COMMON SYSTEMS "V3" TELEPHONE REPEATER LINE AND BALANCING APPLICATION SCHEMATIC FOR USE WITH VOICE FREQUENCY AND CARRIER CKTS.

CHANGES

A. CHANGED AND ADDED FUNCTIONS

A.1 A repeating coil circuit comprising a 120-type repeating coil, options for DX or SX signaling and some equalization is provided for use on short nonphantomed 4-wire lines of exchange-type cable.

B. CHANGES IN APPARATUS

B.1 Added

In Fig. 3.5

1 - 120-type repeating coil (A)
(120C, 120CS, 120E, 120ES, 120F, 120FS, 120G, or 120GS)
1 - 437A capacitor (F)
4 mf
1 - 439A capacitor (G)
2 mf
1 - 145A resistor (H)
988 ohms

In Fig. 9.03

1 - 145A resistor (A)
909 ohms

D. DESCRIPTION OF CIRCUIT CHANGES

D.01 The title formerly read:

COMMON SYSTEMS
"V3" TELEPHONE REPEATER
AND NONREPEATERED
LINE AND BALANCING
APPLICATION SCHEMATIC
FOR USE WITH
2 AND 4 WIRE CABLE AND OPEN WIRE,
MESSAGE AND ORDER WIRE CKTS.

D.02 The Sheet Index and the sheet numbering system were expanded and all new circuit figures and tables were listed in the Sheet Index.

D.03 New figure titles and numbers were added to the Topical Index.

D.04 New options were added to the Lettered Options Table 0.11 and to the Record of Circuit Changes Table 0.22.

D.05 In Table 1.0, page 1.01, the 107A and 107D networks were replaced by 115BP and 115BR networks respectively.

D.06 In Table 1.0, page 1.03, note 14 was changed in order to avoid reissue of the drawing every time a new voice-frequency cable is designed.

D.07 In Table 1.0, page 1.03, information on line facility 19FNB D88 was removed from the same column as the 19FNB H88 since it was relocated in the same table on a previous issue.

D.08 Information was added to the Centralized Intracircuit Connections Table 2.0 for all additions and changes in the drawing.

D.09 In the Repeating Coil Constants Table 3.13, impedance ratio and resistance information was added for the 120-type repeating coils.

D.10 In Fig. 3.4 the labeling of the (D) capacitor was changed to (D3) since this figure is sometimes on the same panel as another (Fig. 7.11) which has a capacitor designated (D).

D.11 Fig. 3.5 and notes 3.5A through 3.5F were added to a new page numbered 3.5. This figure provides a repeating coil circuit for nonphantomed 4-wire lines.

D.12 Connecting information to Fig. 3.5 was added to Fig. 7.11.

D.13 On page 9.0 filter information was added to note 9.0A for 19H88-50-type cable.

D.14 Fig. 9.0 was renumbered 9.01.

D.15 Figs. 9.02 and 9.03 were added, connecting information was added to Figs. 9.01 and 9.14, and note 9.0D was added on page 9.0 in order to show how the miniature 4-wire terminating set return loss may be improved in the field.

D.16 In Fig. 9.01 option "TS" was labeled. This option was previously shown but not labeled.

D.17 Connecting information to Fig. 3.5 was added to Fig. 10.0.

D.18 Cross-connection Figs. 73, 74, and 75 were added on page 20.3B, which was also added.

D.19 Page 20.3 was changed to page 20.3A.

D.20 Information covering J68651BG was added to cross-connection Fig. 153.

D.21 Figs. 155 and 157 were rated "Mfr. Disc." and Figs. 176 through 183 were added.

All other headings under Changes, no change.

1. PURPOSE OF CIRCUIT

1.1 This circuit is intended for use with 2- and 4-wire (toll and exchange area) cable, 2-wire open wire, and 2- and 4-wire order wire circuits and shows application of line and 2-wire balancing equipment for repeatered and nonrepeatered circuits, and for physical, phantom group, and split phantom group circuits.

2. WORKING LIMITS

2.1 None.

3. FUNCTIONS

3.1 Provides means for employing repeaters for the purpose of inserting amplification in a 2- or 4-wire circuit.

3.2 Provides for terminating a 2- or 4-wire circuit, with or without amplification, by means of

3.21 2-wire repeating coil hybrid circuits which include normal but flexible equalizers,

3.22 2- and 4-wire repeating coil circuits,

3.23 a resistor hybrid for dispatch and order wire circuits and short 2-wire line extensions,

3.24 a terminating circuit for 2- and 4-wire circuits not requiring precision balancing.

3.3 Provides means for adapting standard message circuit arrangements to

3.31 2-wire dispatch circuits (as for railroad and pipe line company use),

3.32 2- and 4-wire order wire circuits.

3.4 Provides means for obtaining full or limited flexibility in

3.41 equalization in accordance with signaling,

3.42 circuit line and balancing conditions,

3.43 interchangeability between phantom and physical circuit requirements,

3.44 split phantom group arrangements for noncomposited and composited lines.

3.5 Provides bypass relays for automatically cutting out ac-operated repeaters in case of power failure.

3.6 Provides for the additional equalization, external to repeating coil hybrids, required for 135-cycle signaling and for the auxiliary equalization required by provisional open wire circuits, longer sections of nonloaded cable, and some order wire circuits.

3.7 Provides high-pass filters for protecting the type 1A echo suppressor, and low-pass, voice-frequency filters.

3.8 Provides for signaling, compositing, and associated network balancing.

3.9 Provides a 3-way and a 4-way order wire bridging network together with associated pad, jack, and relay circuits.

4. CONNECTING CIRCUITS

4.1 For information figures and external connections to this drawing, see Section AA263.022 (J68651).

4.2 For complete connecting information in block diagram form, see "V3" Key Sheet, SD-59070-02.

DESCRIPTION OF OPERATION

5. METHOD OF INDEXING - SECTION 0

5.1 The information appearing on this drawing is divided into 13 major sections appearing in numerical order from 0 to 20. The pages of the drawing composing a section are arranged so that the first digit of the page number is the same as the section number. Each section is subdivided by means of a decimal system so that the first two digits of each circuit figure, table, or circuit note number is the same as the number of the page on which the item appears. (See Topical Index, page 0.0.) Where space permits, the circuit notes and tables which refer to a particular circuit figure are placed on the same section page as that on which the figure appears. Thus, by referring to the index, all information relating to the particular administrative phase or group of equipment of interest may be readily located.

6. ENGINEERING TABLES - SECTION 1

6.1 Table 1.0

6.11 This table provides, on a 2-wire basis, information for determining the circuit needs, i.e., codes of repeating coils, networks, filters, and circuit equalization, in accordance with each line facility listed. The table comprises three pages: page 1.01 covers open wire, toll entrance cable, and provisional open wire; page 1.02 covers toll cable and pairs associated with coaxial cable; page 1.03 covers exchange area cable.

6.12 To use this table, read along the top line to the column headed by the type of facility involved. Then, read down that column to find the circuit needs listed opposite the various circuit elements and conditions. (See 6.3 for example.)

6.2 Table 1.1

6.21 This table provides additional engineering information based on phantoming, signaling, and compositing conditions. The three major divisions of this table cover: repeatered circuits (terminal repeater points and through repeater points); nonrepeatered circuits (terminal points and through points) for certain phantom group conditions; grounding and spare simplexing provisions.

6.22 Due to the manner in which Table 1.1 was prepared, numerous combinations of phantom group and other circuit arrangements may be properly obtained through its use. These many arrangements are required from the standpoint of circuit flexibility to accommodate those cases where the circuit conditions for the two sides may differ and where the circuit conditions for the sides may differ from those for the phantom.

6.23 To use this table, enter the columns which apply as indicated by the heading of that column. Read down until the circuit need is found opposite the signaling and compositing condition involved.

6.3 Example

6.31 Assume that the following conditions be specified. Open wire of 104-mil copper; phantom group with dc-operated terminal repeaters; no compositing; repeated 20-cycle signaling on sides, repeated 135-cycle signaling on phantom; phantom-simplexed telegraph channel.

6.32 Page 1.01 of Table 1.0 provides for open wire. Enter table in columns headed by 104-mil copper open wire. All pertinent information in Table 1.0 will be found in these columns. It is first necessary to choose one of the repeat coil or repeat coil hybrid circuits of Section 3. In accordance with Table Note No. 7, provide Fig. 3.0 for each side and phantom.

6.33 To equip each side circuit, provide the following for: repeat coils (A) and (B) of Fig. 3.0, 173E's; precision network, 115T per Fig. 6.04; filter, 128A (no carrier line filters being specified in 6.31); equalizers, strapping option "S2" in Fig. 3.0 and, in accordance with Table Note No. 6, option "X" in Fig. 3.0.

6.34 To equip each phantom, provide the following for: repeat coils (A) and (B) of Fig. 3.0, 173D's; Fig. 3.0, option "V" a (PH) resistor of 18 ohms; precision network, 115Y per Fig. 6.04; filter 128A; equalizers, Fig. 7.03 with equipment option "E5."

6.35 To complete the job, it is now necessary to refer to Table 1.1. Enter the table under the repeatered circuits division and under the terminal repeaters subdivision.

6.36 To complete each side circuit: provide Fig. 10.0; on the switchboard side, provide Fig. 9.0 in accordance with Table Note No. 1; on the line side, provide Fig. 3.0 with condition C5; also, since 20-cycle signaling is specified, provide Fig. 4.01 with option "J."

6.37 To complete phantom: provide Fig. 10.0; on the switchboard side, in accordance with Table Note No. 1, provide Fig. 9.0; on the line side, provide Fig. 3.0 with condition C6.

6.38 Now, enter the table under "SX" Telegraph and Grounding Features, Repeatered Circuits, Phantomed Facilities. Provide option "SX" in the Fig. 4.01 which was previously specified for each side circuit. To derive the phantom-simplex, provide Fig. 4.03.

6.39 Any additional information which may be required can be found in the notes associated with each circuit figure and in Table 2.0.

7. INTRACIRCUIT CONNECTING INFORMATION - SECTION 2

7.1 Key Lead Designations

7.11 To facilitate the showing of connecting information, each lead or pair of leads in the circuit figures is given a designation, "A," "B," "C," etc., referred to as the "Key Lead Designation." These designations are shown in quotes (to distinguish them from the regular circuit lead designations which are also shown) and are used only in conjunction with Table 2.0 (see below) and the connecting circuit information of the Bell System Practice mentioned at the beginning of this CD. The user should bear in mind that key lead "A" of one circuit figure does not necessarily connect to the key lead "A" shown on another circuit figure; it is necessary to refer to the tables in order to employ these key leads correctly. The regular method of showintracircuit connecting information is also shown, that is, by direct reference to the connecting circuit figure. This duplication

not only serves as a means of checking, but also enables the user to employ whichever method may be most convenient to him.

7.2 Table 2.0

7.21 This table uses key lead designations in order to present a centralized, over-all picture of the way in which the various figures on the drawing interconnect. Each set of key lead designations associated with a particular circuit figure and which connects to another circuit figure is listed in a separate vertical column headed by the number of that figure.

7.22 To use this table, first locate the vertical column listing the key lead designations for the circuit figure involved. Read down this column. Each time the key lead designation of interest appears, read across horizontally to find the number of the circuit figure to which connection may be made. Note that one key lead designation may be used to show connection to more than one figure. The table must always be entered at the top. Entering at the right or left, then reading vertically to find the connecting figure will not yield correct results.

7.3 Example

7.31 Assume it is desired to check the information given at the T, NT, and R, NR leads of Fig. 3.2. This information reads, "To Figs. 6.03 and 6.04; see Table 2.0; Lead 'F'."

7.32 Locate the vertical column headed by the number "3.2." Reading down this column, it is found that "F" appears opposite the number "6.03" and "6.04," indicating that the leads on Fig. 3.2 may connect to these two figures.

7.33 As indicated by a circuit note located on page 3.2, connection of circuits external to this drawing may be made at this point. The "F" designation will be used in tables associated with the Bell System Practice previously mentioned to show (in a manner similar to the method employed in Table 2.0 of this drawing) which external circuits may be connected to these leads.

8. REPEATING COIL CIRCUITS FOR VOICE TRANSMISSION - SECTION 3

8.1 Repeating Coil Hybrid, Figs. 3.0 and 3.2

8.11 General

8.111 A side circuit repeating coil hybrid figure may be used to terminate the physical 2-wire line. Where the line circuits are phantomed, two side circuit figures, together with an associated phantom circuit figure, make up a phantom repeating coil hybrid group for terminating a cable quad.

8.112 The repeating coil hybrid proper is made up of repeating coils (A) and (B) connected to terminate the 2-wire line on a 4-wire basis, the 4-wire transmitting and receiving arms being the 2-5 terminals of repeating coils (A) and (B) respectively. The 4-3 and 8-7 windings of each of the coils are connected in series such that a phantom tap can be obtained via terminals 3 and 8 of coil (B) with terminals 4 and 7 of coil (A) forming the 2-wire line terminals of the hybrid. Windings 9-10 and 11-12 of both repeating coils form the network branch of the hybrid and are also connected in series. However, these windings are so poled that in transmission from the 4W receiving (2-5 terminals of coil [B]) to the 2-wire line (the 4-7 terminals of coil [A]) and to the network (the 9-12 terminals of coil [A]), little or no current flows into the 4W transmitting branch (through 2-1 and 6-5 windings of coil [A]), when the hybrid is properly terminated at all points. In transmitting in the reverse direction from the 2-wire line (4-7 terminals of coil [A]) to the 4W transmitting and to the 4W receiving (2-5 terminals of coils [A]and [B], respectively) for the same conditions of impedance terminations, little or no current flows in the network arm of the hybrid. For the side circuit hybrid figures the 2-wire line terminals connect to the cable line; in the case of the phantom circuit hybrid figures they connect to the phantom taps of two side circuit hybrid figures.

8.113 Terminals 2-5 of coils (A) and (B) of the hybrids connect, normally, to leads associated with one side of a "V3" repeater input and output, respectively.

8.114 Capacitors (A1), (A2), and (A3) and resistors (J) and (K) provide sufficient adjustable equalization for most line facilities.

8.12 Fig. 3.0

8.121 Fig. 3.0 is suitable for all cases requiring a line hybrid for a 2-wire repeater circuit except for trunk circuits with loop signaling. It also can be employed for terminating a 4-wire circuit without repeaters for 2-wire extensions. In the latter case, the two "SX" leads obtained via windings 2-1, 6-5 of the (A) and (B) repeating coils may connect to one side of Fig. 4.04 with the other side of Fig. 4.04 connected to terminals 3-8 of the (B) repeating coil to maintain a dc path between the 2- and 4-wire sides.

8.122 Equalization for all line compositing and all signaling conditions, except 135-cycle signaling, is incorporated in the line repeating coil hybrid. Additional equalization required by 135-cycle signaling, nonloaded cable, some order wire circuits, provisional open wire, and railroad dispatch

circuits is obtained by means of the auxiliary equalizer figures.

8.123 Optional wiring and apparatus connected between terminals 3 and 8 and associated balancing wiring and apparatus connected between terminals 10 and 11 of the (A) repeating coil are required for use with the following: bridge-type composite set line and balancing circuit; series-type composite set line and balancing circuit: type E composite set line and balancing circuit figures; and, 20-cycle signaling.

8.124 When a precision line balancing network is not required, a resistor (N) of proper value with option "N" may be provided.

8.13 Fig. 3.2

8.131 Fig. 3.2 is arranged for trunk circuit use with loop or midcoil signaling. Used primarily for physical circuits, it can also be used as a phantom circuit to connect to two side circuit repeating coils or repeating coil hybrids when loop or midcoil signaling is specified for the phantom circuit. In this case the side circuits must employ either 135-cycle or voice-frequency signaling and be noncomposited. This figure is not suitable for use on side circuits for deriving a phantom tap.

8.132 This figure requires a filter when it is associated with a line circuit. When associated with a central office, it does not require a filter.

8.2 Repeating Coil Circuit, Figs. 3.3 and 3.4

8.21 General

8.211 At a circuit terminal or switching point, these circuits provide means for terminating any 2-wire line without repeaters. Where the line circuits are phantomed, two side circuits, Figs. 3.3 or 3.4, together with an associated phantom circuit, Figs. 3.3 or 3.4, make up a phantom repeating coil group for terminating a line quad. Figs. 3.3 and 3.4 may be used to terminate one or two circuits of a split phantom group. Fig. 3.3 is readily convertible to the standard repeating coil hybrid.

8.212 These figures provide arrangements for employing the following: all standard types of signaling including, for physicals or phantom groups, CX signaling on the line side with loop or midcoil signaling on the drop side; bridge-type CX sets (so-called type "C" or "D"); series-type CX set (so-called type "A"); and type "E" CX set.

8.22 Fig. 3.3

8.221 Voice and signaling currents, entering from the line, pass through windings 4-3, 4-3 and 7-8, 7-8 of the (A) and (B) repeating coils. (Transmission may also occur from the repeat coil to the line.)

8.222 The voice currents, flowing through all of the line windings in series, are induced into the 2-1, 6-5 windings of the (B) coil and flow to the circuit terminal or drop. The currents also induce core coupling currents which circulate through the closed path consisting of windings 11-12, 9-10 of the (A) coil in series-opposing with winding 9-10 of the (B) coil. Due to this closed path, the coils (A) and (B) behave as if they had one core. Windings 2-1 and 6-5 of the (A) coil are not used. The particular circuit arrangement of Fig. 3.3 results in a transformation ratio of 9/8 times the hybrid ratio of Figs. 3.0 and 3.2. This is desirable for obtaining good junction return losses at switching points.

8.223 The 135-cycle signaling currents behave in a manner similar to the voice currents.

8.224 Twenty-cycle signaling currents flow through the line windings of both coils in series and out to the "T3" and "R3" leads. The low mutual inductance of the repeating coil connection and the high shunt impedance of capacitors (D1, E1) and (D2, E2) with "Z" and "ZZ" options act to attenuate 20-cycle currents only to a small extent.

8.225 When CX signaling with type "E" CX sets is used, the signaling currents flow through the tip and ring line windings of both (A) and (B) coils independently, except for the low mutual between them. The tip circuit leads out to the "T3" lead; the ring circuit to the "R3" lead.

8.226 When CX signaling with bridge- or series-type CX sets is used, the signaling currents do not flow through the line windings of the (A) and (B) coils but are effectively blocked by the capacitors and flow off the tip and ring leads of the line circuit into the "T" and "R" tap leads, respectively (see Key Lead "C") which connect to either the bridge- or series-type CX set.

8.227 Taps are brought out from terminals 3-8 of the (B) coil with "W" option or from the common strap between the (D1, E1) and (D2, E2) capacitors with "Z" and "ZZ" options of two side circuits, Fig. 3.3, for the purpose of deriving a phantom line circuit for connection to a phantom circuit, Fig. 3.3.

8.23 Fig. 3.4

8.231 Fig. 3.4 performs essentially the same functions as Fig. 3.3. It utilizes a single repeating coil. On 4-wire circuits Fig. 3.4 can be used as an input or output repeating coil.

8.3 Repeating Coil Circuit, Fig. 3.5

8.31 At a circuit terminal or switching point, this circuit provides means for terminating nonphantomed 4-wire lines which are short runs of exchange-type cables between nearby switching offices. This circuit also provides arrangements for employing SX or DX signaling on the line side and can be used as an input or output repeating coil.

9. SIGNALING COMPOSITING AND ASSOCIATED NETWORK BALANCING - SECTION 4

9.1 General

9.11 This section provides the following: 20-cycle signaling arrangements for terminal, repeated, and bypass signaling; means for obtaining a phantom-simplex channel with side circuit hybrids equipped for 20-cycle signaling; type "E" composite sets for CX signaling on 2-wire cable circuits for terminal, repeated, and bypass signaling with suitable balancing circuits for terminal and through phantom groups and phantom group to physical circuits at through circuit points; type "D" composite sets for 4-wire order wire circuits.

9.2 Fig. 4.01

9.21 Fig. 4.01 is a 20-cycle repeating coil circuit for use with a side or phantom circuit at a circuit terminal or at repeated signaling points. It receives from or transmits to the line via a repeating coil circuit, Figs. 3.0, 3.3, or 3.4.

9.22 The (D) retard coil, connected in series with the line side of the 20-cycle ring-through repeating coil (C), builds out the input impedance to the high value required at frequencies above 20 cycles.

9.3 Fig. 4.02

9.31 This dc blocking circuit, when required at terminal repeater points, acts to block out the dc from switchboard circuits.

9.4 Fig. 4.03

9.41 Two side circuit repeating coil circuits each employing a Fig. 4.01 for 20-cycle signaling require, when a phantom-simplex is specified, a Fig. 4.03 to maintain the dc path between side 1 and side 2 of a phantom group.

9.5 Fig. 4.04

9.51 Due to the particular poling of the (C) and (D) retard coils, this figure provides two independent dc paths of one-half the inductance of a single retard coil each effective in the side circuits. The corresponding inductance effective in the phantom circuit is one-quarter of the inductance of a single retard coil. Retards (C) AND (D), together with capacitors (A) and (B), are equivalent to the circuit configuration of a bridge-type composite circuit.

9.52 Fig. 4.04 may be used as a bridge-type (type "D") composite set at nonrepeatered 2-wire cable terminals or at repeater points of 4-wire order wire circuits. It is not suitable for use on open wire circuits for telegraph nor for use on 4-wire message circuits.

9.53 At intermediate 4-wire repeaters on order wire circuits, two Figs. 4.04 are connected back to back for use as a type "D" intermediate composite circuit.

9.54 As a type "E" terminal composite circuit, Fig. 4.04 may be used on cable circuits for CX signaling only. It is not suitable for telegraph.

9.6 Fig. 4.05

9.61 This phantom composite balancing circuit is required in the phantom circuit to balance the effect of a Fig. 4.04 in each of the side circuits of a phantom group.

9.7 Fig. 4.06

9.71 This signaling bypass circuit provides means for bypassing low-frequency signaling, 3-1/2- or 20-cycle and CX, around a repeater or repeating coil circuit at points not requiring repeated signaling.

9.8 Fig. 4.07

9.81 This phantom composite balancing bypass circuit is required in the phantom circuit to balance the effect of Fig. 4.06 in each of the side circuits of a through phantom group.

9.9 Fig. 4.08

9.91 This phantom composite balancing bypass circuit is required in the phantom circuit at a point where the three circuits of an incoming phantom group leave on three physicals or where the phantom is equipped with a terminal repeater and both side circuits leave on physicals, each of the two side circuits being equipped with a Fig. 4.06.

10. BYPASS RELAYS FOR AC-OPERATED REPEATERS - SECTION 5

10.1 Fig. 5.0

This circuit provides means, when employed with ac-operated repeaters, for bypassing the two individual amplifiers of a repeater upon power failure without disturbing the line or signaling equipment. The relays are normally operated, the (ODD) and (EVEN) relays being associated with the "Odd" and "Even" amplifiers, respectively.

11. ADJUSTABLE AND PRECISION-TYPE LINE BALANCING NETWORKS - SECTION 6

11.1 Fig. 6.01

11.11 This adjustable line balancing network, for trunk and dispatch circuits, provides means for balancing open-wire lines equipped with bridge way stations.

11.2 Figs. 6.02 to 6.04, inclusive

11.21 These individual precision networks are used to give suitable balancing for particular lines as covered in the tables of Section 1.

11.3 Fig. 6.05 balances the 52A or equivalent operator's telephone set.

12. AUXILIARY EQUALIZERS AND FILTERS - SECTION 7

12.1 Fig. 7.01

12.11 This figure provides a 5-db pad for use with provisional open wire circuits equipped with 3-kc carrier line filters.

12.12 This pad, connected between the hybrid coil and input equalizer, is required to improve the very poor return losses between the provisional open-wire lines as seen through the 3-kc carrier line filter sets at a 2-wire repeater point.

12.2 Fig. 7.02

12.21 This auxiliary equalizer, for use with railroad dispatch circuits, introduces added low-frequency equalization external to the hybrid repeating coil circuits.

12.3 Fig. 7.03

12.31 This figure may be employed as an auxiliary equalizer for provisional open wire and as an equalizer for circuits with 135-cycle signaling.

12.32 All provisional open wire circuits require Fig. 7.03 in addition to the equalization furnished in the hybrid repeating coil circuits.

12.33 All circuits with 135-cycle signaling require tip and ring blocking capacitors; certain line circuits, at the same time, require the (A) and (B) resistive shunts as well. In these cases, the equalizer elements in the hybrid repeating coil circuits are not used. (See "V" option in Figs. 3.0 and 3.2.)

12.4 Fig. 7.04

12.41 This figure provides means for using the 128-type filters at 2-wire repeater points, some through 4-wire switching points, and at 2-wire terminals of 4-wire circuits.

12.5 Fig. 7.11

12.51 This figure provides a 4-wire equalizer which may also be used on some 2-wire circuits. It consists of a low-frequency series equalizer and a high-frequency shunt equalizer, each of which can be adjusted with some degree of independence.

12.52 On 4-wire circuits, this figure provides input equalization at repeater points.

12.53 The equalization available in the hybrid repeating coil circuit is not satisfactory for nonloaded cable circuits and some of the longer 2-wire repeater sections encountered on order wire circuits. In these cases, Fig. 7.11 is required.

12.6 Fig. 7.12

12.61 This filter, for 4-wire circuits, provides a means for preventing the operation of an echo suppressor by telegraph thump.

13. SPLIT PHANTOM GROUP - SECTION 8

13.1 General

13.11 At special points on line circuits where it is required to equip or terminate the first of the two side circuits of a phantom group while the remaining two circuits go through, the second side circuit requires Figs. 8.01 and 8.02 to balance the effect of the first line equipment.

13.2 Fig. 8.01

13.21 Fig. 8.01 is used to balance a line composite set.

13.3 Fig. 8.02

13.31 Fig. 8.02 is used to balance the effect of a repeating coil and to provide a means for maintaining the through-phantom circuit.

14. FOUR-WIRE TERMINATING CIRCUITS AND ASSOCIATED CIRCUIT FIGURES - SECTION 9

14.1 Figs. 9.01 and 9.11

14.11 Figs. 9.01 and 9.11 provide means for terminating 2- and 4-wire circuits with terminal repeaters. For either circuit the impedance of each pair of terminals is about 600 ohms when the other pairs of terminals are terminated in 600 ohms. These circuits may be employed for very short 2-wire extensions not requiring precision balancing.

14.12 Fig. 9.01 is not suitable for order wire circuits. The loss between either of the 4-wire sides and the 2-wire line can be independently adjusted. For

further details see CD-95137-01 and note 9.0D of the circuit drawing.

14.13 Fig. 9.11 is a resistor hybrid of 10.7-db fixed loss. The theory of circuit operation with 600-ohm terminations is as follows: if a voice-frequency voltage is applied at key lead "F" it will divide at the midpoints of the (C) and (D) resistors, half flowing toward key lead "A" (with "AA" option) and half flowing toward key lead "E." Each of these currents arriving at key lead points "A" and "E" tends to send current towards the (B) and (D) resistors to a common point, key lead "D," but due to the internal turnover in transmission leads between key lead "E" and the (A) and (B) resistors and the symmetry of the circuit, the currents balance out. Thus, when transmitting from key lead "F" to key lead "A" little or no current flows into key leads "D." Likewise, by reciprocity, when transmitting from key lead "D" to key lead "A" little or no current flows into key lead "F." In a similar manner, in transmitting from key lead "A" to key leads "F" and "D" little or no current flows into key lead "E." As employed in this circuit:

Key Lead	Corresponds to the
"A"	2-wire line
"D"	4-wire transmit
"F"	4-wire receive
"E"	balancing network

14.2 Fig. 9.12

14.21 Fig. 9.12 is required for network building out to balance the effect of switchboard cabling and the line building-out capacitance.

14.3 Fig. 9.13

14.31 Fig. 9.13 is used at switching points to obtain good junction return losses. It provides means for building out all of the switchboard circuits to a like impedance.

14.4 Fig. 9.14

14.41 This pad circuit provides means for increasing the transmitting or receiving loss.

14.5 Fig. 9.15

14.51 This compromise balancing network circuit provides means for balancing switched circuits in a 600-ohm switching office.

15. "V3" TELEPHONE REPEATER - SECTION 10

15.1 Fig. 10.0

15.11 This figure shows a 2-way repeater for use on either 2-wire or 4-wire line circuits. It employs two one-way voice amplifier circuits and various battery supply and jack circuit arrangements. These arrangements are shown on the Schematic Drawing mentioned in the box.

15.12 Weak voice currents entering the repeat input via key lead "G" appear at the output, key leads "A" and "B," strengthened by the gain in that direction. Similarly, voice currents entering over key lead "D" appear at the output, key leads "E" and "F," amplified by the gain in this direction. (For details on the amplifiers, see drawing applicable.)

15.13 The input and output impedances of the repeater are approximately 600 ohms. Repeater gains in the two directions of transmission are independently adjustable from about 0 to 35.5 db. The repeaters can be operated at output levels as high as +10 dbm without appreciable distortion.

16. ORDER WIRE - SECTION 11

16.1 Fig. 11.01 - The Order Wire 3-way Bridge Circuit

16.11 This circuit provides an order wire drop at intermediate repeater points.

16.12 This consists of an (IN) and (OUT) pair of 173C repeating coils connected as hybrid coils and a wheatstone bridge circuit interconnecting the two 173C coil hybrids. The 2-wire branches of the (IN) hybrid, via the (ODD) and (EVEN) TRSG pad circuits of Fig. 11.02, are connected across the inputs respectively of the odd and even amplifiers of an intermediate 2-wire repeater. Similarly, the 2-wire branches of the (OUT) hybrid, via the (ODD) and (EVEN) REC pads of Fig. 11.02 are connected across the outputs respectively of the intermediate 2-wire repeater.

16.13 An order wire jack circuit connects via a signaling circuit to the lowest T and R leads while an associated telephone set balancing network connects to the lowest T1 and R1 leads. The (BAL) resistor serves to balance the effect of the signaling receiving circuit which is associated with the order wire jack.

16.14 Normally, the (L) and (N) close limit resistors terminate these T and R and T1 and R1 leads via the normally made contacts of the (SW) relay. When a telephone set is plugged into the order jack, battery is placed on the BR lead, causing the (SW) relay to operate and transfers the connections from the (L) and (N) resistors to the plugged-in telephone set and its telephone set balancing network.

16.15 Arrows in Fig. 11.01 indicate the normal direction of transmission. Outgoing speech or signaling tone entering the T and R leads of the wheatstone bridge are transmitted to the 2-wire branches of the (IN) hybrid, thence via the (TRSG) pads to the inputs of the repeater where they are

mplified and transmitted both ways to the outgoing line circuits. Due to the symmetry of the circuit and to equal gains in the amplifiers of the repeater, the amplified signals entering the 2-wire branches of the (OUT) hybrid are annulled by the turnover in one 2-wire branch so that little or none of the original signals are returned to the wheatstone bridge.

Incoming speech or signaling tone from an input line circuit transverses the associated amplifier of the repeater and is amplified, a part of which is transmitted out to the outgoing line circuit and the remainder entering the associated 2-wire branch of the (OUT) hybrid via the (REC) pad and into the wheatstone bridge. A portion of the energy entering the wheatstone bridge appears as output into the "plugged-in" telephone set, with an equal output being dissipated into the telephone set balancing network. Due to the fair balance between the telephone set and balancing network, little energy is returned to the input of the amplifier. When no telephone set is plugged into the order wire jack the energies are dissipated instead in the (L) and (N) resistors. For this condition a wheatstone bridge balance of about 40 db can be obtained.

16.16 The (N1) and (N2) 733W resistors are compromise balancing networks for the 173C (IN) and (OUT) hybrids.

16.17 The impedance looking into an "IN" or "OUT" terminal with the remaining "IN" and "CUT" terminals terminated in 600-ohm circuits or 300-ohm resistors is normally 3000 ohms. This impedance, when bridged across a 600-ohm line, introduces a shunt loss of 0.9 db.

16.18 The normal loss between an "IN" or "OUT" point and the order wire jack measured between 600-ohm impedances with the remaining "IN" and "OUT" terminals terminated in 300-ohm resistors or 600-ohm lines is about 24 db.

16.2 Fig. 11.02 Transmitting and Receiving Pads

16.21 These pads are impedance building-out resistor pads. Four such pads connect on one side to the 2-wire branch points of the 173C hybrids and one the other side of the bridge across the repeater inputs, for (TRSG) pads, or across the repeater outputs for (REC) pads at the intermediate repeater points. When line circuit conditions require the pad loss to be reduced 5 db, this can be accomplished by reducing the series pad arms from 1000 ohms to 500 ohms and disconnecting the shunt 2700 ohms at the same time.

16.3 Fig. 11.11 - 4-wire 4-way Bridge Circuit

16.31 This figure provides either a 600-ohm low-loss 14.8-db or a 600-ohm high-loss 30-db turn tube circuit. The low-loss circuit requires only series tip and ring resistors, whereas the high-loss circuit employs series tip and ring resistors and shunt resistors.

16.32 The arrows, see Fig. 11.11, indicate the normal direction of transmission. There are four sets of input terminals and four sets of output terminals. The input and output terminals normally associated with a 4-wire line are given the same small letters as a, b, c, and d. Each input terminal connects to a "V3" amplifier output and each output terminal connects to a "V3" amplifier output.

16.33 Speech currents entering at an input terminal "a" transverses the three direct paths of equal (14.8 or 30 db) loss to the output terminals "b," "c," and "d." Due to a turnover introduced as shown in each face of the "cube" circuit figure, little or no current appears at output "a" to be returned to the other side of the fourth circuit as an echo.

16.34 Similarly, because the 4-way bridge circuit is symmetrical, the following three other circuit paths exist:

(a) Tone entering the input terminal "b" appears, attenuated by the circuit, at the outputs "c," "d," and "a," little or no tone being returned to output "b."

(b) Tone entering the input terminal "c" appears, attenuated by the circuit, at the outputs "d," "a," and "b," little or no tone being returned to output "c."

(c) Finally, tone entering the input terminal "d" appears, attenuated by the circuit, at the outputs "a," "b," and "c," little or no tone being returned to output "d."

16.4 Fig. 11.12 Jack and 600-ohm Termination

16.41 This circuit provides termination for the fourth leg of Fig. 11.11 when the fourth 4-wire circuit is not equipped.

16.5 Fig. 11.13 Termination Switching Relay

16.51 This circuit is normally employed at terminal repeater points. It is inserted between the transmitting 4-wire side of the resistor hybrid circuit, Fig. 9.11, and the terminal transmitting side of the "V3" repeater, Fig. 10.0.

16.52 When a telephone set is plugged into the associated terminal order wire jack, battery is placed on the BR lead,

causing the relay (SW) to operate, thus closing the path from the resistor hybrid and the transmitting side of the terminal repeater. With the order wire jack cleared, relay (SW) releases, breaking this path and placing 600-ohm terminations T1 and T2 on the opened leads.

16.6 Fig. 11.14 Line Relay

16.61 This circuit for "N" order wire serves to normally disconnect the order wire jack and its multiples from the drop side of the line-bridging repeating coil of the order wire circuit. When a telephone set is plugged into the order wire jack, battery is placed on the BR lead, causing the relay (L) to operate and complete the transmission path through the made relay contacts.

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