E2-TELEMETRY DATA FACILITIES
MAINTENANCE CONSIDERATIONS

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1. GENERAL

1.01 This section provides information for the maintenance and administration of E2-telemetry data networks. It does not contain maintenance information for telemetry networks required in the application of E2A telemetry such as Telecommunications Alarm, Surveillance and Control System (TASC), the E3 Alarm System, and the ESS Switching Control Center (ESS-SCC). This section is necessary to accommodate the use of the nonstandard data set in E2. E2A telemetry uses the Bell standard 202T data set in private line applications and the 202S in DDD applications. Maintenance of the E2A data sets is given in Section 592-031-500 for the 202T and Section 592-860-500 for the 202S. Data facility maintenance for E2A applications is specified in Section 314-410-300, "Voice Bandwidth Private Line Data Circuits, Maintenance." These considerations are an essential part of the successful implementation and utilization of E-Telemetry Systems. They are particularly important when recognizing the critical role of E2-telemetry use in the many centralized maintenance systems, such as Surveillance and Control of Transmission Systems (SCOTS) and T-carrier Administration System (TCAS).

1.02 This section has been reissued to clarify the contents and purpose of the section as stated in 1.01.

1.03 Emphasis must be placed on the need to treat the maintenance and administration of all E2-telemetry data networks in a manner as near standard as possible. Proper preservice engineering can be the key to providing accurate and continuous service of this Bell System surveillance and control system. Each network leg should have adequate make-good facilities, when possible, to minimize downtime in the event a failure occurs. Engineering should also be aware that maintenance service may require certain agreements when the E2-telemetry facilities cross operating company boundaries and state lines. Because of the established maintenance organization within the Bell System, the maintenance responsibility of E2-telemetry data service ***should*** be assumed by the private line data personnel and ***not*** by the equipment maintenance craft personnel.

1.04 The data channel should be designed by the Customer Service Engineering (or equivalent) organization using the standard techniques applied to customer applications. This design is defined as an unconditioned 3002 multipoint private line data service engineered in accordance with Sections 865-100-101 and 880-420-101 (formerly AB27.350). When the data channel design meets these criteria, good maintenance will be easier to accomplish.

1.05 The most common error in engineering and maintaining E2-telemetry data networks is to treat them as order-wire or maintenance circuits. This approach is a natural outgrowth of philosophy used with previous alarm systems such as B1, C1, or D1, which operate via the transmission of tone bursts to convey information between locations. As a result of the very slow information rate, facility parameters and impairments have little effect on the ability of these systems to perform properly. In order to have the update times required for large scale centralized maintenance systems, the E2-Telemetry Systems use frequency-shift-keying (FSK) data sets at 600 bits-per-second (BPS) which require a well-engineered and maintained data network.

1.06 In order to maintain the network properly once it is engineered, it is imperative that it be treated in a standard manner so the circuit order layout record (COLR) cards will be completed and distributed to the offices responsible for the network. Additionally, ***standard techniques*** call for private line data networks to be routed through special service test boards and provided with access to data test centers (DTC). The latter point is important since it is difficult to maintain and troubleshoot a network of any type adequately if access to the proper test equipment and personnel is not made available.

1.07 The responsibility of the DTCs and serving test centers (STCs) for the E2-telemetry data network should be no different from any other data service. It is necessary, however, for the test centers to be made aware of the existence of the E2-Telemetry System and how to administer problems concerning it.

1.08 Each particular E2-telemetry application has priorities which must be weighed economically against inclusion of available make-good (or alternate) facilities to provide service continuity in the event of equipment or facility failure. Network engineering should include some restoration capabilities, which can vary from full-time dedicated backup for key facilities to a plan for utilizing available spare channels between locations at the time restoration is required. A network must be made good as soon as a trouble is sectionalized if ***any*** form of restoration capability is available and before detailed troubleshooting procedures are implemented. The length of time a system is allowed to remain out of service before a make-good is provided is at the discretion of the E2-telemetry central office with respect to location and function of the sectionalized trouble. It is recommended that preplanned, readily accessible make-goods be available at STCs as a minimum network design. Restoration capability can then be put up on either alternate or low-priority channels when required.

2. E2-TELEMETRY SYSTEM DESCRIPTION

A. System Description

2.01 The E2-Telemetry System provides the capability for remote alarm reporting, status reporting, and remote switch control. Typically, the system can be used for the management and maintenance of broadband systems, traffic networks, short- and long-haul carrier systems, and for similar applications.

2.02 Remote station equipment is usually multipurpose, while the central station equipment dedicates the system to a specific application. Transmission of information between locations is by 600 BPS data words on 4-wire voice-frequency data channels. The data modems apply FSK binary signals to the line at normal data levels.

2.03 Figure 1 shows a typical E2 remote station. The data set circuit packs are identified in one callout and a jack panel for facility access is presented in the other callout. Variations to Fig. 1 do exist, depending upon the system requirements. The E2 central office station has similar equipment arrangements. More detailed information of central station equipment is provided in Sections 201-644-ZZZ.

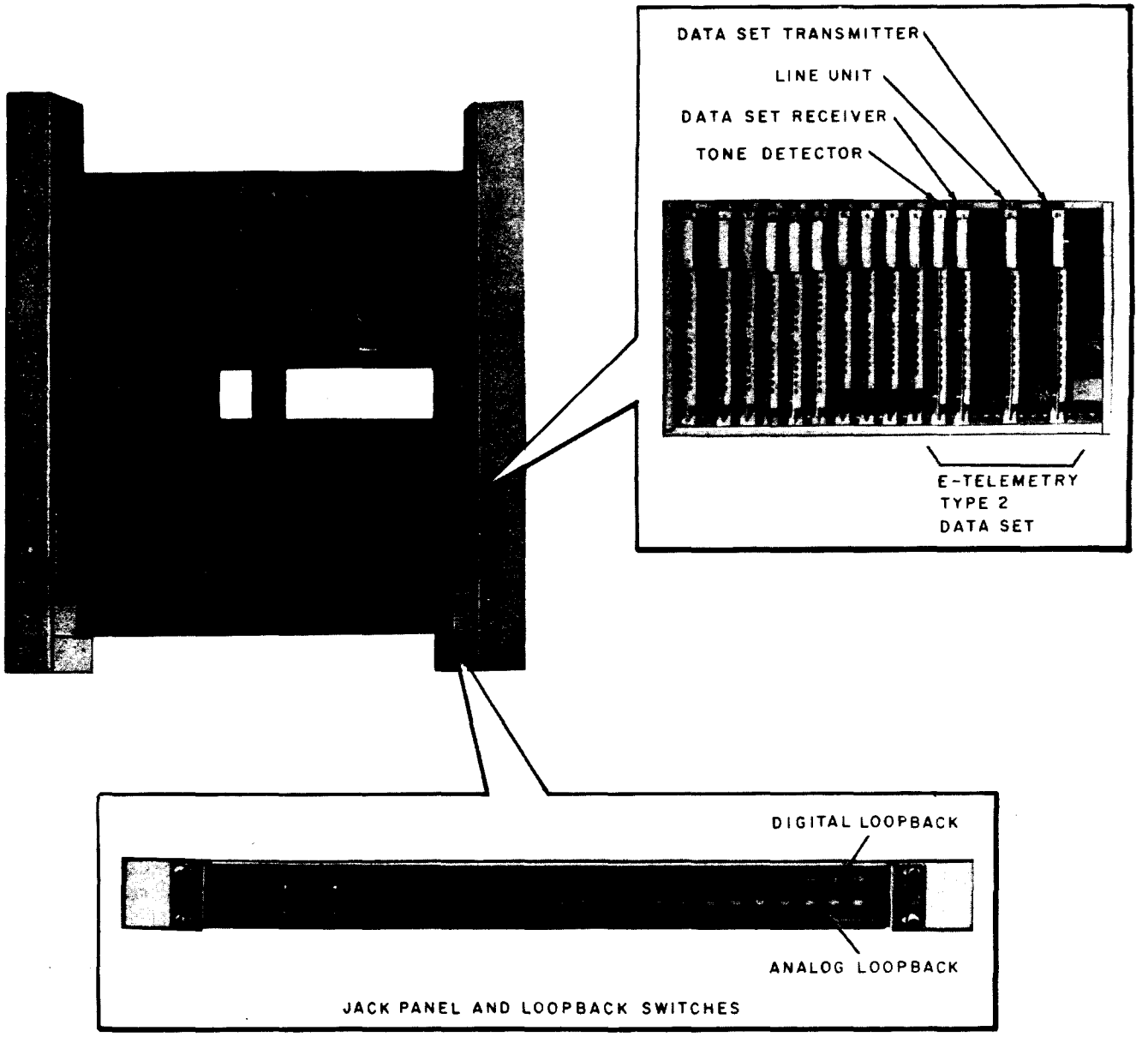


Fig. 1—Typical E-Telemetry Equipment Arrangement

B. Data Set Description

2.04 The data set as shown in Fig. 1 is similar in operation to other Bell System 202-type data sets. It is nonstandard because it is not contained in a typical data set housing, and the circuit packs are not interchangeable with other 202-type sets. Another significant deviation from the standard 202-type data sets is the method of carrier acquisition. The E2-telemetry data set uses a tone detector and provides for fast carrier acquisition (approximately 4 ms) turn-on time. Immunity to out-of-band signals is reduced, but is acceptable when the data set is used exclusively in private line polling systems. Another important difference in the E2-telemetry data set is that the tone detector is factory-adjusted for a sensitivity to just accept the lowest level data signal encountered in a private line channel designed to 3002 specifications. The data set 202D used in private line applications has a sensitivity of about 12 dB greater than this since it is sometimes used in Dataphone® applications. As such, a 12-dB pad is placed in front of the data set 202D when used in private line polling application to make it less sensitive to noise. A 12-dB pad must ***not*** be used with the E2-telemetry data set since this level difference is already accounted for inside the tone detector.

2.05 The E2-telemetry data set is physically integrated into the remaining E2-telemetry equipment. This provides the desired compatibility for power requirements and interfacing. As a result, the standard EIA interface and associated testing capability are not available. However, the E2-telemetry data set remains line compatible with 202-type data sets and operates in the loopback mode with either a data set 202D-type or 202R-type at the DTC or other test location.

C. Identification of Data Set Circuit Packs

2.06 This part provides a brief description of the data set circuit packs, their present manufacture rating, and source references for expanded coverage, should the information be desired. Manufacture discontinued (MD) circuit packs are included because they are still used in the field, and maintenance considerations must be provided for all E2-Telemetry Systems.

2.07 An E2-telemetry data set requires four circuit packs, as shown in Fig. 2. The data set can be maintained using instructions provided in Sections 201-644-503 and 201-644-504 for E2 central station and E2 remote station, respectively. A functional description of the data set is listed in the following paragraphs.

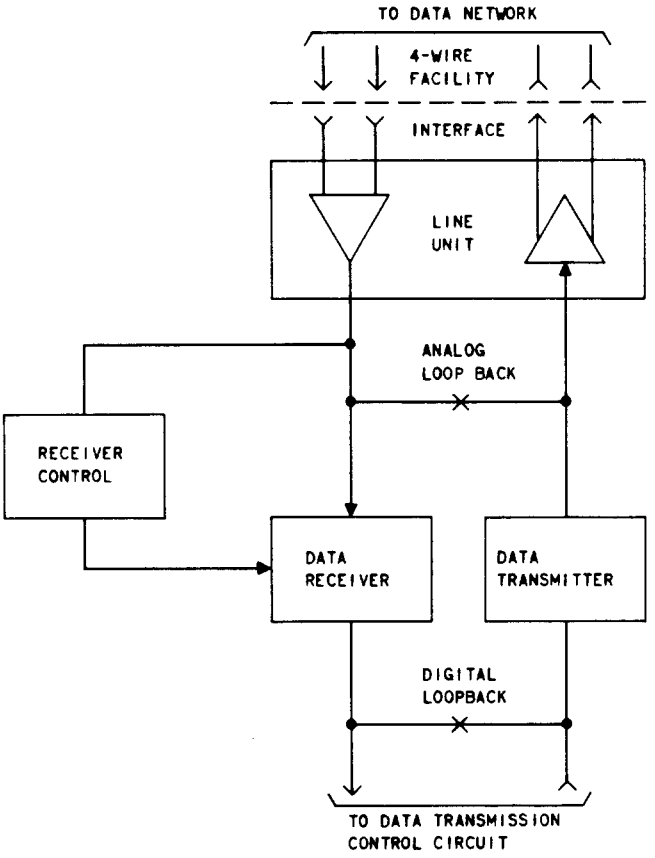


Fig. 2—Typical E-Telemetry Data Set—Block Diagram

Line Units

2.08 The line unit provides the E2-telemetry interface to the 4-wire facility. The various line unit circuit packs available and their present status is provided in Table A. Nominal transmission level points are summarized in Table B.

2.09 Block diagrams for circuit packs (CP) 118 and 119 are given in Fig. 3 and 4, respectively. The major difference between the two is that CP 119 contains a built-in, 4-way, 4-wire bridge. Both circuit packs provide transmission level points (TLPs) of -16 and +7 dBm, which are compatible with standard carrier system TLPs.

TABLE A

CIRCUIT PACK	STATUS	SD REFERENCE	NOTES
118	MD	1C301-01-J2	1
119	A&M	1C301-01-J1	1
120	MD	1C301-01-J2	1
134	Std	1C301-02-J1	2
219	Std	1C301-02-J3	2

Notes:

1. Used with data sets controlled by SD 1C301-01 only.
2. Used with the 600-bps data sets controlled by SD 1C301-02 only.

TABLE B

LINE UNIT CIRCUIT PACK CHARACTERISTICS

UNIT	TRANSMIT TLP	RECEIVE TLP	COMMENTS
CP 118 (MD—Replaced by CP 134)	−16	+7	Standard multiplexer levels recommended for applications where the data set will be connected to carrier equipment and bridging is not required, eg, where the data set is at the end of a spur on an auxiliary channel portion of a network.
CP 119 (A&M—Replaced by CP 134 or CP 219, depending on application)	−16	+7	Standard multiplexer levels recommended for applications where the data set is connected to carrier equipment and bridging is required but standard office bridging arrangements are not usually provided, eg, where the data set is located in the middle of a network composed of auxiliary channel equipment. *Not* recommended for general multipoint use.
CP 120 (MD—Replaced by CP 134)	+13	−3	Standard data set levels recommended for general multipoint network applications.
CP 134 (Std)	+13 or −16	−3 or +7	Standard data set levels recommended for general multipoint network applications. May be optioned at the time of installation for use with carrier systems with or without 4-way split bridge.
CP 219 (Std)	−16	+7	Standard multiplexer levels recommended for applications where data set is used in an E2-Telemetry System associated with L4 and L5 coaxial systems equipment and bridging is required, but standard office bridging arrangements are not usually provided; eg, where the data set is located in the middle of a network composed of pairs within the L4/L5 cable sheath. *Not* recommended for general multipoint use.

2.10 The block diagram of Fig. 3 also applies to CP 120. The distinctive feature of CP 120 is that it has TLPs of +13 and -3 dBm, which are compatible with standard data set TLPs.

2.11 All of the above line unit CPs have been rerated as listed in Table A. These units have been replaced with CP 134 (see Fig. 5), which provides ***either*** set of TLPs as an option, and also provides an optional built-in bridge. The CP 134 bridge is a 4-way, 2-wire, (ie, split bridge) arrangement which is applicable to standard broadcast polling applications.

> ***Note:*** CP 219 (see Fig. 6) is required in those applications utilizing remote call-up (ie, remote-to-remote communications). To date, the only application of remote call-up is in conjunction with the use of E-telemetry monitoring of L-carrier systems.

2.12 For those line units which contain built-in bridges, provision is made to terminate unused ports by strapping options on CP connectors. The use of built-in bridges is a nonstandard arrangement requiring special maintenance considerations which will be discussed in Part 3.

Tone Detector

2.13 The block diagram for the tone detector CP 218 is shown in Fig. 7. It is rated as standard and provides control circuitry for the E2-telemetry receiver. The circuit provides two stages of limiting, with gain adjustment on the first stage allowing the signal threshold to be set so that TP5 is less than 0.5 volt (a logic 1) when a signal level of -29 dBm is provided at the input.

2.14 An R-C timing network provides a nominal 2.5-ms turnoff delay. The turnon delay is controlled by a second R-C network which operates at a nominal 4 ms.

Data Set Receiver

2.15 The block diagram for the data set receiver CP 229 is shown in Fig. 8 and is rated standard. The demodulation scheme is similar to the operation of the 202R-type data set. The logic output signals are applied to the E2-telemetry data transmission control circuits for processing.

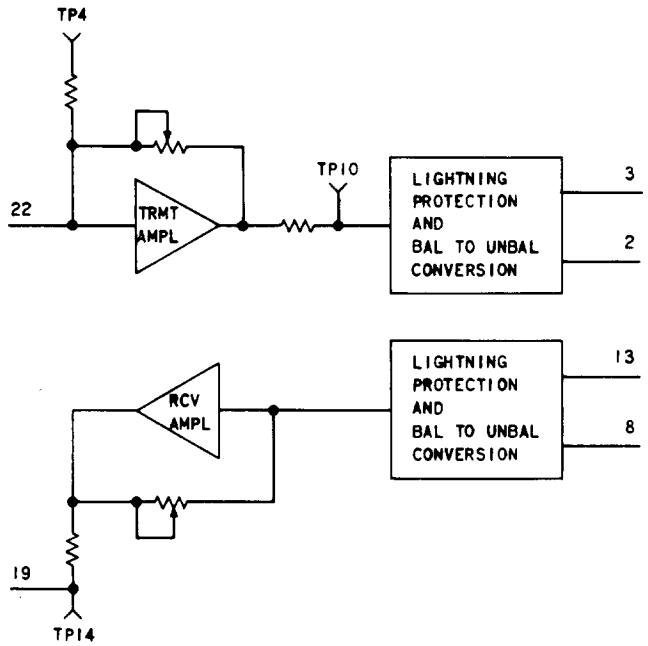


Fig. 3—Block Diagram for Line Unit Circuit Packs 118 (MD) and 120 (MD)

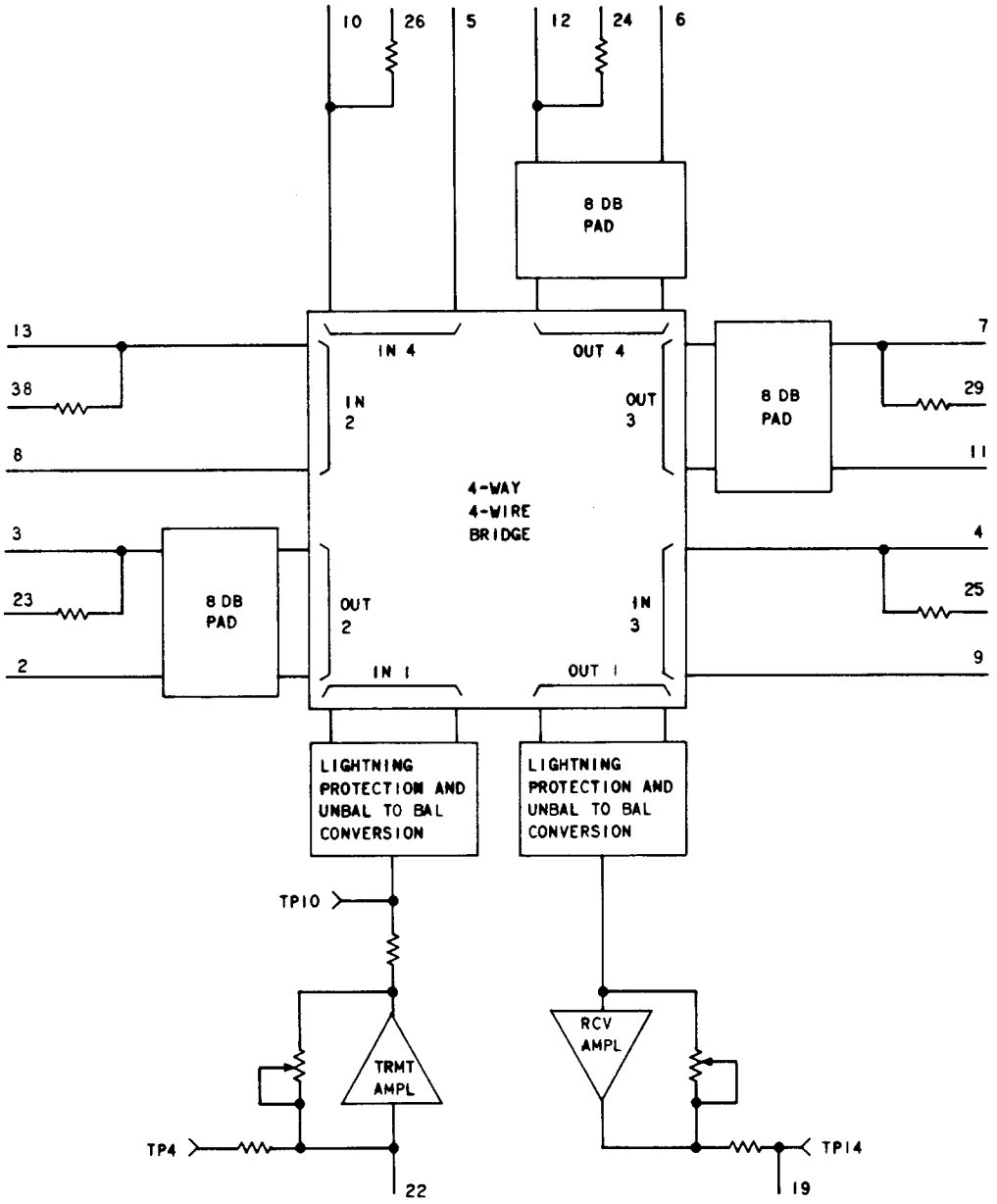


Fig. 4—Block Diagram for Line Unit Circuit Pack 119 (A&M)

Data Set Transmitter

2.16 The block diagram for the data set transmitter CP is shown in Fig. 9. There are two transmitter CPs, and both are represented in Fig. 9. CP 129 is rated A&M and is available only for the maintenance of existing E2-Telemetry Systems originally equipped with that CP. CP 220 is rated standard and differs from the CP 129 circuit by the manner in which the transmitter is terminated. CP 220 is always required in conjunction with line unit CP 134 or CP 219.

Loopback Keys

2.17 The jack panel provides access to the line facility or the data set. Loopback keys are provided on the jack panel to permit attendants to assist a distant DTC or STC to test the facility or the local data set. These tests cannot normally be performed without interrupting service on the remainder of the network. The ANALOG LOOPBACK key provides proper terminations to the data set while routing the incoming line signal back to the testing station. The DIGITAL LOOPBACK key

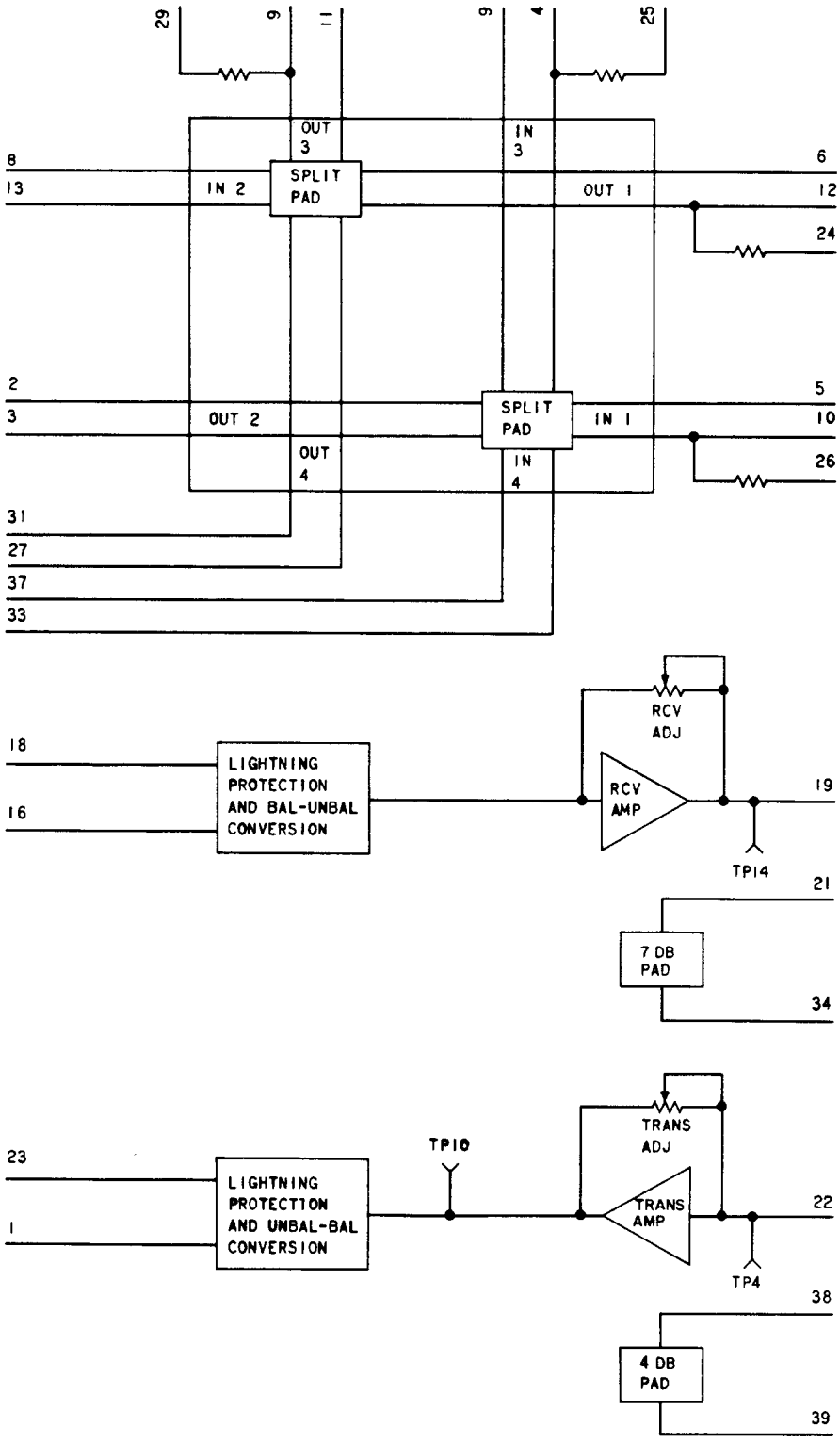


Fig. 5—Block Diagram for Line Unit Circuit Pack 134 (Std)

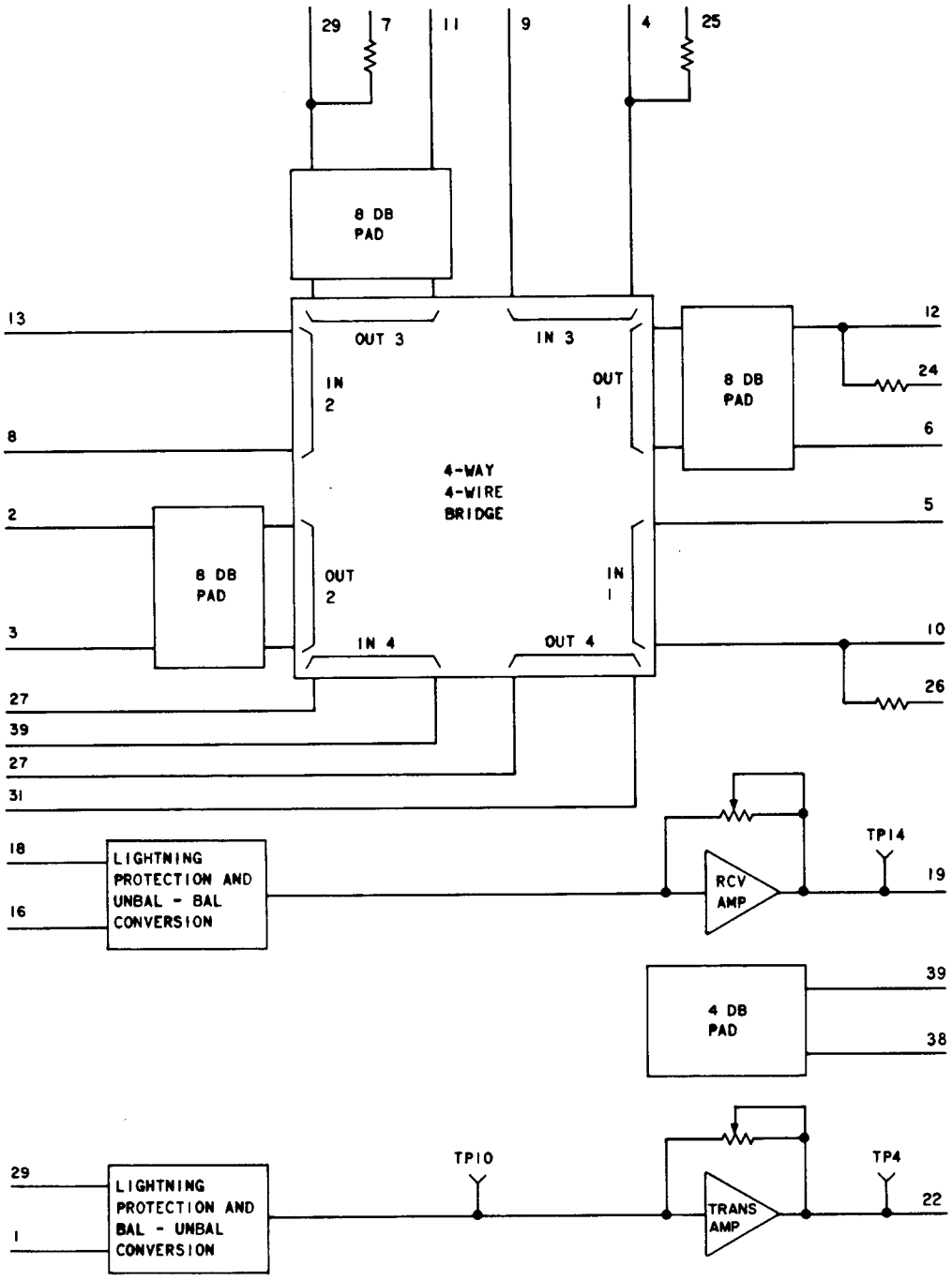


Fig. 6—Block Diagram for Line Unit Circuit Pack 219 (Std for RCU Systems)

provides proper termination to the E2-telemetry logic circuits while routing the demodulated line signal back through the data set transmitter to the testing station. The testing station can inform the attendant which loopback key to operate and use this feature to evaluate the condition of the local equipment.

2.18 Tests may be conducted locally using the jack panel access into and out of the line unit CP. Tests may also be performed from other points in the network if they are equipped with data test equipment and proper data sets.

D. Data Regenerators

2.19 A network containing data regenerators must be treated in a unique manner. The data regenerator is used to extend the E2-Telemetry System when the network size exceeds the maximum allowed by 3002 requirements. The data regenerator should not be used as a substitute for good engineering practices in normal size networks. It is recommended for network maintenance that, wherever possible, regenerators be installed only in those offices capable of operating as a plant control office (PCO). Since a data regenerator is

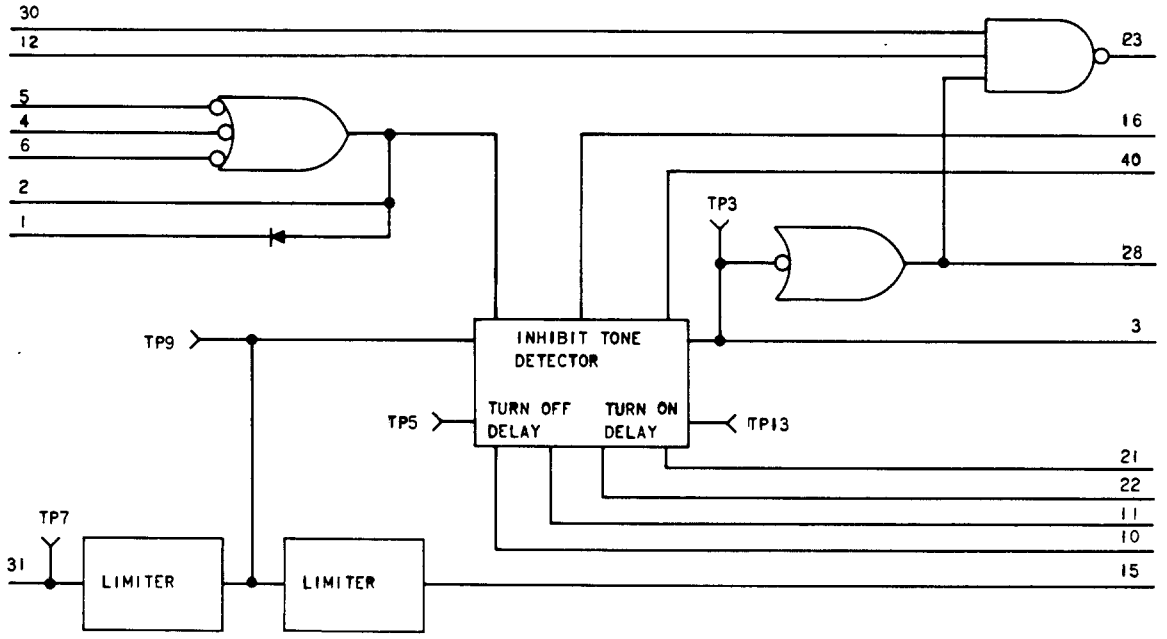


Fig. 7—Block Diagram for Tone Detector Circuit Pack 218 (Std)

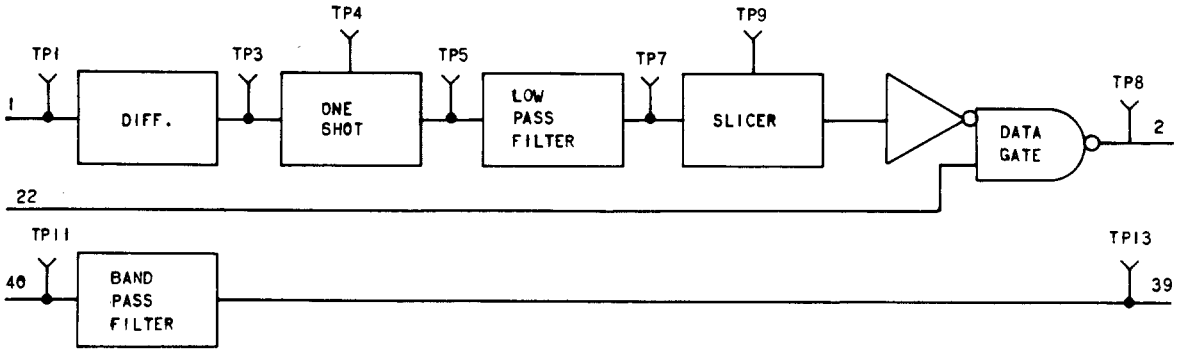


Fig. 8—Block Diagram for Data Set Receiver Circuit Pack 229 (Std)

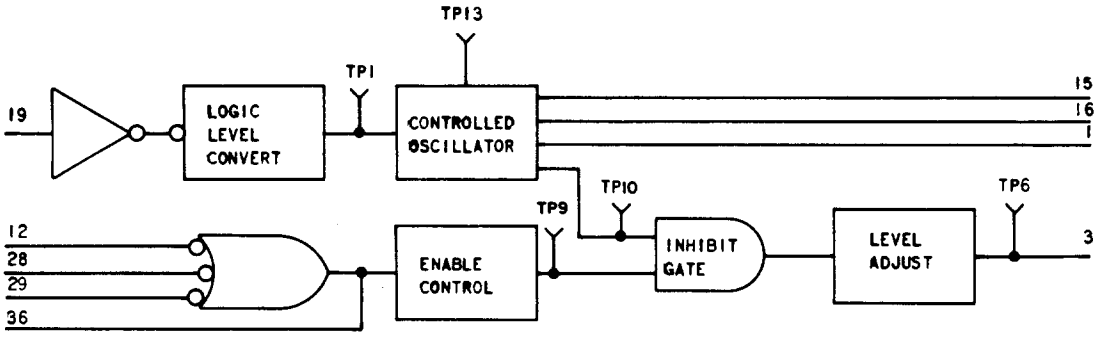


Fig. 9—Block Diagram for Data Set Transmitter Circuit Packs 129 (MD) and 220 (Std)

incapable of passing a test tone or data test signal, the network sections between regenerators must be treated as separate 3002 data networks and individually tested as such. It will be the responsibility of the PCO assigned to the data channel between regenerators (or from a regenerator to the end of the network) to perform any tests required to maintain that portion to 3002 standards. That responsibility shall exist from the LINE IN to LINE OUT jacks on the regenerator.

2.20 Figure 10 illustrates a large multipoint network with a data regenerator installed at STC "B," allowing expansion of the network beyond the 6-link restriction of the 3002 specification. In this example, the portion of the network between STC "A" and STC "B" is maintained to 3002 parameters jointly by the two STCs. The 3002 data circuit is defined from the VF IN and VF OUT jacks at the E2 central to the LINE OUT and LINE IN jacks at the regenerator. STC "A" would normally operate as the network control office (NCO) in an arrangement of this type. The remaining portion of the network, that beyond STC "B," is maintained solely by STC "B." The 3002 specification in this case applies from the LINE IN and LINE OUT jacks at the regenerator to the VF OUT and VF IN jacks at the far-end stations.

2.21 The data regenerator itself shall be tested and maintained as a separate entity according to Section 201-644-510 pertaining to that equipment. It should be reemphasized that it is not possible to test through a data regenerator with any signal other than one with E-telemetry format. A detailed description of the data regenerator is contained in Section 201-644-110.

E. Network Arrangments

2.22 Depending upon the type of central station used, one or more data networks may be connected to a central. Three common types of networks are briefly described for maintenance considerations.

Hub Arrangement

2.23 The arrangement of a data network has a very pronounced effect on its maintainability and reliability. A hubbed network, as shown in Fig. 11, is preferred for ease of maintenance since all legs of the network are accessible from a single STC. Trouble sectionalization and location can be done rapidly since coordination with other offices is not required. The hubbed network also allows full advantage to be taken of the capabilities of the 829-type data auxiliary set. These data auxiliary sets may be used to provide the terminating interface between the serving facility and the E2-telemetry remote, and provide the ability for remote line-side loopback from an STC. Reliability of the hubbed arrangement is excellent, assuming that the circuits do not enter the STC on a single carrier system or cable, since a single facility failure will result in the loss of only one far-end station.

Tree Arrangement

2.24 The general multipoint or tree network shown in Fig. 12 is probably the most common arrangement that will be encountered. In most cases, facility availability, design application, and economical use of facilities will dictate this type of network rather than the more desirable hubbed configuration.

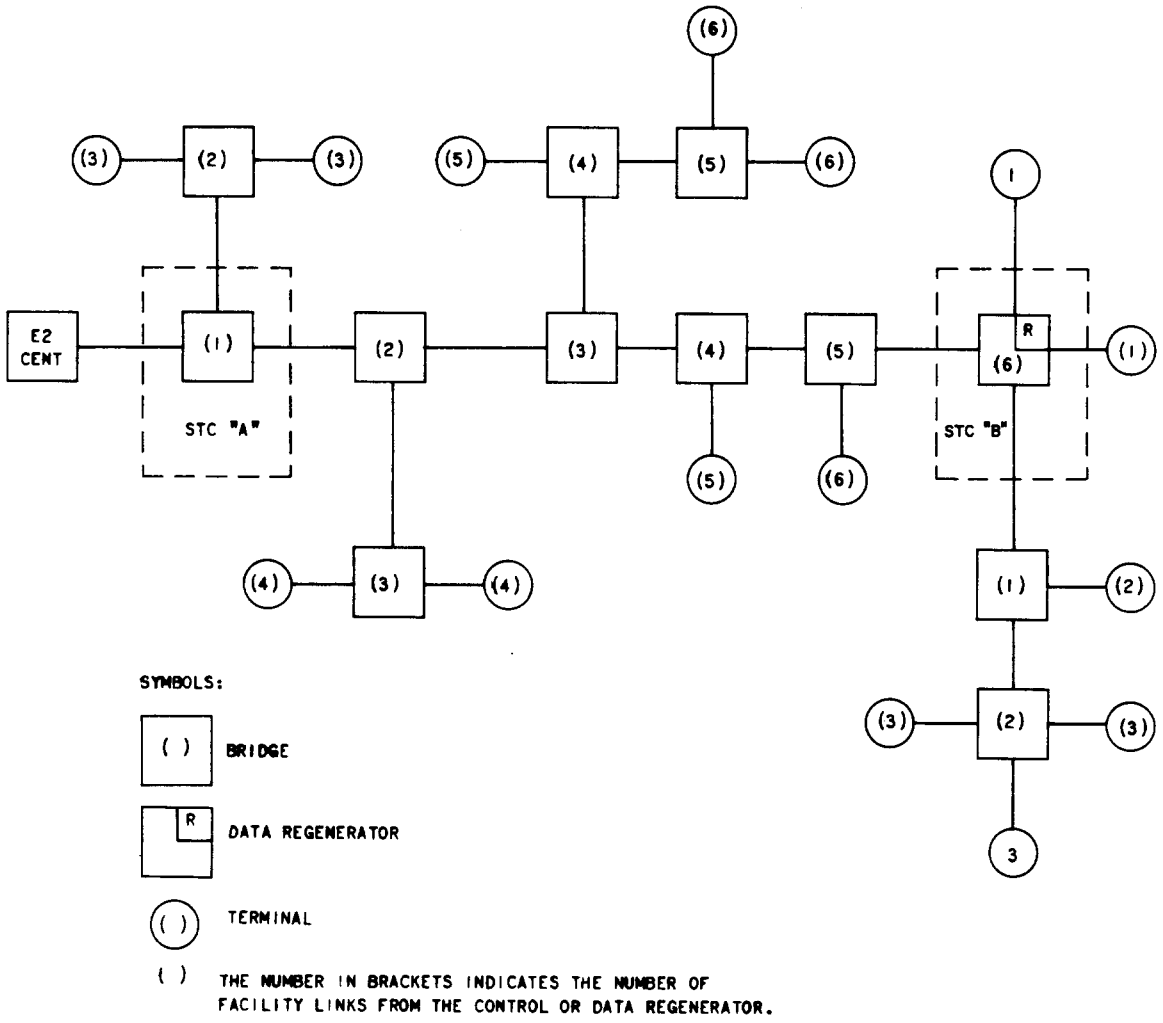


Fig. 10—Large Multipoint Network Illustrating the Use of a Data Regenerator

2.25 If each bridging point is located in a manned office designated as an STC, nearly the same capabilities may be realized as in the hubbed network. Trouble location may be somewhat slower due to the coordination required between offices, however. The effect of a single facility failure will vary depending on its location. Consideration should be given to alternate routing for restoration or make-goods during the initial engineering stages of this type of network. At a minimum, those facility sections serving as backbones between bridges should have preplanned make-goods available in the event of a failure.

Route-Oriented and Nonstandard Arrangements

2.26 The straight-line or route-oriented type of network shown in Fig. 13 should be avoided if at all possible. This type of facility layout results in a network that is extremely hard to maintain due to the presence of bridges in unmanned offices along the route. Unless personnel can be dispatched to several offices along the route simultaneously, sectionalization and trouble location will be time-consuming and difficult. A single failure can affect the entire network; and with bridging at unmanned locations, a make-good may be impossible to perform without dispatching personnel. The expected downtime in the event of almost any type of failure on a route-oriented network will by necessity be high; this must be considered in light of the system usage and service priorities. Additional downtime will probably be encountered since the personnel dispatched to the unmanned sites may be equipment maintenance people unfamiliar with data testing. There is presently no standard way to perform remote loopback tests on this type of network, since the 829-type data auxiliary sets are

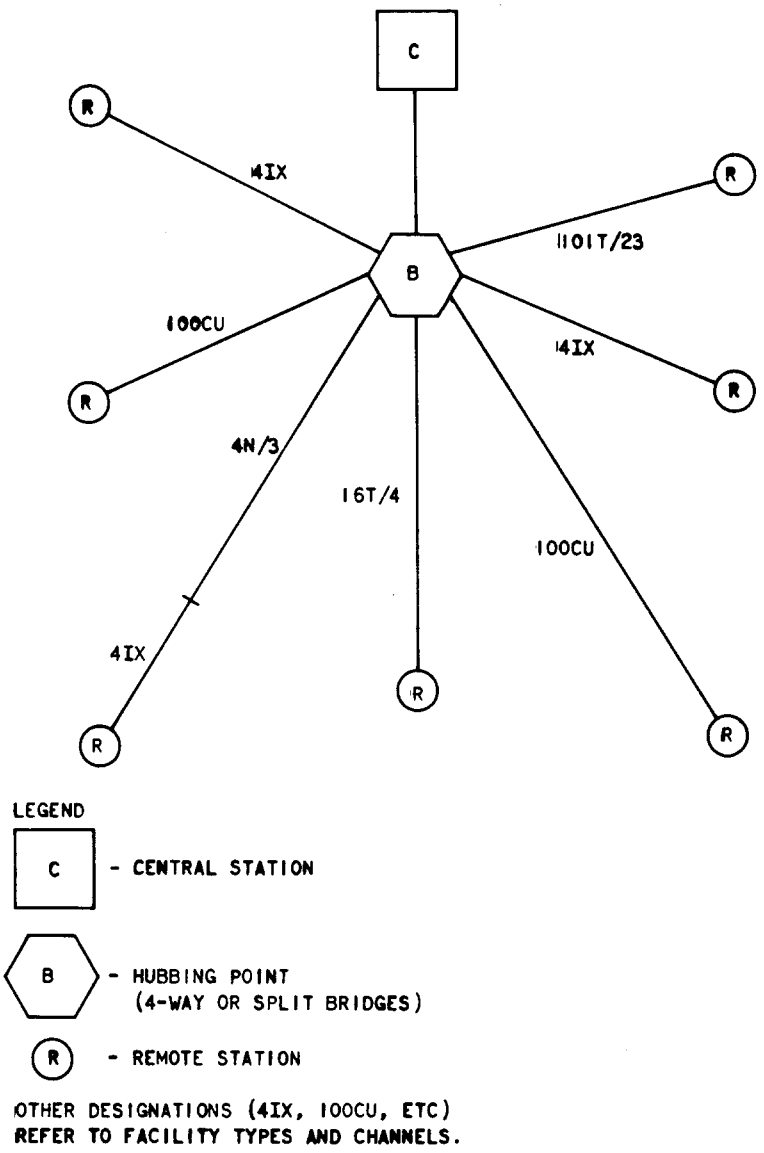


Fig. 11—Hubbing Configuration

not capable of the selective operation required in this case.

2.27 A special case of the route-oriented layout is likely to be encountered in conjunction with microwave radio routes. This special arrangement utilizes KS-20999 multiplex equipment on radio auxiliary channels. This multiplex employs baseband bridging, and special techniques are required to sectionalize and make measurements in this type of system. These techniques are discussed in Part 3. It is recognized that in many long-haul applications, the auxiliary channel may be the only means of providing data facility access to particular terminal stations. If, however, a choice exists, it is desirable to choose the more standard data layout arrangements.

2.28 Because there is considerable reluctance to bring auxiliary channel circuits into special service test boards or DTCs, test and troubleshooting capabilities are in many cases severely limited. Also, with no private line board appearance, it is likely that the required preservice tests will not be performed. It is recommended that STCs and DTCs be used if at all possible.

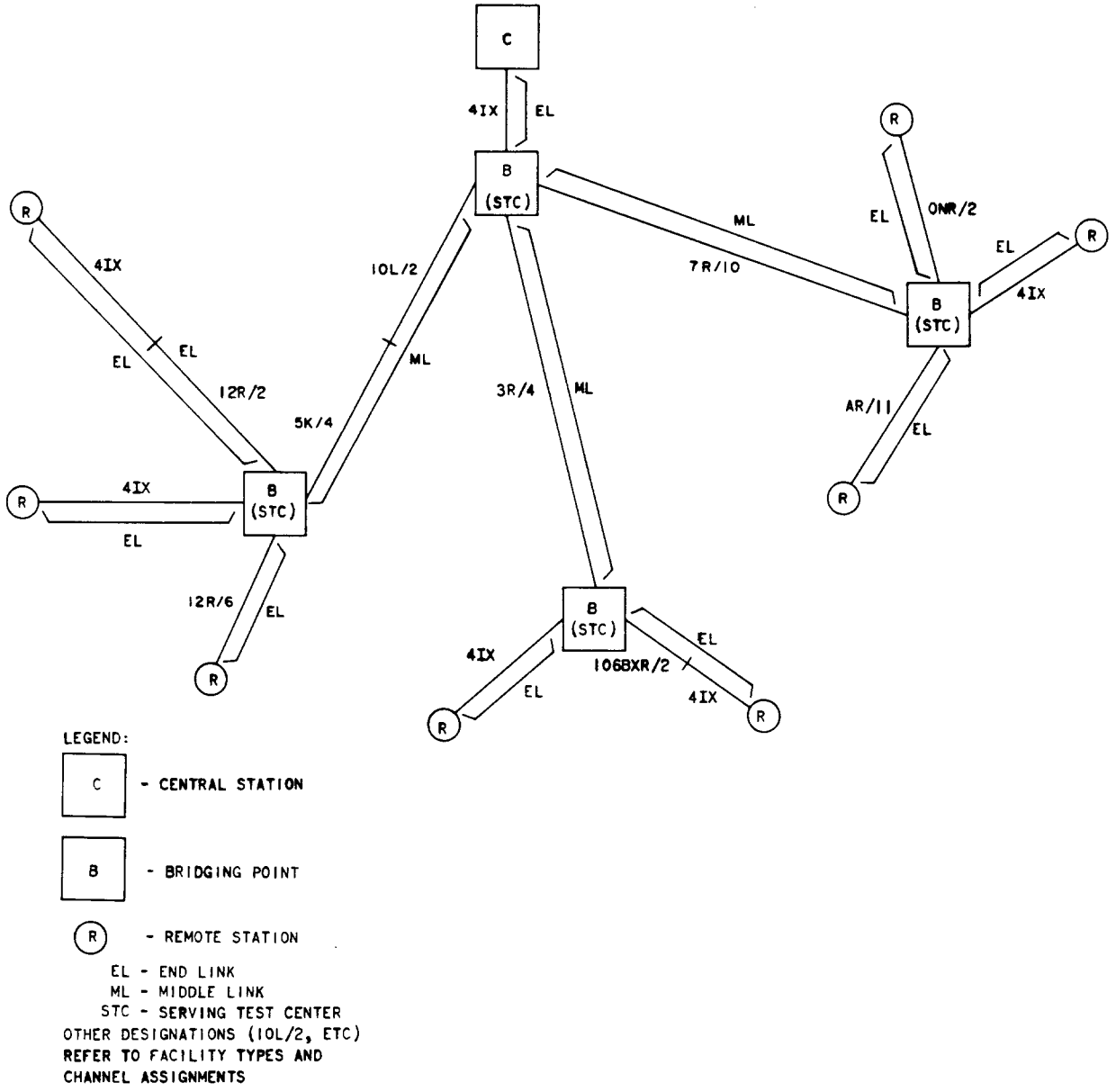


Fig. 12—General Multipoint Tree Configuration

2.29 One particular problem that must be considered during the initial engineering stage, if not during the route layout, is the effect on the network integrity if the auxiliary channel is taken across area boundaries at baseband. In general, if it is at all feasible, the auxiliary channel should be brought to voice frequency at the area boundary.

3. MAINTENANCE CONSIDERATIONS

3.01 Good maintenance begins with a properly engineered data network. In this context, "properly engineered" is defined as an unconditioned 3002 multipoint private line data network engineered in accordance with Sections 865-100-101 and 880-420-101. The network should be designed by the Customer Service Engineering, or equivalent, organization using standard techniques such as those applied to customer data network applications.

3.02 In order to maintain the network properly once it is engineered, it is imperative that it be treated in a standard manner so that COLR cards will be completed and distributed to the offices responsible for the network. Additionally, standard techniques call for private line data

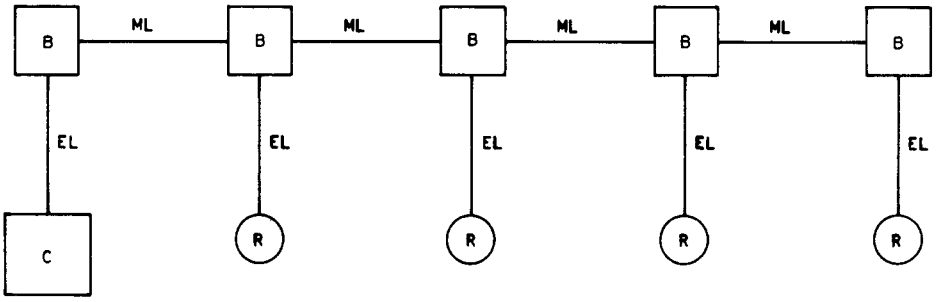


Fig. 13—Basic Route Configuration

networks to be routed through special service test boards and also have access to DTCs. The latter point is important, since it is difficult to maintain and troubleshoot adequately a network of any type if access to the proper test equipment and personnel is not made available.

3.03 It should be emphasized that equipment maintenance personnel should ***not*** maintain the data service for E-telemetry. In general, equipment maintenance groups are not equipped with either the proper test equipment or experience to cope with this type of service. However, it is recognized that in some circumstances it will be necessary to enlist the aid of equipment maintenance personnel. A typical example is a radio route served by auxiliary channel equipment where the radio maintenance personnel are also responsible for the VF channels serving the locations involved. In situations of this type, the equipment maintenance personnel should work under direction from the responsible DTC or STC. Equipment maintenance personnel assistance in maintaining or troubleshooting the data network should be minimized and preferably limited to the operation of loopback keys or making required patches and terminations at the far-end locations. If it is necessary for some portion of the data network to be completely maintained by equipment maintenance personnel, it is recommended that the references listed in Part 5 be available at the maintenance centers to which they are assigned. In addition, a brief training program should be conducted to familiarize those personnel with data transmission testing and some of the problems that may be encountered. It should be an "on-going" program with personnel changes.

3.04 The responsibility of the DTCs and STCs where the E-telemetry data network is concerned should be no different from any other data service. It is necessary, however, for the test centers to be made aware of the existence of the E2-Telemetry System and how to handle problems concerning it. This is primarily the responsibility of the Operating Company (Long Lines and/or Associated TELCO) involved, as priorities will differ depending on the telemetry application. In some cases, the operation of the E2-Telemetry System is vital in maintaining the integrity of the switching and transmission plant. The test center personnel should be made aware of this fact and primed to react accordingly.

A. Circuit Transmission Requirements

3.05 The circuit order tests and maintenance procedures for type 2 data sets outlined in Section 314-410-500 are required for ***all*** E-telemetry data networks. That section also lists required test apparatus capable of performing the necessary test procedures.

3.06 To provide effective E2-telemetry monitoring, the facility should meet the nominal transmission levels of the data set at that location. Nominal TLPs for line units available in E2-Telemetry Systems are listed in Table B. All transmission tests ***must*** be performed at data level (-13 dBm0, ***not*** at the stated TLP.

3.07 The concept of TLPs is simply a convenient method of denoting ***relative*** levels throughout transmission systems, with respect to some reference point referred as a 0 transmission level point (0 TLP). The 0 TLP is usually defined at a central office test board. Relative to this point, some fairly standard level points encountered for the carrier facilities are the channel MOD-IN and DEMOD-OUT jacks which are given as -16 TLP and +7 TLP, respectively. This does ***not*** mean that the signal power level at the MOD-IN is -16 dBm. It simply means that the signal power level

at the MOD-IN is 16 dB below whatever level exists at the 0 TLP. A thorough understanding of the TLP concept and the manner in which transmission levels are referenced to TLP is a necessity. A discussion of that concept and its use may be found in Sections 314-410-500 and 865-100-101.

3.08 It should be noted that transmission requirements of an E2-Telemetry System using line unit CP 119 present some difficulty in both circuit order and maintenance testing. Note also that the output ports of the 4-way, 4-wire bridge are padded down 8 dB resulting in a 23-dB through loss instead of the normal 15 dB. The administration of a data network with CP 119 line units must be slightly modified, since standard data offerings do not cover the situation where bridging is accomplished internally to a data set.

3.09 The major difficulty in testing a network using CP 119 is the lack of access to the drop leg (the data set input and output) of the bridge. As a result the bridge cannot be separated from the data set, and any data set tests must be performed through the bridge. If loopback tests are performed, it is recommended that all bridge legs except the one to the DTC be terminated. This is to prevent a possible overload of carrier systems or cables downstream from the data set being tested. With a looped data set, the signal at the output ports of the bridge may be as much as 6 dB high due to an inphase addition of the incoming and looped signal.

B. Nonstandard Arrangements

3.10 There are two types of data networks often used by the E2-Telemetry System which differ considerably from typical data applications. These are the radio auxiliary channels using the KS-20099 multiplex and those systems utilizing the maintenance pairs available in the L4 or L5 coaxial cables.

3.11 The KS-20099 multiplex is a baseband bridged system offering up to 24 voice-frequency channels for use as maintenance circuits, order wires, etc. A description of the multiplex operation is contained in Section 865-100-101 under the heading "Route Oriented Configurations." Circuit order testing presents few problems in this system if two simple rules are followed:

(1) The network must be treated as point-to-point from the E2-telemetry central to each far-end station.

(2) The network must be tested and aligned from the central location out, as adjustment in the near links affects those further down the route.

3.12 Troubleshooting and sectionalization procedures are severely limited when KS-20099 multiplex is used, and the strategy employed must be based largely on experience with a given system. Any measurements made as an aid to sectionalization must be made with the facility in service, as it is not possible to remove the E-telemetry data facility from service independent of the order-wire and maintenance lines. These measurements must be made with carrier system test equipment (37B, 7A, etc).

3.13 If an auxiliary channel system using the KS-20099 multiplex crosses an area or company boundary at baseband, careful consideration ***must*** be given to how the system is to be tested and maintained. The problem may be circumvented if, in the early stages of engineering the auxiliary channel, it is possible to bring the circuits down to voice frequency at the boundary and interface of the two areas or companies at that modulation level. In the more general case, where it is not possible to bring the circuits down to VF, the problem must be handled administratively by assigning the maintenance responsibility on the basis of baseband section rather than geographic boundary. The result of this assignment permits one company to maintain and test the facility at VF, thus reducing the amount of coordination effort required to perform trouble sectionalization.

3.14 An additional limitation in sectionalization is a result of the network layout itself and is not unique to the auxiliary channel application. This applies equally well to L-carrier routes and other route-oriented facilities. A possible action, if a network goes down, is to begin sectionalization tests at the network midpoint. Next, progress to the section in trouble by moving to the midpoint of the facility half found to be in trouble for the next measurement. This procedure must be repeated until sectionalization is made and may require considerable time and travel to accomplish. If the KS-20099 multiplex is used, it ***may*** be possible in

some cases to localize a trouble to a particular switching section by forcing switches to standby or protection channels one section at a time. It must be anticipated that any trouble location in a network of this type will be time-consuming and will result in a considerable amount of service downtime.

3.15 Those applications utilizing L4 or L5 cable pairs or older auxiliary channel multiplex systems can be tested and maintained using standard data facility testing techniques, keeping in mind that sectionalization may be somewhat difficult.

3.16 Prior to testing, it should be determined if the network contains a data regenerator. When regenerators are present, network sections up to but not including the regenerators must be treated as individual 3002 data networks and tested as such. The regenerator is not capable of passing a test tone or data test signal and only responds to a signal with E2-telemetry format. The regenerator itself is ***not*** routined at an annual interval and is maintained as a separate entity according to the Bell System Practices for that equipment.

> ***Note:*** There are very few E2-telemetry data regenerators presently in service.

C. Preservice Testing

3.17 After the E2-telemetry data channel has been engineered, maintenance and repair of any future malfunctions might be expedited if an overall digital sketch and a segment digital sketch for multipoint circuits, as covered in Section 682-300-960-LL and addendums, are included with the COLR cards. This block diagram would be part of the records at each testing and control office and provides faster evaluation of each segment of the network. Notations that alternate circuits are, or are not, available between remotes and would also be valuable information.

3.18 The system must be tested and test results documented before being turned up for service. All circuit order tests for a type 2 data set should be made and accurately entered on the record card. The ability to sectionalize and locate a source of a trouble rapidly, once it is ticketed, is directly dependent on the records kept at NCO, PCO, and STC. Therefore, it is necessary to maintain COLR cards and Forms E-5596 (data transmission history cards) with the latest system changes and results.

3.19 A circuit which has been tested and found marginal should not be put into service until the cause of the marginal condition has been found and corrected. Experience has shown that marginal circuits turned up because of the pressure to meet service dates, or simply because they are considered "good enough," exhibit a long history of troubles and long downtimes. It is more economical to provide a circuit meeting all the requirements from the start rather than trying to correct for marginal or failed requirements after the network is in service. It is the responsibility of the user to remain aware of the circuit order test progress and results. The circuit should not be accepted until all tests have been performed and requirements met.

3.20 An additional condition for acceptance shall be the successful performance of data tests from a DTC and operation of the E2-telemetry central over the network. If it is a new network being turned up for the first time, the DTC should run tests with each far-end station. If the number of stations preclude such tests because of the time required, the expected worst case(s) shall be selected and tests performed with those locations. If stations are added to an existing network, tests shall be required to only those stations unless problems arise due to the extension of the network.

3.21 Loopback tests of the significant transmission parameters must be performed between appropriate points in the network to establish benchmarks for later routine and trouble locating tests. The results of these tests are to be entered on the E-5596 card or a locally generated equivalent.

3.22 Service performance and dependability will be notably better if the circuit is treated in a standard manner and COLR cards are completely documented. All entries listed on the card (MILES, TEST FREQ., etc.), together with a simple circuit sketch when possible, are important and will be valuable to the system if a malfunction occurs. Duplicate copies of these cards should be available at the NCO, STC, PCO, DTC, and special service test boards, as the system requires. Information which may be superflous at one location may be necessary at another location to expedite a repair to the system. Up-to-date information is as important to system maintenance as is access to the proper test equipment and qualified personnel.

D. General Trouble Detection and Restoration

3.23 The E2-telemetry central station personnel should be the first to detect a system malfunction. By using the E2-telemetry central display unit and control features, maintenance personnel may isolate a malfunction with an analysis similar to the pattern shown in Fig. 14. The length of outage for a given trouble can be substantially reduced by good coordination and communication between the E2-telemetry central personnel and the NCO. It should be kept in mind that the E-telemetry operator is, in general, a very knowledgeable data customer. In many cases, the operator can pinpoint network problems by analyzing his console displays. Considering the ability of the personnel and the information available at the console, it is necessary that the E-telemetry personnel provide the NCO with a trouble report which is as complete and detailed as possible.

3.24 Once a malfunction is detected, local procedures for isolation should be followed. If possible, an alternate route should be set up to provide service continuity for remote stations which may be blocked by the malfunction. The ability to provide service continuity on the network through the use of make-good or alternate facilities in the event of an equipment or facility failure must be weighed against the economics of providing that ability and the priorities associated with the particular E-telemetry application. The restoration capability built into the network when it is engineered may vary from full-time dedicated backup for key facilities to a plan for whatever alternate channels may be available between the necessary locations at the time restoration is required. If any form of restoration capability is available, the network must be made good as soon as the trouble is sectionalized and before extensive troubleshooting procedures are implemented. Discretion must be exercised in determining how long to let a system (or part of a system) stay out of service before make-goods are applied.

3.25 It is recognized that the final determination of restoration capability must be based on the availability of facilities, either alternate or otherwise, that may be used for that purpose. It is recommended that, at a minimum, the STCs have preplanned make-goods that are readily accessible and can be put up on either alternate or low-priority channels when required.

E. Detailed Trouble Isolation and Testing

3.26 Following the general system diagnostic discussed above, if the trouble is suspected to be in the facility serving a remote, the first step in trouble location should be line-side loopback testing of the suspect portion(s) of the data network. Line-side loopback capability is normally established by a key operated manually by personnel at the far-end station. If the network is a hubbed or tree configuration using STCs, remotely operated line-side loopback can be established by the use of 829-type data auxiliary set terminating units (or equivalent). In the event that the far-end station is unmanned, then every effort must be made to determine that the trouble is located in that portion of the network before a dispatch is made. However, once the trouble location is pinpointed, maintenance personnel should be dispatched. If loopback keys are not installed and a line-side loopback is desired for transmission tests, Fig. 15 provides the required patching information for the currently available line unit options. In general, a line-side loopback should be performed first to assure that the facility has not deviated beyond the benchmark requirements established during circuit order tests.

3.27 If line-side loopback tests meet the requirements, then a digital (drop-side) loopback should be established and data performance tests conducted by a DTC. It is recommended that access to a DTC be made available, when required, for either circuit order testing or troubleshooting after the facility is in service. If the DTC is located at a point removed from the NCO or the E2-telemetry central location, a patched circuit of known transmission parameters may be used to tie the DTC to the facility to be tested. If a DTC is not available to the control office on the facility to be tested, the tests can be performed from an STC with portable 900-type data test set (or equivalent) equipment or either a data set 202D, 202R, or 202T, whichever is available.

3.28 It should be noted that the data performance test is not totally conclusive in that it does not detect problems that may exist involving start up or turnaround of the data set. It is, however, very likely that if the data performance test is successful, the trouble does not involve the data facility or data set. In that event, the trouble should be referred to the E2-telemetry maintenance personnel as a probable terminal equipment problem.

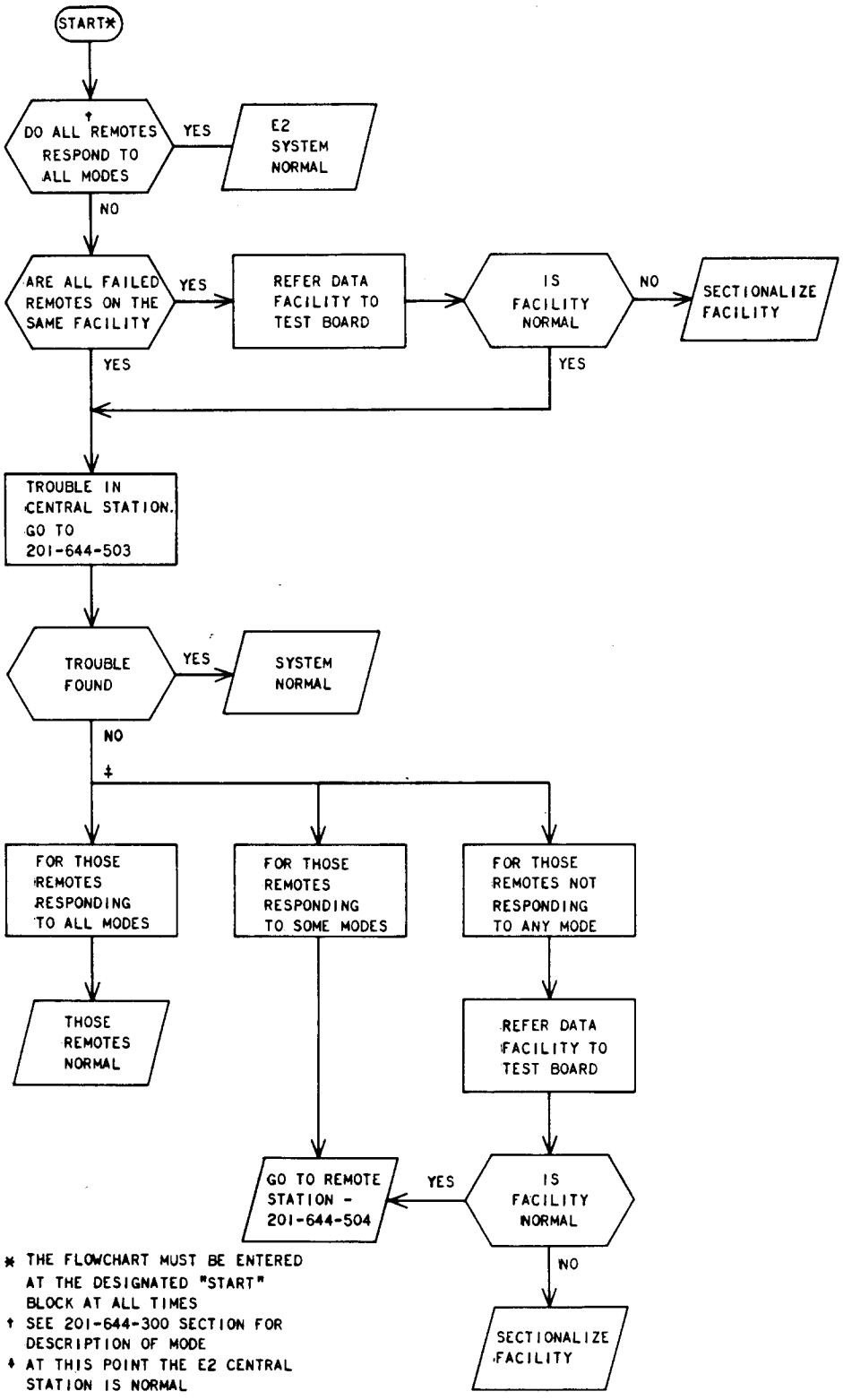
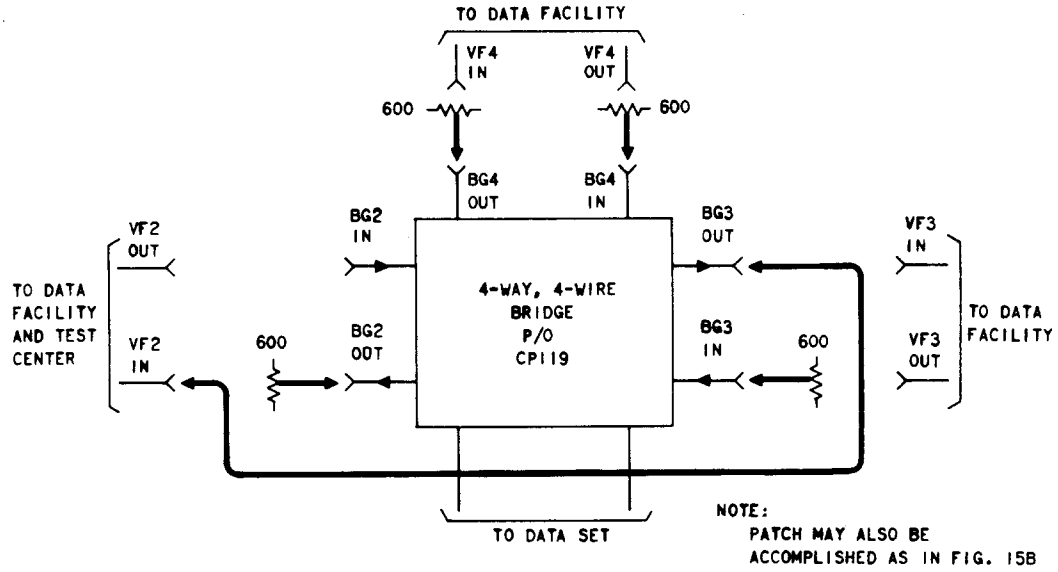
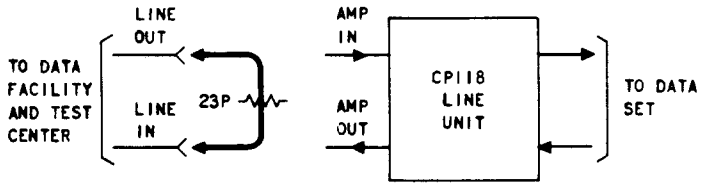


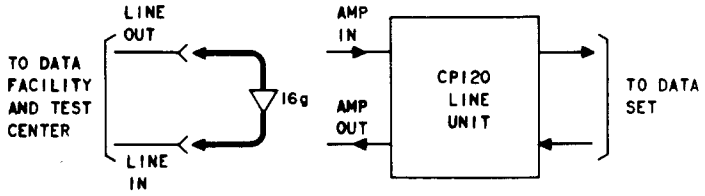
Fig. 14—Initial Diagnosis



A. PATCHED LINE-SIDE LOOPBACK, CPI19 LINE UNIT



B. PATCHED LINE-SIDE LOOPBACK, CPI18 LINE UNIT



C. PATCHED LINE-SIDE LOOPBACK, CPI20 LINE UNIT

Fig. 15—Patched Line-Side Loopback

Data Performance Tests

3.29 There are two basic kinds of data performance tests made from a DTC with the remote data set in the digital loopback mode. Static tests are used to check the responses of the distant data set and provide a gross measure of facility gain characteristics. Dynamic tests provide an indication of the error-rate performance of the facility and the distant data set. When applied to an E2-telemetry network, the data performance test is performed with the distant data set looped back at the point it would normally interface with the E2-telemetry terminal equipment. By operating in this fashion, there is no problem of interface incompatibility with the data test equipment. The distant station loopback key must be operated manually by the remote office attendant for digital loopback.

Static Tests

3.30 The static test provides measurement of facility threshold, receive level, and slicer threshold. For the purpose of this test, these terms are defined as follows:

(a) Facility threshold—The signal level, measured at the sending station (the DTC), at which the distant data set begins to exhibit random tone dropouts

(b) Receive level—The signal level received at the DTC, measured at mark and space frequencies

(c) Slicer threshold—The frequency at which the distant data set makes the mark-space transition.

3.31 The facility threshold measurement provides an indication of the margin remaining at the distant data set receiver after facility variations have been taken into account. Assuming a perfectly flat frequency response and exact lineup levels, that margin should be 16 dB. In practice it is expected that the margin measured will be somewhat less than 6 dB due to facility roll-off, 1000-Hz lineup tolerances, etc. At initial turnup time, the margin must be greater than 8 dB. It is recommended that if during routine testing the measured margin is 4 dB or less, the facility in question should be referred for more detailed testing.

3.32 The receive level measured at the DTC may be used to estimate the condition of the facility from the distant data set to the DTC. It provides an estimate of the 1000-Hz lineup level and facility roll-off by checking the response at mark and space frequencies.

3.33 Measurement of the distant data set slicer threshold provides an indication of the "state of health" of that receiver and detects any bias toward mark or space that could result in an unacceptable error rate. In the loopback mode, the slicer threshold test also provides a quasi-dynamic test of the distant data transmitter. With a tone centered exactly at the threshold frequency of the slicer, the receiver output will be a random series of logic ones and zeros. This random series is then transmitted and may be monitored at the DTC. It should be pointed out, however, that this test is not valid with the E2 600-baud data set as it presently exists, since there is a hysteresis effect present in that slicer circuit which precludes a sharp threshold at a single frequency.

3.34 There are two ways in which an E2 data set may be tested: either locally using standard transmission test equipment or remotely from a DTC. (Tests may also be performed from other points in the network if they are equipped with data test equipment and proper data sets.) The latter is a test of both the facility and data set and may consist of both static and dynamic testing.

3.35 A completely different kind of static test may be performed at the remote office directly on the data set. This is basically an alignment check and employs transmission-type equipment. The static test as performed locally is as follows (see Fig. 16):

(1) Operate loopback key.

(2) Using a 21A transmission measuring set (TMS) or equivalent, apply a 2100-Hz tone at -13 dBm0 ±0.5 dB.

(3) Change the 21A TMS frequency to 1300 Hz; listen on monitor and note frequency shift to a lower note as the frequency is changed. The data set output remains at -13 dBm0 ±0.5 dB.

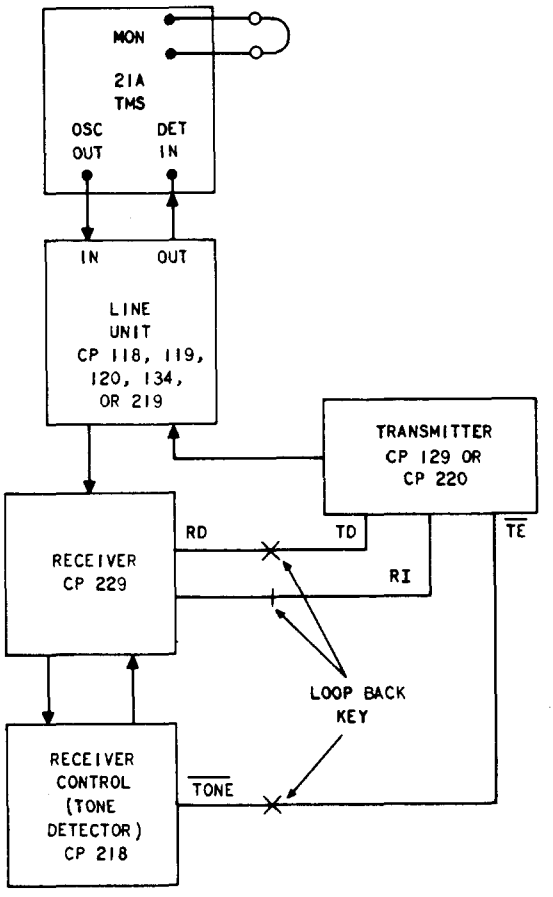


Fig. 16—E2 Data Set Loopback Test Arrangement

(4) Decrease the 21A TMS output level slowly until level of -26 dBm0 is reached. At -26 dBm0 ±0.5 dB, the data set ceases transmitting.

(5) Return the 21A TMS output to -13 dBm0 (note that transmitter again keys on) and slowly increase the frequency while listening to the monitor. The tone heard in the monitor shifts from low to high at a frequency between 1680 and 1750 Hz.

Note: This test must be performed by ***increasing*** the test frequency from 1300 Hz. If a repeat test is required, it must be started from 1300 Hz.

3.36 If a data set failure is indicated during the static test, refer to Section 201-644-503 or 201-644-504 for data set alignment and troubleshooting procedures.

Dynamic Tests

3.37 The dynamic data performance test can also optionally be performed remotely from the DTC or from an STC with both the proper 900-type test equipment and data set. The dynamic test consists of the transmission of quasi-random data to the distant data set. The signal is demodulated in the receiver, looped to the transmitter input,

and retransmitted. A bit-by-bit comparison of the transmitted and received data is made at the center, with each discrepancy being recorded as an error. The number of errors permitted to meet the criterion of 1 error in 10^5 bits for a 3002 network may be computed as follows: Errors permitted =

$$\frac{\text{(600 bps) (60 sec/min) (Test interval—min)}}{10^5 \text{ bits/error}}$$

$$=(0.36)\text{ (Test interval—min)}$$

For a 15-minute test, the errors permitted would then be (0.36) (15) = 5.4 or 6 errors when rounded off to the next larger whole number. In addition, any three 1-minute intervals where the number of errors exceeds 4 may be discarded.

3.38 The test and the procedures for performing the dynamic test are described in Section 668-102-512, Steps 165 through 196. The maximum measured error rate shall be 6 errors in 15 minutes; however, any three 1-minute bursts exceeding 4 errors may be excluded from the test results. The polling test set developed by Southern Bell should ***not*** be used when testing E2 data sets, as the start interval generated by the E2 data set is not compatible with the 202D and 202R carrier acquisition times. This incompatibility is not significant when making bit-error tests, since continuous data is transmitted and the carrier acquisition timer in the DTC data set remains on.

3.39 In summary, the data performance tests may be used to provide indications of the following:

(a) Facility condition—DTC to distant data set

(b) Facility condition—distant data set to DTC

(c) Functional condition of distant data set

(d) Ability of facility to handle data signals with an acceptable error rate.

3.40 Should the data performance tests not meet requirements and the trouble is determined to be not in the data set (slicer, tone detector threshold, etc.), then end-to-end network tests must be performed. The following is a suggested order in which to perform the tests, but may be varied to suit the observed conditions.

(a) C-message noise

(b) Impulse noise

(c) Single frequency interference

(d) Lineup levels

(e) Frequency response

(f) Envelope delay distortion.

3.41 Two points must be kept in mind when performing these tests: (1) when measuring C-message noise in compandored circuits such as found in N-carrier systems, a correction factor of 18 dB must be added to the noise reading; and (2) if the C-message noise requirement is met, the single frequency interference requirement is normally also met.

3.42 If the tests outlined above do not indicate the cause of the trouble, the remaining tests outlined in Section 314-410-500 (frequency shift, harmonic distortion, phase jitter) must be performed. At this point, if the trouble cannot be cleared, it should be referred to the Area Data Specialist.

F. In-Service Tests

3.43 A special test that can be performed utilizing the E-telemetry equipment is the measurement of word-error-rate (WER). This test requires three 6-digit event counters and may be used to verify the performance of the facility and data set when normal E-telemetry data is present on the network. A WER measurement may be helpful when a trouble exists, but cannot be isolated by means of the usual transmission tests. An example of such a problem might be a trouble resulting from the interaction of two or more transmission impairments. The test is performed by connecting the counters to the following points in the data transmission control circuit (SD-1C302-01):

- ERR Flip-Flop (TP 11, CP 94)
- FSR Flip-Flop (TP 9, CP 94)
- RCV Flip-Flop (TP 14, CP 93).

3.44 The counters should be adjusted to trigger on the negative-going transitions which occur as the flip-flops set. The interpretation of the points being monitored are as follows:

- RCV indicates the total number of words received by the remote station being tested.
- ERR indicates the number of words received with either a parity error or as the result of a false start.
- FSR indicates the number of false start resets (a false start is an incomplete word which could be due to valid word with a tone dropout or a hit of sufficient duration to momentarily enable the tone detector).

By counting the number of errors in a sufficient number of received words (between 20,000 to 100,000), the WER may be calculated as follows:

$$WER = (ERR) - (FSR)/RCV$$

Acceptable performance is 1 error in 2000 received words, or WER = 5×10^{-4}. A performance worse than 1 error in 1000 received words indicates the network should be routined.

3.45 It should be noted that if different modes of operation (ie, alarm polling, status reporting, or remote switch commands) result in significantly different error rates, a terminal trouble may be indicated. Again, it must be emphasized that a large number of received words must be counted in each mode before valid comparisons can be made. It may not be possible in a manually operated system to generate the required number of status display requests or remote switch commands in any reasonable length of time; therefore, WER measurements must normally be limited to the alarm poll mode in these systems.

3.46 The test described above may also be used to verify the performance of a particular facility section by appropriate looping and patching at the far-end station and central. Examples of this arrangement are given in Fig. 17 and 18. The actual patching configuration will be a function of the network layout and will vary accordingly. Care must be exercised when setting up the facility patches, since 3002 data circuit requirements can easily be exceeded. In the examples shown, it is assumed that remote B is operating normally; but, trouble has been experienced in trying to communicate with remote A. The purpose of the test is to verify that data facility X and the data set at A are performing properly. It should be pointed out that if the test is successful it can be reasonably assumed that no trouble exists in the suspected facility or data set; however, if the test is not successful, additional detailed tests will be required to determine if a trouble really exists. One potential problem with this type of test, when the data set at A is included in the circuit, is that the start sequence arriving at data set B is shortened. This could result in an unsuccessful test, particularly if facility Y contains compandored N-carrier systems. A variation of the same test is to perform a line-side loopback ahead of data set A and check only facility X. The problem with this test is that the total facility makeup between the data set at the central and remote B may exceed 3002 limits. This use of the WER test should generally be restricted to those cases where normal test procedures fail to isolate a trouble to either the data facility or terminal equipment.

G. Routine Tests

3.47 There are no routine tests for the E2-telemetry ***data sets***. However, carrier system routines must be performed to maintain adequate data service. The carrier routines are to be performed in accordance with the practices for the type of system involved. Before initiating any tests, a circuit release must be obtained from the E2-telemetry central via the NCO. It is preferable to obtain the release at least 24 hours prior to testing to allow the network control to set up an alternate facility for the test duration. At a minimum, a make-good should be set up locally prior to contacting the NCO for permission to take the circuit. ***None of the facilities comprising an E2-telemetry network should be taken out of service for any reason without a circuit release. No E2-telemetry facilities should be changed by a circuit change order or routine order without assurance that the new circuit is meeting the same requirements as for the existing facility.***

3.48 It is suggested that every E2-telemetry data channel be given routine data tests at annual intervals in accordance with Section 314-410-500. Releases and make-goods should be established as suggested in 3.47.

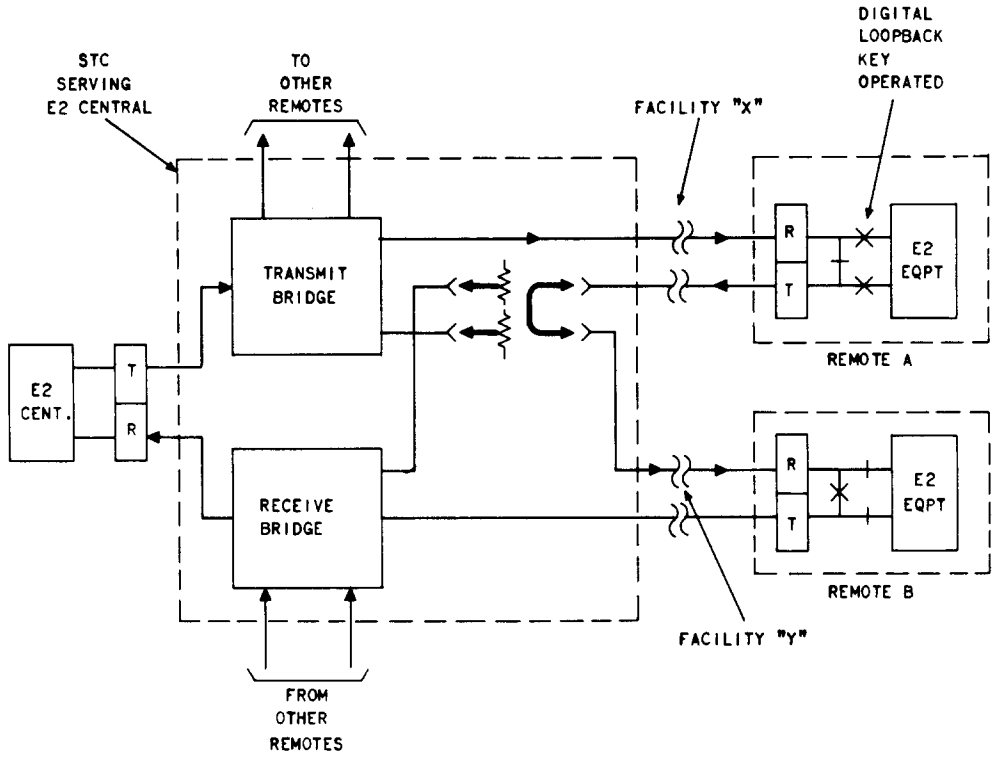


Fig. 17—Patching to Allow Communication to Remote B Via Facility "X" Plus "Y" and the Data Set Located at Remote A (Split Bridge at Central)

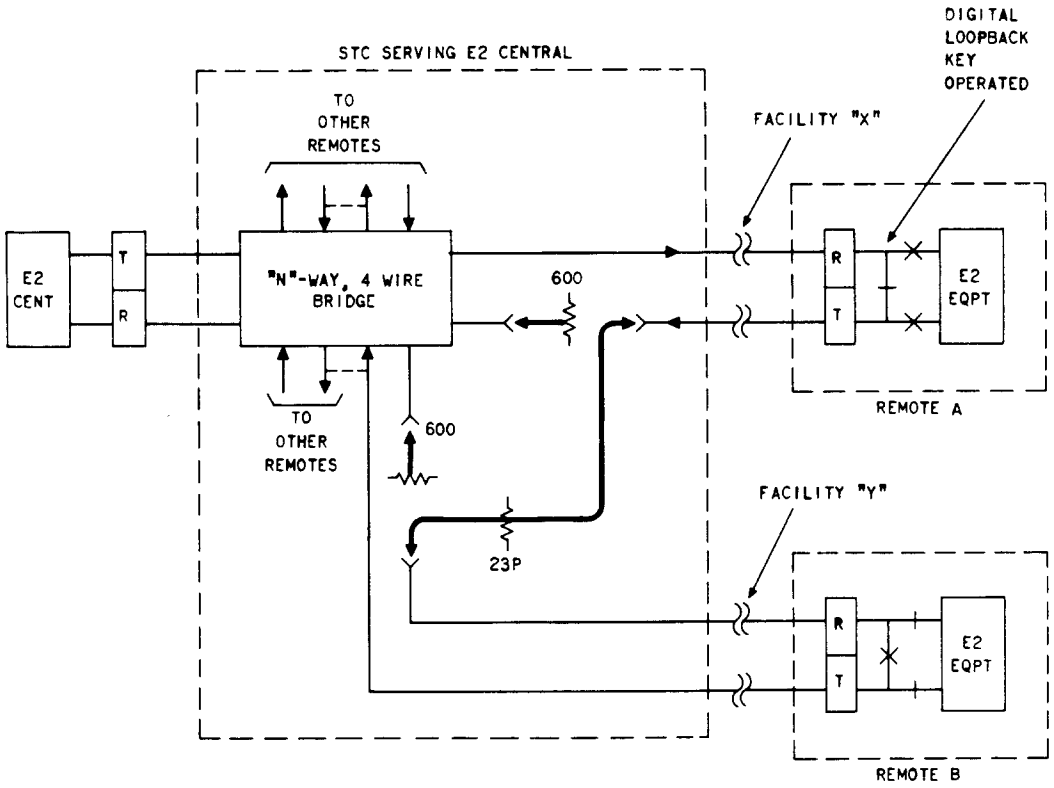


Fig. 18—Patcing to Allow Communication to Remote B Via Facility "X" Plus "Y" and the Data Set Located at Remote A (4-Wire Bridge at Central)

4. TROUBLE REPORTING PROCEDURES

4.01 The length of outage for a given trouble can be substantially reduced by good coordination and communication between the E2-telemetry personnel and NCO. Also, the ability to sectionalize and locate the source of a trouble rapidly is directly dependent on the up-to-date records kept at NCO, PCO, and STC.

4.02 A console operator monitoring the central maintenance panel may be the first to recognize when a line goes in trouble. The operator can use a procedure such as described in 3.20, together with the proper COLR card and the overall sketch, if required, and try to isolate the trouble to a facility or the remote E2-telemetry equipment.

4.03 If the console operator is sucessful in determining the trouble, a more complete trouble ticket can be provided to NCO. A well engineered E2-Telemetry System will also provide a designated priority to the facility segments with respect to the nature of the service provided. In some locations, there may be a requirement that remote offices be manned within an hour in the event of a telemetry failure. Well documented COLR cards and knowledge of available make-good circuits can improve the nominal average downtime for a facility failure.

4.04 There can be conditions where the data performance testing is not conclusive, such as not detecting problems that may exist involving start up or turnaround of the data set. If the data performance tests are successful, there is high probability that the trouble does not involve the data set or facility. Then the trouble should be referred to the E-telemetry maintenance personnel as a probable terminal equipment problem.

4.05 When the cause of a trouble cannot be determined using the tests suggested in Part 3 and the tests outlined in Section 314-410-500, the trouble should then be referred to the Area Data Specialist. A prearranged plan for assistance in trouble escalation should be available for each network arrangement; ie, troubles reported as "came clear" should be referenced for technical escalation on the third occurrence. General guidelines will vary with each network because of layout, facility mix, access availability etc.

4.06 When a facility cannot be restored in the established allotted time interval, then it is suggested that full use of the existing data technical support (DATEC) teams be made. These teams have been set up to assist with those data transmission problems which do not yield to the usual set of tests and measurements. Guidelines regarding the data technical support plan are provided in Section 010-521-100. A directory of DATEC personnel, with addresses and phone numbers, is provided in Section 010-521-101.

5. REFERENCES

5.01 The following is a list of circuit descriptions (CDs), schematic drawings (SDs), and Bell System Practices (BSPs) associated with the E-Telemetry System.

CD and SD	TITLE
1C301-01	Common Systems—E2 Status Reporting and Control System—Data Transmission Circuit
1C301-02	Common Systems—E2 Status Reporting and Control System—Data Transmission Circuit
1C302-01	Common Systems—E2 Status Reporting and Control System—Data Transmission Control Circuit
1C319-01	Common Systems—E2 Status Reporting and Control System—Multidirectional Data Regenerator Circuit

SECTION	TITLE
010-521-100	Data Technical (DATEC) Support
010-521-101	Data Technical (DATEC) Support—Designee Directory
201-644-100	E2 Status Reporting and Control System — Overall System — Description
201-644-110	E2 Status Reporting and Control System — Multidirectional Data Regenerator — Description

SECTION	TITLE
201-644-112	E2 Status Reporting and Control System — Manual Alarm Central — Description
201-644-113	E2 Status Reporting and Control System — Status Polling Central — Description
201-644-312	E2 Status Reporting and Control System — Manual Alarm Central Operating Procedures
201-644-501	E2 Status Reporting and Control System — Initial Trouble Diagnosis — Central Station
201-644-503	E2 Status Reporting and Control System — Troubleshooting Procedures — Central Station Tests
201-644-504	E2 Status Reporting and Control System — Troubleshooting Procedures — Remote Station
201-644-510	E2 Status Reporting and Control System—Troubleshooting Procedures—Multidirectional Data Regenerator
201-644-550	E2 Status Reporting and Control System — Remote Station Connections and Central Station Display — Overall System — Tests — Interconnection and Display
314-410-500	Voice Bandwidth Private Line Data Circuits — Test and Requirements
668-102-512	904A/B and 904C/D — Test Procedure — Data Sets 202C- and 202D-Types Loopback and Dynamic Tests
682-300-960LL	Circuit Layout — Private Line Digital Cards — Large Multipoint Circuits
865-100-101	Transmission Maintenance Systems — E-Telemetry Systems-Data Network — Engineering
880-420-101 Formerly AB27.350	Private Line Data Circuits — Voice Bandwidth — General Design Information