

TYPE K-1 CARRIER TELEPHONE SYSTEM

KEY OPERATED AMPLIFIER AND LINE SWITCHING ARRANGEMENTS

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1. GENERAL

1.01 This section covers the description and operating principles of the amplifier switching and line switching circuits for use in maintaining type K-1 carrier equipment and systems. The switching circuits described herein employ lever-type keys for directly performing the transfer operations without the use of relays.

1.02 These switching circuits facilitate the maintenance of multi-channel carrier systems by permitting parts of a working system to be readily interchanged with comparable parts of an alternate system or spare components, without appreciable interference to the services handled by the facility. As the carrier system may be operating with carrier telegraph on one or more of its channels, the criterion for satisfactory switching has been based on the amount of distortion introduced in telegraph transmission by the switching operation. To avoid interference with telegraph, it is necessary that the changes in transmission level during switching be kept at a minimum and that the difference in phase shift through the two components should not be material.

1.03 Although a deviation regulator consists of an amplifier and regulating equipment, it is switched together with the preceding section or sections of line in the manner of a line switch. This permits pilots to be supplied to the alternate deviation regulator so that it will assume the proper gain before being placed in service.

(A) Amplifier Switching Circuit

1.04 The amplifier switching circuit provides arrangements for utilizing alternate equipments in place of the similar regular equipments listed below, in order to facilitate those maintenance operations which otherwise could not be made on a working system. For the sake of simplicity, the circuit is designated as an "amplifier switching circuit," although it is also used for switching the tandem combinations listed below:

- (1) A Line Amplifier at a Non-Twist Point.
- (2) A Line and Twist Amplifier in Tandem.
- (3) A Line Amplifier, Twist Amplifier, Group Demodulator and Auxiliary Receiving Amplifier in Tandem.
- (4) A Group Modulator and Transmitting Amplifier in Tandem.

1.05 In addition to these individual applications, the output portion of the amplifier switching circuit is used at the receiving end of a line or line section, in conjunction with a line switching circuit or switching hybrid coil at the transmitting end to permit the replacing of a line or line section of a working system by an alternate line or line section when switching the following combinations:

- (1) A Section of Line, Including a Group Terminal and One or More Line Amplifiers.
- (2) A Section of Line, Including One or More Line Amplifiers but no Group Terminal.
- (3) A Section of Line Equipped with Deviation Regulators.

(B) Line Switching Circuit

1.06 The line switching circuit, in conjunction with the output portion of an

amplifier switching circuit, provides arrangements for utilizing an alternate line in order to release the regular line for those maintenance operations which otherwise could not be made on a working system.

1.07 For carrier systems equipped with deviation regulators, it is necessary to resupply a-c pilots to deviation sections when the regular pilots have been interrupted due to switching or other cause. If a test pilot supply circuit is not available, the line switching circuit may be used for this purpose.

2. AMPLIFIER SWITCHING

(A) Switching Circuit

2.01 The switching circuit will be discussed in its application to line amplifiers; where the switching of other equipments is involved, the discussion is also applicable. A schematic of the circuit is shown in Fig. 1.

2.02 Two four-conductor patching cords, equipped with four-finger plugs on one end, provide a means of connecting to the input and output of the amplifier to be switched out of the circuit. Similarly, two two-conductor cords, equipped with two-finger plugs at one end, are used for connecting to an alternate amplifier. A multiple unit lever-type key with parallel contacts provides for

making a transfer of the inputs and outputs of the amplifiers by a single operation of the key lever. The input side of the circuit includes a 1:1 ratio balanced and shielded repeating coil for interrupting longitudinal voltages and prevent unbalancing the line during the switching operation. Jacks are provided to permit access to the regular amplifier for tests after the switch is completed.

2.03 When the switching key is in the initial position, the insertion of the four-finger plug into the input line and equipment jacks establishes a parallel path with the normal contacts of the jacks before any of the normals are opened; the parallel path is via the repeating coil and key contacts. Similarly, the output four-finger plug replaces the circuit through the jack normals by a path through key contacts but no repeating coil is involved. The two-conductor cords and associated plugs connect the input and output terminals of the alternate amplifier to open contacts on the switching key when it is in the normal position.

2.04 The operation of the switching key from the regular toward the alternate position connects the four terminals of the alternate amplifier in parallel with the corresponding four terminals of the regular amplifier, and then, transfers the terminals of the regular amplifier to test jacks which

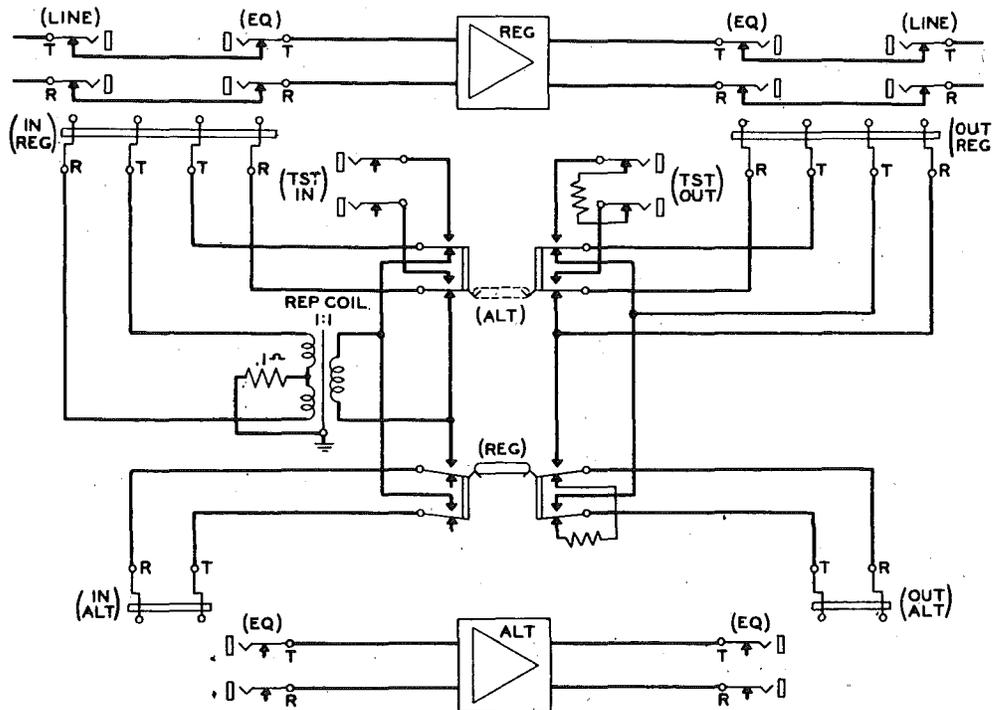


Fig. 1 - Schematic - Amplifier Switching Circuit

provide a means for making tests on the out-of-service amplifier. After maintenance operations are completed on the regular amplifier, restoration to normal is in the reverse sequence of switching.

2.05 When switching a deviation regulator in a deviation section, pilots must be supplied to the alternate deviation regulator to permit it to regulate prior to the switching operation. To accomplish this, the preceding section or sections of line are switched in conjunction with the amplifier. The line switching circuit at a preceding station is used to supply transmission and pilots to the alternate line. The output portion of an amplifier switching circuit is used to perform the transfer at the output of the amplifiers. The switching procedure is identical to that described for line switching.

### (B) Transmission

2.06 The nature of the level fluctuations due to the operation of the amplifier switching circuit is shown in Fig. 2.

2.07 This figure relatively shows the transmission variation resulting from each step performed in the switching of an amplifier. The diagram is based on the assumption that both the regular and alternate amplifiers are adjusted to the same gain.

2.08 When the input four-finger plug is inserted in the line and equipment jacks, the 1:1 ratio repeating coil is added in series with the line resulting in a drop in level of about .1 db from normal. During the operation of the switching key, as it starts its travel from the regular position, either the input or output of the alternate amplifier is bridged across the line; this results in a drop in level of 3.5 db from normal. After both the input and output connections are made between the alternate amplifier and the line, the drop in level is reduced to 1 db from normal; the latter condition occurs when the key lever is near mid-position. In operating the key from mid-position toward the alternate position, either the input or output of the regular amplifier is first disconnected resulting in a level change to -3.5 db from normal; upon further travel of the key lever, both the input and the output of the regular amplifier are disconnected and transmission is .1 db below normal level. The restoring operations result in level fluctuations of the same values and in reverse order; these fluctuations introduced by the switching circuit are not noticeable on voice circuits and do not contribute substantial distortion to voice frequency telegraph transmission over type K carrier channels due to the small magnitude of the level changes and the short duration of the operation. If, however, the switch involves regular and alternate group terminal equipment

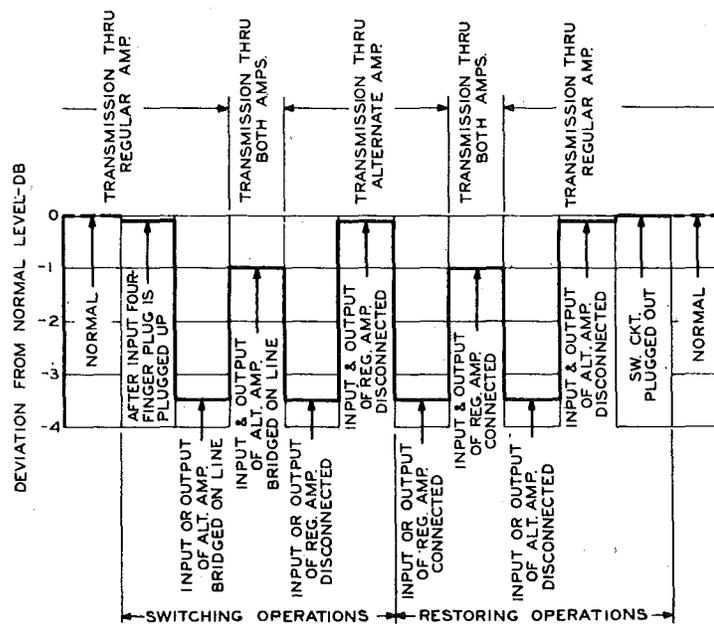


Fig. 2 - Representative Level Diagram - Amplifier Switching Operations

operating on separate carrier supplies, telegraph distortion might result due to phase differences in the carrier supplies.

2.09 Satisfactory switches will result with normal operation of the switching key. If the key is operated extremely slowly, however, distortion may be introduced in the telegraph circuits.

2.10 It is essential that the switching key be locked in its regular position when plugging up the four-finger plugs, in order to guard against opening the line.

2.11 Any odd number of turnovers in the circuit wiring of the amplifiers will result in a momentary transmission interruption during the switching operation due to the phasing out of the transmission when the amplifiers are in parallel. Tests are made at the time of amplifier installation to insure that all turnovers are eliminated.

2.12 Small differences in gain between the regular and alternate amplifier do not contribute substantial switching distortion. The difference in gain, however, should not exceed 3 db.

2.13 Some caution is desirable with respect to leaving cords plugged into the test jacks when not actually conducting tests on the out-of-service amplifier. The test jacks are connected to back transfer contacts on the switching key and, when the key is properly adjusted, these contacts are broken when the amplifier is restored to service; however, an improper spring adjustment might, in some cases, result in a momentary connection of test tone, via the test jacks, to the input of both amplifiers when they are operating in parallel.

### (C) Equipment

2.14 A front view of the switching panel is shown in Fig. 3.

2.15 The equipment for one or two switching circuits, with the exception of the cords and output test jacks, is mounted on a 19" x 5-7/32" panel. Rack space for mounting the panel is provided in the input sealed test terminal bay above the initial complement of jacks.

2.16 At intermediate stations the output test jacks are mounted on a 19" x 5-7/32" panel which is located above the initial complement of line jacks in the output sealed test terminal bay. At terminal stations, miscellaneous jacks in the high frequency patching bay are used as output test jacks.

2.17 The patching cords are 6' long and are suspended from cord mountings located about 7' from the floor; when not in use, the input cords hang at the left side of the input sealed test terminal bay; the output cords normally hang at the right side of the output sealed test terminal bay.

2.18 The two-finger plug is provided with pin tips at the cord end for effecting a bridged connection by means of a 308A plug; this provision facilitates pilot level measurements and monitoring connections. The four-finger plug is provided with a ferrule which serves as a handle for inserting and extracting the plug; also, a guide pin is provided on the side of the plug which engages a hole in the jack mounting and properly orients the plug with respect to the jacks. No pin tips are provided on this plug.

2.19 The switching key embraces a spring latch for locking the lever in either the regular or alternate position. The key design inherently provides a definite sequence of certain contacts; parallel contacts are provided in all cases.

2.20 Coupling between input and output portions of the circuit has been kept low by means of capacitance shielding.

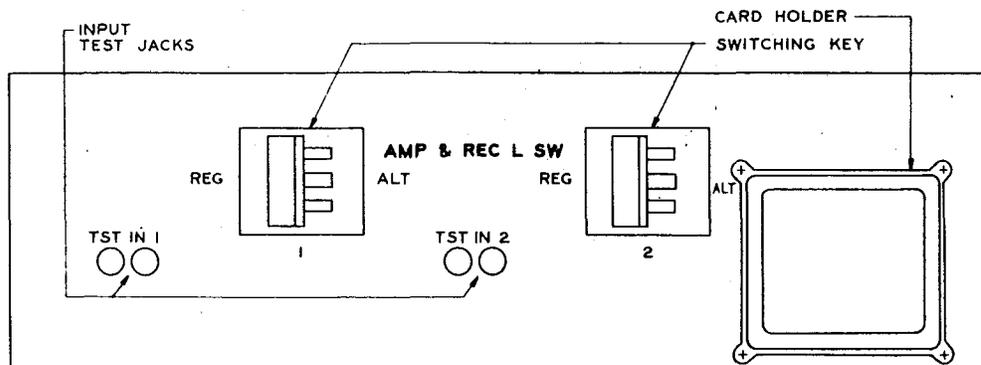


Fig. 3 - Front View - Amplifier Switching Panel

### 3. LINE SWITCHING

#### (A) Switching Circuit

3.01 The line switching circuit embraces only the facilities required at the transmitting end of a line section over which it is desired to make a switch. At the receiving end of such a line section the transfer is performed by the output portion of an amplifier switching circuit previously described.

3.02 A schematic of the line switching arrangements is shown in Fig. 4.

3.03 A four-conductor patching cord, equipped with a four-finger plug at one end, provides a means for connecting to the regular line without interrupting transmission.

3.04 The insertion of the four-finger plug in the output line and equipment jacks establishes a parallel path with the normal straps of the jacks before any of the

normals are opened; after the plug is fully inserted, the alternate normal path is via straps in the four-finger plug. Similarly, a two-conductor cord, equipped with a two-finger plug at one end, is used for connecting to the alternate line. When no plugs are inserted in the test or auxiliary switching amplifier jacks, the plugging up of the four-finger plug bridges the auxiliary switching amplifier onto the regular line through a 41 db high impedance bridging pad. The auxiliary switching amplifier which is equipped with a phase equalizer, in combination with the bridging pad, provides for transmission to the alternate line in phase with direct transmission of the regular line; the gain of the switching amplifier compensates for the combined loss of the bridging pad and phase equalizer and provides for comparable levels on both the regular and alternate lines. Jacks are provided to permit access to the regular line for tests after the switch is completed; contacts on the test jacks are provided to prevent the transmission of test tone over the

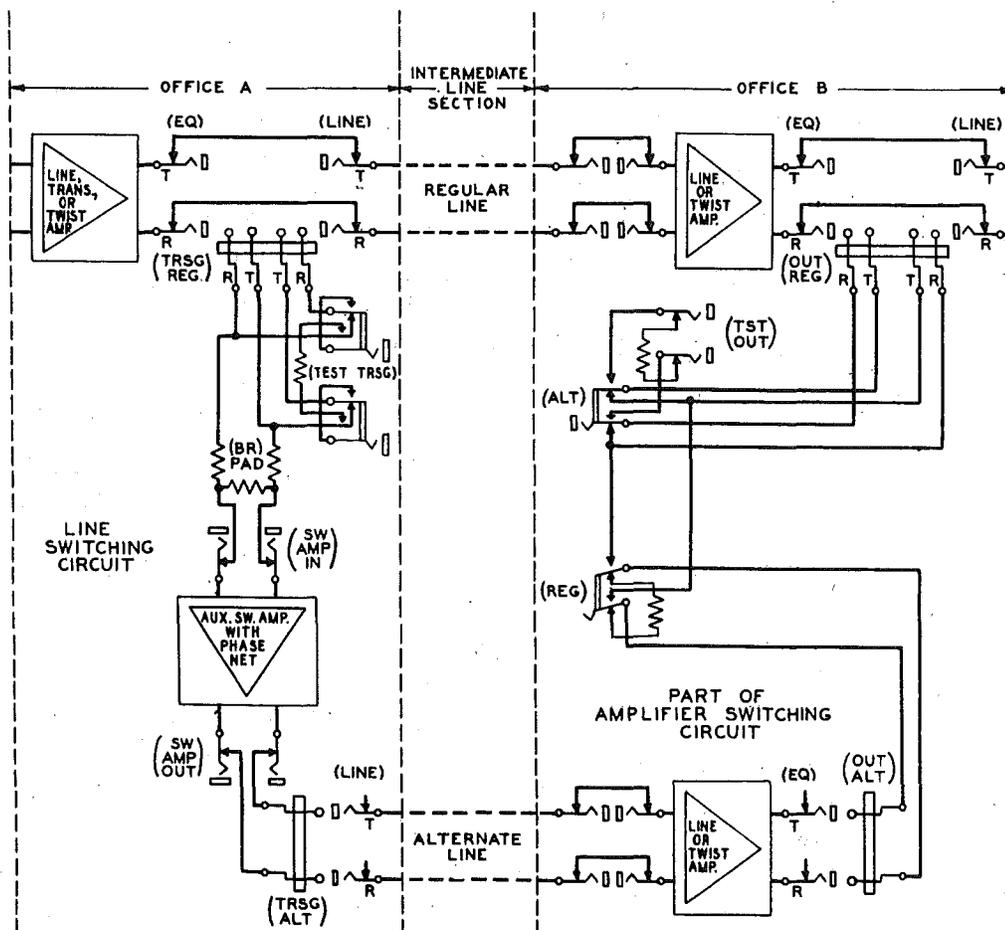


Fig. 4 - Schematic - Line Switching Arrangements

alternate line while a plug is being inserted in the jacks, and to replace the line termination on the regular amplifier by a resistance. The insertion of a plug in the test jacks in the case of a deviation regulator section switch will interrupt the pilots of the regular section. If a test pilot supply circuit is available, pilots are resupplied from this to the test jacks of the switching circuit. Test signals may be then applied to the line by means of the test jacks of the test pilot supply circuit.

3.05 After duplicate transmission is established over the alternate line, the output cords of an amplifier switching circuit at any succeeding station may be used to connect to both the regular and alternate lines; service may then be switched to the alternate line by means of the key in the amplifier switching circuit at the receiving end of the line. When switching deviation sections, sufficient time must be allowed to permit the alternate line to regulate. The procedures for operating the key are the same as in the switching of amplifiers. Jacks in the amplifier switching circuit are used for receiving transmission over the regular line for testing purposes. Restoration is in the reverse order of switching.

3.06 The auxiliary switching amplifier used with the line switching circuit is essentially the same as the terminal transmitting amplifier described in other sections of the Bell System Practices. It is a three-stage amplifier using two 310A and one 311A tubes. The usual provision of a Yaxley jack as well as grid and cathode resistances permits the use of the LR or LAC tube test set

for measuring space current as required. Connections are provided for control of heater current which also permits the measurement of cathode activity with the LR or LAC test set. Jacks are provided to permit use of the auxiliary switching amplifier for miscellaneous test purposes when the amplifier is not being used for switching.

3.07 For switching line sections originating at a transmitting terminal, transmission may be applied to an alternate line equipped with group terminal equipment by means of a patch cord connection from a hybrid coil located between the channel and group equipment of the regular line to the alternate group modulator. The switch is performed at the receiving end of the line by the output portion of an amplifier switching circuit in the same manner as described previously.

3.08 When removing a deviation regulator from service on a line arranged for pilot channel regulation, it is first necessary to supply pilots to the alternate deviation regulator so that it will assume the proper gain before it is placed in service. This is accomplished by switching the preceding section or sections of line in conjunction with the deviation regulator, thereby supplying pilots and transmission to the alternate deviation regulator prior to transferring the outputs.

3.09 To regulate a deviation section of line which has been disconnected from its regular pilot supply, pilot frequencies from a test pilot supply circuit are applied to the sending end of the line section. If no test pilot supply circuit is

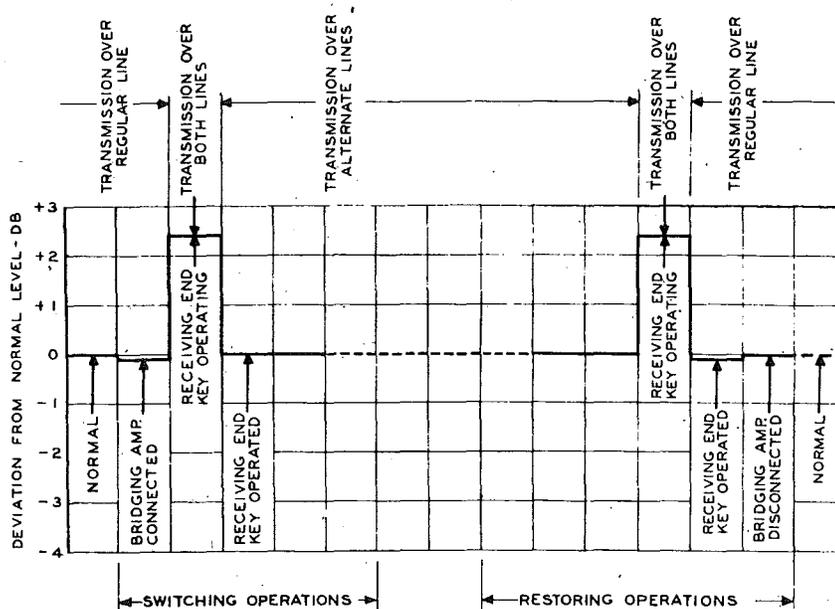


Fig. 5 - Representative Level Diagram - Line Switching Operations

available, pilots from an active line may be applied to the interrupted section by means of a line switching circuit. This is accomplished by inserting the four-finger plug of the line switching circuit into the output equipment and line jack of an active line and the two-finger plug into the line jack of the disconnected line in the manner described for line switching. The amplifier switching circuit is not required at the receiving end as the switch is not completed.

### (B) Transmission

3.10 The nature of the level fluctuations during line switching procedures is shown in Fig. 5.

3.11 This figure relatively shows the transmission variation resulting from each step performed in the switching of a line. The diagram is based on the assumption that both the regular and alternate lines are operating at the same net loss. When switching sections of line equipped with deviation regulators, the transmission characteristic is modified by the compensating action of the regulators.

3.12 After the transmitting end four-finger plug is inserted in the line and equipment jacks, transmission over the regular line is about .1 db below normal due to the loss introduced by the high impedance bridging pad. During the travel period of the switching key at the receiving end the outputs of both lines are momentarily connected in parallel; this results in a rise in transmission of 2.4 db from normal. The restoring operations result in level fluctuations of the same values and in reverse order. The insertion of a plug in the input test jacks terminates the regular amplifier in a resistance in place of the line. As the amplifier is momentarily connected to both the line and the resistance, a level fluctuation of -3.5 db from normal is produced when a test plug is inserted or withdrawn. These fluctuations are not noticeable on voice circuits and do not contribute substantial distortion to voice frequency telegraph transmission over type K carrier channels. Any odd number of turnovers in the wiring of the lines and equipment, however, will result in a momentary transmission interruption during the switching operation. If, however, the switch involves regular and alternate group terminal equipment operating on separate carrier supplies, telegraph distortion might result due to phase differences in the carrier supplies.

3.13 The auxiliary switching amplifier proper is identical with that used as a

transmitting amplifier between the group modulator and the line. In addition, a phase equalizer has been designed to compensate for the phase shift inherent in the amplifier design. The addition of the phase network equalizes the over-all characteristics so that little phase difference exists between the regular and alternate lines.

3.14 The amplifier proper has a constant flat gain in the band from 12 to 60 kc of about 66.5 db. The input circuit to the amplifier consisting of the phase equalizer as used in this application has a net loss of about 25.5 db. This results in a net gain for the amplifier and network of about 41 db. The input and output impedance of the network and amplifier is substantially 135 ohms. The amplifier is provided with two feedback paths. The outer feedback path is from the output transformer to the input transformer through a 164A feedback network and provides control of the gain within the transmitted band of frequencies, giving the amplifier a flat characteristic; the amount of negative feedback afforded by this path is in the order of 9 to 15 db, depending on the frequency being transmitted. The inner feedback path is from the output bridge to the grid of the first tube and provides control of frequencies above the transmitted band, which results in an improvement of stability and a reduction in harmonic output.

### (C) Equipment

3.15 A front view of the switching panels is shown in Fig. 6.

3.16 The equipment for one or two switching circuits, with the exception of amplifier, cords and switching amplifier input jacks, is mounted on a 19" x 5-7/32" panel. At both intermediate main stations, and terminal stations, rack space for mounting this panel is provided in an output sealed test terminal bay above the initial complement of line jacks. At intermediate main stations, the auxiliary switching amplifier input jacks are mounted on a 19" x 5-7/32" panel which is located above the initial complement of line jacks in an input sealed test terminal bay. At terminal stations, the auxiliary switching amplifier input jacks are located in the piling rail of the input sealed test terminal bay.

3.17 The patching cords are 6' long and are suspended from cord mountings located about 7' from the floor; when not in use, the cords hang at the right side of the right output sealed test terminal bay.

3.18 The two-finger plug is provided with pin tips at the cord end for effecting a bridged connection by means of a 308A plug. The four-finger plug is provided with a

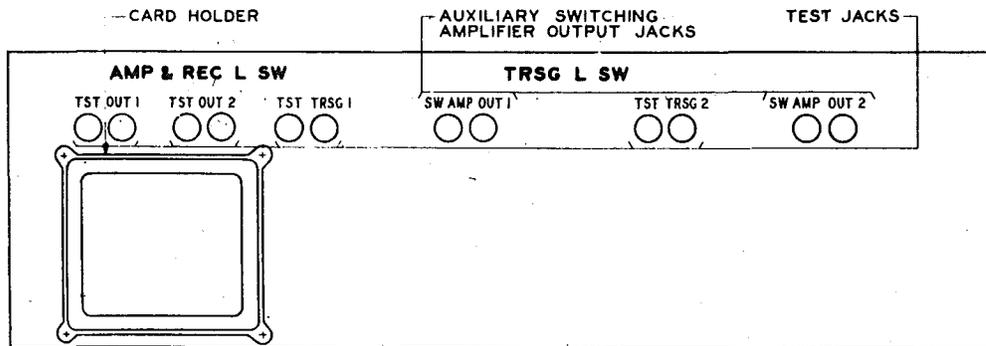


Fig. 6 - Front View - Line Switching Panel

ferrule which serves as a handle for inserting and extracting the plug; also, a guide pin is provided on the side of the plug which engages a hole in the jack mounting and properly orients the plug with respect to the jacks. No pin tips are provided on the four-finger plug.

3.19 The auxiliary switching amplifier is mounted in miscellaneous relay rack space in the regular amplifier bay lineup.

#### 4. LIST OF DRAWINGS

##### (A) Circuit Drawings (Not Attached)

SD-64939-01 Amplifier Switching

SD-64914-01 Line Switching  
SD-64329-02 Auxiliary Switching Amplifier

##### (B) Equipment Drawings (Not Attached)

ED-64939-01 Amplifier Switching  
ED-64914-01 Line Switching  
ED-64329-02 Auxiliary Switching Amplifier  
ED-61764-01 Sealed Test Term. Bay Aux. Station  
ED-61765-01 Ca. Plan Aux. Sta.  
ED-61756-01 Floor Plan Aux. Station  
ED-61857-01 Sealed Test Term. Bay Main Station  
ED-61768-01 Cord Mounting Assembly

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