PRIVATE LINE TELEPHONE SERVICE
MULTISTATION SYSTEMS
DESCRIPTION

CONTENTS PAGE

1. GENERAL

1.01 This section describes arrangements to provide multistation private line telephone service over toll and exchange facilities in which all stations can communicate with all others with substantially the same grade of transmission. Frequently circuits with special operating and/or equipment features will be provided for a specific customer. In these cases, the necessary instructions should be prepared by each of the operating companies involved, as required, to facilitate the operation of the circuit. While this section describes arrangements for providing multistation private line service, many of the features are also applicable to two-point private line circuits. Provision is made for signaling the various stations on the circuit and for switching between such multistation lines as may be required.

1.02 Certain terms used in referring to various parts of the multistation private line circuit are defined in the following:

44-Type Bridge: A resistance network interconnecting four 4-wire facilities so arranged that each may transmit into the bridge and receive from the bridge. Each connection transmitting into the bridge is called an input terminal or input and each connection transmitting out of the bridge is called an output terminal or output. A pair of terminals, one input and one output is referred to as a leg.

46-Type Bridge: Similar to the 44-type bridge except it is arranged to interconnect six 4-wire facilities.

Toll Facilities: Facilities between any two toll offices. In this section, for convenience, these will frequently be referred to as "lines." These are also referred to as "interexchange" facilities.

Branch: All the facilities between a leg of a bridge and an associated station. This may include toll as well as exchange facilities.

Loop or Local Channel: For the purposes of plant operation there is no difference between a loop and a local channel as applied to multistation private line service over toll facilities. A loop or local channel consists of all the facilities between the last toll office and the subscriber. A loop will usually consist of subscriber loop facilities and one or more exchange trunks. The loop may be 2-wire or 4-wire. The portion of a 4-wire loop used for transmitting from the station is called a transmitting loop, and the corresponding portion used for receiving at the station is called a receiving loop.

Toll Office: Office at which toll facilities terminate.

Local Central Office: Telephone central office through which exchange portion of loop may be cross-connected.

Exchange Trunk Facilities: Facilities between two local central offices or between a toll office and a local office.

Subscriber Loop Facilities: Facilities between local central office and subscriber location.

1.03 The arrangements and type of equipment to be used at both the central offices and the private line station are determined mainly by the customer's requirements and by the equipment and facilities available. One of the most important requirements of a multistation private line circuit is that the volume delivered to each receiver be substantially the same no matter which station is talking. The above holds true even when two or more circuits are switched together.

1.04 Various signaling systems and combinations of signaling systems can be used to "call" the various stations on a private line circuit. Some types of signaling systems are: loudspeaker signaling, manual code ringing, ringdown signaling, 600-1500-cycle (2-tone) selective signaling, and code selective signaling. The above signaling systems are discussed in detail in Part 5 of this section.

2. TRANSMISSION FEATURES — CENTRAL OFFICE

(A) Bridging Arrangements

2.01 Several bridging arrangements are provided by standard drawings. The types most commonly used are the 44-type bridge and the 46-type bridge. The first number designates a 4-wire bridge and the second number designates the number of legs. Each leg provides a point of connection for a 4-wire facility. One of the essential requirements of 4-wire bridges is that they provide equal, relatively low loss transmission paths from each input to the outputs of all other legs. This loss is usually in the order of 15 to 20 db. Another requirement is that the return current path from an input terminal to the output terminal of the same leg be relatively high, 50 db or more depending on the usage of the bridge.

2.02 Schematics in this section sometimes show 44-type bridges and at other times show 46-type bridges. Bridges of the two types can be used interchangeably by making suitable level adjustments in the connecting circuits.

44-Type Bridge

2.03 The 44-type bridge is a resistance network designed to interconnect four 4-wire lines. As shown in Fig. 1 it consists of four legs, each leg being comprised of an input terminal and output terminal. Within the bridge structure there is a transmission path connecting each input terminal with the three output terminals of the other three legs giving a total of 12 paths linking the desired input and output terminals. These paths, however, also provide transmission paths between each bridge input and the other bridge inputs, and between each bridge input and the output on the same leg of the bridge. The paths between bridge inputs are in general of no importance, but transmission paths between a bridge input terminal and the output terminal of the same leg will cause return currents on the 4-wire circuit which if of appreciable magnitude might result either in singing or objectionable echo. These return currents are controlled as follows: There are six individual paths from any input terminal to its corresponding output terminal. Each of the six paths consists of a direct path from the input terminal to the other three output terminals and from each of the three output terminals there are two paths, consisting of two direct paths in series, back to the output terminal associated with the input terminal. Turnovers suitably located in the bridge network as indicated in Fig. 1, cause three of these six paths to be 180 degrees out of phase with the other three paths. As these six transmission paths theoretically have the same loss, they will cancel each other in pairs and the resulting loss between an input and its corresponding output will be infinite. In practice, all of these paths will not have identical losses because of manufacturing tolerances in the resistances and because of differences in the impedance of the lines or repeaters connected to the other three legs of the bridge, since each of the latter constitute a shunt on any transmission paths that pass through that bridge terminal.

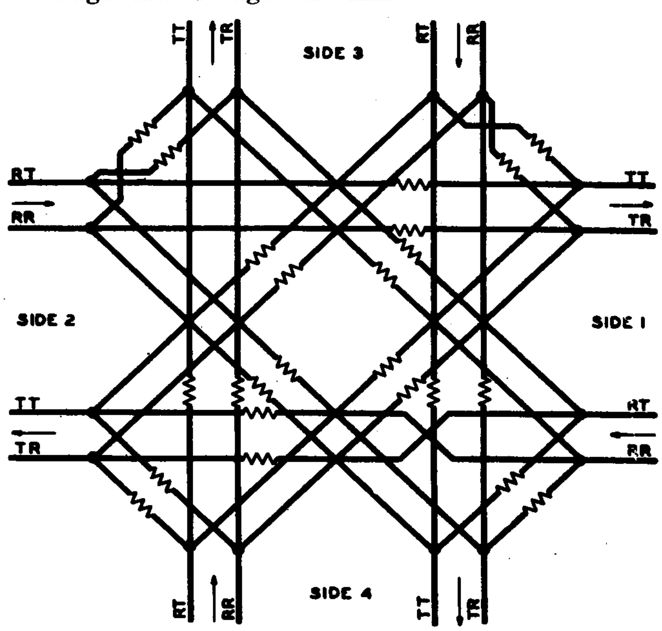


Fig. 1 — Schematic of 44-Type Bridge

2.04 With all bridge terminals terminated in 600 ohms, the transmission loss between any input terminal and the output terminals of the other three legs will be approximately 15 db and the loss between any input terminal and the output terminal of the same leg will be in excess of 75 db. For some combinations of unbalances such as short-circuiting or opening two or more terminals of the bridge, this loss may be reduced to a value as low as 38 db.

2.05 The impedance of the bridge is about 650 ohms with nominal termination of 600 to 700 ohms. Since the bridge has a relatively high loss, its impedance does not vary greatly with various terminations. Some operating companies have changed the value of resistors in some 44-type bridges to make the impedance close to 600 ohms.

2.06 Although the standard 44-type bridge is for practical purposes a symmetrical circuit when properly terminated, it is unsymmetrical with respect to reflected or return currents. The level of any such extraneous currents entering the bridge may be at output 4, as much as 9.6 db above that at any of the other outputs. For this reason, leg 4 should either be assigned to a branch circuit or be left spare. On some critical services where a spare leg might be used for rerouting or patching the main-line circuit, it is preferable to assign leg 4 to a branch and leave a different leg spare. Modifications of the standard bridges by some operating companies have eliminated the restriction regarding the use of leg 4. However, if in doubt, the above rule should be followed.

2.07 The 46-type bridge is similar in nearly all respects to the 44-type bridge except that it has six instead of four legs. The bridge, shown in Fig. 2, has a transmission path connecting each input terminal with the five output terminals of the other five legs giving a total of 30 paths linking the desired input and output terminals. These paths, however, also provide transmission paths between each bridge input and the other bridge inputs and between each bridge input and the output on the same side of the bridge. As was the case in the 44-type bridge the paths between bridge inputs are in general of no importance, but transmission paths between a bridge input terminal and the output terminal of the same leg must be kept at a high loss in order

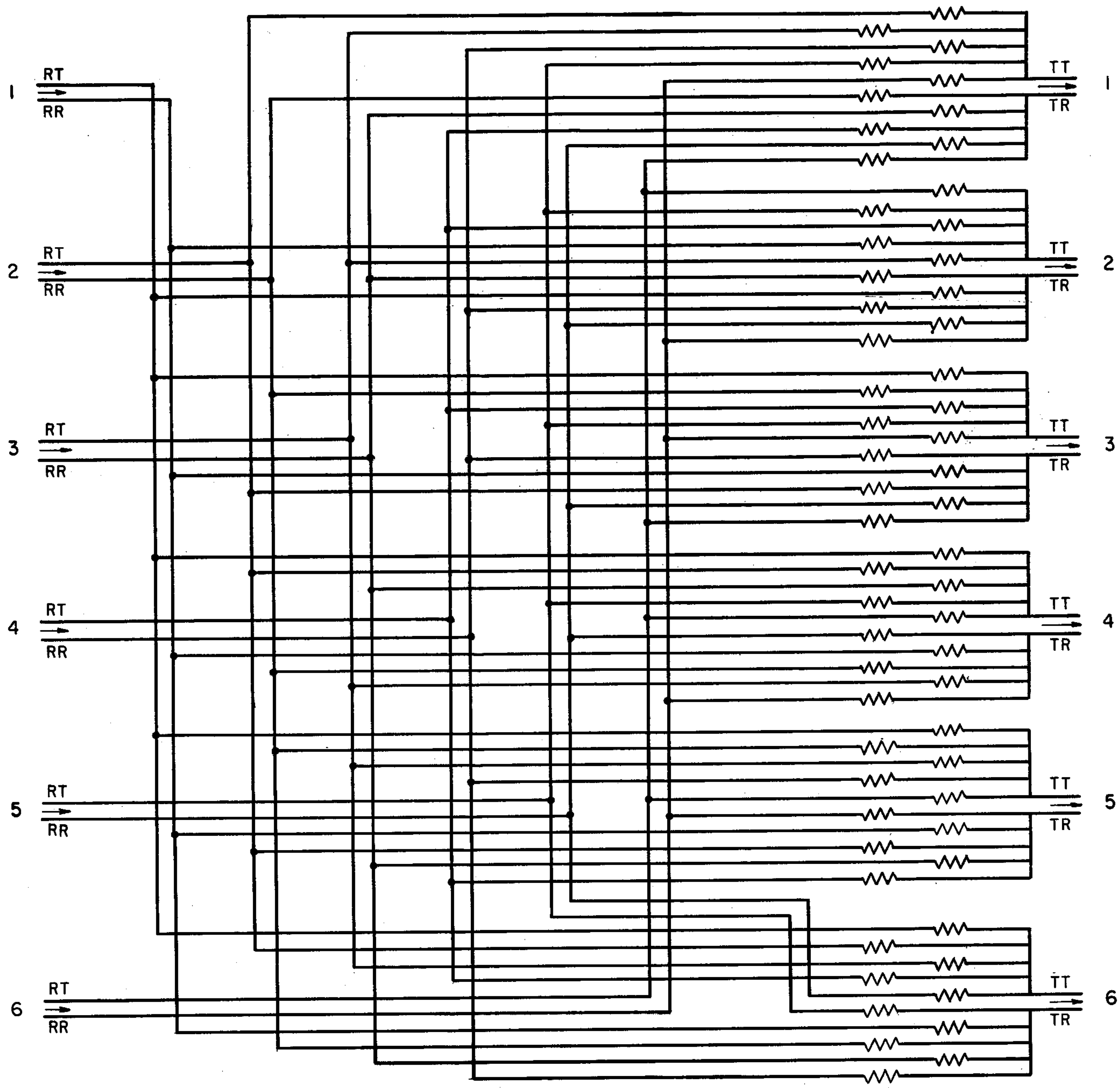


Fig. 2 — Schematic of 46-Type Bridge

to keep return currents to a minimum. There is a direct path from an input terminal to the other five output terminals and from each of the five output terminals there are four paths, consisting of two direct paths in series, back to the output terminal associated with the input terminal. This makes a total of 20 paths from each input terminal back to the output terminal of the same leg, and providing all resistors are of exactly the same value, all of these paths will have exactly the same loss. Suitable turnovers in the above paths are such that 10 of these paths will be 180 degrees out of phase with the other 10 paths and thus will cancel. Theoretically with all inputs properly terminated the loss from an input terminal to the output terminal of the same leg will be infinite; but due to manufacturing tolerances of the resistors and due to differences in the impedance of equipment and facilities connected to the legs of the bridge, the loss will be less than infinity.

2.08 When all bridge terminals are properly terminated the transmission loss between any input and the output terminals of the other five legs will be 19.5 db. Due to losses in cabling the loss of the 46-type bridge is many times considered to be 19.8 db or 20.0 db when engineering private line circuits. The loss from an input terminal to the output terminal of the same leg should exceed 80 db if all terminals are terminated in 600 ohms. The impedance of the bridge is approximately 600 ohms with nominal terminations of 600 to 700 ohms. The bridge impedance does not vary greatly with various terminations.

2-Wire Straight Bridge

2.09 This arrangement shown in Fig. 3, is simpler and has less loss than the other types of 2-wire bridges. It is frequently useful where the additional loss of another type of 2-wire bridge would necessitate a repeater not otherwise needed. The straight bridge has some severe limitations, however, which must be considered. Line or loop facilities having serious irregularities (such as might be presented, for example, by a loop of complex make-up) when connected together directly through a straight bridge arrangement will have a limiting effect upon the degree of balance obtainable across any repeater or other hybrids connected to other bridge legs. Also, the calculated losses of the straight bridge arrangement assume 600-ohm terminations on all appearances. In actual use these terminations are likely to vary appreciably from 600 ohms, and consequently the real loss of the bridge arrangement may differ appreciably from the computed value. The losses for the several arrangements most commonly used are as follows:

Total Number Bridge Legs	Bridging Loss (db) Assuming Same Value (Usually 600 Ohms) Terminations on All Legs
3	3.5
4	6.0
5	8.0
6	9.5

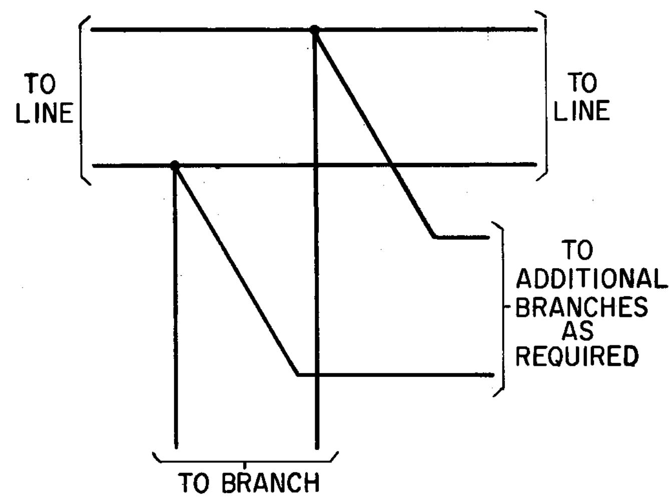


Fig. 3 — Schematic Diagram of 2-Wire Straight Bridge

2-Wire Resistance Bridge

2.10 The loss of this type bridge, which is illustrated in Fig. 4, is several db greater than the straight bridge arranged for the same number of legs, so that it is generally used where repeaters are employed on the circuit branches. Where the additional loss is not a governing factor this resistance bridge is usually preferable to the straight bridge. While use of this bridge will not always produce improvement in singing margin, trouble such as a short circuit on one of the circuit branches would be less likely to affect the other branches or the singing margin of the over-all circuit. The value of R and the corresponding transmission losses for the several 600-ohm bridge arrangements most commonly used are as follows:

Total Number Bridge Legs	Resistor R Ohms	Bridging Loss (db) Assuming Same Value (Usually 600 Ohms) Terminations on All Legs
3	100	6.0
4	150	9.5
5	180	12.0
6	200	14.0
7	214	15.5
8	225	17.0
9	233	18.1
10	240	19.2

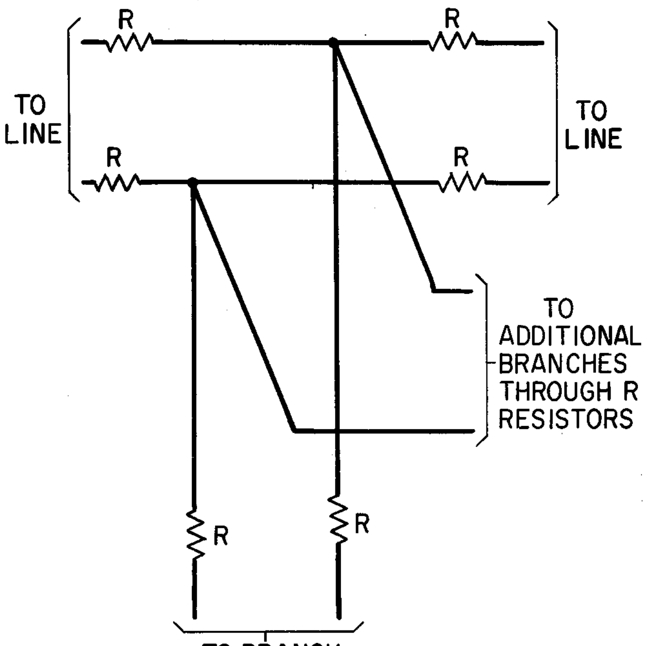


Fig. 4 — Schematic Diagram of 2-Wire Resistance Bridge

2-Wire Pad Type Bridge

2.11 This bridge is shown in Fig. 5. Although the impedance improving features of this type of bridge makes it desirable for singing purposes and for minimizing the effects of a trouble on one circuit branch upon the other branches, its relatively high loss limits its application generally to those cases where each branch is equipped with a repeater. The losses for the several bridge arrangements most commonly used, with a 5 db pad 600-ohm in each leg, are as follows:

Total Number Bridge Legs	Bridging Loss (db) Assuming Same Value (Usually 600 Ohms) Terminations on All Legs
3	13.5
4	16.0
5	18.0
6	19.5

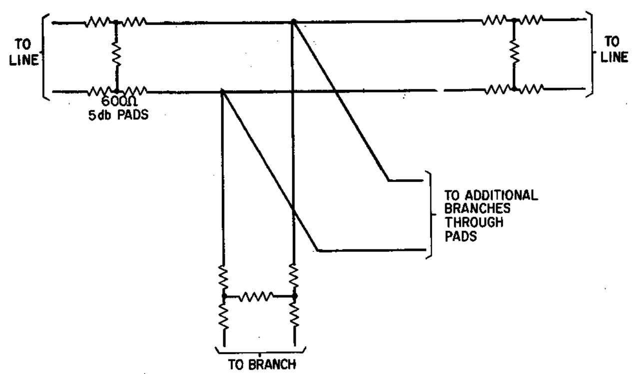


Fig. 5 — Schematic Diagram of 2-Wire Pad Type Bridge

(B) Talk-Back Features

2.12 A 4-wire layout (including 4-wire loops and station arrangements) provides the talker with no sidetone path since the standard 4-wire station arrangement affords no connection between the transmitter side of the circuit and the receiver side of the circuit. In addition, if two or more stations are bridged together at the same location, these stations will be unable to hear each other. It is necessary, therefore, to provide an external transmission path, called a "talk-back" path. This must be so arranged that it does not cause objectionable echo or return currents on the main circuit. The talk-back must be inserted at a central office that is not separated from the station by facilities having an appreciable time delay since this would cause the talk-back to sound like echo rather than sidetone. Generally the talk-back path is placed at the toll office nearest the station. The several ways of accomplishing this as discussed in the following paragraphs, are:

(1) A talk-back amplifier.

(2) A resistance type talk-back bridge.

(3) An arrangement which uses the spare leg of a 4-wire bridge.

2.13 ***Talk-Back Amplifier:*** One method, indicated in Fig. 6, makes use of an amplifier or one-half of a 4-wire repeater to interconnect the transmitting and receiving sides of the branch. With this arrangement there is no feedback from C to B since the amplifier is a one-way device. The two main transmission paths from A to B and from C to D each have a loss of about 3.5 db due to the bridging effects. The gain of the talk-back path from A to D is the gain of the amplifier less 7.0 db. In general the amplifier gain will be set so that the transmission from the station talker to his own receiver and those of other receivers at the same location will be equivalent to transmission from distant talkers to the same receivers.

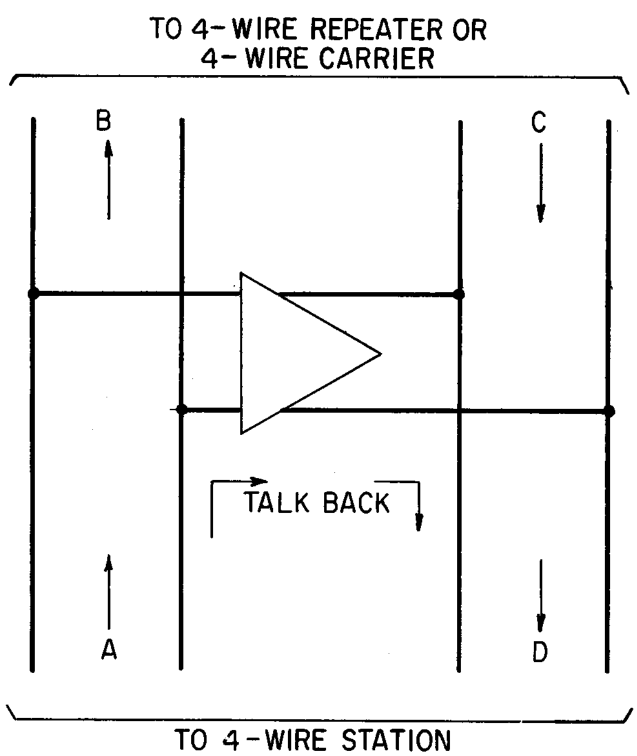


Fig. 6 — Talk-Back Amplifier

2.14 ***Resistance Talk-Back Bridge:*** A second method of obtaining talk-back is shown in Figs. 7 and 8. This arrangement consists of a resistance network which is inserted in the 4-wire branch. The networks and their application are shown in Figs. 7 and 8. The levels shown are typical of levels commonly used. The networks differ only in the value of resistances used and the losses of the networks. The network shown in Fig. 7 causes a 3 db insertion loss in both the transmitting and receiving sides of the branch and provides a 21 db loss from one side of the 4-wire branch to the other side. The network shown in Fig. 8 has a 1.5 db insertion loss and a 23.0 db talk-back loss. Talk-back bridges cannot be used unless a repeater is associated permanently with the branch since the loss would be too great for satisfactory talk-back even though the loop losses were zero db. When branches are associated with bridges, as shown in Figs. 7 and 8, the talk-back bridge having 21 db talk-back loss is usually provided for circuits using 44-type bridges and the one having 23 db loss is provided with 46-type bridges. When talk-back bridges are used with 4-wire bridges the levels are set so that standard office levels are retained at the 4-wire bridge. It will be noted that since this is a 2-way device, feedback is provided to the main circuit as well as the branch. This feedback is in the form of an echo or part of a singing path, but with the levels shown in Figs. 7 and 8 the talk-back levels transmitting into the bridge are 36 db below circuit level in the case of the 44-type bridge and 43 db below circuit level in the case of the 46-type bridge. In general this amount of feedback or echo on the main circuit is not objectionable, although where special services, such as picture transmission are encountered, even this amount of echo may prove objectionable. Also on large multistation networks, especially those with 2-tone signaling, it is generally necessary to keep the number of resistance talk-back bridges to a minimum and instead use talk-back amplifiers whenever possible. The return current on the main circuit can be neutralized by the use of another talk-back bridge on leg 3 of a 44-type bridge. In this case, however, it is necessary that all wiring and cross connections be carefully connected tip for tip and ring for ring, since a turnover from the normal connections would result in the two return paths adding rather than canceling.

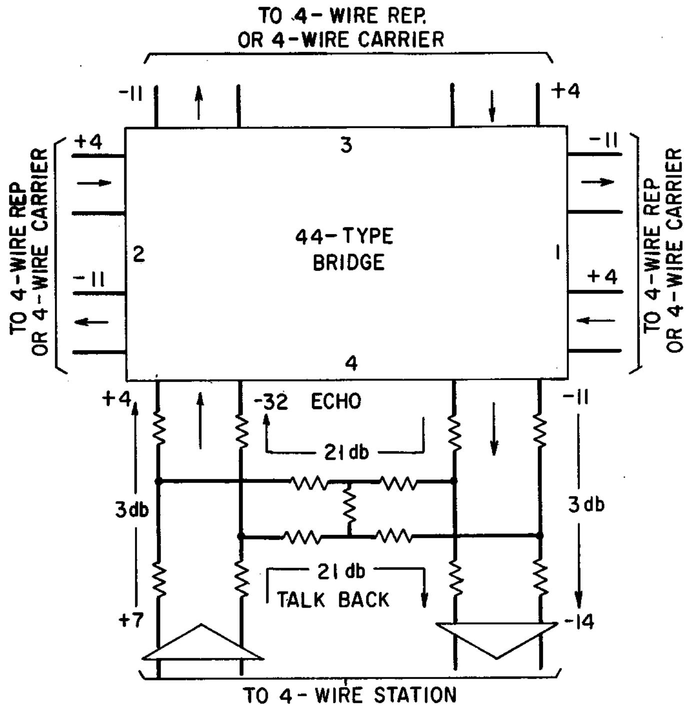


Fig. 7 — Talk-Back Bridge Connected to 44-Type Bridge

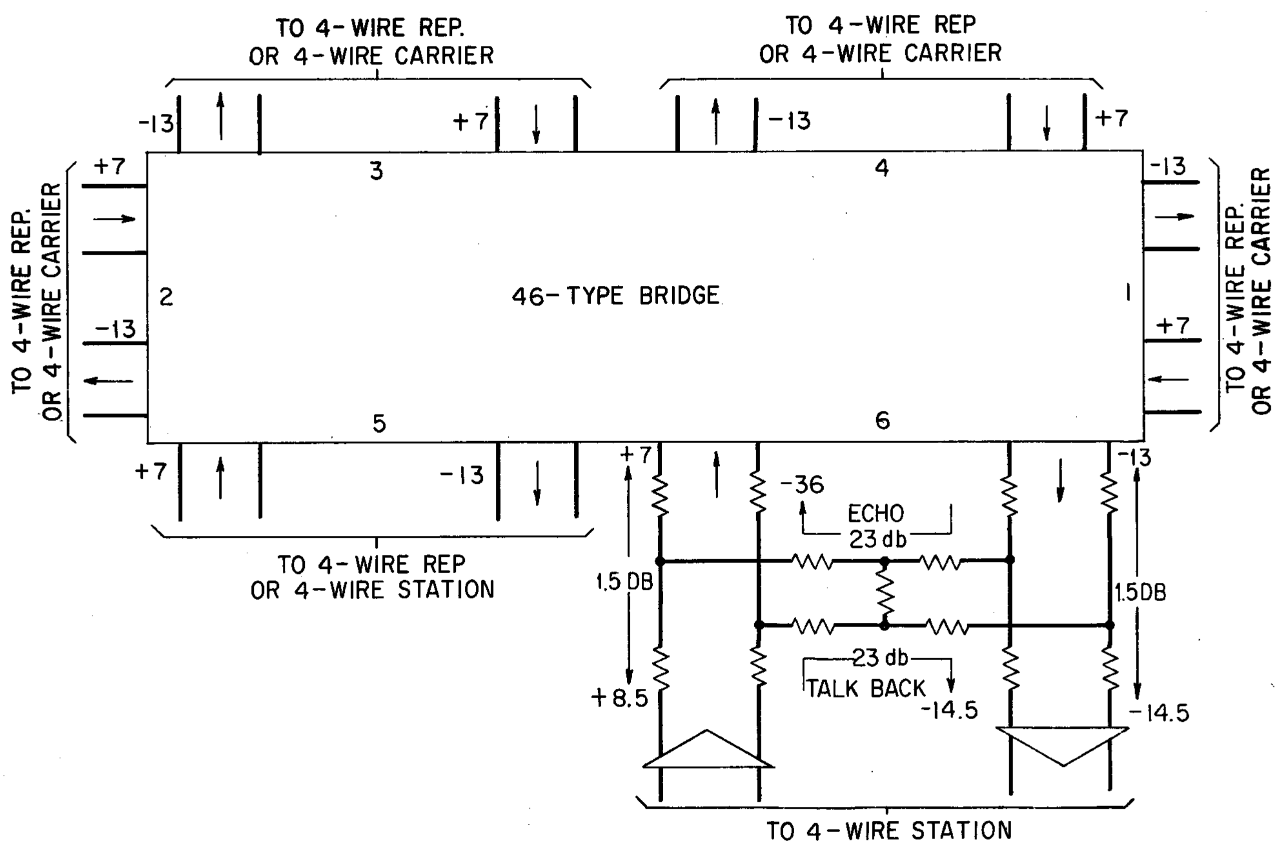


Fig. 8 — Talk-Back Bridge Connected to 46-Type Bridge

2.15 ***Talk-Back by Spare Leg of 4-Wire Bridge:*** A third talk-back arrangement is indicated in Fig. 9 in which advantage is taken of a spare leg of the bridge when available. Although Fig. 9 shows a 44-type bridge, the same arrangement can be used with a 46-type bridge. The transmitting side of the branch is connected to the input terminals of leg 4 of the bridge, and the receiving side of the branch is connected to the output terminals of leg 3 of the bridge and the unused terminals are terminated in 600-ohm resistance. In this way transmission from the branch is returned to it through the 44-type bridge at the same level as it is fed to the main line section of the circuit. Therefore, if the bridge is lined up for equal transmission in all branches connected to the bridge, the talk-back transmission will be equal to the direct transmission. With this arrangement no additional echo paths are introduced.

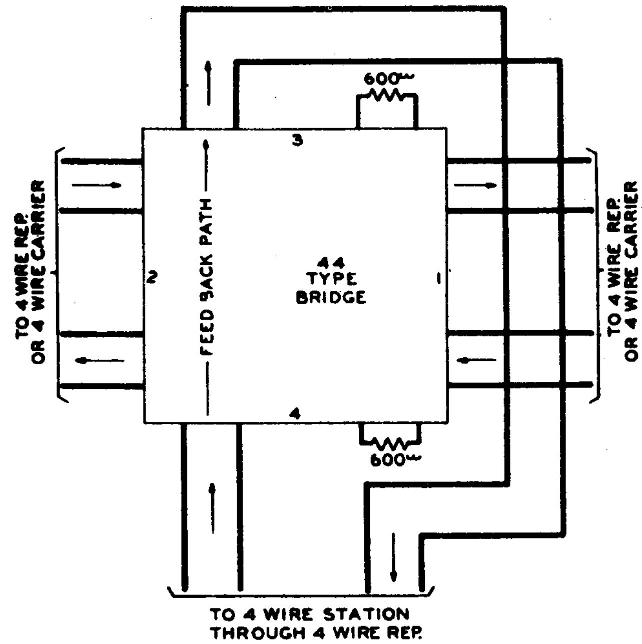


Fig. 9 — Talk-Back Obtained From Spare Leg of 44-Type Bridge

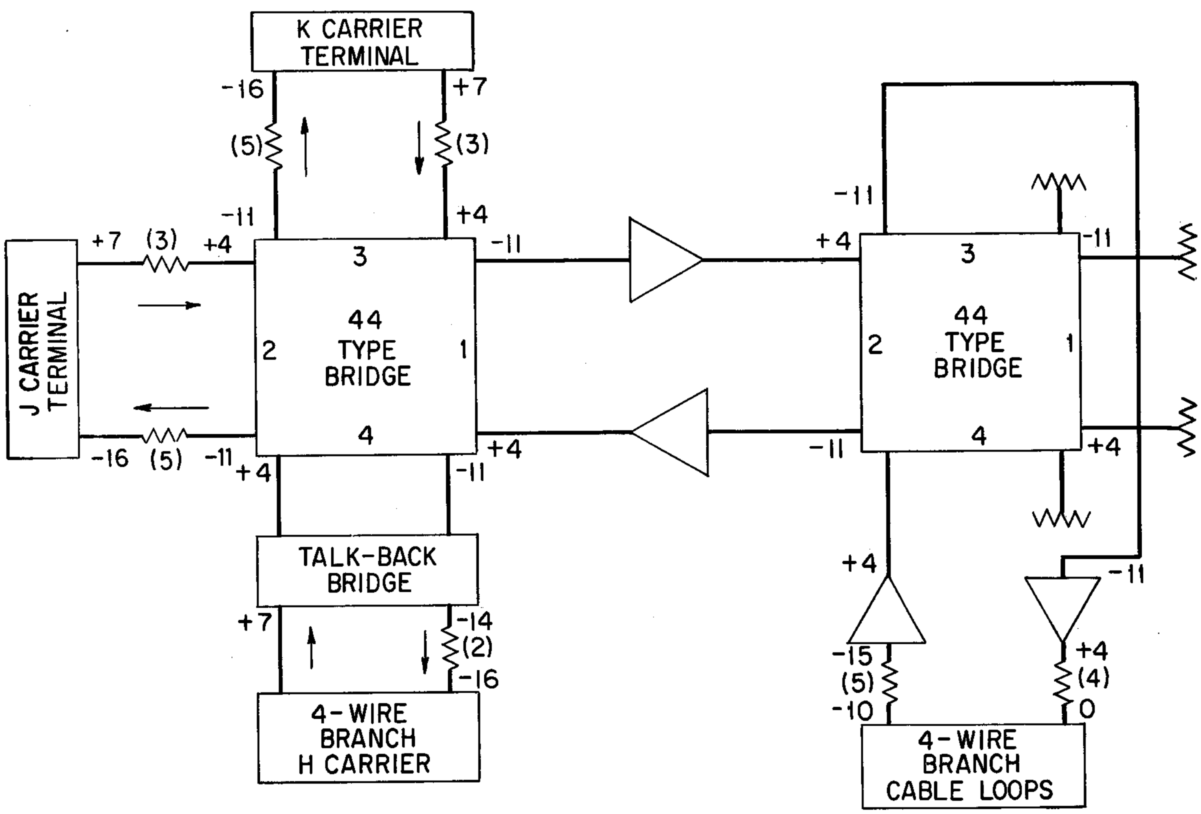


Fig. 10 — Typical Private Line Circuit Layout Using 44-Type Bridges

(C) Central Office Layouts

2.16 Figs. 10 and 11 show typical interconnections of 4-wire facilities, branches, 4-wire bridges, and talk-back arrangements. As commonly used, the input levels for 44-type bridges are either +4 or +7 and the output levels are −11 or −8. Generally all bridge input levels at a given office are set at the same level for both 44-type and 46-type bridges (i.e. +4 or +7 as commonly used.)

2.17 Fig. 10 shows two 44-type bridges interconnected with a 4-wire repeater. Typical levels are shown on the drawing. Pads of the 1 "C" type are furnished between many of the legs and the 4-wire facility. These pads are used to match the bridge level to the level required for the facility.

2.18 A typical private line circuit arrangement using a 46-type bridge and talk-back repeater is shown in Fig. 11.

2.19 A 44-type bridge permits the interconnection of four 4-wire facilities and the 46-type bridge permits the interconnection of six 4-wire facilities. The capacity of bridges can be increased by the use of tandem bridges using 4-wire repeaters to interconnect a leg of one bridge to a leg of another bridge. Thus, for each additional bridge used after the first one, the net increase in available outlets is two less than the number of legs on the additional bridges. For example two 44-type bridges in tandem will provide six usable outlets, three 44-type bridges will provide eight usable outlets, two 46-type bridges will provide ten usable outlets, etc.

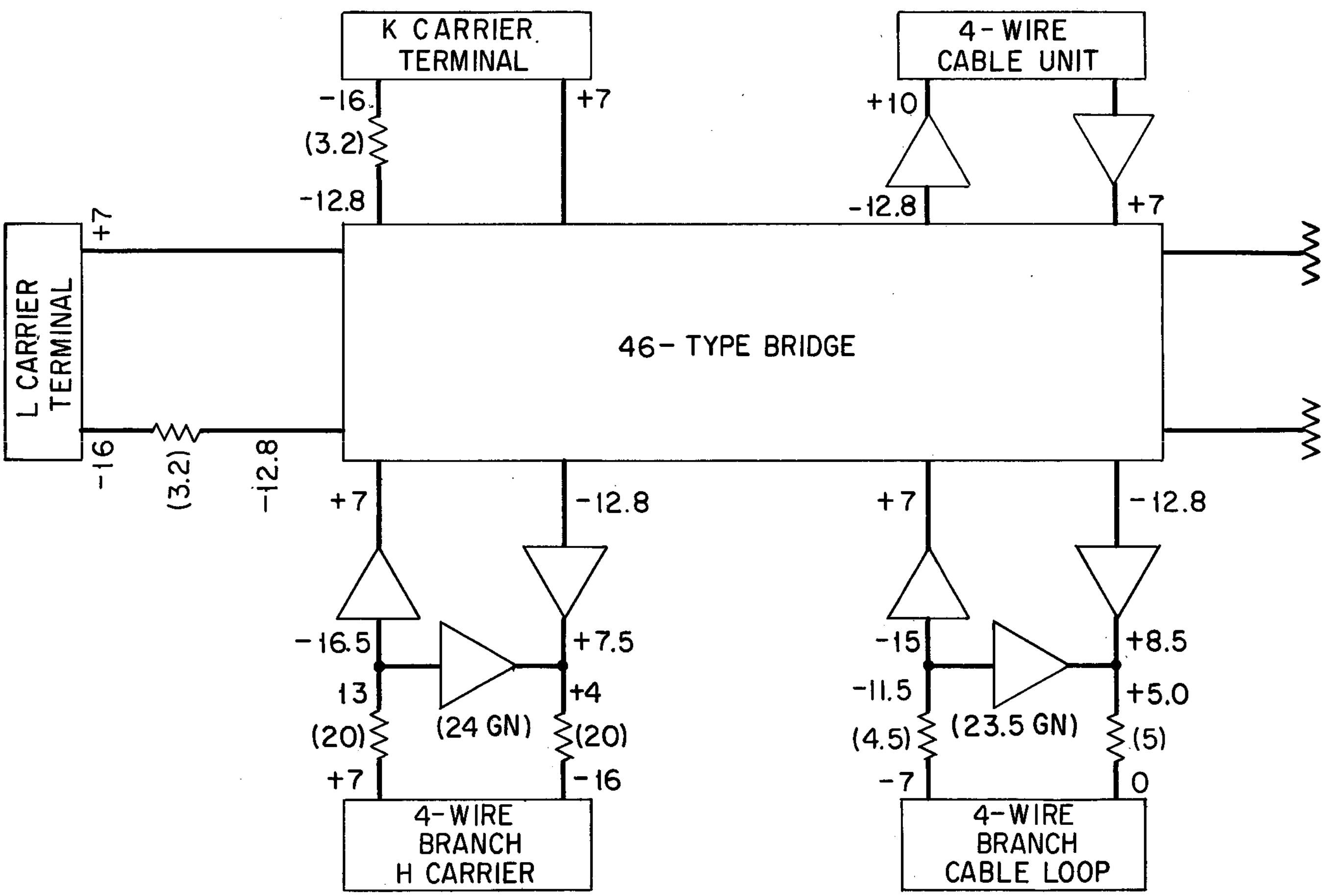


Fig. 11 — Typical Private Line Circuit Layout Using a 46-Type Bridge

2.20 When available, the use of a single 46-type bridge is preferable to using tandem 44-type bridges. This will usually reduce the number of cross connections and also reduce the number of repeaters. This is desirable from both an economy standpoint and also as a means of reducing the chances of service interruptions. If tandem bridges are used, the main or backbone layout should contain only one bridge and the other bridge(s) should be used to feed loops and side legs.

2.21 When two 44A1 repeaters are connected in tandem with a resistance pad between them, with or without a 4-wire bridge between them, singing is likely to occur in the vicinity of 10,000 cycles. This problem is frequently encountered when 44A1 repeaters are used to interconnect two 4-wire bridges. A simple modification to prevent singing in the above case is covered in the section entitled "44A1 Telephone Repeater Sets."

(D) Switching Arrangements

2.22 Arrangements for switching multistation private line telephone circuits terminated at the same location are shown schematically in Figs. 12 through 17. Switching operations are accomplished by 4-wire switching relays using 4-wire bridges as interconnecting devices. The operation of the switch relays is controlled by one or more private line stations using dc channels between the central office and a station or by 2-tone selective signaling. The dc control channel system used for signaling and switching control is discussed in Part 4 of this practice. From a transmission standpoint a switching arrangement is similar to a plain bridging arrangement since in the switched condition two or more circuits are interconnected and appear as one circuit to the bridge. In the nonswitched condition, the circuits appear as terminal circuits either routed through a bridge or without a bridge. Some of the more commonly used switching arrangements are described in the following paragraphs.

2.23 ***Arrangement for Interconnecting Two Circuits at a Bridging Point. Use of Loop Normally Connected to Bridge During Switched Condition:*** An arrangement to switch two circuits as discussed above is shown in Fig. 12. If both circuits have bridges the transmission path designated "Line of Circuit 1" will connect to a 4-wire bridge via a 4-wire repeater. A 44-type bridge is used with the line and branch of Circuit 2 connected respectively to Legs 2 and 3 of the bridge, the loop of Circuit 2 to the local station being connected to Leg 4. In the nonswitched condition the line of Circuit 1 connects through contacts of the SL1 relay to its loop, Side 1 of the bridge being terminated. In the switched condition operation of the SL1 relay connects the line of Circuit 1 to Side 1 of the bridge, leaving the loop of Circuit 1 open. With the branches illustrated a talk-back bridge is provided for Circuit 2 but a talk-back repeater is provided for Circuit 1 since, as discussed in Paragraph 2.11, the talk-back bridge can only be used where gain is provided in the loop. Other talk-back arrangements may be used for Circuit 2.

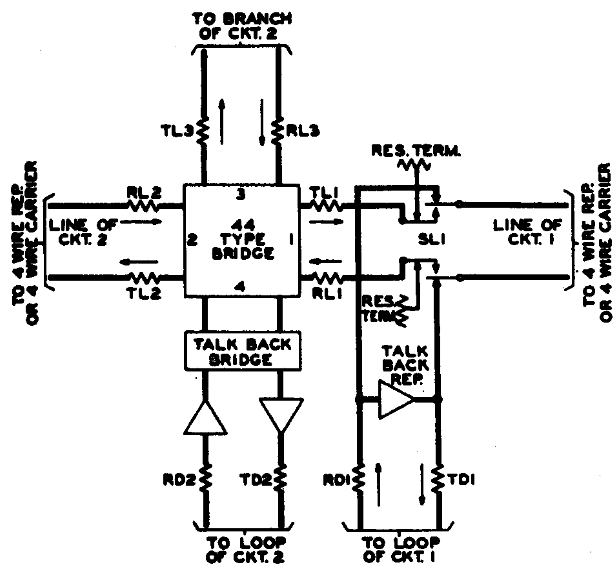


Fig. 12 — Switching Arrangement for Interconnecting Two Circuits at Bridging Point. Use of Loop Normally Connected to Bridge in Switched Condition.

2.24 Since all bridge levels in any given office are kept at a standard level, pads TL2, RL2, TL3, and RL3 may be required to convert from the levels at the facility to the bridge level. Pads TL1, RL1, TD1, and RD1 are not always required since, as in the case shown in Fig. 12, adjustment of levels can be made by adjusting the loop repeater gains. In the description of other switching arrangements that follows, discussion of pads will be limited to those pads that pertain directly to the switching arrangement. Pads TL1, RL1, TD1, and RD1, shown in Fig. 12, are frequently required. The RD1 pad and TL1 pad are used to obtain the proper level into the toll circuit from the transmitting loop and the bridge respectively. Pads TD1 and RL1 provide the desired levels into the receiving loop and bridge respectively. Although the levels from the loop and from the bridge will be alike or will have a planned difference, the RD1 and TL1 pads will not both be required if a repeater is associated with the toll circuit since one of the pads can be 0. Similarly, TD1 and RL1 may not both be required. When fixed gain carrier channels appear in the line, however, the value of the level as well as the difference is fixed by circuit conditions and both pads may be required.

2.25 ***Arrangement to Interconnect Two Circuits at a Bridged Point. Loop of Switched Lines Used on Switched Connections:*** This arrangement is shown in Fig. 13 and is similar to Fig. 12 except that in the switched condition the loop of Circuit 1 is substituted for the loop of Circuit 2 on Leg 4 of the bridge, the loop of Circuit 2 being left open. The values of Pads RD1, TD1, RL1 and TL1 are so chosen that the same levels exist on the line of Circuit 1 when connected to its loop and when connected to Leg 1 of the bridge. The levels on the loop side of the repeater of Leg 4 of the bridge, to which the loop of Circuit 1 may be switched are thus determined by the levels from Pad RD1 and into Pad TD1. Therefore, with this arrangement Pads RD2 and TD2 will usually be required to adjust the levels from the transmitting loop and into the receiving loop of Circuit 2 respectively.

2.26 ***Arrangement to Interconnect Two Circuits at Nonbridging Points:*** A third arrangement to interconnect two circuits is shown in Fig. 14. In the nonswitched condition both loops are connected to their respective lines through line relays SL1 and SL2. In the switched condition the interconnection of the two circuits is accomplished by introducing a 44-type bridge, so arranged that Loop 2 through relay SD5 connects to a repeater on Leg 4 of the bridge, Loop 1 being left open. This arrangement permits the adjustment of the net loss to the loop connected to the bridge in the switched condition. This adjustment may be of advantage when a 2-wire loop is employed and the loop is used only for supervision and monitoring, since the loss to the loop may be increased, thereby reducing echo and return currents on the overall connection.

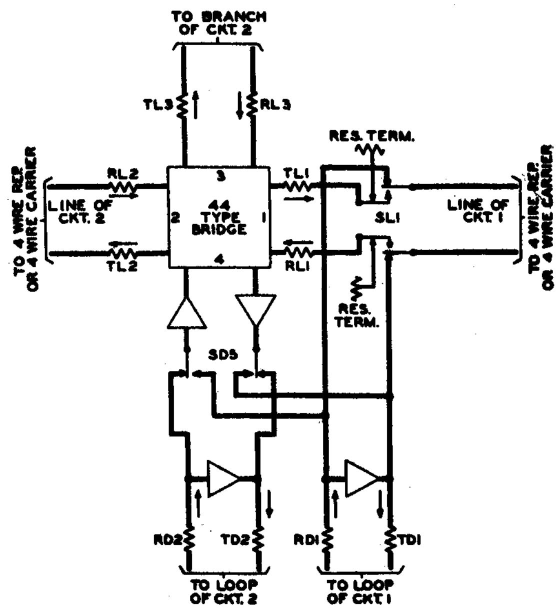


Fig. 13 — Switching Arrangement for Interconnecting Two Circuits at Bridging Point. Loop of Switched Line Used on Switched Connections

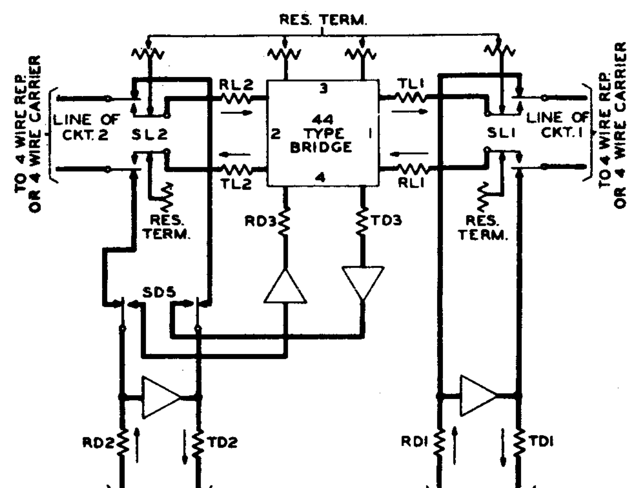
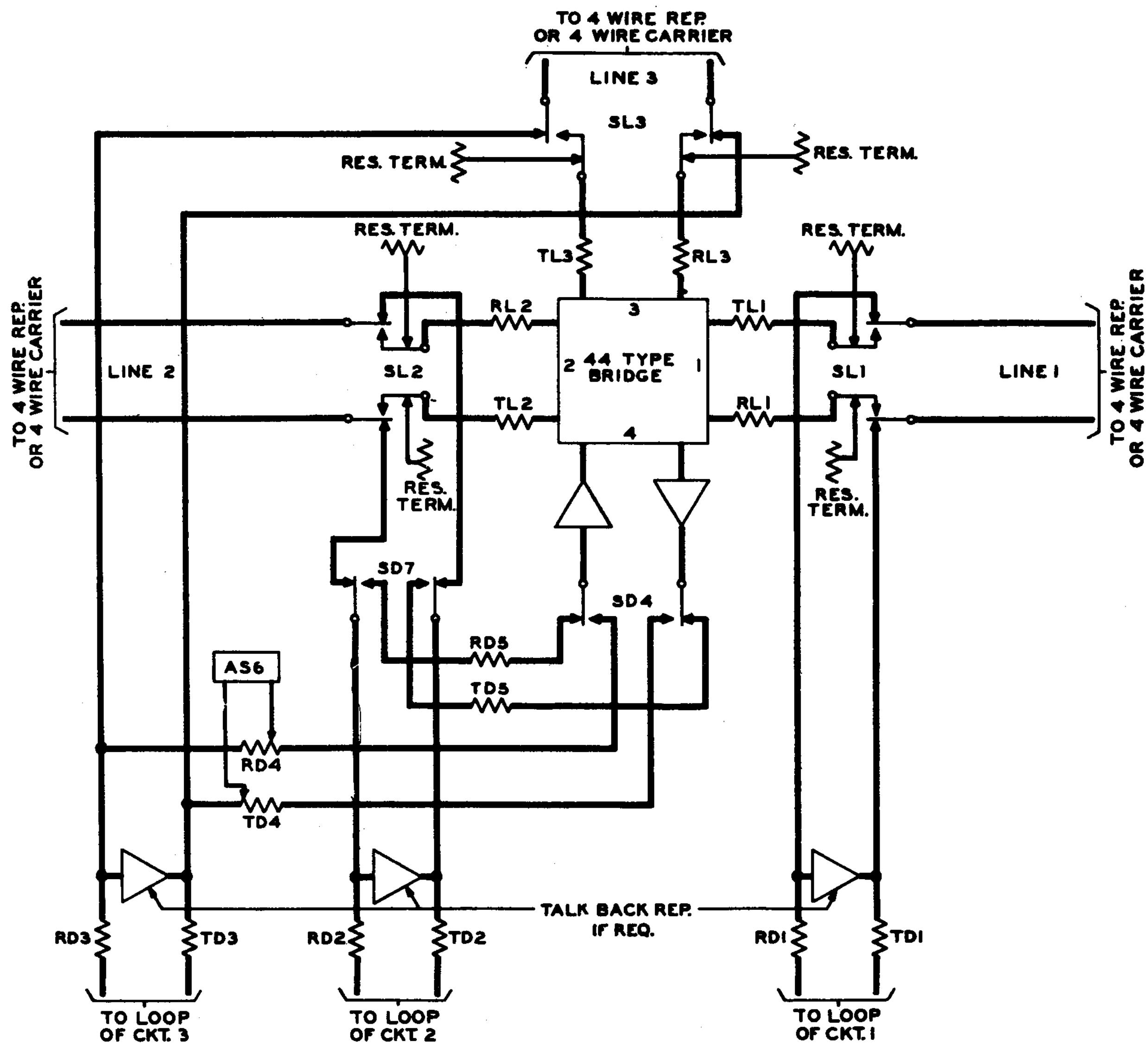


Fig. 14 — Switching Arrangement for Interconnecting Two Circuits at a Nonbridging Point

2.27 ***Arrangement to Interconnect any Two of Three Circuits:*** An arrangement to interconnect three circuits, any two at a time, is shown in Fig. 15. The circuits shown as lines 1, 2, and 3 in Fig. 15 may have their own individual bridges in addition to the switching bridge that is shown. If the circuit or circuits have bridges, the lines will connect to a 4-wire repeater and then to their individual bridges. Under control of three keys at the station the toll lines of any two circuits may be connected to the 44-type bridge through operation of the SL relays and the loop of one of the circuits is connected to the repeater on Leg 4 of the bridge by operation of the SD4 or SD7 relays.

2.28 Provision is made for including the RD5, TD5, RD4, and TD4 pads to adjust the levels into the repeater connected to Side 4 of the bridge. Usually these pads may be omitted by adjusting the RD2, TD2, RD3, and TD3 pads to provide the same losses for Loops 2 and 3. Where it is necessary to use different line levels for Circuits 2 and 3, however, the loop losses cannot be adjusted to the same value and RD4 and TD4 or RD5 and TD5 pads will be required.



CIRCUITS INTERCONNECTED	SWITCHING RELAYS OPERATED
1-2	SL1, SL2, SD7
1-3	SL1, SL3, SD4
2-3	SL2, SL3, SD4

Fig. 15 — Switching Arrangement for Interconnecting Any Two of Three Circuits

When Circuit 3 is in a nonswitched condition, Pads RD4 and TD4 are bridged across it. Relay AS6 is provided with these pads to open their shunt paths and thus prevent their causing a bridging loss.

2.29 ***Arrangement to Interconnect Three Circuits in Any Combination:*** An arrangement to switch three circuits in any combination is shown in Fig. 16. With this arrangement a switching bridge is used and no loops are disconnected in the switched condition. The levels at all legs of all bridges will be the same. The three 4-wire repeaters are lined up the same as though they were used to interconnect two bridges directly.

2.30 ***Arrangement to Interconnect Four Circuits in Any Combination:*** Fig. 17 shows an arrangement that permits connecting four circuits in any combination of two, three, or all four. Two, two-circuit combinations can be switched at the same time by switching two of the circuits into the first switching bridge and by switching the other two circuits into the second switching bridge. No loops are disconnected in the switched condition. The repeaters shown in Fig. 17 are lined up the same as repeaters used to connect two bridges without a switching arrangement.

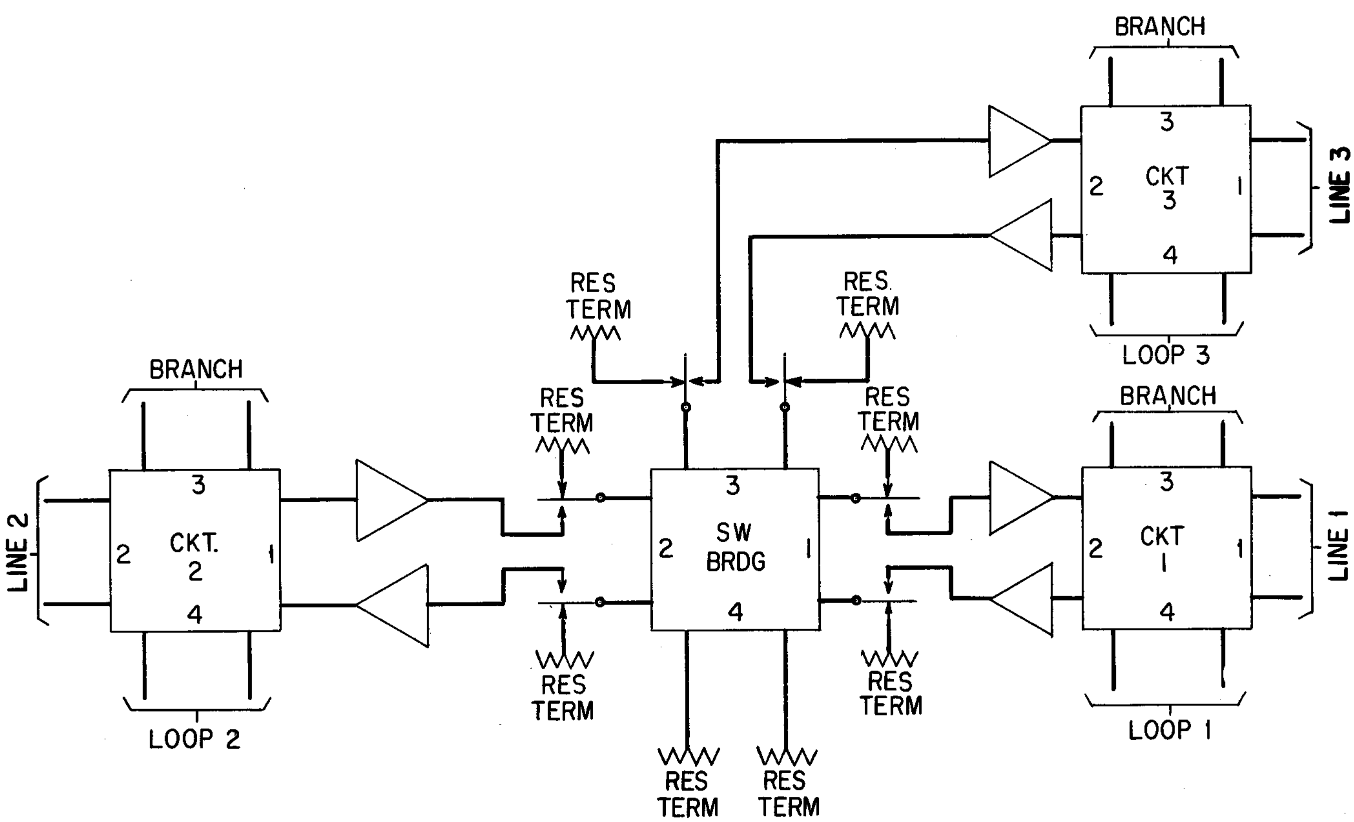


Fig. 16 — Switching Arrangement for Interconnecting Three Circuits in Any Combination

TO CONNECT	TO	OPERATE
CIRCUIT 1	SW BRDG 1	SL1-1
CIRCUIT 1	SW BRDG 2	SL1-2
CIRCUIT 2	SW BRDG 1	SL2-1
CIRCUIT 2	SW BRDG 2	SL2-2
CIRCUIT 3	SW BRDG 1	SL3-1
CIRCUIT 3	SW BRDG 2	SL3-2
CIRCUIT 4	SW BRDG 1	SL4-1
CIRCUIT 4	SW BRDG 2	SL4-2

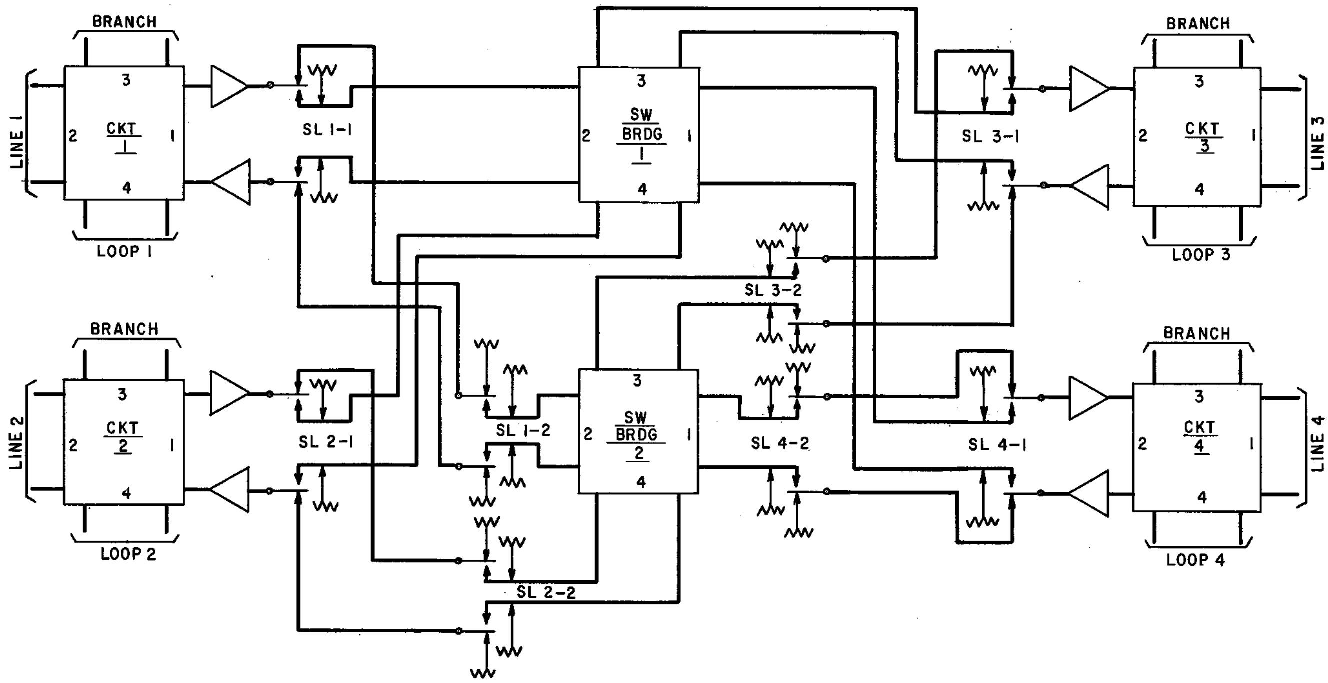


Fig. 17 — Switching Arrangement for Interconnecting Four Circuits in Any Combination

3. STATION FEATURES

3.01 Private Line Telephone circuits usually terminate in a station (an instrument or a jack circuit for a plug-in instrument), a PBX, and/or key equipment. The equipment at a customer's location can be classified as being either common equipment or station equipment. The common equipment is the private line circuit termination that is common to all stations at a customer's location. The station equipment is the instrument, induction coil, etc, that is furnished at each station. Circuits suitable for use with both 2-wire and 4-wire loops, including station levels, are discussed in the following paragraphs.

(A) 4-Wire Station Arrangements

3.02 ***4-Wire Common Equipment:*** One type of common equipment used for terminating a 4-wire loop is shown in Fig. 18 and is usually referred to as a 4-wire termination. It consists of A and B loop transformers, A and C pads, and C and D autotransformers. The type of A and B transformers are selected so that the loop impedance, determined by the length, gauge, and loading, is matched to the 600-ohm impedance of the equipment towards the station. Connections to the loop side of the transformers provide dc channels as required. The A and C pads are of the 1 "C" type and are used to match the levels of the station instruments to the levels required for the loops. These pads are sometimes omitted if no level adjustment is required. The C and D autotransformers are always used if the 4-wire loop serves more than one station, the use being optional if only one station is fed from the loop. A maximum of 10 stations can be multipled on the station side of the autotransformers. The autotransformer taps to be used are determined by the number of stations multipled, the taps being selected to compensate for the impedance mismatch that would be caused by multipling the stations. The circuit levels at the A and B transformers are shown on the circuit layout cards of private line telephone circuits. Table 1 gives typical 1000-cycle losses of a 4-wire private line termination from the loop side of the A and B transformers to a station and includes the effects of bridged stations. Zero db A and C pads are assumed. A different type of termination is used with "packaged station equipment" and is discussed later in this part of the practice.

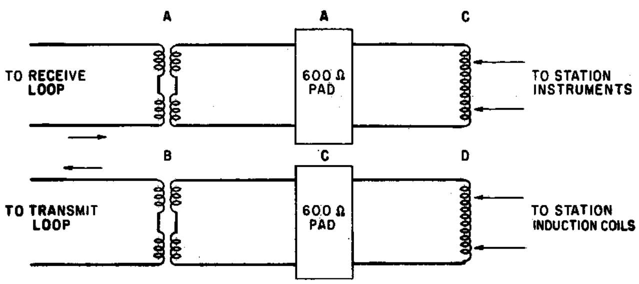


Fig. 18 — Private Line Station Equipment — 4-Wire Common Equipment

TABLE 1

Stations on Line	Loss of 4-Wire Termination
1	.5
2	3.8
3	5.4
4	6.7
5	7.7
6	8.5
7	9.3
8	10.1
9	10.6
10	11.0

3.03 ***Station Equipment — Station Circuit and Talk Battery:*** The station induction coil and T relay, shown in Fig. 19, are furnished in the path between each transmitter and the autotransformer. The talk-battery supply in addition to furnishing battery for talking is also used for relay operations, lamp operation, etc. Various talk-battery supplies of both local and common types are used. The induction coil is wired as a simple step-up transformer and converts the low impedance of the transmitter to a 600-ohm impedance for connection to the circuit termination. The T relay is operated when the station is ready to talk, control being accomplished through switchhook contacts or through auxiliary jack contacts of a headset jack. If a push-to-talk handset is used the T relay control circuit is also wired through the push-to-talk button. When the relay is nonoperated the transmission path is opened with a 600-ohm termination connected toward the line. In order to conserve transmitter battery the primary of the induction coil is also opened when the T relay is nonoperated. The contacts of the relay are adjusted with a sequence of operations which avoids clicks on the line and on the station receiving circuit. Auxiliary contacts of the relay are used to restore signals and perform other dc control operations when the circuit is in use at the station. The reference point for the levels shown on circuit layout cards is the point between the station induction coil and the autotransformer. The impedance at this point is 600 ohms.

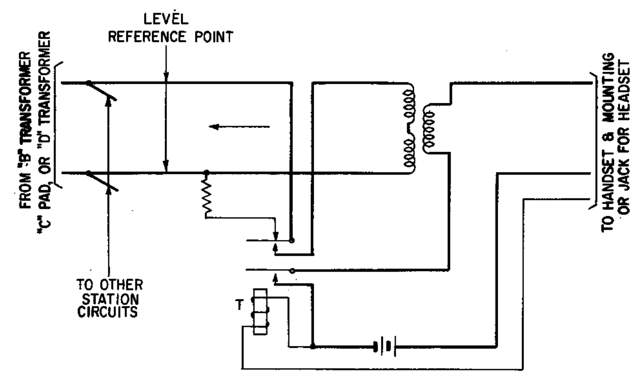


Fig. 19 — Private Line Station Equipment — 4-Wire Station Circuit

3.04 ***Station Equipment — Telephone Instruments:*** Each private line station requires either an instrument or a jack for a plug-in instrument. Shown in Fig. 20 are two commonly used station arrangements, a push-to-talk handset and a headset jack. The receive path from the autotransformer is connected to a 600-ohm termination or loudspeaker in the "on-hook" condition and to a handset receiver or headset jack in "off-hook" condition; the connections being made through the switchhook contacts of the handset mounting or auxiliary contacts of the headset jack. The switchhook contacts also close the path to the handset transmitter. As commonly used, handsets have F1 or T1 transmitters and HA3 or U2 receivers and headsets have N1 transmitters and HC4 receivers. The levels at a station as shown on circuit layout cards is the level at the input to the receiver. The impedance at this point is 600 ohms.

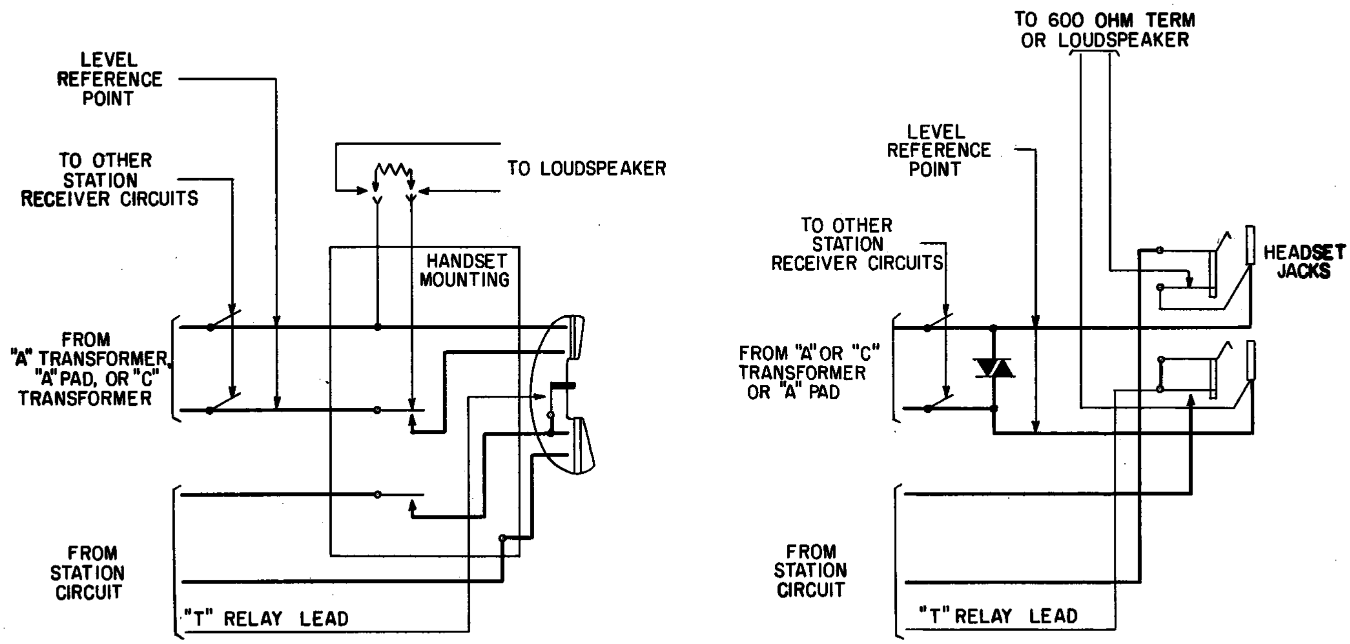


Fig. 20 — Private Line Station Equipment — Station Instruments

3.05 A complete station arrangement is shown in Fig. 21. The autotransformers and all the equipment to the left of them is common to all stations fed from the loops. All other equipment is repeated for each station connected to the autotransformers. Various types of handsets and mountings or headset jacks can be substituted for the push-to-talk handset. Fig. 21 shows the station equipped with a monitoring jack circuit. Monitoring receivers are usually 716C-type, 2400-ohm impedance, and introduce a bridging loss to the station receivers of less than 1 db.

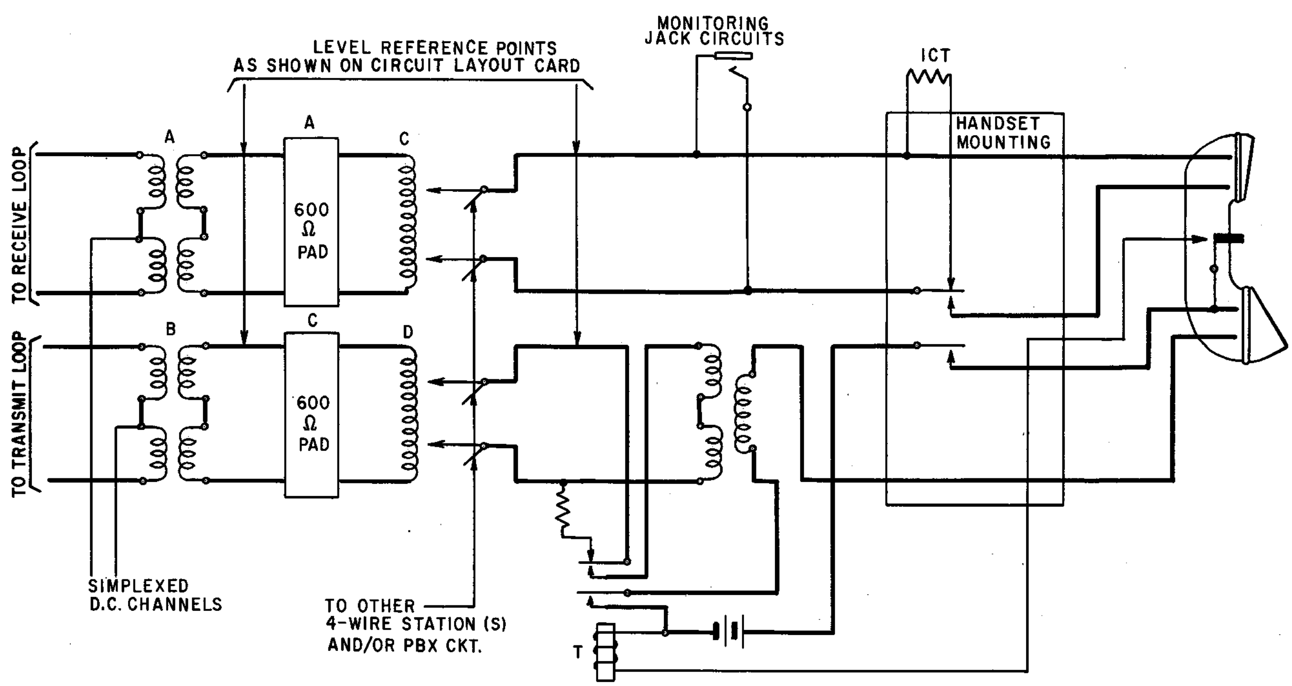


Fig. 21 — Typical 4-Wire Private Line Station Arrangement

The number of monitoring receivers used is usually limited to three per private line circuit termination.

3.06 ***4-Wire Package Equipment:*** The transmission aspects of packaged 4-wire station equipment are somewhat different from those discussed in Paragraphs 3.02 through 3.05. Fig. 22 is a schematic of the transmission paths of a 4-wire package termination. No A and C pads or autotransformers are used. The loop transformers are arranged to have a 9:1 impedance ratio and thus a low impedance termination is presented to the stations. With this arrangement the loss due to impedance mismatch decreases as the bridging loss increases thus providing a more uniform station loss for the various numbers of stations that might be bridged. The approximate losses of the 4-wire arrangement between the line terminals of the receive loop transformer and the receiver and between the line terminals of the station induction coil and the line terminals of the transmit loop transformer are shown in Table 2. These losses include the effect of bridged stations. In the transmit direction it is assumed that only one push-to-talk button is operated at a time. These figures are based on a loop impedance of 900 ohms. The various equipment features of package equipment are discussed in Part 8 of this section.

TABLE 2

Transmission Losses of 4-Wire Arrangement

Number of Stations	Bridging * Transmitting	Loss * Receiving
1	5.0	3.7
2, 3 or 4	6.7	5.8
5 or 6	8.6	8.3

* Includes loss of 177D repeat coil.

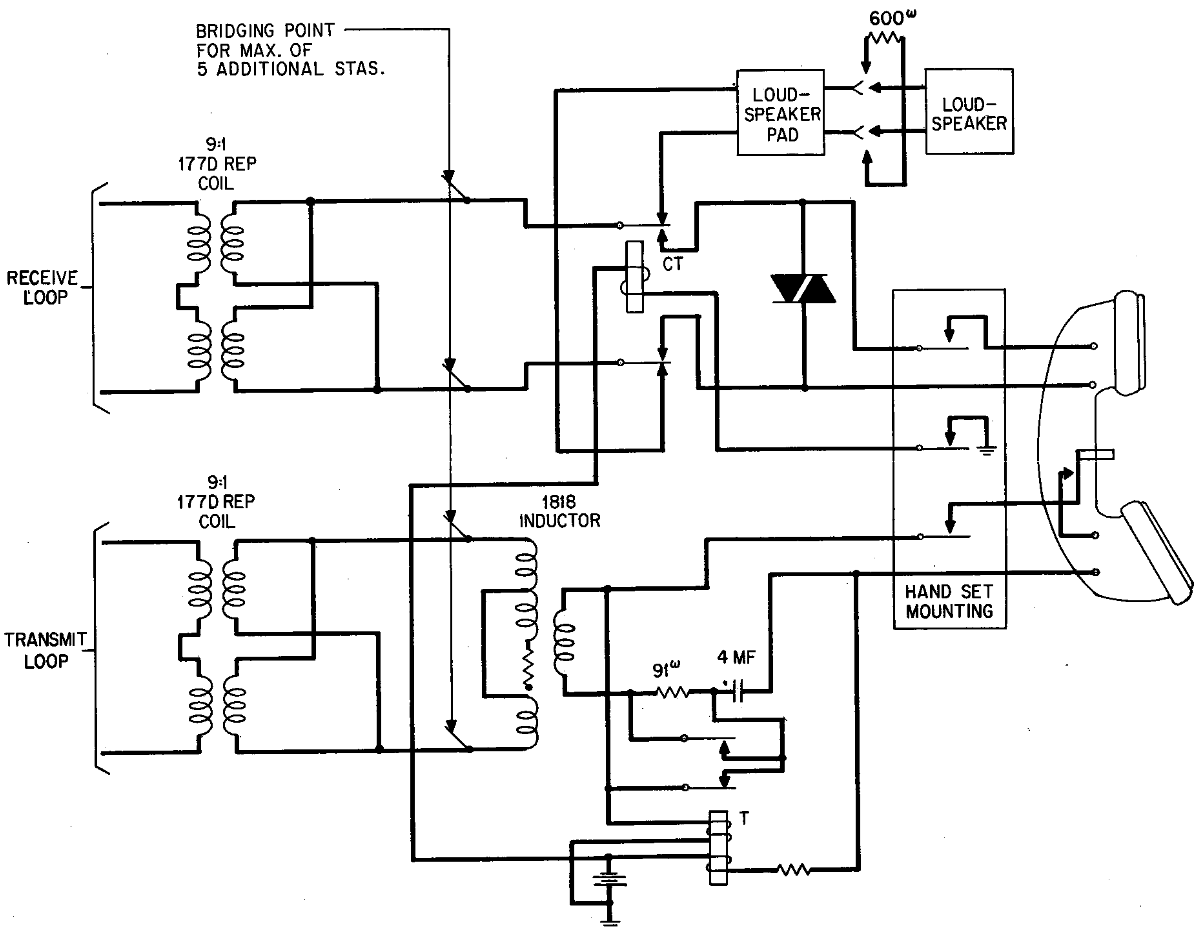
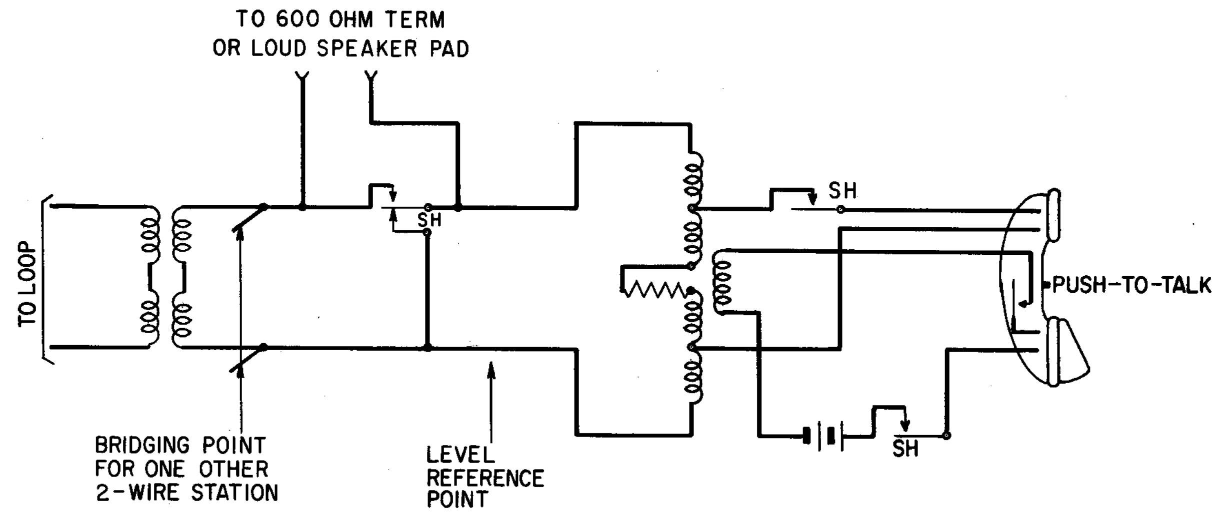


Fig. 22 — 4-Wire Private Line Station Circuit Using Package Equipment



NOTE: SH DESIGNATES SWITCH HOOK CONTACTS

Fig. 23 — Typical 2-Wire Private Line Station Arrangement

(B) 2-Wire Station Arrangements (Fig. 23)

3.07 The important transmission features of the 2-wire station circuit consists essentially of a loop transformer and a handset with antisidetone station induction coil. In the idle (on-hook) condition the loop is connected to either a 600-ohm termination or to a loudspeaker circuit. Use of loudspeakers is discussed in another part of this practice. The loss of the circuit consists only of the loss of the loop transformer and of the bridged multiple stations. Provision is made to multiple one additional station. The field use for this station circuit is limited, particularly if more than one station is required, since the bridged losses caused by multiple connections must be compensated for by increase in the gains of the repeater at the adjacent toll office. Since there is a 2-wire path around this repeater, increases in gain will be limited by the echo and return currents on the main circuit.

(C) Key Equipment

3.08 Key equipment is used at airports or similar locations where one or more attendants may be required to select any one of several private lines. Depending on the features furnished, the attendant by operation of the proper key can connect his telephone set to a central office line, to a PBX line, to a tie line to other key equipment positions, or to private line circuits. Since the attendant's telephone set, key equipment, tie lines to other key equipment positions, etc, are not associated with a specific private line circuit, the circuit layout cards available at a central office may not show all of these features. Because many tests are made from the attendant's telephone set and so that the test room attendant will have a general knowledge of key equipment, a brief description of the various types of key equipment is included in this section. It would be impractical to describe in this section all of the circuits for all the various types of key equipment. The descriptive material in this section is limited to a very general description of types of key equipment and a description of some 102A key equipment circuits. In some cases specific applications of key equipment are covered in sections covering circuits or networks for a specific customer such as the Federal Aviation Agency.

101-Type and 102-Type Key Equipment: These types of key equipment are similar except the 101-type is suitable for only 2-wire terminations whereas the 102-type is suitable for both 2-wire and/or 4-wire terminations. These types use lever type keys with associated lamps. All types of signaling can be used.

109-Type Key Equipment: Similar to 102-type equipment and is intended for use where the number of lines (maximum of five) is so limited that the provision of 102-type key equipment is not desirable. Push button keys are used.

111-Type Key Equipment: Comparable to the 102-type but has special features developed for the Federal Aviation Agency.

3.09 ***Attendant's Telephone Circuit — 102A Key Equipment — Loudspeaker Signaling:*** The attendant's telephone circuit used with the 102A key equipment arranged with loudspeaker signaling is shown schematically in Figs. 24 and 25. Since circuits terminating either 4-wire or 2-wire may be connected to the 102A key equipment, the attendant's telephone set is arranged to operate either 4-wire or 2-wire, depending on the line to which it is connected, this selection being automatic. The circuit arrangements make provision for multiplying other stations to the attendant's telephone circuit. A loudspeaker is used for receiving incoming signals. When the line key in the key equipment is not operated or the attendant's telephone set is not in the jacks, the loudspeaker is connected to the circuit. The considerations involved in the use of the loudspeaker and adjustment of the B pad are discussed in Part 5 of this section.

3.10 Fig. 24 shows schematically the attendant's telephone circuit in the 4-wire condition. A 600-ohm idle circuit termination is bridged across the transmitting side of the circuit and the loudspeaker circuit is bridged on the receiving side. When the line key is operated and the telephone set is in its jacks, the loudspeaker is replaced by the receiver in the attendant's telephone set and the idle circuit termination is removed. The transmitter is connected to the circuit through an induction coil connected as a simple transformer. A 40-ohm resistance, which is under control of the transmitter current, replaces the transmitter impedance when the push-to-talk key is released in order to provide a constant termination on the transmitting side of the circuit. The earlier attendant's telephone circuit (Drawing SD-69150-01 now rated A and M only) is not suited to connect to the 4-wire station circuits. The station levels shown on circuit layout cards are the levels on the loop side of the station transformer and on the loop side of the varistor. The impedance at those points is 600 ohms.

3.11 Fig. 25 shows schematically the 2-wire condition of the attendant's telephone circuit arranged for loudspeaker signaling. Operating the line key removes the loudspeaker set from the circuit and connects the attendant's telephone circuit to the line when the telephone set is in its jacks. A relay under control of the transmitter battery substitutes a resistance for the transmitter when the push-to-talk key is released in order to provide a constant termination for any multiple stations which may be present.

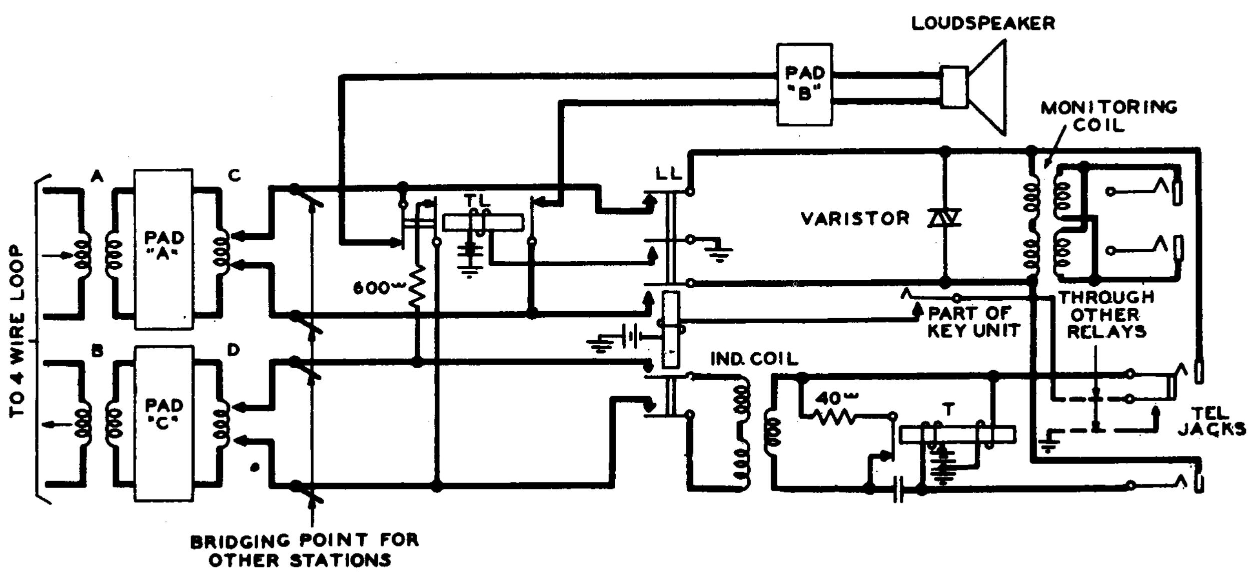


Fig. 24 — Attendant's 4-Wire Telephone Circuit — 102A Key Equipment Arranged with Loudspeaker

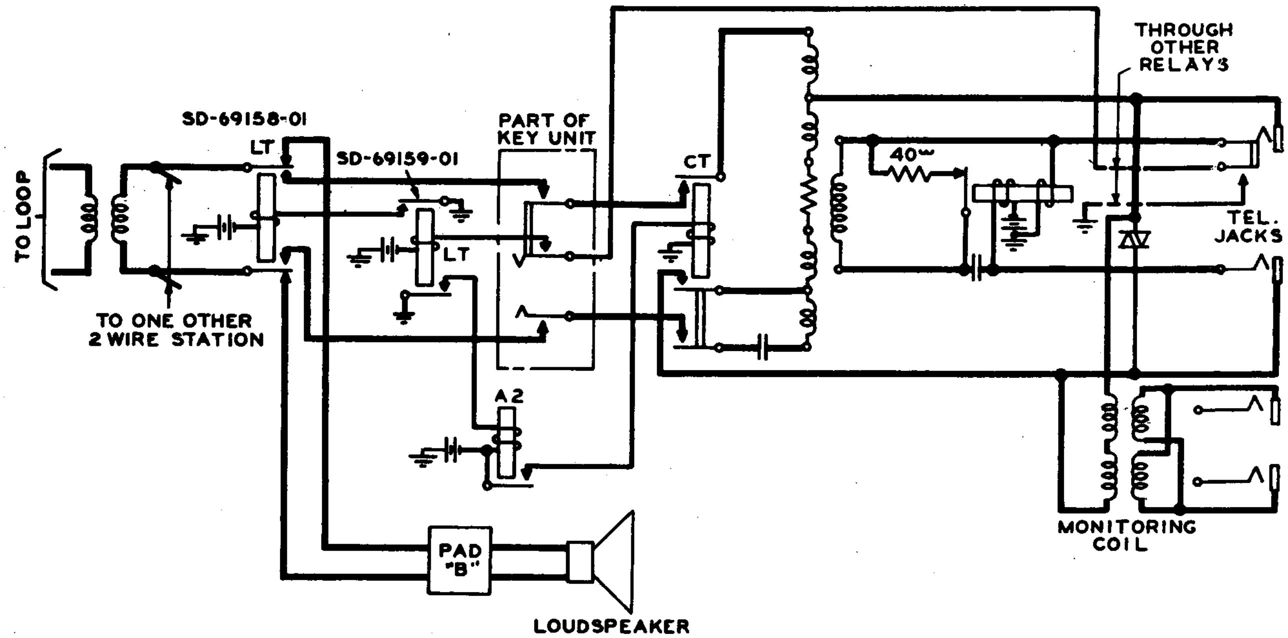


Fig. 25 — Attendant's 2-Wire Telephone Circuit — 102A Key Equipment Arranged with Loudspeaker

3.12 *Earlier Station Arrangements:* In addition to the station arrangements described, Drawing SD-69158-01 includes earlier arrangements now rated A and M only, but which are still widely used. The operation is generally similar but because of impedance differences these older circuits cannot be multipled to the standard stations without modification. The older circuit has receiving station equipment which is nominally 150 ohms instead of 600 ohms of the standard circuit and the transmitting side does not have the impedance matching autotransformer arrangements but instead uses a 4 to 1 impedance ratio in the loop transformer to match several multiple stations. Drawing SD-69158-01 also includes figures to provide modification of this circuit to make it suitable to multiple with the standard figures. The modification consists principally of replacing the low impedance HA1 receiver with the higher impedance HA3 receiver and rewiring the existing transformers to provide the same autotransformer arrangement as is provided in the standard circuit.

3.13 *Attendant's Telephone Circuit — 102A Key Equipment — Lamp and Buzzer Signaling:* This attendant's telephone circuit differs from that just described in that incoming signals are by means of lamps and buzzer rather than loudspeaker. The main change other than the signaling features is a change in line circuit termination.

3.14 Fig. 26 shows schematically the attendant's telephone circuit and circuit termination for a 4-wire key equipment station with lamp and buzzer signaling. No provision is made for bridged stations. In this case, a manual long line circuit (SD-69164-01) is required, the loop transformers and idle termination being part of this long line circuit. The other equipment in Fig. 26 is part of the key equipment. The transmitter is replaced by a 40-ohm resistor when the push-to-talk key is released. The earlier attendant's telephone circuit (Drawing SD-69150-01 now rated A and M only) will also be found in this application, but with this set there is an additional 3 db transmitting loss in the 4-wire condition because the network included in the induction coil for use in the 2-wire condition remains in the circuit.

3.15 The 2-wire condition of the attendant's telephone circuit is shown by Fig. 27. The arrangement shown is that in which dc or ringdown signaling is employed and the idle circuit termination provides a satisfactory singing point for the 2-wire repeater or 4-wire terminating set at the adjacent toll office. No appreciable loss is caused by the manual long line circuit.

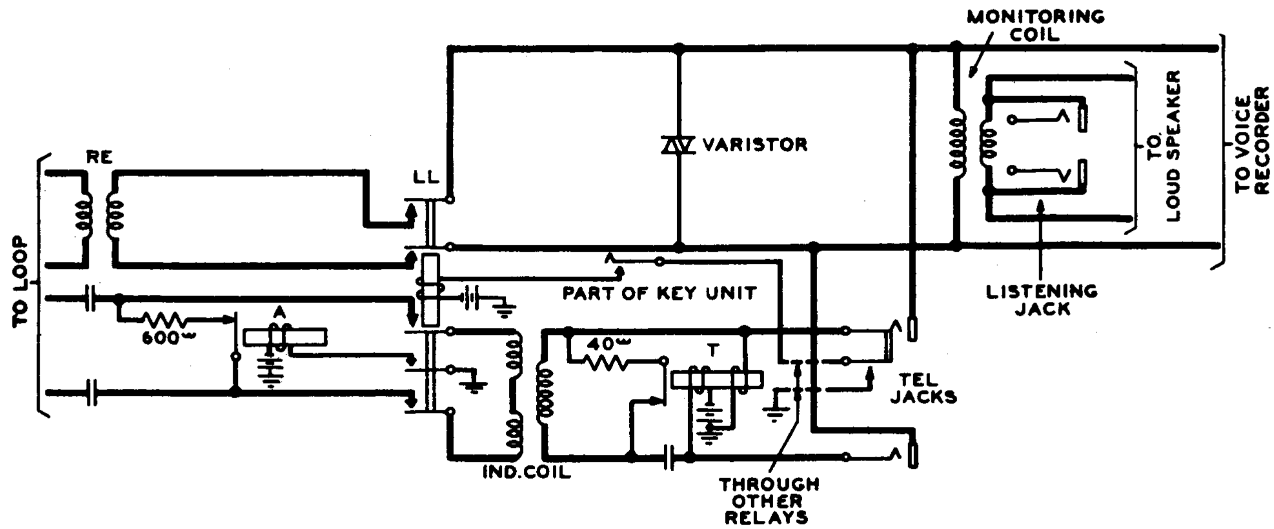


Fig. 26 — Attendant's 4-Wire Telephone Circuit — 102A Key Equipment-Lamp and Buzzer Signaling

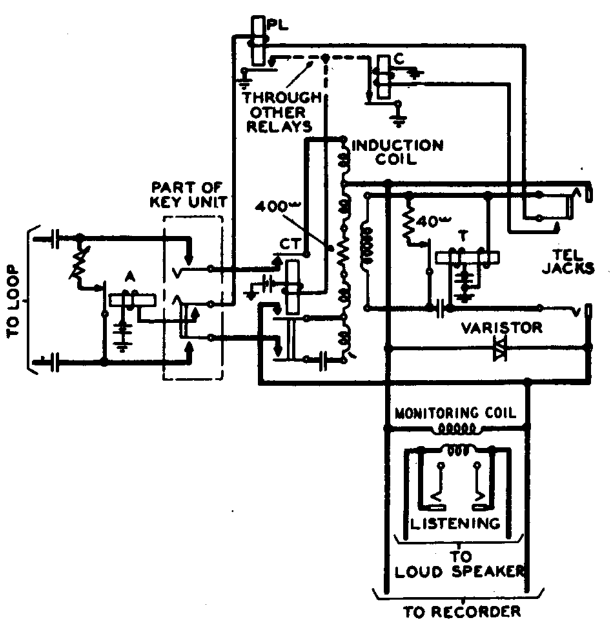


Fig. 27 — Attendant's 2-Wire Telephone Circuit — 102A Key Equipment-Lamp and Buzzer Signaling

Other Features

3.16 Separate monitoring jacks are provided with the attendant's telephone and key circuits and connections are made to the receiving side of the circuit through a 94F transformer connected to provide an impedance ratio of 6 to 1. This provides a loss to the monitoring receiver of approximately 8 db and provides approximately 0.7 db loss to the attendant being monitored.

3.17 Multiple jacks which are not shown in Fig. 25 or 26 are provided in the attendant's key and telephone circuit for use of a second operator. These are bridged across the transmitter and receiver of the first circuit but there is a separate battery supply for each transmitter. There will be a 3.5 db bridging loss if both jacks are used simultaneously. The transmitting loss will occur, however, only when both operators have their push-to-talk key operated since the release of the key of either set will remove a 40-ohm resistance which replaces the transmitter.

3.18 The attendant's telephone and key circuit may also be associated with supervisor's positions. When monitoring, the supervisor is connected through the monitoring coil mentioned in Paragraph 3.16 but when talking the supervisor's position is bridged across 2-wire incoming lines. The supervisor's position is provided with its own station induction coil. In the talking condition there is a 3.5 db bridge loss in the attendant's set, or 6 db if two attendants are simultaneously operating, each with their push-to-talk key operated.

3.19 Leads are provided directly across the receiver, for connections to a voice recorder. These leads remain connected across the receiver

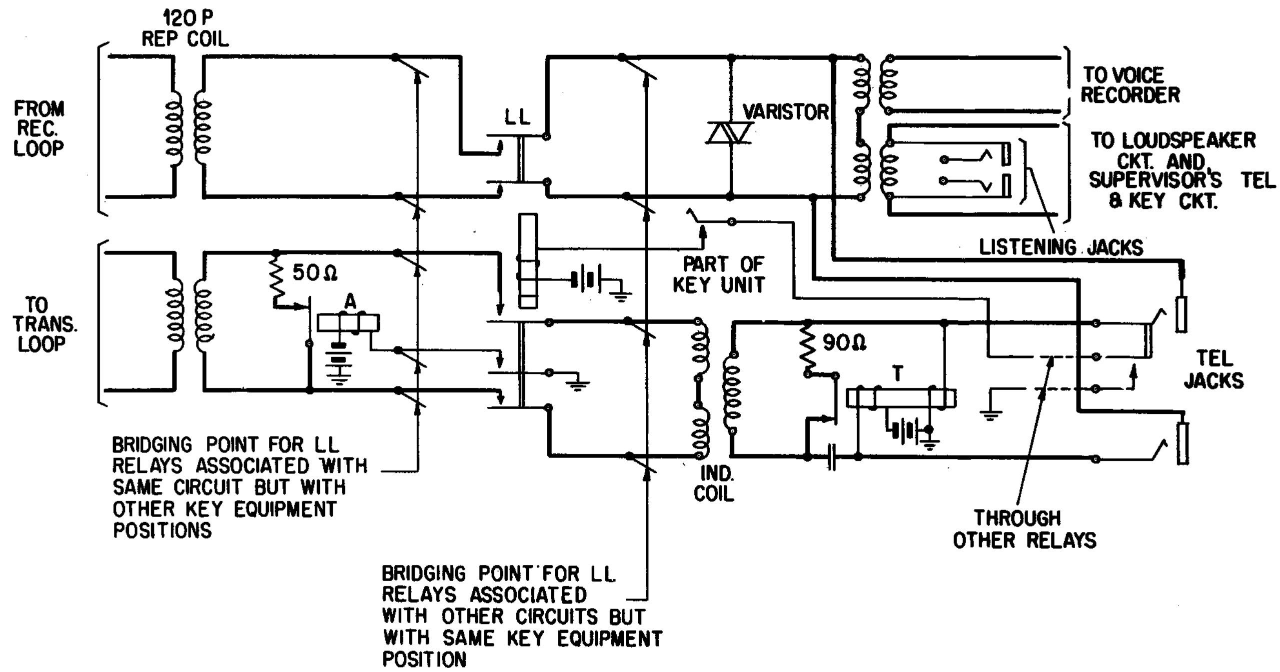


Fig. 28 — Attendant's 4-Wire Telephone Circuit — 102A Key Equipment-Lamp and Buzzer Signaling. Arranged to Minimize Level Variations as the Number of Bridged Stations Varies.

on both 2-wire and 4-wire connections to private line circuits, but they cannot be connected when the receiver is associated with PBX and central office lines. When recording is done, an isolating coil is ordinarily used. This coil may be a 1:1 ratio if the recorder has a high input impedance; otherwise a monitoring coil is used. The voice recorders are customer owned and operated.

3.20 Shown in Fig. 28 is an arrangement for use at locations having multiple key equipment stations. This arrangement is designed to reduce level variations as key equipment stations are bridged on the private line circuit. This termination is mainly used on circuits provided for the Federal Aviation Agency and the detailed description of it may be found in the section covering "Arrangements for the Federal Aviation Agency."

(D) PBX Terminations

3.21 ***PBX Termination for 2-Wire Loops:*** Shown in Fig. 29 is a typical circuit for terminating a 2-wire private line loop in a PBX. A wide variety of PBX tie trunk circuits are available. Some of the factors that are considered in selecting PBX tie trunk circuits are the type of PBX and the type of signaling. A typical PBX tie trunk circuit consists of a transformer which is bypassed by 20-cycle outward ringing, an ac relay for receiving incoming rings, and various supervisory relays. Provisions are made for receiving either locked in signals for ringdown signaling or nonlocked in signals for code ringing. PBX tie trunk circuits are available that will permit the use of 2-tone signaling. The idle circuit termination shown in Fig. 29 is an integral part of some PBX tie trunk circuits and in other cases is provided as a separate item. 2-wire loops associated with multistation circuits always require idle circuit terminations.

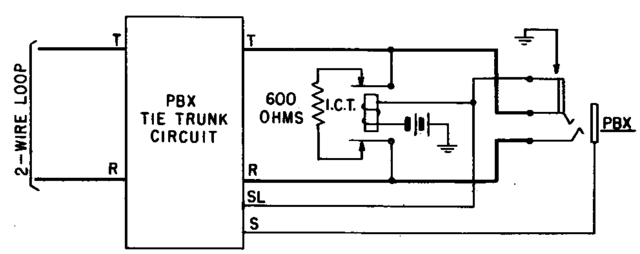


Fig. 29 — Typical Arrangement for Terminating a 2-Wire Loop in a PBX

3.22 ***PBX Termination For 4-Wire Loops:*** Each private line circuit that terminates in a PBX requires a PBX tie trunk circuit; and if the loop is 4-wire, a PBX auxiliary trunk circuit. Fig. 30 is a schematic of the arrangement used for terminating a 4-wire private line loop in a PBX. The type of A and B transformers is determined by the length, gauge, and loading of the loops. If required, transmit and receive pads (A and C pads) can be used after the A and B transformers. If the circuit has multiple stations autotransformers are also used. The two 173-type transformers form a 4-wire terminating set. A compromise network consisting of a 600-ohm resistor and a 2 μf capacitor in series balances the connections that are made at the PBX jack. With no cord in the circuit at the PBX no ground is applied to the SL lead, the "A" relay will not be operated, and the transmitting circuit will be open with a termination applied towards the loop. This results in a perfect balance when no plug is in the PBX jack. When a plug is inserted in the jack at the PBX, ground is furnished to the SL lead for operation of the A relay. The balance obtained in this condition is dependent on how nearly the impedance of the PBX connection (connected trunk or operator's headset) matches the compromise network. Some PBX tie trunk circuits do not have an SL lead for connection to the A relay. In this case the A relay circuit is not furnished and the leads designated A and B are strapped together. A 2-wire idle circuit termination (Paragraph 3.21) may be furnished when the A relay is omitted. Fig. 30 shows the ringing path connected to a composite arrangement of the receive loop. The same arrangement can be used for the transmit loop, or the ringing path can be connected to the simplexes of the transmit and receive loops. Connection of the ringing path in this manner prevents the reduction in 20-cycle voltage that would be caused by ringing through the 173-type transformers (over the voice path).

(E) Station Levels

3.23 The engineering of net losses of private line telephone circuits is based on what is sometimes referred to as "2-wire reference level." This assumes the use of 2-wire F-type handset station terminations with F1 transmitter units and HA1 or HA2 receiver units. The level from the transmitter at the line terminals of the station induction coil is assumed to be zero dbm, thus the receiving level at the same point is equal to the circuit net loss. A commonly used receiving 2-wire reference level is −10 dbm.

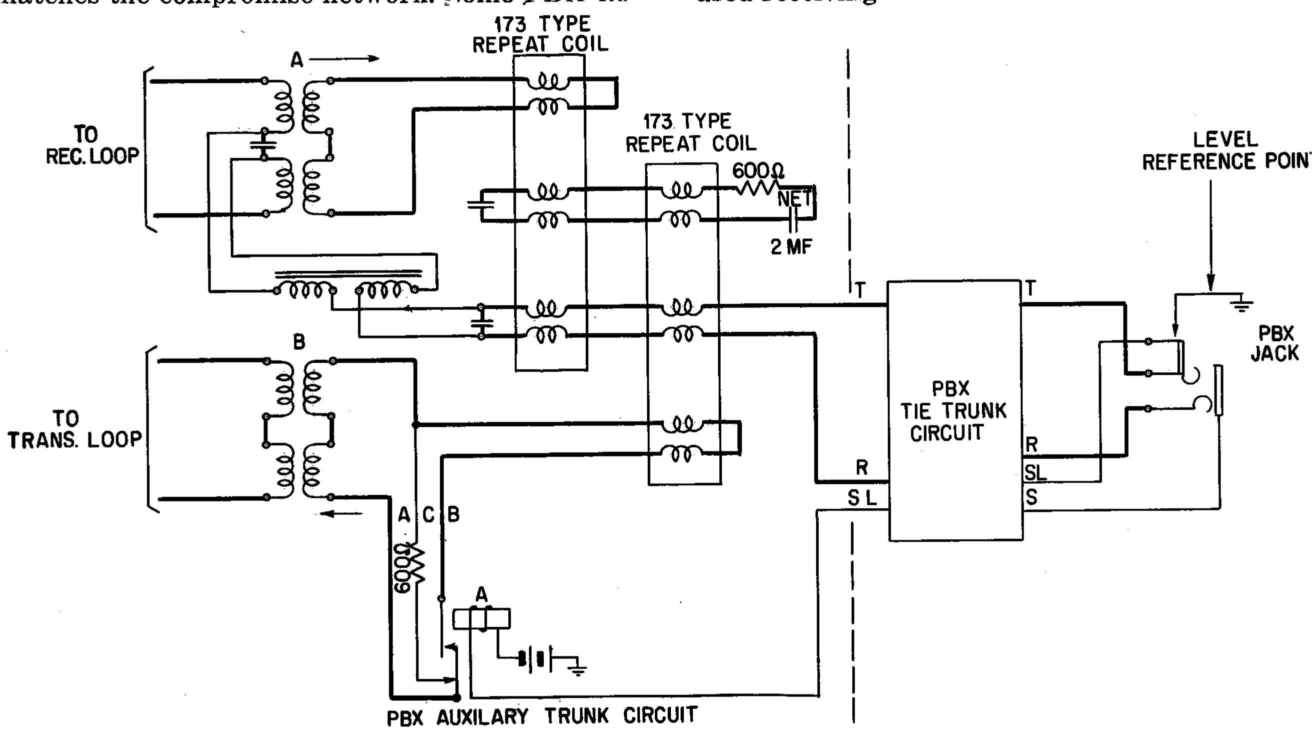


Fig. 30 — Typical Arrangement for Terminating a 4-Wire Loop in a PBX

3.24 The efficiency of the station set increases when it is operated 4-wire since the division of power inherent in 2-wire station circuits is eliminated. This results in an improvement in transmission that is considered to be 3 db both transmitting and receiving. This improvement is reflected in the station levels shown on the circuit layout card and in the engineered losses between the station set and the main part of the private line circuit. The transmitting level at the line side of the station induction coil is considered to be 3 db higher or +3 dbm. In the receive direction the 3 db improvement in efficiency permits a 3 db lower input level. Therefore, the circuit losses are engineered so that the level at the input to the receiver (no induction coil is used in the receive path of a 4-wire arrangement) will be 3 db lower than if the station were 2-wire.

3.25 The levels discussed in the preceding paragraphs assumed the use of F-type handsets equipped with F1 transmitters and HA-type receivers. Other type instruments such as G-type handsets (T1 transmitter — U2 receiver) or headsets (N1 transmitter — HC4 receiver) are frequently used. The efficiency of these instruments is compared to the efficiency of the F-type handsets when station levels are engineered. Based on presently available information, the T1 transmitter is 5 db more efficient and the N1 transmitter is 5 db less efficient as compared to F-type handsets. Therefore the transmit level at the line terminals of the induction coil at a 4-wire station using a G-type handset with a T1 transmitter would be considered to be +8 dbm. The level would be −2 dbm if a headset with an N1 transmitter were used. The U2 receiver is 5 db more efficient and the HC4 receiver is 2 db more efficient as compared to the HA receiver in an F-type handset. These differences are also considered when the station levels are engineered. For example, the level at the input of a U2 receiver at a 4-wire station would be −18 dbm if the circuit were engineered for −10 dbm 2-wire reference level. This includes the 3 db gain in efficiency for 4-wire operation and the 5 db gain in efficiency for use of a U2 receiver. In a like manner the level at the input of an HC4 receiver operated 4-wire would be −15 dbm. Previously the efficiency of a headset using N1 transmitters and HC4 receivers was considered to be 3 db less transmitting and 3 db better receiving as compared to an F-type handset. These figures are still frequently used in the engineering of circuits; especially circuits for the FAA. Where stations with different types of instruments are multipled to the same autotransformers, auxiliary pads in the individual station legs can be used to match the levels, the levels can be engineered for the type of instrument that is used the most, or compromise levels can be used.

3.26 PBX levels cannot be computed in quite the same way as other station levels since the type of instruments used and the losses of trunks that might be connected at the PBX will vary. The levels at the PBX jack are usually considered to be the same as the 2-wire reference level, i.e., a 2-wire handset with F1 transmitter and HA2 receiver.

3.27 If a 4-wire private line circuit loop terminates in both a PBX and a 4-wire station an arrangement shown in Fig. 31 is required to compensate for the different station levels. The 2-wire PBX arrangement is 3 db less efficient than the 4-wire station arrangement and the hybrid coil arrangement causes an additional 4 db loss to the PBX. This 7 db difference in efficiency is compensated for by a network, shown in Fig. 31, that introduces approximately 7 db additional loss in the transmit and receive

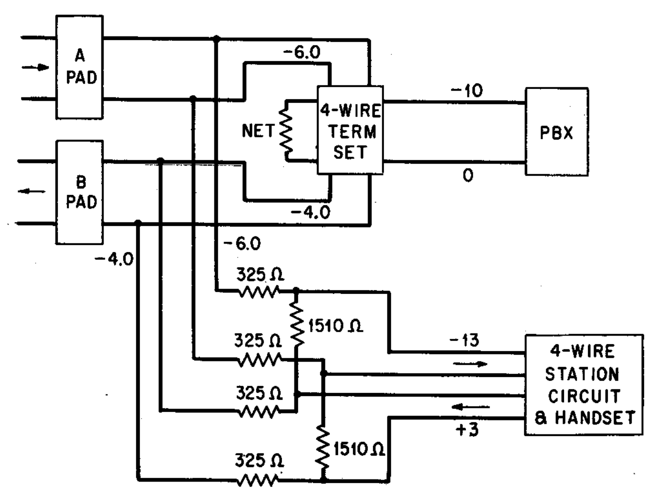


Fig. 31 — Level Matching and Talk-Back Arrangement for Use When a 4-Wire Station and PBX Are Connected to the Same 4-Wire Loop

paths to the 4-wire station. No talk-back arrangement is used at the central office, the talk-back path being through the resistance network. By using different value resistors in the network another 4-wire station can be bridged. The resistance network that is used for talk-back also introduces some echo to the main-line circuit. For this reason, its use is not always feasible on some large multistation networks, especially if they are equipped with 2-tone signaling. If it is not used, a separate 4-wire loop is required for the 4-wire stations.

3.28 The station levels as engineered for a private line circuit are shown on the circuit layout card. The reference point is at the line terminals of station transformers associated with 2-wire stations and with the transmitting path of 4-wire stations. In the receiving direction at 4-wire stations, the reference point is the input to the receiver. The PBX jack is the reference point for PBX terminations. The level reference points are shown in Figs. 21, 23, and 30.

4. SWITCHING CONTROL AND DC SIGNALING ARRANGEMENTS

(A) Switching Control Systems

4.01 Operation of a key at a station is commonly used to control the operation and release of switching relays at a central office. The key is used to either apply a ground to a single dc channel (ground return dc control) or to apply a short to a pair of dc channels (loop dc control). At the central office the dc channels are connected to the windings of line relays; the operation of which furnishes ground or battery for the operation of switching relays (Part 2), ringing relays, or auxiliary relays. Auxiliary relays are used with switching arrangements such as the one shown in Fig. 15. Referring to Fig. 15, three dc control circuits equipped with line relays would be required. The operation of a line relay would cause an associated multicontact auxiliary relay to operate. Each auxiliary relay would control the operation of switch relays associated with a single switching operation. For example, the auxiliary relay for interconnecting circuits 1 and 2 would operate switching relays SL1, SL2, and SD7.

4.02 In many cases the 2-tone signaling equipment (Part 5 of this section) that is used for signaling is also used to control switching arrangements. Individual codes are assigned for each switching operation and selectors at a station are set to respond to those codes. The selectors, when the proper code is dialed, will furnish momentary grounds to applique circuits (Fig. 32) at the station. The applique circuit will lock up and ground a dc channel to the central office. The circuits at the central office are the same as those discussed in Paragraph 4.01. To disconnect the circuits another code is assigned with a selector set to that code. The ground from the selector will cause the applique circuit to release removing the ground to the central office. With this type of switching control system any station with 2-tone sending equipment can dial the codes to operate the switches. Separate selector equipment is provided for the switching functions but the other 2-tone equipment is shared with the selectors used for signaling. The applique circuits and 2-tone receiving equipment for switching can also be located at the central office in which case the grounds furnished by the applique circuits operate the switch relays directly. Since circuits equipped with 2-tone equipment for switching are usually equipped with 2-tone signaling, the most economical arrangement is to locate all of the 2-tone equipment at a station and thus avoid duplication.

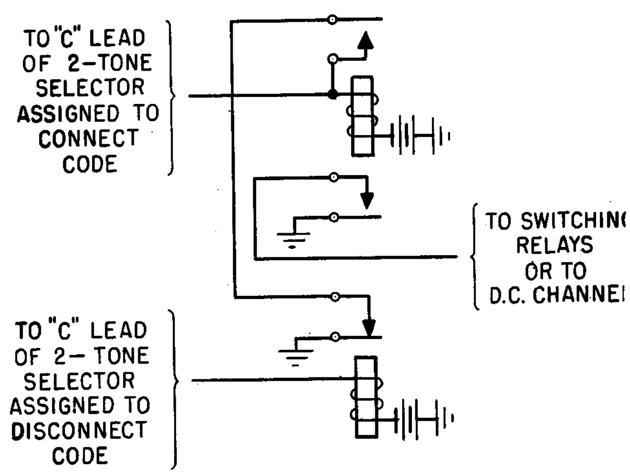


Fig. 32 — Applique Circuit for Use with 2-Tone Dialing Equipment When Used for Switching Control

(B) Derivation of Dc Channels

4.03 Dc facilities between a station and a central office are usually obtained by compositing or simplexing the loops. Occasionally separate conductors or telegraph facilities are used. Commonly used arrangements for compositing and simplexing private line loops are shown by Figs. 33A, 33B, and 33C. Similar arrangements are used at both the central office and the station. Table 3 shows the uses of the various arrangements.

TABLE 3

Arrangement	Shown By	Suitable For
Simplex	Fig. 33A	Telegraph, Ground Return Control Systems, and Loop Control Systems
Composite	Fig. 33B	Loop Control Systems
Composite	Fig. 33C	Ground Return Control Systems and Loop Control Systems

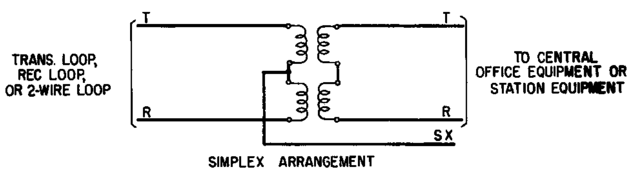


Fig. 33A

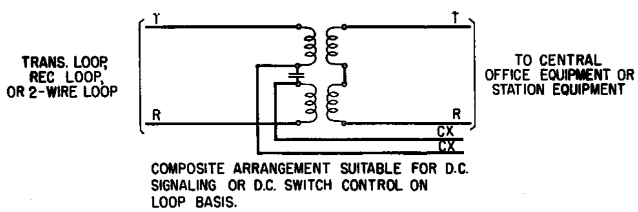


Fig. 33B

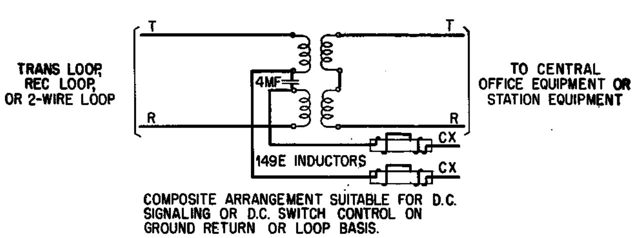


Fig. 33C

Fig. 33 — Transformer Arrangements for Obtaining Simplexed and Composited DC Channels From Loops

4.04 Dc channels for switching control are not normally obtained from the same loop that is used for transmission of outward 20-cycle ringing from the station since the loop transformers are disconnected when ringing current is applied to the loop. The selection of arrangements to be used, as shown in Fig. 33, depends on the number of control circuits required, the number of loops available for compositing or simplexing, the resistance of the loops, and whether the loop includes open wire.

(C) Line Relay Circuits For Dc Control

4.05 As was discussed in Paragraph 4.01, the application of grounds and shorts at a station controls the operation of line relays at the central office. Some of the line relay circuits are discussed in the following paragraphs.

4.06 *Cable Line Relays:* Commonly used cable line relay circuits are shown in Fig. 34 (operation on a ground return basis) and Fig. 35 (operation on a loop basis). The line relay circuit most commonly used is limited to use with dc circuits having from 6375 to 10,350 ohms resistance with a minimum insulation resistance of 30,000 ohms. The lower value of resistance applies for batteries of 20 to 28 volts and the higher value for 48-volt batteries. If the relay is operated on a ground return basis, the allowable maximum resistance of the external dc circuit is reduced as the maximum earth potential increases. Information regarding allowable dc resistance is covered on standard drawings.

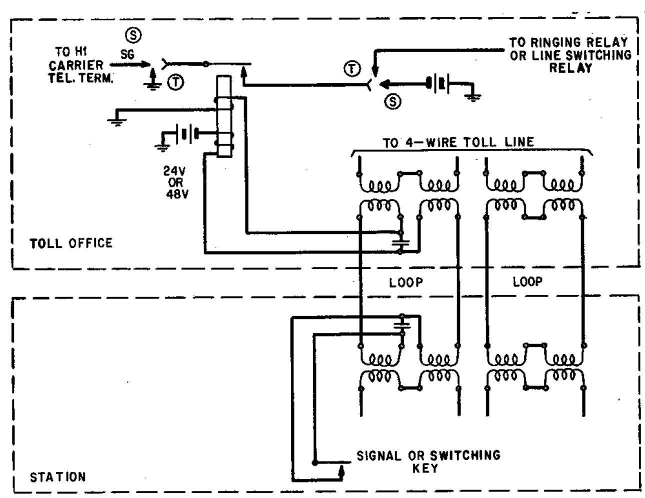


Fig. 34 — Cable Line Relay for Switching or Signaling Control-Operated on Ground Return Basis

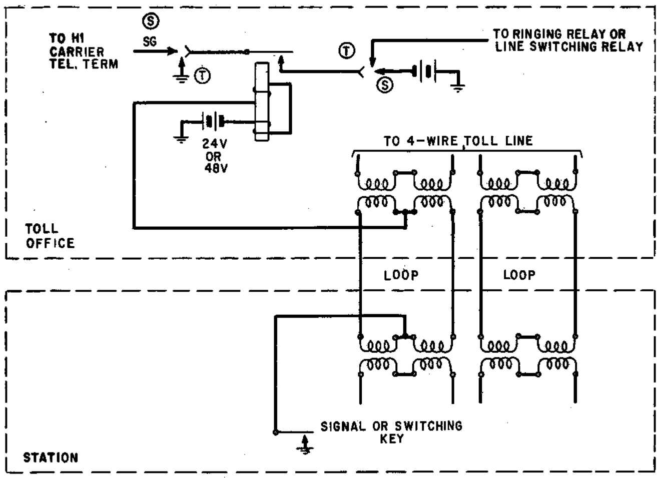


Fig. 35 — Cable Line Relay for Switching or Signaling Control-Operated on Loop Basis

4.07 ***Open Wire, One Channel per Pair of Dc Facilities:*** For open wire loops or for combination open wire and cable loops in which the minimum leakage is expected to be less than 30,000 ohms, relay arrangements such as the one shown in Fig. 36 are provided in order to compensate for leakage. Line relay L is a polarized relay with three windings. Winding S is used for biasing, Winding P2 is used for operating, and P1 for leak compensation. The operating winding (P2) operates from a ground applied at the station by means of the signaling key. The compensating winding (P1) is connected to a dc facility similar to that used for the operating winding. Since the facilities connected to the operating and compensating windings are similar, leakage currents through these two windings of the relay will generally be approximately equal, and because relay terminals of opposite polarity are connected to the two line facilities, the leakage currents will cancel each other. A leak compensating resistance is provided for use with this arrangement as a compromise substitute for a leak compensating wire where it is not feasible to provide a separate wire for compensation. In effect it increases the biasing ampere turns of the relay which minimizes the effect of line leakage but does not provide the same protection against leakage effects as would a compensating wire. This is discussed further under line relay operating ranges, Paragraph 4.10.

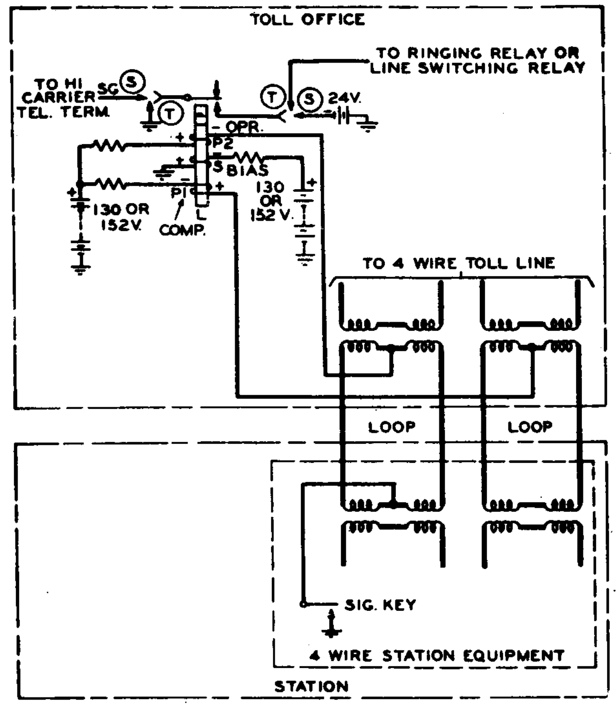


Fig. 36 — DC Signaling or Switching Control Channel for Open Wire

4.08 ***Open Wire, Two Channels per Pair of Dc Facilities:*** Fig. 37 shows arrangements providing two signaling channels per pair of dc facilities. It consists essentially of two polarized relays with three windings each arranged similarly to the line relay discussed in Paragraph 4.07. In this case the operating winding of each relay is in series with the compensating winding of the other relay with current flowing in opposite directions through the two relays. The operating winding of Relay L is wired in series with a compensating winding of Relay L1 and the operating winding of Relay L1 is wired in series with the compensating winding of Relay L. This arrangement requires but two conductors for two channels with the limitation, however, that both relays cannot be operated simultaneously. It would, therefore, not be suitable for an arrangement where it was required to operate a switching arrangement over one of the channels and at the same time signal over the other channel.

4.09 ***Open Wire, Three Channels per Two Pairs of Dc Facilities:*** Fig. 38 provides for three dc signaling channels using two pairs of dc facilities. This arrangement makes use of three

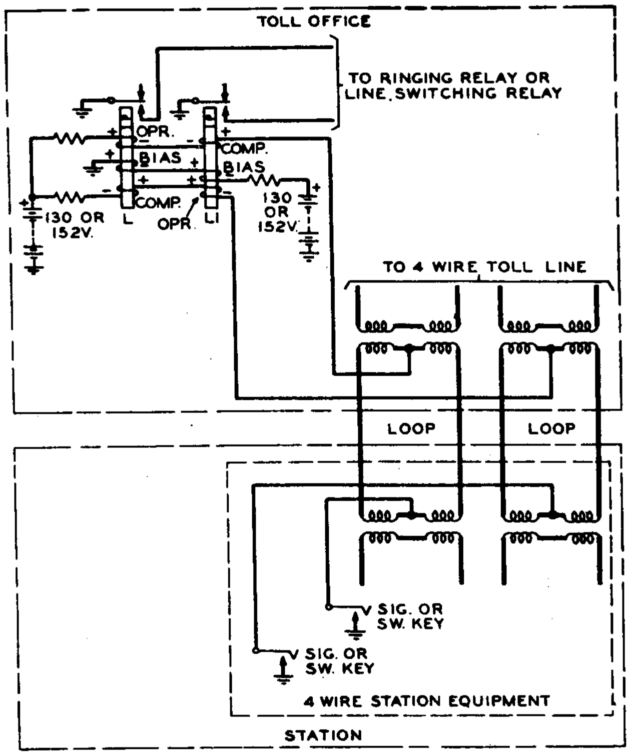


Fig. 37 — Two DC Signaling or Switching Control Channels for Open Wire

polarized relays, the operation of which is similar to that described in Paragraphs 4.07 and 4.08. In this case three of the dc facilities are connected to the operating windings of the three relays and the fourth facility is used as a compensating wire for each of the relays. The three relays may be connected to ringing relays or to the switching relays or various combinations of both. There is no limitation as to simultaneous operation of the relays as there is in the arrangement described in Paragraph 4.08.

4.10 ***Switching Control and Dc Signaling Ranges of Open Wire Loops:*** The arrangements shown in Figs. 36, 37, and 38 have allowable resistance and leakage requirements that vary with different combinations of these factors and earth potential. The ranges of these circuits are shown in graphical form on standard drawings. The curves are based on the assumption that:

(a) When a leakage on either the operating or the compensating paths is at its maximum, the leakage on the other side will be at least two-thirds as great.

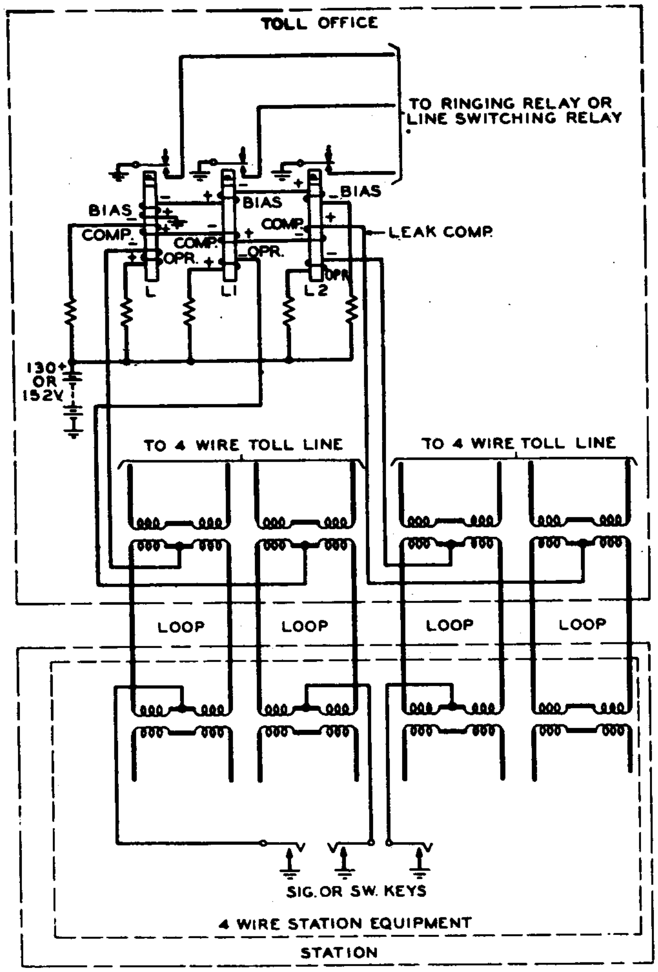


Fig. 38 — Three DC Signaling or Switching Control Channels for Open Wire

(b) The leakage is considered lumped at the midpoint of both operating and compensating wires.

(c) The leakage may be to ground or to earth potential of the same polarity or of the same or a lower voltage as the earth potential at the distant end of the subscriber loop.

For the range curves which slope upward, the release characteristic of the relay is the controlling factor and except for the positive earth potential is the only limiting factor for the length of loop considered. Where the curves slope downward, the operate characteristic of the relay is the limiting factor and becomes more important as the positive earth potential increases. While the curves are based on the use of 130-volt battery, they also apply to 152-volt battery, although the margin for operation of the relay is usually greater in the latter case. Since insulation resistance will usually be the limiting factor on long open wire loops, composite arrangements will generally permit operation over longer loops than with simplex arrangements. When a leak compensating resistance (Paragraph 4.07) is used instead of a leak compensating wire, the protection against false operation resulting from line leakage is considerably reduced.

5. SIGNALING SYSTEMS AND ASSOCIATED ARRANGEMENTS

5.01 The determination of the type of signaling to be applied to a particular multistation private line circuit depends largely on the customer's needs. These will vary from the requirement for no signaling at all, or perhaps signaling in one direction only between a few stations, to the extreme case in which a large number of stations may signal any of the other stations individually, all of them at one time, and possibly certain preselected groups of stations.

(A) Loudspeaker Signaling

5.02 On many circuits one station will control the operations at all of the other stations. A signaling system in common use for circuits operated in the above manner is a loudspeaker signaling system. All of the stations except the station controlling operations are equipped with a loudspeaker so that they can be paged to the circuit. The control station can also have a loudspeaker or it can be signaled in some other manner. A station equipped with a loudspeaker can also monitor the circuit without restricting their activities by using a telephone set. Loudspeaker signaling has some definite disadvantages which are:

(a) Its efficiency varies inversely with room noise.

(b) Its audible range is usually limited to the confines of one room or a small area unless auxiliary loud-speaker units are used.

(c) It can too easily be reduced in volume, or turned off, and inadvertently forgotten. This is very likely to happen if the circuit is improperly lined up and the volume from the various stations is considerably different.

5.03 The basic loudspeaker circuits for use at a station are shown in Fig. 39; the top circuit being the one most commonly used. The arrangement using the 124A amplifier is capable of delivering considerably more volume and is used where room noise level is high. Various types of loudspeakers are available and are shown on standard drawings. If a loudspeaker is used on a circuit that is equipped with 600-1500-cycle selecting signaling, a band elimination filter to eliminate the two tones is used on the loudspeaker side of the B pad. Information on 100-type loudspeakers can be found in Section 024-101-100.

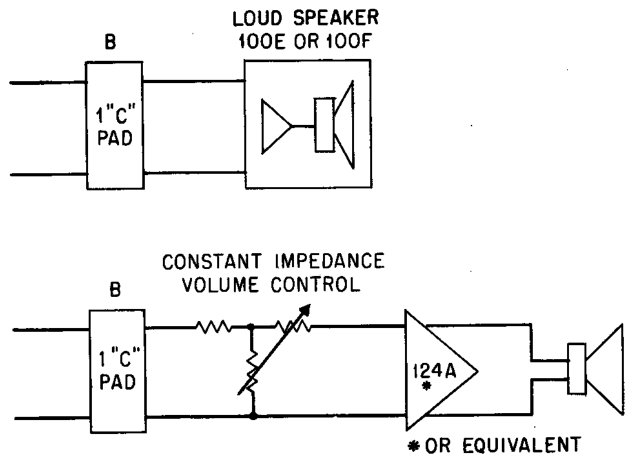


Fig. 39 — Loudspeaker Circuits for Use at Private Line Stations

5.04 The loudspeaker can be connected to the private line circuit in several different ways. If the loudspeaker is to serve only one station, the loudspeaker circuit is usually connected in place of the termination designated "ICT" in Fig. 21. The receive path from the central office is connected to the loudspeaker circuit in the on-hook condition and to the station receiver in the off-hook condition. The change in connections as related above is accomplished by switchhook contacts, auxiliary headset jack contacts, key equipment operation, or a combination of them.

5.05 In some cases the customer may desire to have the loudspeaker operative at all times except when the push-to-talk button is operated. The circuit is wired in this case so that the speaker operation is controlled by both the

T relay and the switchhook contacts. This arrangement is shown in Fig. 40. With the handset in the on-hook condition a 600-ohm termination and the loudspeaker circuit are multipled to the circuit from the receiving autotransformer. In the off-hook condition, push-to-talk button normal, the loudspeaker circuit and the handset receiver are multipled. In the off-hook condition push-to-talk button operated, the handset receiver and a 600-ohm termination are multipled. This arrangement is equivalent to two receive stations and one transmit station when computing the station loss and when determining the proper C and D autotransformer taps to use.

5.06 In case one loudspeaker is to serve more than one station, it can be connected to the C transformer as a separate station. The connection to the loudspeaker circuit is made via a loud-speaker cutoff relay circuit. With the relay nonoperated the loudspeaker is connected to the circuit and with the relay operated the loudspeaker is disconnected. The relay operation is controlled by switchhook contacts, headset jacks, etc, of one or more stations.

5.07 Other arrangements of loudspeakers are also available, only those most commonly used have been covered in this practice.

5.08 When a loudspeaker, mounted at ear level is connected to Bell System plant, and where room noise does not exceed about 55 db, it is necessary to limit the net gain of the associated amplifier to about 30 db in order to minimize the possibility of reproducing intelligible crosstalk. The "B" pad in Fig. 39 is so adjusted that with the amplifier set for maximum gain the 30 db figure will not be exceeded. In the case of the 100-type loudspeaker or other units having comparable gain, the B pad is made 30 db for these conditions. In many locations where the special private line station equipment is installed, the room noise is greatly above the 55 db figure, and in such cases it is necessary to provide a greater level from the loudspeaker in order to override the room noise. This is done by decreasing the value of the B pad and is permissible since the increase in room noise will make it correspondingly difficult for any attendant to hear intelligible crosstalk if such crosstalk should occur. Consequently, the selection of the B pad is based on the ambient room noise as shown in Table 4. Pad values of less than 20 db would be expected to result in objectionable overloading with the 100-type loudspeaker set, but not with the 124-type amplifier and loudspeaker.

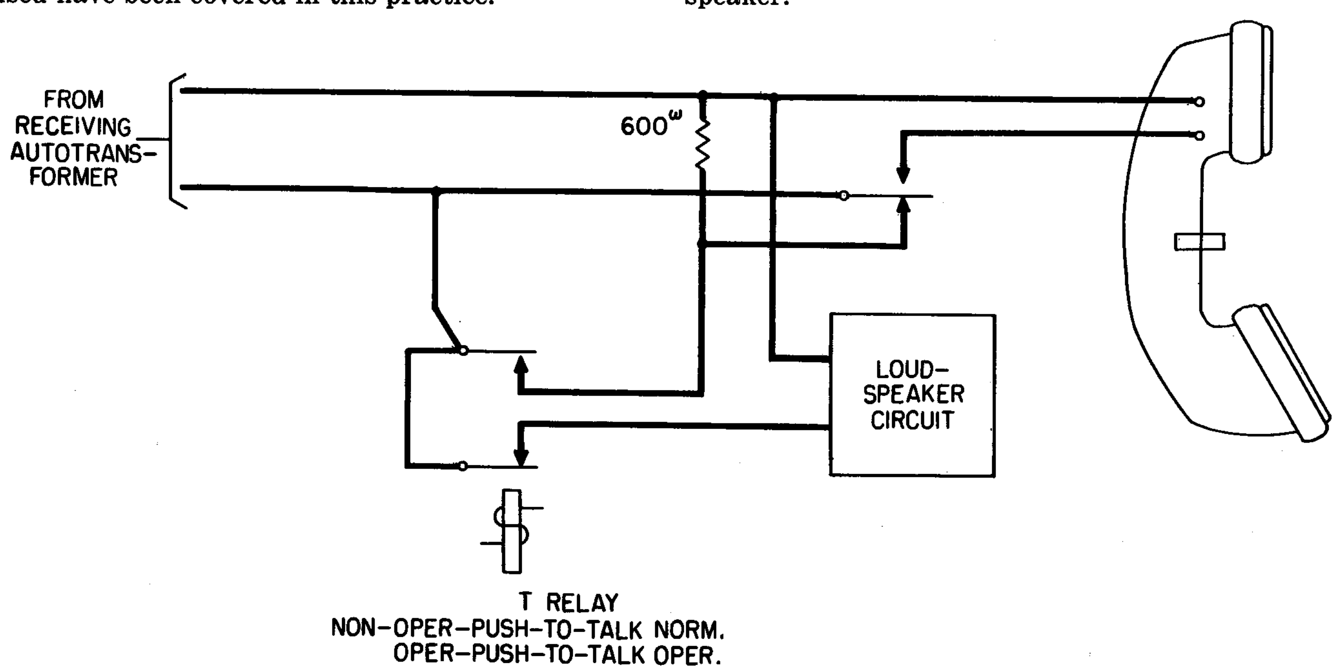


Fig. 40 — Station Loudspeaker Arrangement-Loudspeaker Cut-off Controlled by Push-To-Talk Button

TABLE 4

Room Noise — db	Pad Losses — db
55	30
60	25
65	20
70	15
75	10
80	5
85 or higher	0

5.09 For a given allowable loudspeaker input pad (Pad B — Fig. 39) the output level of the loudspeaker can be increased by increasing the level delivered from the adjacent toll office. Since this, however, would influence the level in the receiver, an adjustment would be required somewhere at the station equipment. Pad A (Fig. 21) can be used to provide this loss adjustment but Pad A is also in the path leading to the loudspeaker. Since the allowable loud-speaker gain is determined by crosstalk considerations, it is generally computed from the point of connection of the station equipment to the loop circuit. Pad A, therefore, has the same effect as Pad B on the amount of crosstalk the loudspeaker will pick up for a given loud-speaker gain and Pad B could be reduced by an amount equal to the value of the A pad. The loss due to the bridged station also has a similar effect on the loud-speaker gain, as measured from the connection to the loop. Ordinarily, adequate loud-speaker volume can be obtained without taking advantage of these factors to reduce the value of "B" pad from that shown in Paragraph 5.08. However, the use of Pad A whenever feasible, particularly where less than three stations are multipled, affords an added measure of protection from a crosstalk standpoint.

(B) 600-1500-Cycle (2-Tone) Selective Signaling

5.10 A brief description of 2-tone signaling systems and associated circuits is covered in the following paragraphs. The detailed description of 2-tone signaling equipment may be found in Section 310-430-100. The two tones (600 cycles and 1500 cycles) transmitted from and to the customer's station lie in the normal voice-frequency band and no signaling equipment is normally required at the central office. All 2-tone equipment is normally located at the customer's station. However, in some few cases 2-tone equipment for switching operations will be installed at a central office as discussed in Paragraph 4.02.

5.11 Pulses of tone of the two frequencies are transmitted from stations by the operation of standard telephone dials. Each station, PBX, or key equipment position is equipped to receive a signal when one or more codes is dialed. Group and/or master codes are sometimes used in which case the dialing of a single code will signal several stations. The dialing of an assigned code (four or five digits) by any station on the private line circuit, or on a private line circuit that has been switched to the first circuit, will operate the signaling indicating device (bell, horn, lamp etc,) at the station(s) whose code was dialed.

5.12 Referring to Fig. 21, the receiving 600-1500 cycle selective signaling circuit is bridged across the private line termination between the A transformer and the A pad. The loss, caused by the bridging of the receiving circuit which has a high impedance input, is negligible. The sending 600-1500-cycle connector is inserted between the B transformer and the C pad. The connector circuit only connects the 600-1500-cycle sending equipment when a station is dialing, and thus introduces no loss in the talking path.

5.13 A station signal circuit, Fig. 41 is a simplified schematic, is provided for each station so that the signals will "lock in." A momentary ground is applied to the C1-C20 lead by the 2-tone selector when the assigned code is received. The ground will operate the L relay which is held operated by the ground that is connected through the L and SW relay contacts. Operation of the L relay furnishes battery for operation of buzzers, horns, relays, lamps, etc, at the station. When the call is answered, the removal of the phone from the mounting, the operation of the push-to-talk button, or other similar operations will connect ground to the SW relay winding. Operation of the SW relay removes the ground from the L relay causing it to release. An automatic time out circuit, which will cause the L relay to release if the signal is not answered in approximately 20 seconds, can be used with the signal circuit.

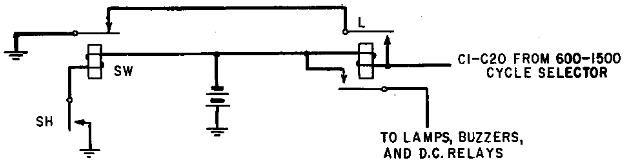


Fig. 41 — Station Signal Circuit — 2-Tone Signaling

5.14 If the circuit terminates in a PBX, the PBX tie trunk circuit performs the functions of the station signal circuit described in Paragraph 5.13.

(C) Manual Code Ringing

5.15 Manual code ringing employs the use of devices at the station (bells, lamps, horns, etc) that operate only during the time that a signal is being received, i.e. the devices do not lock in. Twenty cycle signaling is usually employed over open wire or cable loops. Occasionally instead of providing loops between the central office and the station a 4-wire carrier channel is used with one terminal located at the customer's station. In this case dc signaling is often used between the station equipment and the carrier terminal. The codes are normally assigned by the customer and consist of a combination of long and short signals. While this system has advantages from a cost standpoint it also has disadvantages which are:

(a) The customers receive all signals and must carefully listen to determine if their code was received. When loud operating horns, gongs, etc, are used the receipt of unnecessary signals can be annoying to the customer.

(b) Improper signaling by the customer, such as not ringing for proper length of time, may result in the wrong station answering or in no station answering.

(c) Its use is generally not satisfactory on circuits having more than 10 to 12 stations.

5.16 The station circuits for receiving incoming signals are shown in Figs. 42 and 43. Either a subset bell or a 20-cycle relay to operate a separate ac or dc horn, bell, etc, can be used. Several of the 20-cycle relays can be used in multiple if there are requirements for more than one indicating device. Reduction in the 20-cycle voltage that would be caused by the loop transformers, pads, etc, is avoided by bridging the bell or 20-cycle relay on the transmit or receive loop on the loop side of the A and B transformers.

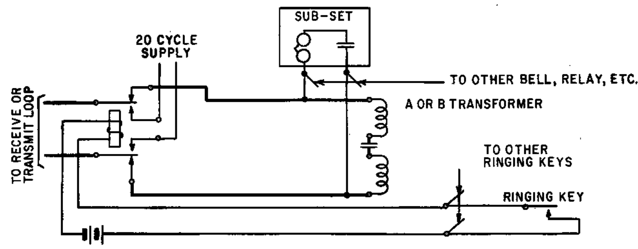


Fig. 42 — Station Equipment — Subset and Ringing Key

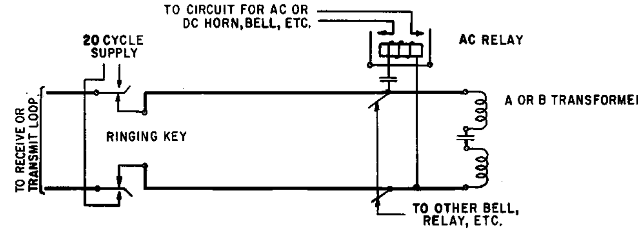


Fig. 43 — Station Equipment — 20-Cycle Relay and Ringing Relay

5.17 Typical station circuits for application of 20-cycle ringing current towards the central office are also shown in Figs. 42 and 43. The 20-cycle ringing current is applied directly to the transmit loop or receive loop thus avoiding reduction in the ringing voltage that would be caused by the station equipment. The 20-cycle ringing current can be applied through a ringing key or by a relay whose operation is controlled by a ringing key. At locations having multiple stations an arrangement is usually provided that uses a ringing relay, the operation of which is controlled by multipled ringing keys.

(D) Ringdown Signaling

5.18 The station equipment for ringdown signaling is usually arranged to lock in on the first signal received. However, equipment such as that used for manual code ringing is sometimes used. With locked in signaling, the signal at the station, indicated by the operation of a bell, lamp, buzzer, etc. remains in until the call is answered or, if a time out feature is provided, until it times out. Ringdown signaling has its widest application on two point circuits and on multistation circuits where one station is equipped to receive ringdown signaling and all others employ loudspeaker signaling.

5.19 A typical station circuit for locked in inward signaling is shown in Fig. 44. The R relay, bridged on the transmit or receive loop, operates from the 20-cycle ring and is held operated through the nonoperated contacts of the SW relay. The operation of the R relay is used to operate bells, horns, buzzers, lamps, etc. When the call is answered the removal of handset from mounting, operation of push-to-talk button, or other operations, depending on how the circuit is wired, will operate the SW relay causing the R relay to release.

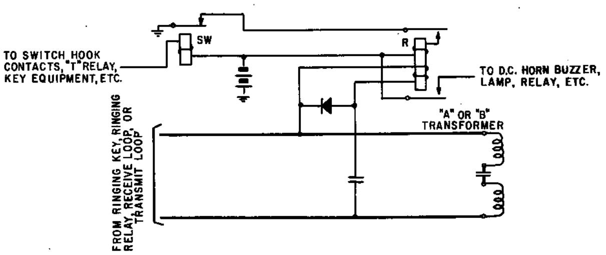


Fig. 44 — Station Signal Circuit — 20-Cycle Locked-In Signaling

5.20 The arrangements for outward signaling are the same as those described in Paragraph 5.17. If the station is not required to receive inward signals, dc outward signaling is sometimes used.

(E) Code Selective Signaling

5.21 The station circuits for ringdown signaling are also used for code selective signaling; the required selector equipment being located at the central offices. On circuits with code selective signaling each station is equipped with a ringing key and rings a designated code for each station. The selectors at the central office, one for each 2-wire or 4-wire loop, count the rings, and if the number of rings received matches the selector setting a single 20-cycle ring is applied to the customer's loop. Some of the advantages and disadvantages of this signaling system are:

(a) The cost is more than manual code ringing but less than two tone signaling.

(b) The customer only receives a signal when his particular location is desired, but there is no provision for selecting one station of a group of stations multipled on the same loop.

(c) Code selective signaling is considerably slower than two tone signaling.

5.22 Ten usable codes are available consisting of from one to ten rings. The length of rings is not important so long as they are of sufficient duration to operate standard central office signaling units. The pauses between rings should not exceed approximately two seconds for satisfactory operation.

5.23 A schematic of the selective signaling equipment connected to standard signaling units is shown in Fig. 45. The drawing covering the equipment is issued by the Long Lines Department.

5.24 ***Inward Signaling:*** Incoming rings at the central office are converted to battery on the SG lead which operates the A relay. The A relay operation, in step with the incoming rings, completes the rotor circuit thus moving the selector one step for each ring. The movement of the selector to the first step mechanically closes the "off-normal" contacts. Operation of the "off-normal" contacts closes the B relay circuit so that it will operate each time that no ring is received at the central office (A relay released). While the B relay is operated the C1 capacitor will charge through the 3-megohm resistor and after two to three seconds will be charged sufficiently to allow VT1 to conduct. When VT1 conducts a circuit is completed that permits the C relay to operate. Assuming normal intervals between rings, the delay provided by the slow operate time of the C relay and the charging time of the C1 capacitor prevents the operation of the C relay until after the last ring of the code has been received. Operation of the C relay connects ground to the movable arm of the selector which grounds the S1 lead or S2 depending on the code received.

5.25 ***Code Received for Which Selector Is Set:*** Ground on the S1 lead will operate the E relay which performs the following functions: It will connect battery to the SG lead of the 20 x dc ringer for application of a 20-cycle ring towards the station. It will lock operated

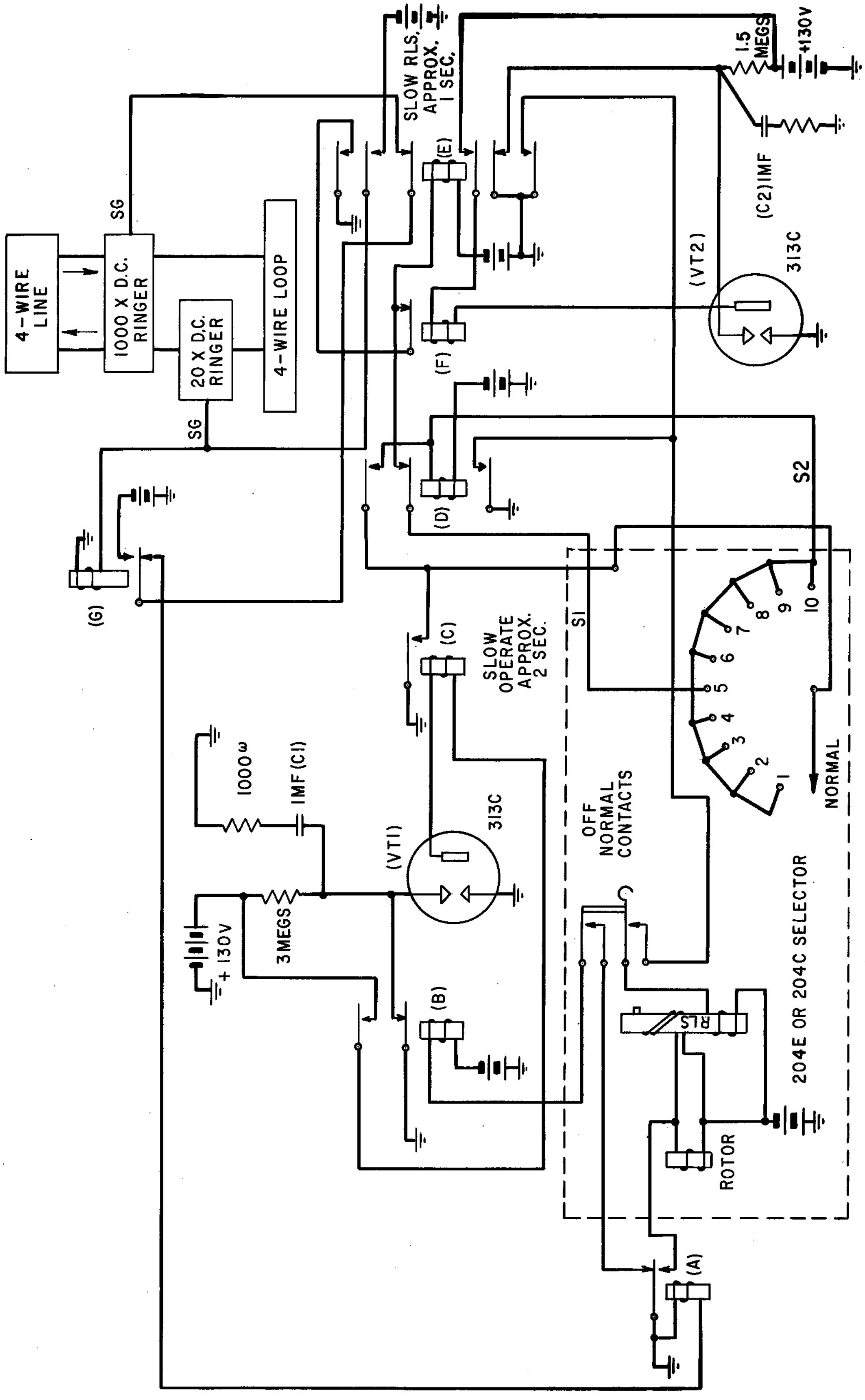


Fig. 45 — Central Office Code Selective Signaling Arrangement

through nonoperated contacts of the F relay. It will complete the release winding circuit of the selector causing the selector to return to normal thus opening the "off-normal" contacts. When the "off-normal" contacts open, the B relay will release grounding the C1 capacitor. Tube VT1 will cease to conduct releasing the C relay. At the same time the operation of the E relay allows the C2 capacitor to charge through the 1.5 megohm resistor. After one to one and one-half seconds tube VT2 will conduct and complete the circuit for operation of the F relay. Operation of the F relay causes the "slow release" E relay to release. Release of the E relay grounds capacitor C2 causing VT2 to stop conducting. The F relay then releases. The operated time of the E relay, determined by the charging time of the C2 capacitor and the release time of the E relay, is long enough to insure a 20-cycle ring towards the station of sufficient duration to operate the station signal circuit.

5.26 *Code Received Other than the One for Which Selector Is Set:* Ground on the S2 lead will operate the D relay which completes the release winding circuit. After the selector has returned to normal the "off-normal" contacts open causing the B and C relays to release.

5.27 *Outward Signaling:* During outward signaling the selector circuit is made inoperative by operation of the G relay.

5.28 The selector is set for the code(s) assigned to the station associated with the selector by connecting the S1 lead to the terminal number(s) that corresponds to the assigned code. All other terminals are connected to the S2 lead.

5.29 Options available on the Long Lines Department drawing make it applicable for use with many standard toll line signaling units.

5.30 A modification of the arrangements described in Paragraphs 5.21 through 5.29 is used at some 102A key equipment terminations provided for the Federal Aviation Agency. The selector equipment in this case is located at the customer's location. The equipment "counts" the number of rings received at the station and signals one of three key equipment positions depending on the number of rings received. This arrangement, covered on Drawing B-759841, is suitable for use at both ends of a 2-point circuit, or at one location on a multistation circuit where all but one location employs loudspeaker inward signaling.

(F) Central Office Signaling Arrangements

5.31 The signaling systems described in this section, except 2-tone and loudspeaker signaling, employ 20-cycle or dc signaling between private line stations and toll central offices. Conversion from dc or 20 cycles to signaling frequencies suitable for transmission over toll facilities is accomplished by the use of standard toll signaling units and ringing relays at the central office. The frequencies commonly used on the line are 135 cycles, 1000 cycles, and single frequency signaling over carrier facilities such as "N" and "O". When 1000-cycle signaling is used the level adjusting resistance is strapped so that the proper level ring is transmitted to the line. It is sometimes desirable to strap all ringers in an office for the same output level. This can be done by using pads and amplifiers arranged so that the ringers can be located at a point in the circuit where the circuit level and ringing levels are properly matched.

5.32 It is beyond the scope of this section to describe the specific arrangements of signaling equipment that are used at central offices. These arrangements are covered on the application schematics of standard drawings and in practices on signaling equipment.

5.33 *Use of 20-Cycle x Dc Ringers on Long Loops:* A central office arrangement for 2-way signaling, using 20 cycles on the receive loop and 1000 cycles on the line, is shown in Fig. 46. The 20-cycle receiving circuit of the 20 x dc ringer is bridged across the tip and ring of the transmission path. Therefore, the amount of 20-cycle current delivered to the 20-cycle receiving circuit of the ringer depends on the 20-cycle impedance of the circuit on the line side of the ringer. As commonly used on toll message circuits the impedance presented to the 20 x dc ringer would be that of the terminating set or approximately 600 ohms. The RD1 and TD1 pads as shown in Fig. 46 are optional; and assuming that no RD1 pad is used, the 20-cycle receiving circuit will be bridged across the impedance presented by the outputs of the two half repeaters in parallel, the 1000 x dc ringer having no effect on the impedance. The input and output impedances at 20 cycles of 4-wire repeaters are usually very low as compared to 600 ohms, and when two are connected in parallel, as is the case of Fig. 46, the impedance is reduced even more. Therefore, where 20-cycle ringing is used over long loops, it may be necessary to isolate the 20 x dc ringer from any 4-wire repeaters. This can be accomplished by using an RD1 pad of at least 6 db or by inserting 2 μf capacitors in the **tip** and ring of the transmission path on the line side of the 20 x dc ringer.

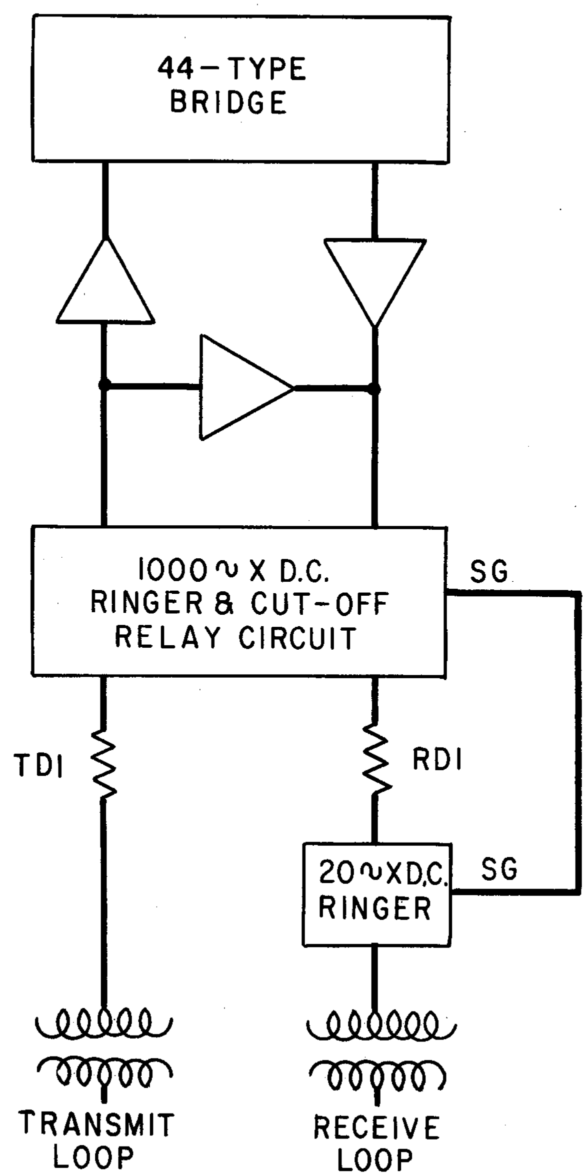


Fig. 46 — Typical Central Office Arrangement — 2-Way Signaling with Talk-Back Repeater

6. CENTRAL OFFICE TESTING AND PATCHING ARRANGEMENTS

6.01 A general description of some of the basic arrangements that tend to improve the servicing and maintenance of private line telephone circuits is included in the following paragraphs. Some of the arrangements can be provided locally using existing testroom equipment and jacks while in other cases detailed engineering of the office layout by engineering forces is required.

6.02 ***Special Jacks for Testing and Patching Private Line Telephone Services:*** In addition to the jacks furnished with carrier channels, repeaters, and at primary testboards for open wire and cable facilities, the use of other jacks is desirable at bridging offices and offices where loop facilities are connected to the circuit. In large offices, these jacks are often part of a special testboard for private line testing. In smaller offices where special private line service testboards are not provided, local arrangements can normally be made using miscellaneous testboard jacks. In all cases, the special jacks should be located so that all of those associated with a single circuit are accessible from a single test position. Some of the points where jacks are commonly inserted are shown in Fig. 47. They are: (1) between each leg of a 4-wire bridge and the associated carrier channel, repeater, loop, or resistance termination, (2) between loop transformers and the other central office equipment, (3) between loop transformers and loop conductors, (4) in the dc channels used for signaling and switching control, and (5) in the switching relay transmission paths. Spare legs of bridges should always have jacks connected between them and the associated resistance terminations so that they can be used in testing and in establishing patches and reroutes.

6.03 ***Talking and monitoring on private line circuits with 4-wire loops and/or 4-wire bridges:*** The servicing of 4-wire multistation private line circuits can best be done using a 4-wire talking set connected to the special testing jacks discussed in Paragraph 6.02. Several different 4-wire talking set arrangements are presently used, but the basic requirements, shown in Fig. 48, are the same in each case. The basic 4-wire talking set consists of a push-to-talk handset, induction coil wired as a transformer,

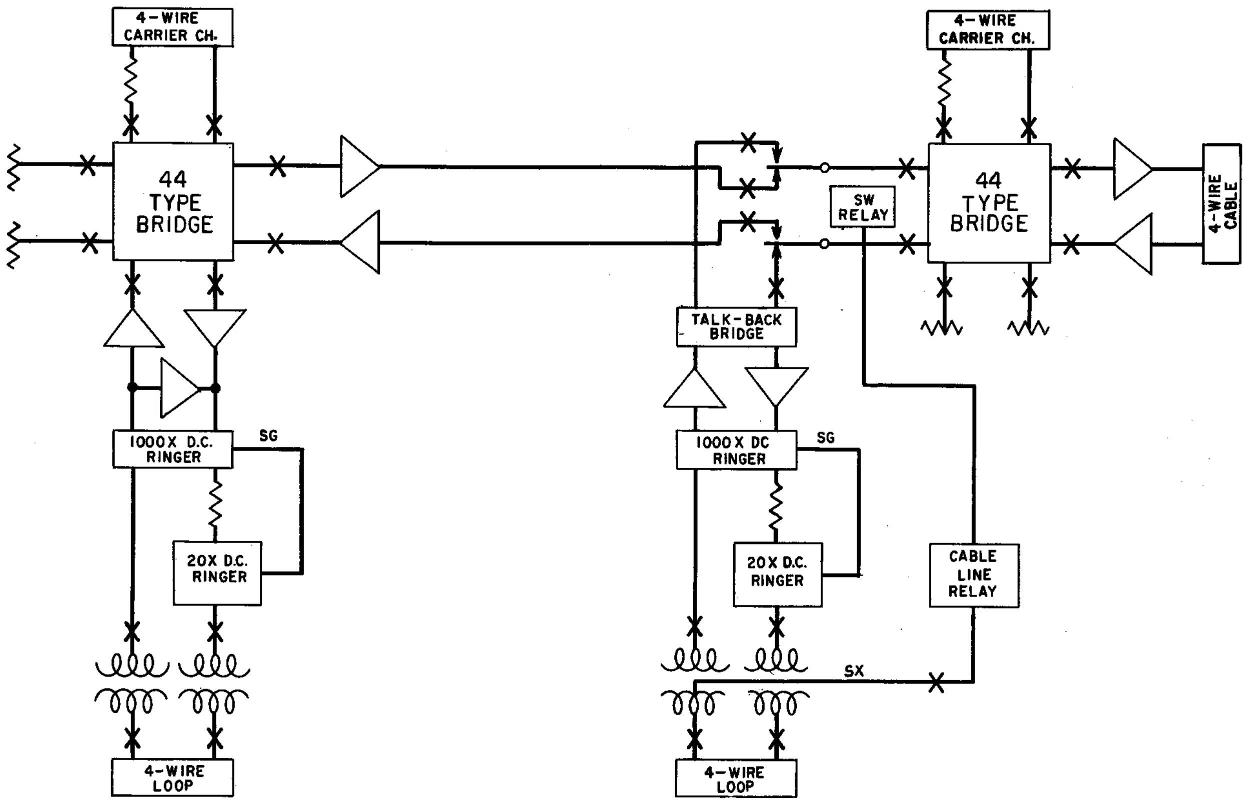


Fig. 47 — Typical Central Office Private Line Circuit Arrangement Showing Location of Special Testing Jacks

and talk-battery supply. A talk-back arrangement is usually provided for sidetone, but it must be arranged so that there is no transmission path from A to B since this would insert an echo path in the circuit to which the talking set is patched. The A and B terminals are jack terminated so the talking set can be patched to various test points of circuits. Idle circuit terminations are used in both transmission paths to keep the impedance approximately 600 ohms at points A and B whether the handset is on-hook or off-hook. The idle circuit termination in the receive path is usually connected through a jack circuit so that a loudspeaker can be substituted for the termination. With this arrangement the loudspeaker is operative when the handset is on-hook. The +3 and −13 levels are those most commonly used with the type handset shown when operated 4-wire. The talk set is often patched to a spare leg of a 4-wire bridge since both in service and out of service tests can then be made from the same point. Many times it is desired to talk and test on a portion of the circuit that is out of service in which case the 4-wire set is usually connected to the facility or loop at the point where it connects to the leg of the bridge. Except when the talk set is connected to a spare leg of a bridge, the insertion of the patch cords to connect the 4-wire telephone set will of course disconnect the line under test from the private line telephone circuit. Since the talk set will at various times be connected to a bridge, to a line that connects to a bridge, and to a loop, each of which has different transmit and receive levels; the level adjusting arrangements are required so that the level of the 4-wire talking set can be adjusted to approximately match the level of the circuit to which it is patched. For example, the level into the talk set receiving circuit from a leg of a 44-type bridge might be −11 dbm whereas the level fed to the same receiving circuit of the talk set if connected to a circuit that normally connects to an input leg of the same bridge would be +4 dbm. This 15 db difference in levels would also be reflected in the levels that might be connected to the transmitting side of

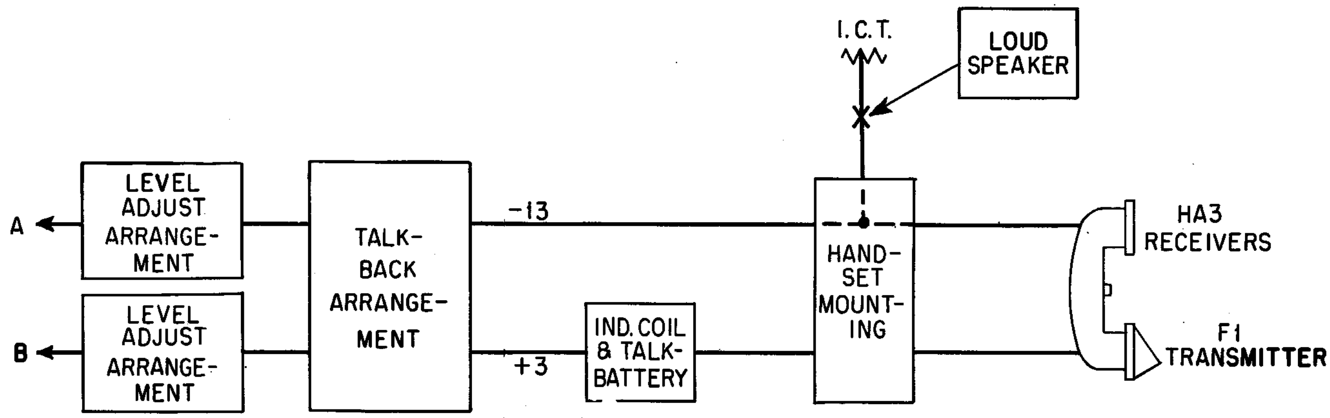


Fig. 48 — Typical Central Office 4-Wire Talking Set Arrangement

the 4-wire talk set. Various methods are used for adjusting the levels. One such arrangement uses two, three position keys for adjusting pads. This gives the user a choice of three different transmit and receive levels. The advantages of using the 4-wire talk set described above are: the level of the circuit can be matched at various test points permitting quality talking and listening tests; no return current path is inserted in the private line circuit; and when connected to a spare side of a 4-wire bridge, in service testing of voice levels, noise, cross-talk, etc, can be done without causing interference to the private line circuit. Some of the additional features provided by the 4-wire testing arrangement per Drawing SD-95463-01 are: outward signaling of 20 cycles, 135 cycles, 1000 cycles, and 600-1500 cycles can be applied to the private line circuit; 600-1500 cycle signals from private line stations can be tested; and transmission tests can be made; all through the connections established when the 4-wire talking set is patched to the private line telephone circuit.

6.04 ***Talking and Monitoring Circuits with 2-Wire Loops:*** Because the degree of balance on a circuit with 2-wire loops is determined by how close the impedance of the networks matches the impedance of the loops, testing on these circuits requires special precautions so that the balance is not disturbed. Talking 2-wire on the circuit can be done using standard talking circuits such as those at a #5 Testboard or with a telephone set per SD-95463-01. With the talk key closed the monitor jack associated with the loop can be used for monitoring the circuit with little effect on the circuit balance. To talk 2-wire on a private line circuit or to make transmission tests from a 2-wire loop usually requires that the circuit be removed from service. By cross connecting the network through a jack, shown in Fig. 49, testing can be done by connecting the transmission measuring equipment or telephone circuit to the 2-wire side of the terminating set and by substituting a 600-ohm termination for the network.

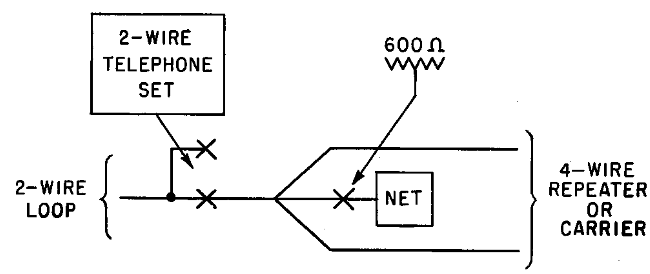


Fig. 49 — Central Office Arrangement for Testing Private Line Telephone Circuits with 2-Wire Loops

6.05 ***Use of Volume Indicators in Private Line Telephone Testing:*** Volume indicators of the type commonly used in program transmission servicing can be used to advantage in testing private line telephone circuits. Some of the convenient uses of a volume indicator are: monitoring of voice levels, monitoring 1000-cycle and 600-1500-cycle signaling levels, and limited use in place of a transmission measuring set. Shown in Fig. 50 is a simple resistance network that can be used to connect a volume indicator to a private line telephone circuit. Also shown is one method of connecting a volume indicator to the network. As used for private line telephone testing, the "in," "out," and "monitor" terminals are usually jack terminated so that they can be patched to various test points. The impedance at the terminals is approximately 600 ohms. One of the ways that this arrangement can be used is to patch the "in" and "out" terminals to a set of normalling jacks in a circuit transmission path. For example, the "in" terminal can be patched to the output of a bridge side and the "out" terminal patched to the transmitting branch that is fed from the bridge. The insertion loss is approximately 0.2 db regardless of whether the monitor terminals are open or terminated. The loss from the "in" terminals to the "monitor" terminals is approximately 27.6 db. Another way that this arrangement can be used is to patch the "in" terminals to the output of a spare side of a 4-wire bridge. The "out" terminals are then terminated in 600 ohms. Either a 600-ohm termination, a loudspeaker, or the receive side of a 4-wire talking set can be used to provide the termination. The losses are the same as discussed above so long as the "out" terminal is terminated. When the "in" side is connected to a spare side of a bridge and the "out" side is connected to the 4-wire talking set arrangement (Fig. 48), a testing and monitoring arrangement complete with telephone set, loudspeaker for monitoring, and volume indicator for level observations and transmission tests is connected to the private line circuit. Since the loss from the "in" terminal to the "monitor" terminal is approximately 27.6 db, the voice amplifier is required to raise the monitor level before it enters the volume indicator. Following is the procedure for calibrating the volume indicator arrangement:

(a) Calibrate the volume indicator following procedures given in the practice for the type of volume indicator used.

(b) Terminate the "out" terminal in 600 ohms.

(c) Connect a 600-ohm — 1000-cycle oscillator to the "in" jack.

(d) Adjust the output level of the oscillator so it is the same as the level of the circuit at the point where the arrangement is going to be connected (usually −11 or −8 when it is connected to a bridge output).

(e) Set the volume indicator for 600 ohms.

(f) Set the input attenuator that is part of the volume indicator to a convenient point (+4 is a convenient setting for a 754E-type volume indicator).

(g) Adjust the voice amplifier gain until the volume indicator meter reads zero.

The volume indicator when connected to a point in the circuit for which it is calibrated will read deviations from circuit level when a 1000-cycle tone is applied at circuit level.

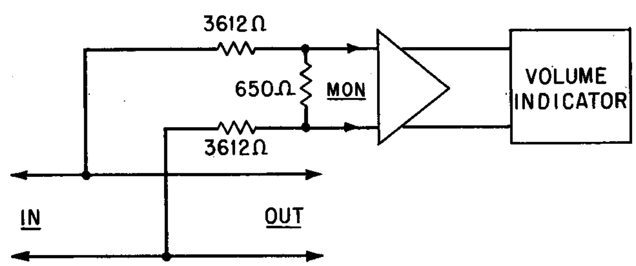


Fig. 50 — Arrangement for Using a Volume Indicator for Private Line Servicing

7. ALTERNATE SERVICES AND SUPPLEMENTARY USES OF PRIVATE LINE TELEPHONE SERVICES

(A) Alternate Services

7.01 Alternate services permit a private line customer to select various types of service using the same toll facilities between central offices. These services are arranged so that the customer can use only one type of service at a time. Several types of alternate services are: Private Line Telephone — Foreign Exchange, Private Line Telephone — Facsimile, Private Line Telephone — Telegraph, and Private Line Telephone — Data Transmission. Switches or relays, located at either the central office or the customer's station, are used to change from one type of service to another. When switch relays are used at the central office the switching circuits and control circuits are similar to those described in Parts 2 and 4 of this section. When the circuit is conditioned for private line telephone service, the transmission and equipment arrangements are similar to the private line telephone arrangements discussed in this practice. In some cases the operation of a relay switch to change from telephone service to an alternate service merely connects the private line loops to equipment owned and maintained by the customer. Pads are provided when necessary so that the levels of the private line circuit and the customer's equipment will match. The customer's equipment must meet certain requirements, such as level limitations, frequency, etc. Many of the alternate service arrangements are especially engineered and designed and locally prepared instructions are often helpful in the servicing of such circuits.

(B) Supplementary Services

7.02 *2-Tone Equipment:* In addition to signaling and switch control applications of 2-tone equipment, the 2-tone receiving equipment and applique circuit (Paragraph 4.02) can be used to perform many other functions under control of stations that are equipped for 2-tone dialing. The operation of the applique relay, under control of the 2-tone equipment, can be used to operate relays for turning pumps on and off etc. In other words any equipment, the operation of which can be controlled by the application or removal of dc, can be controlled using 2-tone receiving equipment and an applique circuit.

7.03 *Connection to Private Radiotelephone System:* A multistation private line circuit can be arranged to interconnect with a private mobile (or aircraft) radiotelephone system. The technicalities involved in effecting such interconnections vary widely, depending on such details as type and design of the private line circuit, the design of the radio equipment, whether the telephone set of the radio equipment is 2-wire or 4-wire, etc. The information in this practice cannot follow through these interconnections in detail because of the number of variables.

7.04 The interconnections with mobile or aircraft radio systems can be accomplished on either a 2-wire or 4-wire basis. The nature of its service is such that a large percentage of the users will probably be airlines, pipe line companies, etc, that is companies whose private line service would be of the longer, more complex variety — consequently 4-wire layouts. Interconnection with mobile radio systems is usually on a 4-wire basis.

7.05 Private mobile radio systems usually operate on a single frequency basis, although occasionally interconnection may be required with a radio system that uses different transmitting and receiving frequencies. The latter arrangement simplifies the interconnection inasmuch as there is no need to alternate the radio transmitter and receiver. In the case of single frequency operation, however, it is necessary to activate the transmitter and receiver alternately, and where the radio system is interconnected with a private line circuit this control feature must be extended to those private line stations which will communicate with the radio stations.

7.06 The control feature referred to in the preceding paragraph can be extended to the private line stations in several different ways: (1) by means of a dc (telegraph type) channel and push-to-talk control; (2) over the voice path by some means of tone control, (3) by a voice operated control. Because the features provided by interconnecting mobile telephone and private line circuits vary so widely, in fact they are usually specially engineered for each application, it is not practicable in this section to describe specific or typical application.

8. EQUIPMENT FEATURES

8.01 Various standard drawings cover the equipment used at central offices and private line stations in providing private line telephone service. The features provided by the most commonly used drawings are described briefly in the following paragraphs.

8.02 *SD-55647-01:* Figures of this drawing cover the bridges, ringing relays, switching relays, line relays, etc, that are used in the central office. Application schematics of the drawing show interconnection of this equipment and other standard central office equipment for providing private line telephone services.

8.03 *SD-66679-01:* Figures of this drawing cover the equipment arrangements at a customer's station for terminating a 4-wire loop in a PBX. Fig. 51 of this section shows a typical layout in block diagram.

8.04 *SD-69158-01:* This drawing covers the equipment at a customer's location that is provided for terminating 2-wire loops in 2-wire stations and 2-wire key equipment with loudspeaker signaling. 4-wire arrangements are also covered to a limited extent, however, equipment per SD-69167-01 is generally used. A typical 2-wire station arrangement is shown in Fig. 52 of this section.

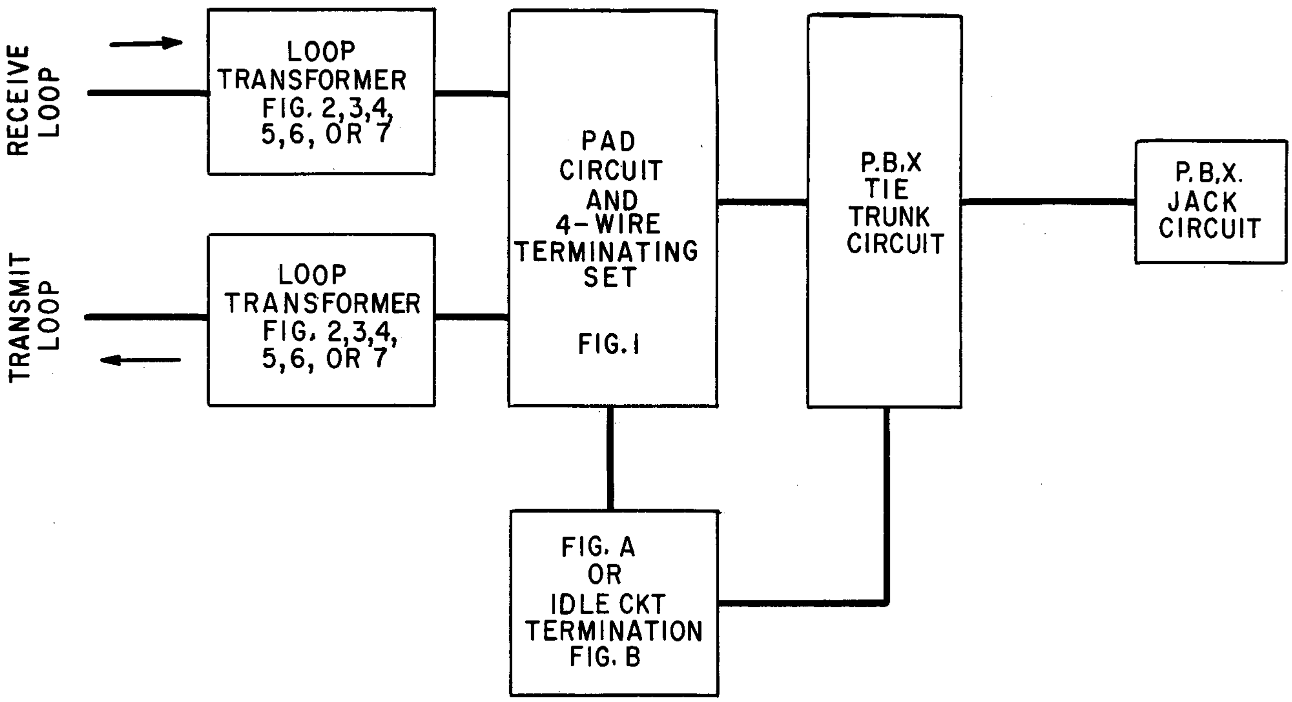


Fig. 51 — Arrangements for Terminating a 4-Wire Loop in a PBX Using Figs. From SD-66679-01

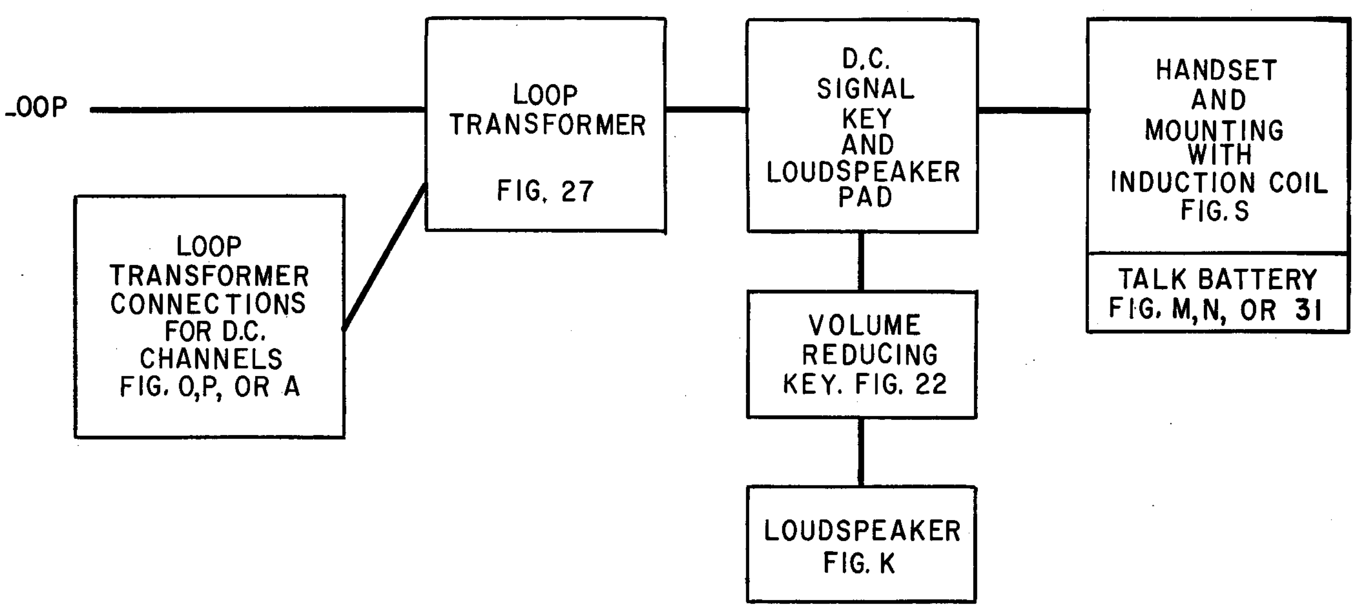


Fig. 52 — 2-Wire Private Line Station Arrangement Using Figs. From SD-69158-01

8.05 *SD-69159-01:* This drawing covers 102A key equipment and associated station equipment. Other drawings cover the equipment for terminating the loops associated with 102A key equipment.

8.06 *SD-69163-01:* This drawing covers 109A key equipment and associated station equipment. The drawing also covers the equipment required to terminate the station loops.

8.07 *SD-69164-01:* Figures of this drawing cover the station signal circuits and loop terminating circuits for 2-wire and 4-wire loops with dc or 20-cycle inward signaling to 102A key equipment positions.

8.08 *SD-69167-01:* This drawing is the one most commonly used in furnishing private line telephone service. The figures of the drawing provide the following: 4-wire common equipment for stations and for 102A key equipment positions with loudspeaker signaling, 4-wire station equipment, station signal circuits for 20-cycle locked in and nonlocked in signaling, station signal circuits for 2-tone signaling, loop terminating equipment for 102A key equipment stations with 2-tone signaling, and other miscellaneous items such as loudspeaker cutoff relays, line pickup relays, etc. Fig. 53 of this section is a block diagram of typical 4-wire station arrangements.

SD-69254-01 (Package Station Equipment)

8.09 This drawing provides arrangements made up of equipment from standard key telephone units plus standard jacks, handset mountings, handsets (G- or F-type), headsets and keys. These arrangements are intended to minimize engineering and installation time and expense and will fulfill the requirements of a large majority of the orders for private line telephone service. Figs. 54 and 55 show the important features and arrangements available for two and four wire private line terminations.

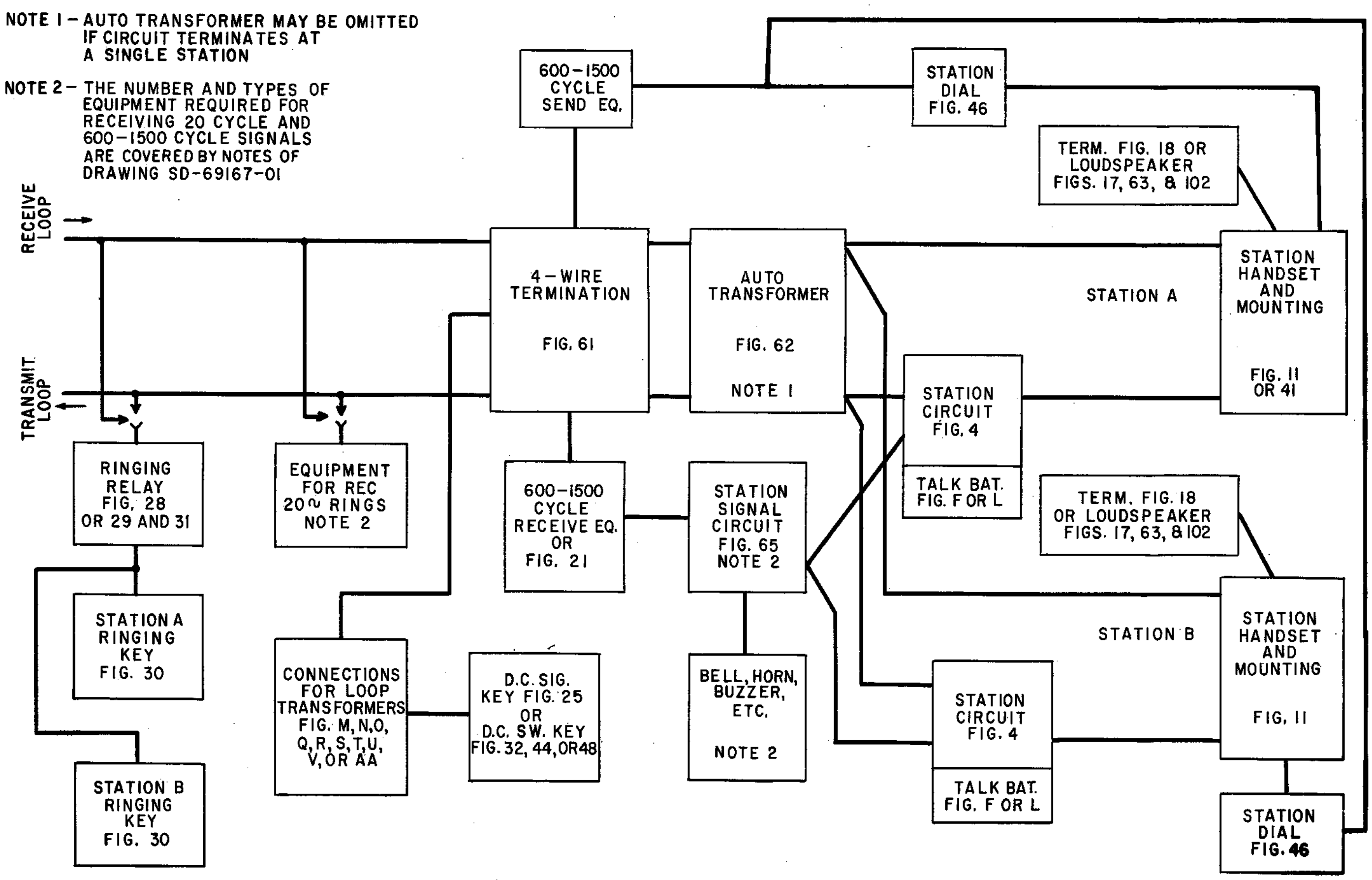


Fig. 53 — 4-Wire Private Line Station Arrangement Using Figs. From SD-69167-01

8.10 Some of the operating features provided in the packaged 2- and 4-wire private line termination are:

(a) For 4-wire loops, a 9 to 1 impedance step-down ratio, to permit bridging from one to six stations with a bridging loss variation of not more than 4 db.

(b) For 2-wire loops, provision for one station only, but with optional wiring permitting adjustment to match loop impedance.

(c) Provision for the connection of a loud-speaker.

(d) Cutoff of a common loudspeaker from a main and several extension stations.

(e) Provision of idle circuit terminations for stations in on-hook condition.

(f) Use of 20-cycle outward ringing.

(g) Use of a subset for audible incoming ringing.

(h) Use of two-tone selective signaling, both inward and outward.

(i) Control of a central office switching function.

(j) Use of plug-in or hang-up hand sets.

(k) Use of plug-in head telephone sets.

(l) Use of cradle-type telephone set.

(m) Provision of a dial to control two-tone selective signaling.

(n) Variable loudspeaker pad.

8.11 For features not provided by the package equipment, a combination of equipment per SD-69254-01 and SD-69167-01 can be used.

8.12 ***218A Key Telephone Unit (Fig. 56):*** The 218A Key Telephone Unit is made up of the following equipment items:

(a) 181B Inductor — This unit is used as the station induction coil and converts the low impedance of the station transmitter to approximately 600 ohms. Options are available

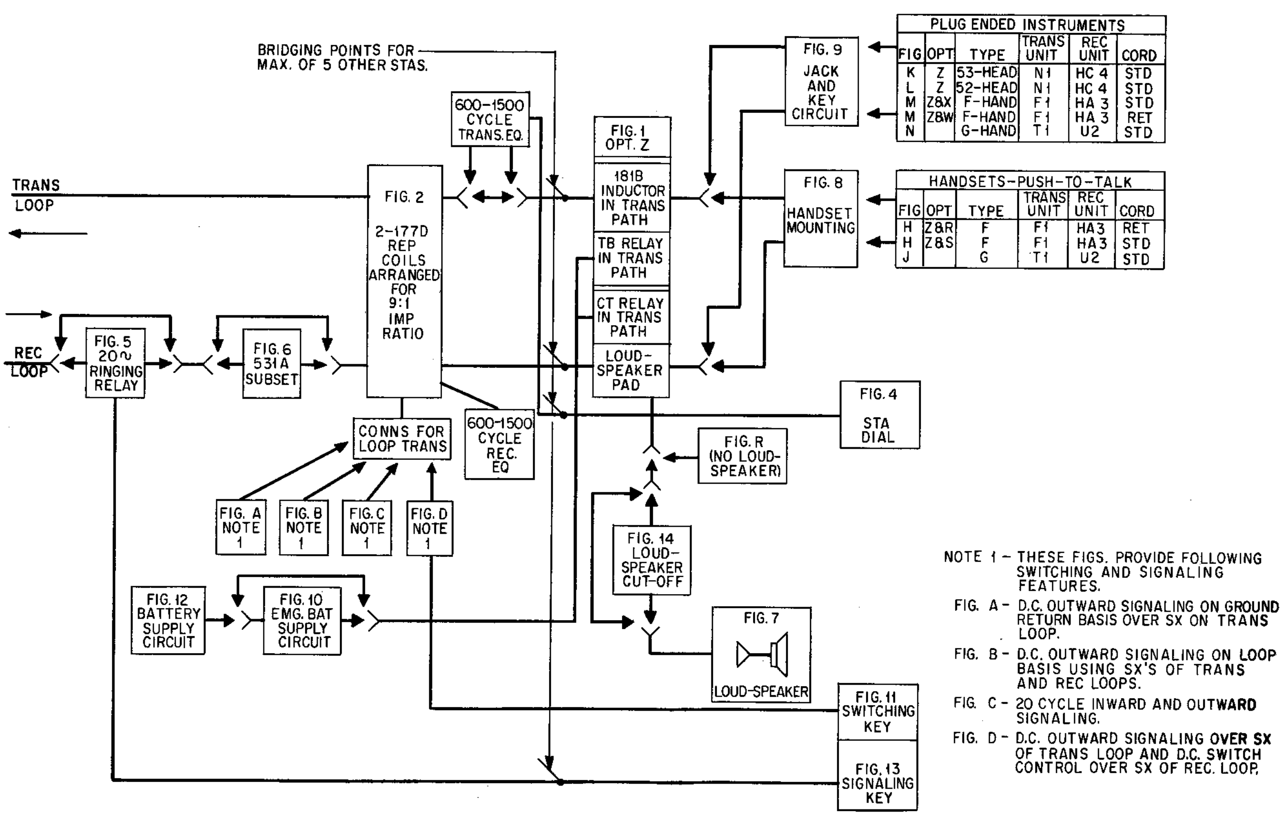
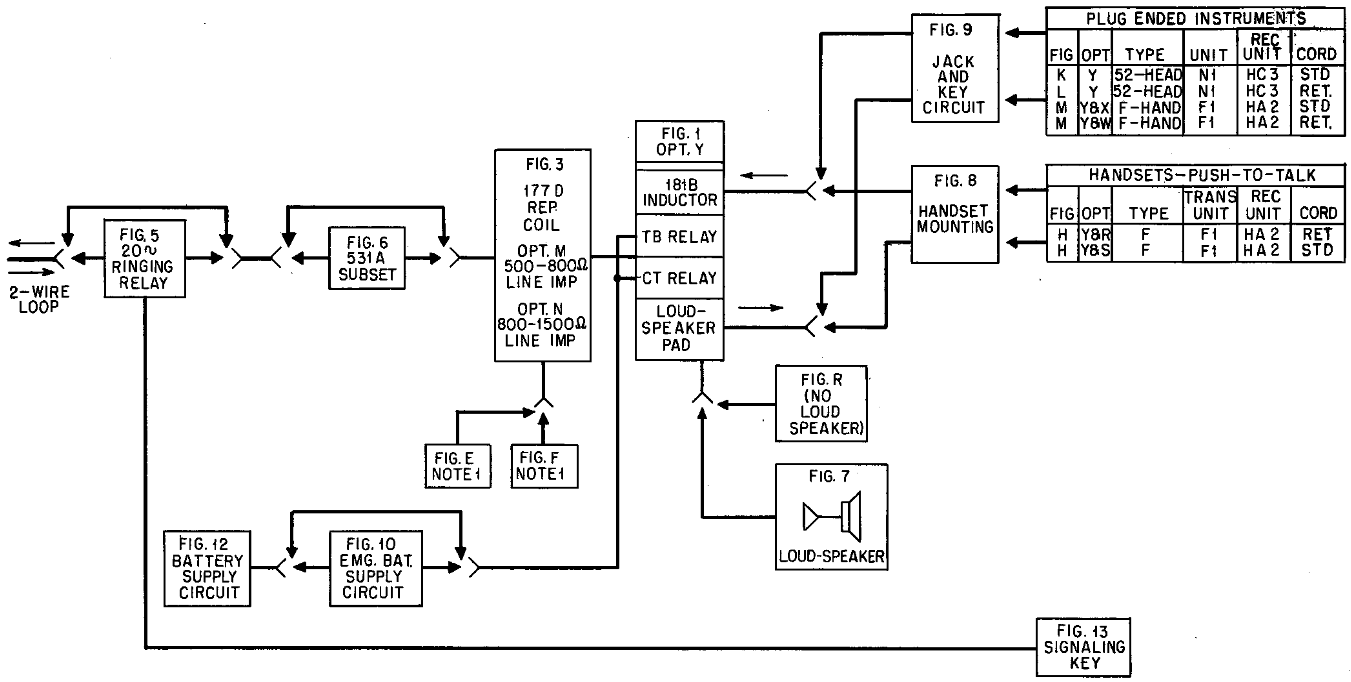


Fig. 54 — 4-Wire Packaged Equipment Arrangements Using Figs. From SD-69254-01



NOTE 1. FIG. E – D.C. OUTWARD SIGNALING. GROUND RETURN BASIS OVER SX.
FIG. F – 20 CYCLE INWARD AND/OR OUTWARD SIGNALING.

Fig. 55 — 2-Wire Packaged Equipment Arrangements Using Figs. From SD-69254-01

so that it can be connected for 2-wire stations with an antisidetone network or for 4-wire stations without the network.

(b) A varistor for bridging across the receiver path.

(c) Two wire spring type relays. One relay (CT relay, type AF123) is controlled by switchhook contacts or headset jack contacts. The relay is operated when the station instrument is "off-hook." With the relay nonoperated, the receiving path from the central office is connected to either a loudspeaker or to an idle circuit termination. When operated, the relay connects the receiving path to the station receiver. Other contacts of the CT relay establish connections that permit switching, signaling, and dialing. The other relay (TB relay, type AJ-40) is controlled by the operation of push-to-talk button or by the operation of a talk key. When operated, talk battery is furnished to the transmitter. When the TB relay is nonoperated, the talk battery is disconnected and the transmitter is replaced by a 91-ohm idle circuit termination.

(d) Various resistors and capacitors.

(e) A variable loss pad for use with a loudspeaker. The pad has a dial with calibrated steps. Table 5 shows the pad settings that are required depending on the room noise.

Table 5

Loudspeaker Pad Calibration

Room Noise Level	Setting
60 db or less	0
65 db	20
70 db	30
75 db	40
80 db	50
85 db	100

8.13 ***219A Key Telephone Unit (Fig. 57):*** Comprising this unit are two 177D repeat coils and two capacitors. The two repeat coils can be used for terminating one 4-wire loop or two 2-wire loops. Options available make it possible to strap the coils for a 9 to 1 impedance ratio for 4-wire loops, or to strap them to match the impedance of 2-wire loops. The capacitors

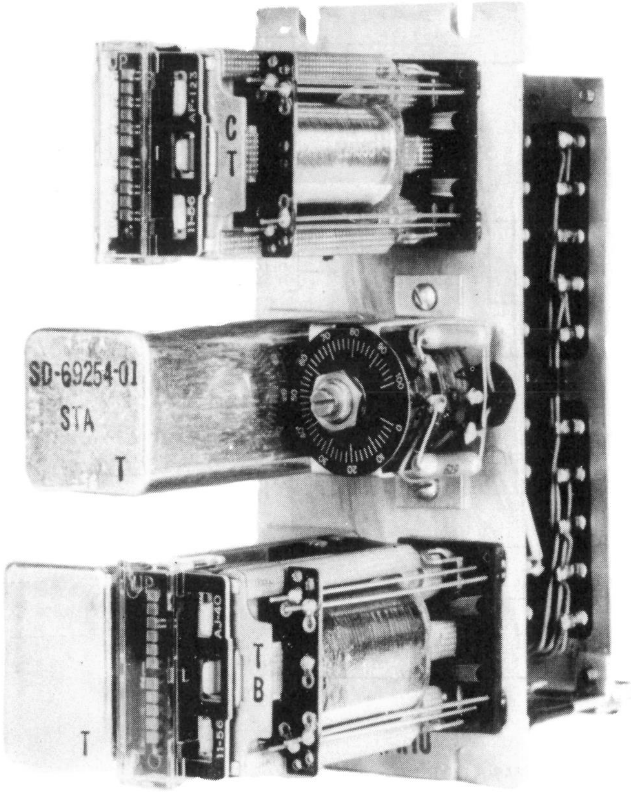


Fig. 56 — 218A Key Telephone Unit

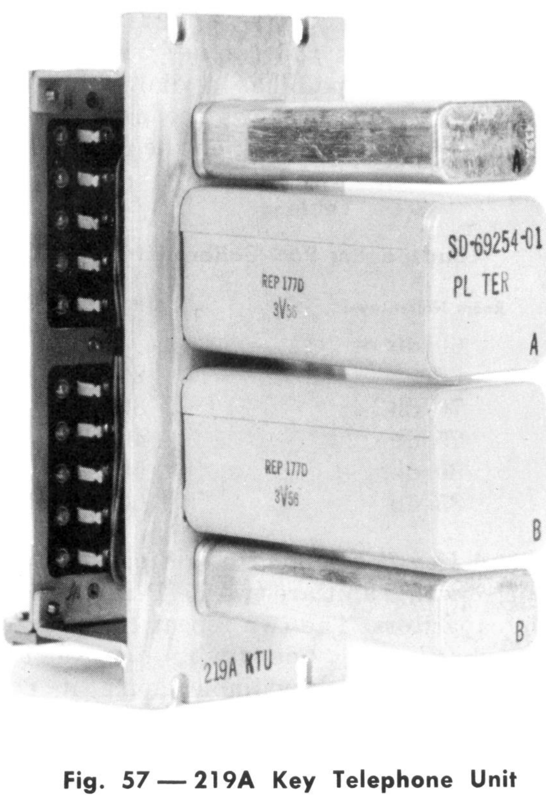


Fig. 57 — 219A Key Telephone Unit

are used to prevent the shunting of 20-cycle inward ringing or the short circuiting of dc loop signaling.

8.14 ***220A Key Telephone Unit (Fig. 58):*** This key telephone unit consists of a wire spring type relay (Type AF123) and a resistance lamp. The relay can be used as a transfer relay for an emergency battery supply, as a 20-cycle ringing relay, or as a loudspeaker cutoff relay when a single loudspeaker serves more than one station. The resistance lamp is used in conjunction with the 20-cycle ringing supply when the relay is used as a ringing relay.

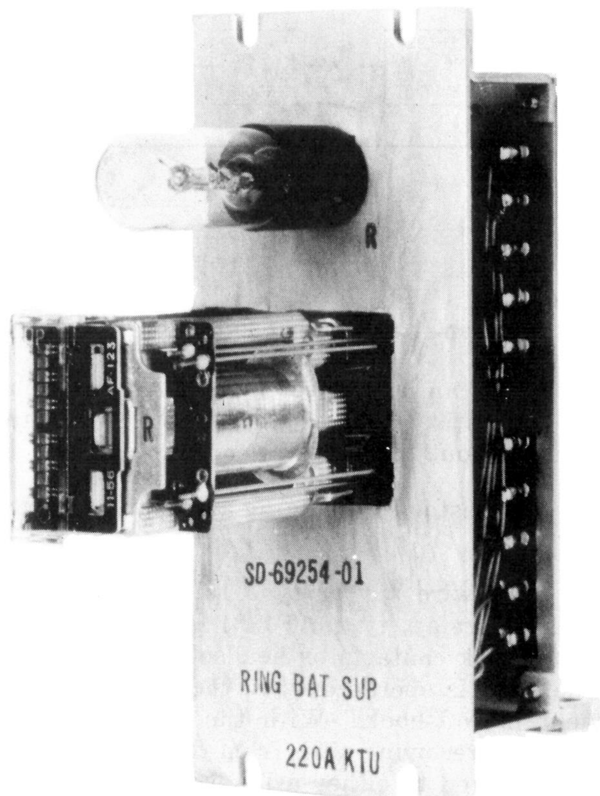


Fig. 58 — 220A Key Telephone Unit

8.15 Each of the three types of key telephone units are 3-1/32 inches wide and 6-15/16 inches high and are designed to mount in standard cabinets or relay racks. Screw type terminals at the rear of the key telephone units are used for interconnecting the units, for strapping to provide various options, and for connecting the units to other equipment.