator, except that, where divided ringing is employed on the rural lines, each call wireless trunk should be provided with a key in order to direct the ringing to the parties on the side of the line which is being called. When this key is non-operated, ringing current will be sent from the toll office to the parties on the ring side of the line and when it is operated, current will be sent to parties on the tip side of the line.

On positions where call wireless trunks are installed, busy back jacks should be provided to transmit the busy signal

to the toll operator. These jacks are arranged so that, when a call wireless trunk is plugged into a busy back jack, the supervisory lamp on the toll operators cord circuit will be flashed.

Rural Line Multiple. Where more than three positions are required for handling rural lines, a multiple of these lines should be provided in front of the rural positions. This multiple is installed on an eight panel basis in No. 1 boards and on a six panel basis in No. 1-D boards in accordance with standard manual practice.

Official Positions. Where the official P.B.X. is incorporated with the machine switching "A" board and where the number of lines involved is so great that they cannot be conveniently terminated in front of subscribers positions, official positions are employed. Where there are more than three positions handling this traffic, the official lines should be multipled before the positions which handle calls to official lines. This multiple is provided on an eight panel basis in the No. 1 board and on a six panel basis in the No. 1-D board.

Section Framework.

Type of Section. It is considered standard to use a modified form of the No. 1 eight panel three position No. 92 jack subscribers section or a slightly modified form of No. 1-D section for machine switching "A" boards. Where the No. 1-D section is suitable, it should ordinarily be used, as the section framework is not only cheaper than that of the No. 1 board, but the increased relay capacity in the rear of each section permits the mounting of a greater part of the cord circuit relay equipment in the section. Where the No. 1 board is used it will be necessary to mount most of the cord circuit relay equipment in the terminal room and to cable it to the section. The No. 1-D board is also desirable from the fact that it may be obtained in units of one position, a fact which may be of considerable importance in engineering small boards.

Where the machine switching "A" board is not to be lined up with any other type of board, the necessity of providing for checking multiple is the general controlling factor in determining which of these boards should be used. The No. 1-D board has capacity for about 11,000 terminals, and is consequently considered as being limited to installations where the ultimate requirements for checking multiple do not exceed one unit of 10,000 terminals. The No. 1 board will accommodate two full units.

Where the machine switching "A" board is to be lined up with other sections, the type of section in the existing board

should be considered in determining the type of section to be used for the "A" board. Where the existing sections are either No. 1 or No. 1-D sections, these should be used for the "A" board. Where the sections with which the "A" board is to be lined up are No. 1 Low or Intermediate type toll sections, it will be practicable and ordinarily desirable to provide this type of section for the machine switching "A" board. These boards are not maintained as standard however, and where used, the cost will be somewhat higher than for similarly equipped positions installed with No. 1 or No. 1-D framework.

Installation of Checking Multiple. Where checking multiple is installed, the checking multiple will not, ordinarily, appear at the positions adjacent to the cable turning section. The multiple cable is consequently concentrated near the top of the board in order to provide sufficient space for answering jacks in the panels between the cable turning section and the first appearance of the checking multiple. As a consequence, the space between the lower edge of this cable run and the top of the multiple space in those panels is not available to assignment for answering jacks; furthermore, the greater part of the panel immediately preceding the first appearance of the checking multiple must be left blank in order to turn the checking multiple cable to permit its appearance in the board. This subject is discussed in greater detail in Section 4-b, Location of Answering Jack Equipment.

Section Framework.

Type of Section. It is considered standard to use a modified form of the No. 1 eight panel three position No. 92 jack subscribers section or a slightly modified form of No. 1-D section for machine switching "A" boards. Where the No. 1-D section is suitable, it should ordinarily be used, as the section framework is not only cheaper than that of the No. 1 board, but the increased relay capacity in the rear of each section permits the mounting of a greater part of the cord circuit relay equipment in the section. Where the No. 1 board is used it will be necessary to mount most of the cord circuit relay equipment in the terminal room and to cable it to the section. The No. 1-D board is also desirable from the fact that it may be obtained in units of one position, a fact which may be of considerable importance in engineering small boards.

Where the machine switching "A" board is not to be lined up with any other type of board, the necessity of providing for checking multiple is the general controlling factor in determining which of these boards should be used. The No. 1-D board has capacity for about 11,000 terminals, and is consequently considered as being limited to installations where the ultimate requirements for checking multiple do not exceed one unit of 10,000 terminals. The No. 1 board will accommodate two full units.

Where the machine switching "A" board is to be lined up with other sections, the type of section in the existing board

should be considered in determining the type of section to be used for the "A" board. Where the existing sections are either No. 1 or No. 1-D sections, these should be used for the "A" board. Where the sections with which the "A" board is to be lined up are No. 1 Low or Intermediate type toll sections, it will be practicable and ordinarily desirable to provide this type of section for the machine switching "A" board. These boards are not maintained as standard however, and where used, the cost will be somewhat higher than for similarly equipped positions installed with No. 1 or No. 1-D framework.

Installation of Checking Multiple. Where checking multiple is installed, the checking multiple will not, ordinarily, appear at the positions adjacent to the cable turning section. The multiple cable is consequently concentrated near the top of the board in order to provide sufficient space for answering jacks in the panels between the cable turning section and the first appearance of the checking multiple. As a consequence, the space between the lower edge of this cable run and the top of the multiple space in those panels is not available to assignment for answering jacks; furthermore, the greater part of the panel immediately preceding the first appearance of the checking multiple must be left blank in order to turn the checking multiple cable to permit its appearance in the board. This subject is discussed in greater detail in Section 4-b, Location of Answering Jack Equipment.

Where checking multiple is to be installed or where provision for checking multiple is to be made, careful consideration should be given to the fact that, if the machine switching "A" board is lined up with other types of sections, there may be two heavy cable runs in either the "A" sections or the existing sections, depending on which of the classes of positions is adjacent to the cable turning section. This condition will ordinarily reduce the amount of checking multiple which may be installed. This difficulty may be partially overcome in the No. 1 board where the machine switching "A" positions are at the foot of the board by running one unit of checking multiple cable along the ceiling and feeding it in through the roof just ahead of the positions where it is required. Where this is done, it will be necessary to leave the two panels just ahead of the first appearance of the checking multiple blank, in order to turn the checking multiple cable. It is not considered practicable to feed more than 10,000 terminals through the roof of the board in this manner. If there is space in the rear of the board, however, it will of course be practicable to run additional checking multiple cables in this space.

Modification of the No. 1 Section. Drawing 807-108 shows the section assembly of the modified No. 1 board. Figure 1 of this drawing shows the front view, the dimensions of which are the same as the dimensions of the standard manual No. 1 subscriber's section shown on American Telephone and Telegraph Company's drawing 122-A-20.

Figure 2 shows a section through a position. The principal modification lies in the change in provision for the multiple cabling and consequent narrowing of the section by seven inches. It will be seen from these drawings that the multiple cable shelf has been removed. A series of iron details, one of which is shown on the drawing, support the outgoing trunk multiple. These details are secured to a horizontal iron detail as shown and are provided one per stile casing.

Where checking multiple is specified, cable pins similar to those used in the No. 1 toll section are furnished for supporting the multiple wiring. The supporting member shown on the drawing is tapped on 2" centers to accommodate these pins.

The only other material modification in the No. 1 section lies in the omission of the fire protection bulkhead below the multiple cable. This bulkhead is not considered justified in new machine switching "A" positions on account of the small amount of multiple cable which is to be protected.

In new sections, two vertical fire screens of rectangular shape are provided. One of these plates is mounted on the relay irons at the left end of each section and one is placed between sections extending from the cord shelf to the floor and from the front panels to the front of the answering jack running box. It is thought that these screens are justified by the insurance they afford against a fire spreading from one section to another.

Modification of the No. 1-D Section. Where the No. 1-D section is installed as a machine switching A section and no provision for checking multiple is made, no material modifications will be required over the standard manual No. 1-D section. The rear equipment arrangement will of course be different, varying on different jobs, on account of the different types of cord circuits required.

No No. 1-D boards have yet been installed in which checking multiple has been used and the detailed modifications which will be required where checking multiple is installed have not been determined. It is anticipated that the principal modification which will be required will be the removal of the multiple cable shelf, the installation of cable pins for supporting the checking multiple cable, and the provision of details similar to those in the No. 1 board for mounting the outgoing trunk multiple.

Cable Turning Sections. Drawing 807-117 shows the cable turning section provided in connection with No. 1 boards. This section has capacity for two full units of checking multiple and is provided on all jobs where No. 1 boards are installed. The key panel shown on Drawing 807-117 is provided for mounting night alarm keys and clock circuit keys on all jobs where No. 1 boards are installed. This key panel is drilled for the ultimate number of keys required and equipped as specified.

The standard 2'8" cable turning section shown on A. T. & T. Co.'s drawing 136-A-4 is provided for No. 1-D boards

where provision for checking multiple is being made. Where this provision is not made, a smaller section 1'8" in width will be provided. Night alarm keys and clock circuit keys in the No. 1-D board are mounted as outlined in section 4-D.

End Panels. End panels are provided in accordance with standard manual practice. In the No. 1 board, the panels provided are narrowed in order to fit the modification in the No. 1 section used for machine switching "A" boards.

Use of Existing Manual Sections for Machine Switching "A" Positions.

It is believed that, except under exceptional circumstances, the conversion of existing manual sections for use as machine switching "A" sections will not be justified. If there are spare No. 1 or No. 1-D sections in the local area, which will not be required for manual boards within an apparent length of time, it may prove somewhat cheaper to convert these sections to machine switching sections than to purchase new machine switching sections. It is felt however that these sections are more satisfactorily utilized if retained for manual use and that therefore their conversion will seldom be justified. Where it has been determined for operating reasons or from building considerations to line up the machine switching "A" board with an existing toll board, spare toll positions may be also converted, under the same general conditions. It is felt however that on account of the large amount of special work required existing toll sections should not be converted under any circumstances, unless the "A" board is to be lined up with a toll board.

The conversion of other sections, such as No. 10 or No. 9-c sections or the use of desks and other miscellaneous equipment presents such engineering difficulties in the rearrangement of equipment etc. as to make their use except in rare cases, impracticable. Such a case might be encountered when the only possible location for the "A" board was in the same line up with these sections.

Miscellaneous. Drawing 807-108 shows the rear of the front panels of the No. 1 Section covered with lineloum in order to prevent undue noise caused when weights strike the panel. The provision of this linoleum is optional and should be specified.

Tarpaulins should be specified where the line up consists of two or more sections as outlined in G.E.C. 783.

Rear lighting is provided only where specified in the equipment order. Where specified, the lighting provided will be the same as that provided for manual switchboards.

Where the machine switching "A" board is mounted alone, the positions and panels are numbered from "one" up in the direction of growth as in standard manual practice. Where the "A" board is incorporated in a local manual or toll lineup, the positions and panels take their numbers from their location in the lineup.

The use of operating platforms with machine switching "A" boards is considered unnecessary and is not recommended. Where,

however, it is desired to use such a platform, the front panels are arranged so that the lower eight inches may be removed and the platform provided. The equipment order should specify whether or not the front panels are to be arranged for use with operating platforms.

Keyshelves.

Type of Keyshelf. Horizontal keyshelves of standard width (1'2 5/8") are used in connection with both the No. 1-D and the No. 1 boards. Drawing 141-A-65 shows a composite No. 1 section keyshelf equipped with all the types of cord circuits which are used on machine switching A positions, and Drawing 141-A-66 shows a similar keyshelf for No. 1-D sections. As shown on these drawings both of the keyshelves have the same capacity for double ended cord circuits and call circuits as similar keyshelves used in manual practice, although the cord spaces are equipped in a different manner as outlined in these notes.

The two keyshelf drawings, 141-A-65 and 141-A-66 are designed only to show the equipment required with each type of cord circuit, and with single ended cords to show which should be located separately and which may be located two per double ended cord space. The location of the cord circuits shown on these drawings is not typical, except that, in general, single ended cords should be located at the end of the position and double ended cords in the centre. In all cases the cord spaces which are to be equipped with any type of cord circuit should be specified for each position. If a position is partially equipped with one or more types of cords the cord spaces which are to be equipped should be specified; otherwise the cord spaces will be equipped in numerical order.

Drawings 807-110 and 807-111 show the keyshelf dimensions and the type of equipment used on the No. 1 and No. 1-D keyshelves respectively.

Double Ended Common Battery Dialing Cord. Double ended common battery dialing cord circuits are provided as specified on machine switching "A" positions. Each cord is provided with a back and front supervisory lamp and two lever type keys as shown on the keyshelf drawings, with wiring for coin collect and return keys and message register connections. Equipment for coin collect and return keys will be provided only where specified. These cord circuits are arranged for listening key dialing, as outlined in Section 1-c.

Full Universal Cord. Full universal magneto and common battery cord circuits are provided as specified. The keyshelf equipment, method of dialing and operation of signals is the same as in the common battery cords. The provision of coin collect and return keys on these cord circuits requires a material modification of the circuit and involves an appreciable expense. Consequently wiring for coin collect and return keys on universal cord circuits will be provided only where specified.

Intercepting Cord. It is considered standard to wire for three and equip either two or three intercepting cords on all positions designed for handling intercepting traffic. This cord circuit is provided with lamp and key equipment as shown on the keyshelf drawing. Only one intercepting cord is provided per double ended cord space, the front cord space being equipped in all cases.

Connector Terminal Cord. Where connector terminal cords are specified, it is considered standard to wire three cords for this

purpose and to equip either two or three of the cords as specified. Connector terminal cords should be provided one per double ended cord circuit space and are equipped with lamp and key equipment as shown on the keyshelf drawing.

Call Wireless Trunk. Call wireless trunks should be specified only in offices where rural lines are not multipled through the toll board. As outlined in Section 1-c, the call wireless trunk circuit provided to operate with common battery rural lines is different from that provided to operate with magneto rural lines, and consequently the type of rural line should be specified in connection with the trunk. Where common battery rural lines are operated, divided ringing will be provided unless otherwise specified and the rear spring combination on the listening key will be equipped to direct the ringing current.

Test Cord. Test cords are provided as specified at the intercepting position in front of which the trouble observation and test trunks are terminated. The number of cords to be specified should be determined from the probable maximum number of simultaneous tests which will be conducted over these cords at any time. Wiring should be specified for the ultimate maximum number of cords required and equipment specified for the immediate requirements.

The test cords should usually be grouped at one end of the position and where they are easily accessible to the trunks they are designed to serve. It is not believed that, in general, more than six of these cords will be required in any one unit of

10,000 terminals or that more than ten will be required where the "A" board is common to two units of machine switching equipment. Where test cords are provided in other parts of the board for testing through the manual lines or trunks as outlined in section 1-c, these cords form an addition to the number ordinarily required.

Call Circuit from Test Desk. The call circuit from the test desk for ordering up the test cords appears at the position where the test cords are located. It is terminated in a locking key, shown on the keyshelf drawing, and a lamp. As outlined in Section 1-c, a multiple of the key is provided in an adjacent position for team-work or light load operation. The lamp is not multipled and appears in the piling rail between the two positions as shown on Drawing 807-116.

Where it is necessary to provide two groups of test cords, as outlined in the preceding paragraph, two of these call circuits should be specified.

Checking Cord. Where checking multiple is specified, the checking cord shown on the keyshelf drawings will be provided for use in connection with the checking multiple.

Dial and Dial Mounting. It is considered standard to use a 2-E type dial on machine switching "A" boards. This dial is of the same general construction as the 2-A type dial used on subscribers sets except that for circuit reasons, there are five contacts required on each dial instead of four.

A new type of dial mounting, known as the 6000 type has recently been standardized in order to facilitate the replacement of the positional dial by a new one. This dial mounting is described briefly on Page 1, Section 8, Division IX of these notes and in detail in G.E.C. 1260. The location of the dial and dial release key is as shown on the keyshelf drawings and the location of the dial pilot is shown on Drawing 807-116. The dial release key is of the non-locking plunger type with a metal frame top.

Master Keys. The master ring back keys are located adjacent to the right hand cord key and on the same keybase as the dial release key as shown on the keyshelf drawing. These keys are of the non-locking plunger type with metal frame tops. They are designated and colored as indicated on the drawing. Wiring and equipment for these keys is provided only as specified.

Where a master call circuit ringing key is provided on a position, this key is mounted on the same base with the dial release key and the master ringing keys and is located and designated as shown on the keyshelf drawings. Wiring and equipment for this key is provided only where specified.

Where divided ringing is provided on rural lines, the master key referred to in section 1-c for transferring the ringing current to the tip side of the line is also mounted on the master key base. The key button is of the metal frame top type, colored black and provided with a letter designation to indicate

the side of the line on which the ringing current is to be placed in order to call the desired party. The characters will be white in all cases. Wiring and equipment for this key is provided only when specified.

A keybase designed to mount all six of the keys which may be mounted on this strip is provided on all jobs, so that on additions or changes in operating practice it is only necessary to equip the additional keys which are required by the change. The top of the keybase is drilled to accommodate only those key units which are equipped. The various key units will, in all cases, be located on the keybase as shown on the keyshelf drawings, regardless of what combination of keys is required.

Call Circuit Keys. Although space is available for three strips of twelve call circuit keys each on the No. 1-D board and for five similar strips on the No. 1 board, it is seldom that more than one strip of call circuit keys will be required. Wiring for twenty four keys will be provided on the No. 1 board and for twleve keys on the No. 1-D board. Equipment should be specified in multiples of twelve keys for those keys which are required initially. In all cases the strip nearest the operator will be equipped first and additional strips should be equipped successively toward the end of the keyshelf.

Where an emergency call circuit is specified, the call circuit button used for this purpose should be the button farthest from the edge of the keyshelf in the first strip of call circuit

keys equipped. This button is engraved "EMG."

Emergency Call Circuit Cord. An emergency call circuit cord and equipment as outlined in G.E.C. 144 will be furnished where the "A" board is equipped with outgoing call circuit trunks.

Miscellaneous Equipment Items. In all cases and on all positions a ticket pad holder, ticket receptacle and peg count key are procided as shown on the drawing.

Where position clocks are required, the No. 1-A clock circuit should be specified on alternate positions requiring clocks.

Outgoing Trunk Multiple.

General. The outgoing trunk multiple is located immediately above the piling rail in both the No. 1 and No. 1-D boards, as shown on Drawings 807-112 and 807-113 respectively. The outgoing trunks are multipled on a five panel basis in the No. 1-D board and on a six panel basis in the No. 1 board as in manual practice.

The outgoing trunk jacks are mounted twenty per strip, with a designation strip provided above each strip of jacks, as in manual practice. The outgoing trunk multiple is arranged to grow from the bottom up. The jacks in each panel are numbered from left to right, from zero up, beginning with the bottom strip of jacks. As shown on the drawing, stile casing number plates are associated with the outgoing trunk multiple in order to identify the trunks appearing in each panel of the multiple.

In laying out the face equipment, space should ordinarily be left to meet the ultimate requirements of the outgoing trunk multiple. In general, this will not be more than two strips of jacks per panel.

Outgoing Dialing Trunks to First Selectors. Where the ultimate requirement for the outgoing dialing trunk group is more than ten trunks and where the trunks appear in the face of the board three or more times, a group busy lamp is associated with each five consecutive trunks. A combination lamp mounting and designation strip is provided for mounting these lamps and the designation strip used in connection with the trunks.

Delayed Call Equipment. Unless otherwise specified three of the trunks in the outgoing dialing trunk group to first selectors will be equipped for handling delayed calls routed to the "A" board by a calling subscriber who is otherwise unable to complete his call. The delayed call equipment involves an auxiliary jack for each trunk and a certain amount of relay equipment. The auxiliary jack is located in the same strip with the associated trunk jack, each auxiliary jack being adjacent to and on the right of the associated trunk jack. The first trunks equipped in the trunk group should be provided with this feature. Where group busy lamps are associated with a strip of outgoing dialing trunks in which delayed call jacks appear, these lamps will be associated with each five jacks in the same manner as where all of the jacks are equipped as trunk jacks.

Outgoing Manual Trunks. These trunks are similar to the manual trunks outgoing from a manual "A" board. These trunks are used as outlined in Section 1-b and should be specified in accordance with the Step-by-Step Machine Switching Traffic Engineering Practices.

Interposition Trunks. Where interposition trunks are required in the machine switching "A" board for routing traffic from one position to another, automatic trunks will be provided as specified. These trunks will form a part of the outgoing trunk multiple and each trunk will appear in an answering jack and lamp before the operator to whom the call is to be routed.

Supervisors' Trunks. One supervisor's trunk to each supervisor's division is provided in the outgoing trunk multiple in order that any operator may reach any supervisor.

Tone Trunks. Tone trunks may be specified in the outgoing trunk multiple for educating subscribers in the various tones which will be received by them. Each of these trunks is permanently connected to a specific tone, such as the dial tone, line busy signal, audible ringing signal, or vacant selector level tone. Where four-party semi-selective party line service is given it will be necessary to specify one tone trunk for the single ring code signal and a separate trunk for the two ring code signal.

Miscellaneous Trunks. Two-way automatic trunks are provided from the machine switching A board to the repair clerk's desk, chief operator's desk and to the test desk. Ordinarily two of these trunks to each desk will be sufficient in a unit of 10,000 terminals.

In multi-office cities having a centralized complaint desk, direct trunks may be provided to this desk where warranted. In general, however, these desks are reached by dialing a code or connector terminal number.

Where connector terminal cords are provided for two-number toll operation, trunks to the two-number toll board are provided as required for use under this method of operation.

A few trunks to the toll recorder should be specified for each unit of 10,000 terminals.

Offices which are to be reached from the machine switching office by means of manual ringdown, automatic or call circuit trunks, form a part of the outgoing trunk multiple. These offices will as a rule be distant from the machine switching office and will ordinarily be operated on an A-B toll basis. If relatively expensive ringdown trunks are employed, an individual busy lamp should be provided for each trunk when the number of trunks and the number of times the trunks are multipled appear to warrant this expense.

Answering Jack Equipment.

Location. The space which may be assigned to the answering jack equipment is dependent upon the provision for checking multiple. In the No. 1-D board this restriction will rarely affect the layout of the answering jack equipment. In the No. 1 board where allowance is being made for two full units of checking multiple, the space available for answering jack equipment in the panels where the checking multiple is to appear will ordinarily be limited to three strips of answering jacks and associated lamp and designation strips per panel. This restriction is based on the provision of two strips of outgoing trunk jacks at the same time keeping within the maximum desirable operators' reach of 34 inches. Where only one strip of outgoing trunk jacks is provided, four strips of answering jacks may be used without exceeding this reach limitation.

Drawing 807-112 shows the space assigned to answering jack equipment in No. 1 boards equipped with two units of checking multiple. Figure 6 is typical of the panels between the cable turning section and the first appearance of the checking multiple in the board, and shows the space available for answering jacks between the outgoing trunk multiple space and the checking multiple cable run in the rear of the board. It will be necessary to leave the larger part of the panel adjacent to the first appearance of the checking multiple blank, as shown on Figure 5, in order to turn the cable

in panels having various arrangements of answering jack equipment. In general, it is felt that the space in panels equipped with checking multiple is ample for locating those jacks which it is necessary to terminate in front of positions where the checking multiple appears.

Jack Mountings. Where practicable, answering jacks should be mounted on a ten-per-strip basis. It is possible, however, where answering jack space is limited, to mount certain of the answering jacks on a twenty-per-strip basis. Table I of this section together with Drawing 807-112 outlines the equipment of all types of answering jacks in the No. 1 board and enumerates those jacks which may be mounted on a twenty-per-strip basis. Table II and Drawing 807-113 give a similar information for the No. 1-D board. Jack and lamp socket mountings arranged to accommodate number plates are provided for all groups where the jacks are mounted ten per strip, whether the number plates are required or not. This arrangement affords a desirable flexibility, since certain groups of lines may require fairly frequent rearrangement.

Intercepting Trunks from Connector Terminals. It is considered standard to provide one intercepting trunk for each 100 connector terminals in the machine switching unit. Each of these trunks is available to a particular 100 terminals, and all of the vacant terminals in that group are strapped together and cross-

connected to the intercepting trunk at the I.D.F. In addition, from twenty-five to fifty additional intercepting trunks in a full unit should be provided in order to care for cases where several busy lines are affected at one time in the same connector hundreds group.

Intercepting Trunks from Vacant Selector Levels. It is no longer considered standard to connect vacant local selector levels to the machine switching A board, except in case of directory errors. A common "tone supply" circuit is connected to the 153 p.p.s. tone and in general five "tone trunk" circuits are provided for placing the tone on vacant local selector levels. By means of this circuit the tone is placed on the vacant selector levels for three-tenths second, is taken off for two-tenths, on three tenths and off seven-tenths second.

It will be necessary, however, to provide two trunks to the A board from vacant local selector levels in order to care for calls which may be misrouted by directory errors. The trunks in the group intercepting calls to vacant connector terminals are not satisfactory for this purpose.

Intercepting trunks should be specified for intercepting calls from vacant toll regular and toll transmission selectors. The trunks used for intercepting calls to vacant levels on local selectors are not suitable for this purpose and the trunks from vacant levels on toll regular selectors differ from those from vacant levels on toll transmission selectors.

so that three separate groups of trunks from vacant selector levels are necessary. It is contemplated in the future, however, thut talking battery will be supplied the toll train at the toll incoming selector, thereby causing this selector to function as the toll transmission selector. On jobs engineered in this aay the intercepting trunks from vacant toll selector levels will all be of the type used for intercepting calls from vacant levels on toll transmission selectors and consequently only one group of these trunks will be required,

Where there is more than one vacant level on a selector, trunks from these levels are strapped together at the I.D.F. and combined with vacant selector level trunks from other selectors of like type such as local, toll, etc, The entire group may then be divided over as few jacks as are practicable to handle the traffic. In general two trunks to the a board will be sufficient for each group of trunks from vacant selector levels,

Plugging UP Lines. The trouble observation and test trunks will ordinarily be terminated in front of an intercepting operator and ordinarily at the head of the board. It will ordinarily be desirüble to terminate the trouble intercepting trunks in front of the same position,

The number of theae trunks which should be providcd will, of course, vary with local conditions. In general it is felt however that the same general conditions apply to the provision of these trunks as apply to the provision of plugging

up linea in manual practice.

Rural Lines Operated on a Magneto Basis. Rural lines may be terminated at the machine switching A board, as outlined in Section 1-c. Where these lines are operated on a magneto basis, line drops are provided in place of line lamps, and where the rural lines are to operate with common battery dialing cords a ringing key is provided in connection with each line.

Line drops are mounted five per strip and are located immediately above the strip of answering jacks with which they are associated. The answering jacks are mounted ten per strip, so that two strips of drops will be required with each strip of jacks. In order to permit of a vertical association of jacks and drops, which constitutes a material operating advantage, it is considered standard to wire the upper strip of drops to the odd numbered jacks and the lower strip of drops to the even numbered jacks. Ringing keys, where required, are mounted ten per strip immediately below the associated jacks.

G.E.C.'s Nos. 263 and 855 discuss the provision and equipment of rural lines in manual boards in detail. The same general considerations which apply to these lines in manual boards apply to machine switching "A" boards.

Multiple Answering Jacks. Under some conditions where there are a number of positions handling special service traffic it may be desirable to provide multiple answering jacks of the special service and the incoming A-B toll trunks Where the special service team consists of either four or five operators, one

multiple of the answering jacks is ordinarily provided, and where the team consists of six or more operators, both first and second multiple jacks should be provided, Multiple answering jacks are provided on a seven panel basis in the No. 1 board and on a six ganel basis in the No. 1-D board. First multiple jacks should be located so as to extend in the direction of growth of the board from the primary answering jack, and second multiple jacks should be located toward the head of the board from the primary answering jack.

When a position is inetalled the primary answering jacks located in any one panel should be installed first, the first multiple jacks appearing in the same panel, if any, should be looated immediately above them and the second multiple jacks in that panel above the first. It is not endeavored to keep the multiple jacks separate from the primary jacks, and no holly strip is provided between them. If primary jacks are to be added at a later date, these will be located above any existing multiple jacks that may be located in the same panel.

It is desirable, however, where practicable, to install multiple answering jacka on the same numerical basis per strip as the primary jacks, unless space limitations yrevent. Where necessary the multiple answering jacks should be installed on a twenty-per-strip basis in preference to installing primary jacks on this basis.

In numbering answering jacks no distinction is made between primary and multiple jacka, all answering jacks in a

panel being numbered from left to right and from zero up, beginning with the bottom strip of jacks.

Other Answering Jack Equipment. The above paragraphs of this section have described the individual equipment of those groups in which there is a distinct recommendation to be made or where the equipment ia peculiar to the machine switching A board. The remaining answering jack equipment is of the ordinary type, terminating in a jack and lamp at the switchboard. It should be provided as specified in the traffic order and equipped in accordance with Tables I and II.

Checking Multiple,

Test Strip. Drawing No. 807-114 shows a strip of checking multiple for use with a No. 92 jack panel. No checking multiple has yet been installed in a No. 49 jack panel and no multiple strip has been developed for this panel. It is anticipated that if checking multiple is to be installed in a No. 49 jack panel, the strip shown on Drawing 807-114 will be uaed with an adapter to fit the panel.

Construction. Each strip of checking multiple contains 100 lugs or pins arranged in five horizontal rows of twenty each. Each lug corresponds to a connector terminal number and is connected at the I.D.F. to the sleeve conductor of the connector terminal by means of a single wire. In order to set apart the various strips or hundreds groups in the same panel, the top of each strip is grooved and filled with whiting. The pins are made of small brass rods, the front of each of which is flush with the front of the checking multiple strip and slightly concave. These rods extend to the rear of the mounting where they are formed into terminal lugs for connection to the checking multiple cables. In order to facilitate the aelection of any particular pin, the checking multiple strip is provided with white spotting between each five pins in a horizontal row and a horizontal groove is cut in the mounting in line with each horizontal row of pins to act as a guide for the

plug tip. This groove is useful in checking on calls from private branch exchanges. A checking multiple strip is mounted in a panel by 'jack fasteners and flanges on the ends of the strip in a manner similar to that in which a jack strip is mounted,

Capacity of No. 1 and No. 1-D Sections. The checking multiple is installed on an 8-panel basis in the No. 1 board. The overall height of two units of checking multiple installed on this basis is twenty-five inches, so that it may be considered that, after allowing for the ultimate space requirements for the outgoing trunk multiple and the answering jacks, there will be room for the installation of two full units of checking multiple in this type of board in practically all cases, assuming a suitable layout of the answering jack equipment, without exceeding the maximum desirable Operators reach of approximately thirty-four inches.

In the No. 1-D board, the checking multiple is installed on a six panel basis, so that the overall height of a unit of 10,000 terminals is seventeen inches. This increase in height over the height of a similar amount of checking multiple in the No. 1 board, combined nith the lower height of the No. 1-D board itself, will in most cases, prevent the installation of more than 11,000 terminals. For this reason, the capacity of the No. 1-D board is

ordinarily considered as being limited to a single unit.

Numbering arid Growth As shown on Drawing No. 807-112, Figure 1, the checking multiple is arranged to grow from the bottom up. The pins in each checking multiple strip are numbered 0 to 99, the top row of pins being numbered left to right from 0 to 19, the next lower row, 20 to 39, etc. As shown on the drawing, the 96, 97, 98 and 99 hündred groups of the second unit in a No. 1 board will be located in the same layer with the 96, 97, 98 and 99 hundred groups of the first unit.

The stile casings are drilled and equipped with number plates, one number plate being located on the stile casing at the left of each checking multiple strip for the purpose of indicating the particular hundred connector terminals witn which the strip is associated. The stile casing is drilled and equipped, unless otherwise specified, with number plates for one or two units of checking multiple depending uponthe ultimate installation. In case checking multiple is not installed initially the stile caaings will not be drilled or equipped with number plates.

In case a machine switching "A" board has an initial and ultimate installation of one and two units of checking multiple respectively, consideration should be given to ths probability of the first unit of checking multiple being raised or lowered at the time of or before

the installation of the second unit of checking multiple. If it is probable that the first unit of checking multiple will be raised or lowered, it should be specified that stile casing number plates should not be provided for the second unit of checking multiple.

Location. Where checking multiple is provided initially, it is deoirable wherever practicable to locate the checking multiple stripa immediately above the initial installation of answering jacks in order that the operators' reach may be reduced to a minimum. By moving the checking multiple cables nearer to the front of the board, it is possible to provide slack in the skinners so that the checking multiple equipment muy be raised when additions are made to tbe answering jack equipment. A range of three inches in the vertical location of the strips is made available in this way without moving the multiple cable in the rear of the board.

In order to provide a further range throughout which the checking multiple equipment may be located and to facilitate the engineering of machine switching "A" boards, three plans of locating the checking multiple cable have been standardized. These plane are referred to ae Plans A, B and C and it is suggested that these terms be employed in apecifying the cabling arrangement desired for the checking multiple.

The location of the checking multiple cable pins is shown on Drawing 807-108. Plans A, B and C consist of placing the lowest layer of checkingmultiple cables on the cable pins located 4-3/16, 6-3/16 and 8-3/16 inches above the piling block, respectively. The figures in the following table are distances from the piling block to the lower edge of the first layer of checking multiple and indicate the range within which this edge may be located under any of the three plans.

| Plan | Maximum Distance | Minimum Distance |
|---|---|---|
| A | 5-1/4" | 2-1/4" |
| B | 7-1/4" | 4-1/4" |
| C | 9-1/4" | 6-1/4" |

The ultimate requirements of answering jack and outgoing trunk multiple space are the factors which should determine the cabling plan to be employed. Unless otherwise specified, the checking multiple will be cabled in accordance with Plan "B". In all cases, the distance from the piling block to the lower edge of the first layer of checking multiple should be specified.

Miscellaneous Face Equipment.

Rural and Official Line Multiples. The rural and official line multiples are located above the answering jacks as shown on Drawings 807-112 and 807-113. The multiples are installed on an eight panel basie in No. 1 boards and on a six panel basie in No. 1-D boards. The jacks may be mounted either ten or twenty per etrip as specified and may be supplied with or without designation stripa, depending on local operating conditiona and apace limitations. The rural and official line multiples should be specified as outlined in Section 1-c.

Pilot Lamps and Drillings in the Piling Rail. Drawing 807-116 shows the standard arrangement for pilot lamps and their number plates mounted in the piling rail of both No. 1 and No, 1-D eections, Where lamps or number plates are not required in any of the spaces shown as drilled, apparatus blanks will be provided,

Each pilot lamp is provided as a part of the circuit with which it is associated and need not be specified individually. The call circuit pilot is associated with the call circuit from the test desk and will be provided only between the positions where the call circuit key and the call circuit multiple key are terminated,

Fuse Alarm Lamp. Fuse alarm lamps are provided with both No, 1 and No. 1-D Sections although the complete fuse alarm circuit

is required with only the No.1-D section. In the No, 1 board all of the line lamps are grounded through the auxiliary line relay and it is consequently desirable to fuse thio relay to ground. The fuse alarm lamp is installed as a visual signal in case this fuse is blown. The fuae alarm lamp is mounted in accordance with Drawings 807-112 and 807-113.

Busy Back Jacks at Rural Positions. Where call wireless trunks are terminated at the "A" board, busy back jacks to the toll operator should be specified as required, Either two or three of these jacks will ordinarily be sufficient.

These jacks ehould be installed in the lower part of the answering jack space,

Key Sleeve Holder. Key sleeve holders, described in G.E.C. 1055 ahould be specified on alternate positions handling traffic from coin box lines terminated in answering jacks.

Nigh. Alarm and Clock Circuit Keys. In the No, 1 board, night alarm and clock circuit keys are mounted in a key panel in the cable turning section, as shown on Drawing 807-117. In the No. 1-D board, these keys are mounted in the face of the switchboard, in the upper part of the first panel of the first position.

Rear Equipment

General. Each machine switching "A" position presents a separate problem in the arrangement of the rear equipment on account of the different number and type of cord circuite with which it may be equipped. Certain general arrangements are followed, however, wherever practicable and these arrangements are shown for general information on the accompanying drawings.

Arrangement of Wo. 1 Board. Drawing 807-118 showa a possible rear equipment for a No, 1 board. In this type of' board it will be practicable to mount the operator·s telephone aet, the supervisor's circuit, dial circuit and miacellaneous switchboard circuits in the section as shonn on the drawing, and in addition there will be sufficient space to mount the intercepting cord circuit equipment in the section in positiona where these cords are required. It is desirable to confine the space used for these cords to intercepting cord equipment in all positions, not only for the sake of uniformity but because these circuits üre more apt than other types to be added as the board grows and this location will always be available when reyuired, The local form leads for other cord circuits are brought to terminal strips and cabled to the relay rack.

Arrangement of No, 1-D Board, Drawings 807-119, 807-120, 807-121 and 807-122 show for information purposes only

typical rear equipmenta of No. 1-D sections with various combinations of cord circuit equipment. Where this board is used as a machine switching "A" board, it is not practicable as will be seen from these drawings to mount the entire cord circuit equipment for any of the cords in the section as is done in manual practice. The cord circuit equipments are coneequently split, the supervisory relays and those relays whose springs form talking contacts being mounted in the section.

The rear equipment drawings show the probable cornbinationa of cord circuits on fully equipped positions. Where similar combinations of cord circuits are specified on partially equipped positions, the same general arrangement of equipment will be followed, the cord circuits being similarly split and Che relay space not required on the partially equipped position being left vacant.

Relay Rack Equipment.

Drawing 807-123 shows the relay rack used for mounting the line and trunk relay equipment for the "A" board and such of the cord circuit relay equipment as cannot be mounted in the section, This rack is of the unit type and is furniahed in two heights, one of twelve feet and one of nine feet, Where the ceiling height is suitable, the twelve foot unit should ordinarily be specified for machine switching "A" boards.

The rack is single sided and is designed and drilled to mount standard A.T. & T. Co's 19-1/4 inch relay mounting plates on 1-3/4 inch centers, The circuita may be mounted with the apparatus arranged vertically with corresponding relays in like circuita mounted on the same plate, or horizontally with all of the apparatus for one or more circuits mounted on a single plate, Relay rack space considerations are the principal factors in determining the method in which the apparatus is mounted, it frequently being the case that a part of the circuits on one bay have the apparatus arranged vertically and a part have the apparatus arranged horizontally,

The apparatus is assembled on the rack and the local cables for each rack are made up and installed in the shop, each bay being shipped as a completely equipped and wired unit, The local cables are terminated on flat type

terminal strips at the top of the rack. Similar strips are provided for terminating the switchboard cable leads from the distributing frames, switchboard and tie cables. These strips are installed immediately above those terminating corresponding leads from the local form cables and connections are made by pinching and soldering the terminals together. A complete description of these terminal strips and the method of making this connection is given in Div, II, Sec, 3c.

Fuse panels, each panel having a capacity of twenty fuses, are mounted immediately below the terminal pile-ups. These panels are mounted on iron platee as shown on the drawing. These plates are in turn drilled so that they may be mounted on the rack in the same drillings as the relay mounting plates, so that as many fuse panels as are required to care for the circuits on the rack may be provided without providing special drilling.

Cabling and Wiring.

Drawing 807-115 shows the preferred method of cabling the line and trunk circuits incoming to the machine switching "A" board. All of the jacks in the outgoing trunk multiple are cabled to the horizontal I.D.F. and cross-connected to the vertical I.D.F. in accordance with standard manual practice. The jacks in the answering jack space are in general cabled directly to the relay equipments through punchings on the V.I.D.F. except in those groups for which it is contemplated that not more than twenty jacks are required in the ultimate. In these cuses, except for those shown otherwise on the drawing, the jacks will be cross-connected to the relay equipments.

It will be observed that in several of the answering jack groups indentical relay equipments are provided on lines meeting different traffic requirements and consequently grouped separately from a traffic standpoint. In determining the number of lines in a group in order to determine whether these lines should be cross-connected or cabled solidly to the relay equiprnent, lines having identical relay equipment are considered as a single group, regardless of their traffic function,

AMERICAN TELEPHONE & TELEGRAPH CO
Department of
Operation and Engineering

# STEP BY STEP MACHINE SWITCHING EQUIPMENT

## ARRANGEMENT OF MACHINE SWITCHING No 1A SWITCHBOARD KEYSHELF EQUIPMENT

Arranged for Intercepting, Special Service and Rural Operators

14-A-65

Engineer
Draftsman
Checked by

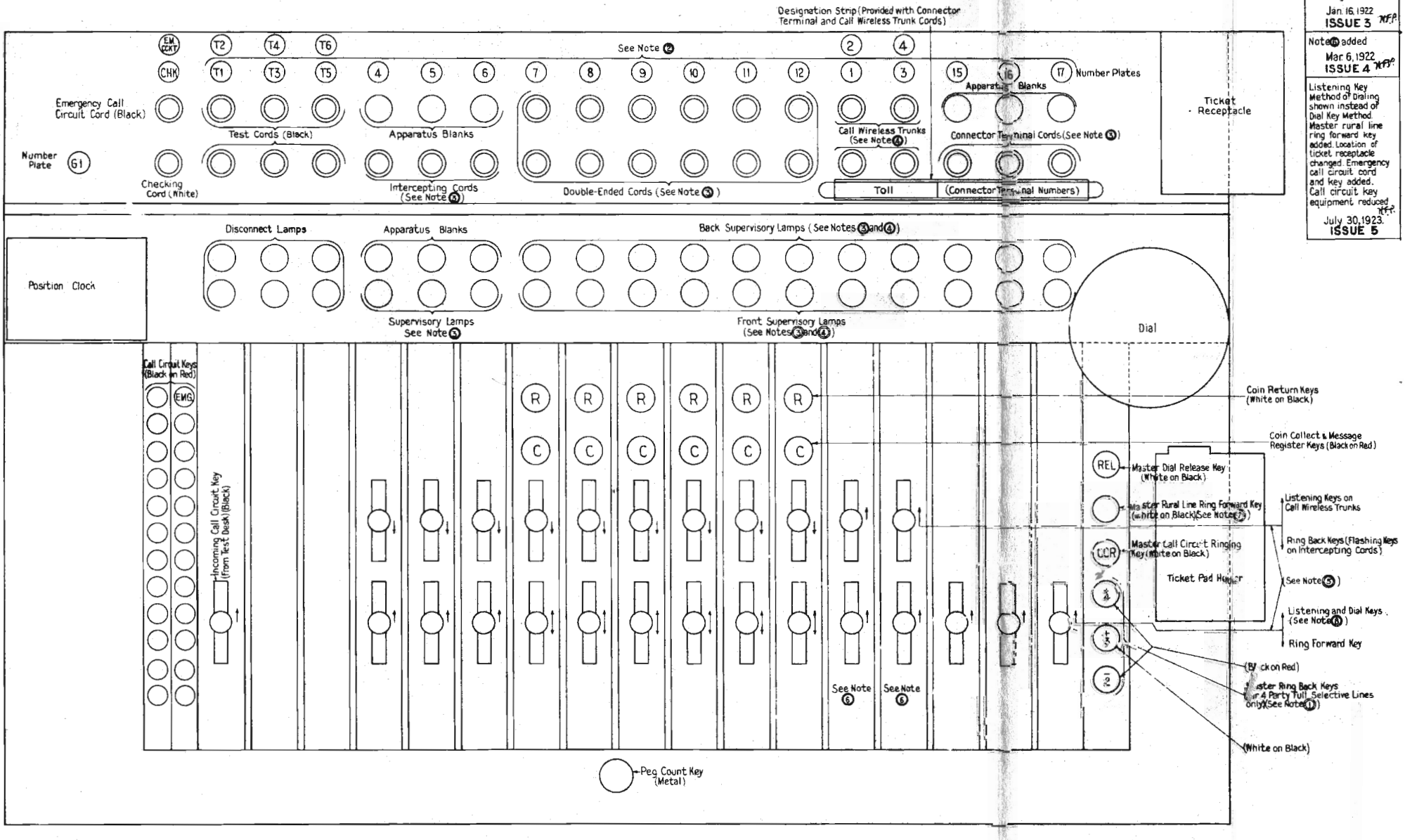
May. 25, 1921
**ISSUE 1**

Checking cord added
Sept 20, 1921
**ISSUE 2**

Cord, Lamp and Key colors changed. Master Ringing Keys rearranged.
Jan 16, 1922
**ISSUE 3**

Note (6) added
Mar 6, 1922
**ISSUE 4**

Listening Key Method of Draling shown instead of Dial Key Method. Master rural line ring forward key added. Location of ticket receptacle changed. Emergency call circuit cord and key added. Call circuit key equipment reduced.
July 30, 1923.
**ISSUE 5**




### NOTES

1. With 4 party semi-selective lines or 2 party lines only, only one master ring back key is required, located in the position of the 5 key shown above, colored red and unmarked.
2. The various types of cords on step by step machine switching positions are shown above for the purpose of outlining the arrangement of equipment associated with each type of cord. The preferred locations for the various types of cords as recommended in the traffic engineering practices should be used as a basis for specifying the location of any type of cord.
3. All intercepting, double-ended and connector terminal cords and their associated supervisory lamps are colored alternately red, white and green.
4. Call wireless trunk cords arranged in a double row and their associated supervisory lamps are colored as follows:- a-Back row-alternately green, red and white.
   b-Front row-alternately red, white and green.
5. All key handles in the front row of keys are colored black and all key handles in the back row are colored red except the call wireless trunk key handles which are black.

### NOTES

6. With common battery rural lines, if divided ringing is employed, a key to direct the ringing must be provided for each trunk. The key associated with each trunk will then become a three way key as follows:-
   a-Thrown away from the operator-Listening
   b-Thrown towards the operator-Directing Ringing
7. With common battery rural lines, if divided ringing is employed, a regular cord ring foward key is used to ring forward on the tip side of the line. Master rural line ring forward key will be operated in addition to regular cord ring forward key to ring on tip side of line. Master rural line ring forward key will be marked with letter used to designate tip side of line.
8. Listening and dial key on regular cords only. Listening key only on connector terminal, call wireless and intercepting cords.

AMERICAN TELEPHONE & TELEGRAPH CO.
Department of
Operation and Engineering

# STEP BY STEP MACHINE SWITCHING EQUIPMENT

## ARRANGEMENT OF MACHINE SWITCHING No1-DA SWITCHBOARD KEYSHELF EQUIPMENT

Arranged for Intercepting, Special Service and Rural Operators

141-A-66

Engineer
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Checking Cord added
Sept. 20, 1921
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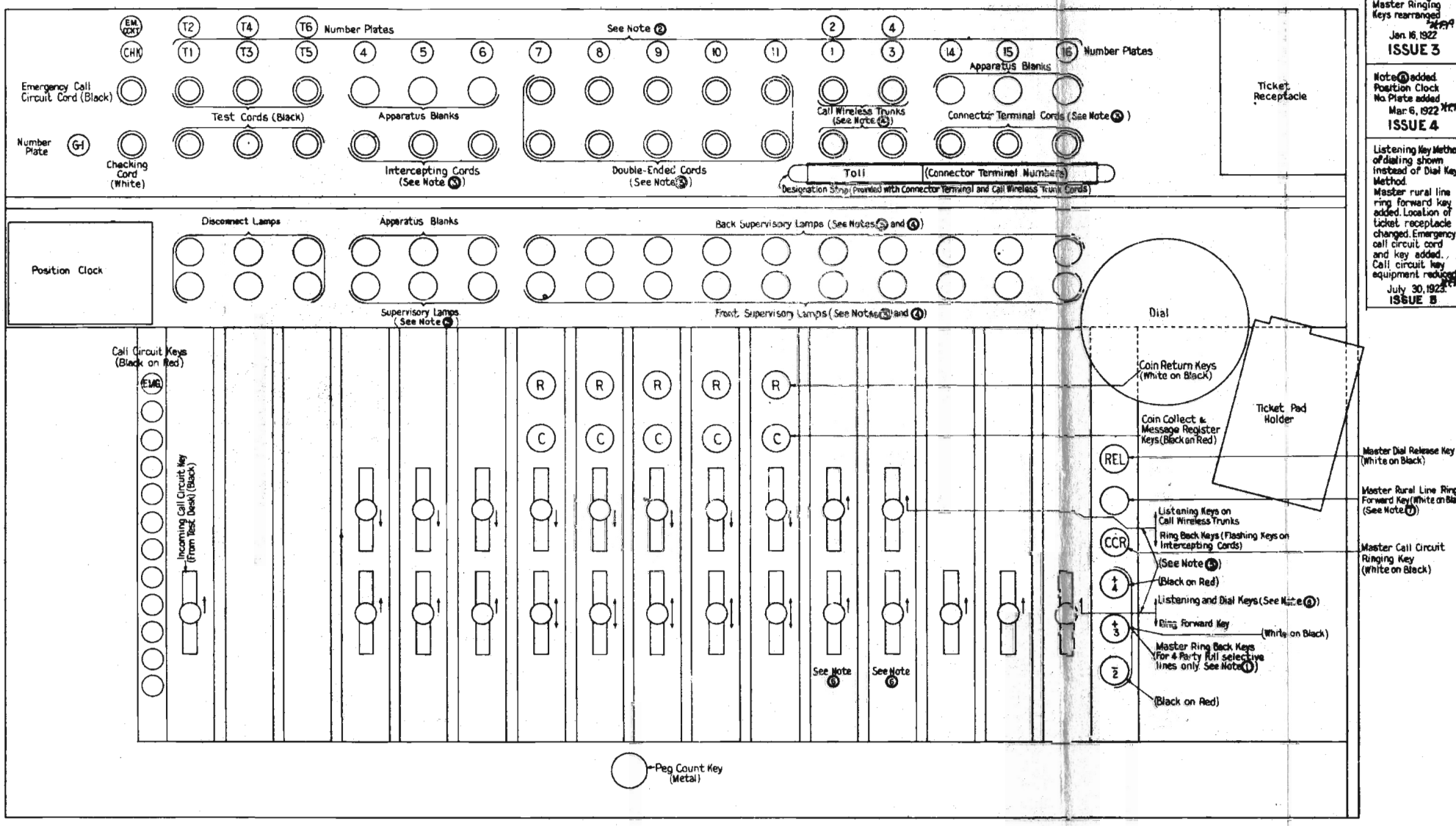
Note (A) added. Position Clock No. Plate added
Mar. 6, 1922
ISSUE 4

Listening Key Method of dialing shown instead of Dial Key Method. Master rural line ring forward key added. Location of ticket receptacle changed. Emergency call circuit cord and key added. Call circuit key equipment reduced.
July 30, 1923.
ISSUE 5




### NOTES

(1) With 4 party semi-selective lines or 2 party lines only, only one master ring back key is required, located in the position of the '3' key shown above, colored red and unmarked.

(2) The various types of cords on step by step machine switching 'A' positions are shown above for the purpose of outlining the arrangement of equipment associated with each type of cord. The preferred locations for the various types of cords as recommended in the traffic engineering practices should be used as a basis for specifying the location of any type of cord.

(5) All intercepting, double-ended and connector terminal cords and their associated supervisory lamps are colored alternately red, white and green.

(A) Call wireless trunk cords arranged in a double row and their associated supervisory lamps are colored as follows:-
a-Back row-alternately green, red and white
b-Front row-alternately red, white and green

(S) All key handles in the front row of keys are colored black and all key handles in the back row are colored red except the call wireless trunk key handles which are black.

### NOTES

(6) With common battery rural lines, if divided ringing is employed, a key to direct the ringing must be provided for each trunk. The key associated with each trunk will then become a three way key, as follows:-
a-Thrown away from the operator-Listening.
b-Thrown towards the operator-Directing ringing.

(7) With common battery rural lines, if divided ringing is employed, regular cord ring forward key is used to ring forward on ring side of the line. Master rural line ring forward key will be operated in addition to regular cord ring forward key to ring on tip side of line. Master rural line ring forward key will be marked with letter used to designate tip side of line.

(8) Listening and dial key on regular cords only.
Listening key only on connector terminal, call wireless and intercepting cords.