ERROR ANALYSIS AND FAULT DETECTION
SOFTWARE SUBSYSTEM DESCRIPTION
NO. 3 ELECTRONIC SWITCHING SYSTEM

CONTENTS PAGE

Figures

1. GENERAL

1.01 This section provides a description of the error analysis and fault detection procedures for peripheral circuits (lines, trunks, service circuits, and network links) used by the No. 3 Electronic Switching System (ESS). These software programs direct the detection and analysis of faults occurring during call processing and network peripheral sequences.

1.02 When this section is reissued, the reason for reissue will be listed in this paragraph.

1.03 A list of abbreviations, acronyms, and terms used in this section is included in Part 4.

1.04 The following Bell System Practices provide background information related to No. 3 ESS fault detection and error analysis processing:

(a) Peripheral Control—Section 233-151-155

(b) Translations—Section 233-151-150

(c) Basic Call Processing—Section 233-151-130

(d) System Control—Section 233-152-125.

1.05 The following programs contain the codes and comments which detail fault detection and error analysis processing in the No. 3 ESS.

(a) Peripheral Order Interpreter Program (POINT), PR-3H168, interprets data words from the peripheral catalog (PCAT) and translates these words into peripheral orders.

(b) Catalog of Peripheral Control Sequence (PCAT), PR-3H167, contains sequences of data words interpreted by POINT which result in the issuance of orders to the peripheral devices, including appropriate tests.

(c) Peripheral Order Subroutines (POPS), PR-3H169, provide peripheral error processing for default handling of certain failures and for filling out the error analysis buffer.

(d) Trunk, Line, Service Circuit, and Network Line Error Analysis (TSVEA), PR-3H256, provides subroutines which perform the various error analyses required by the contents of the error buffer.

(e) Trunk, Line, Service Circuit, and Network Link TTY Message Handler (TSVREQ), PR-3H257, provides subroutines which remove or restore circuits and provides TTY message formats.

(f) Maintenance Subroutines for Replicated Circuits and Lines (TSVSUB), PR-3H258, provide test vertical administration and miscellaneous maintenance subroutines such as link out-of-service checks, line idle, etc.

1.06 The major portions of fault detection (Fig. 1) performed in the No. 3 ESS are initiated either by call processing routines or during the peripheral action sequences. Among the tests initiated are:

- Continuity checks
- False cross and ground (FCG)
- Power cross (PWX).

Failure of one of these tests is detected as a fault. The system may analyze the fault and retry the call or may abort the call immediately. Regardless of the system reaction, any detected fault is logged into the error buffer for detailed error analysis.

1.07 The error buffer is accessed once each base level loop and the errors in the buffer are statistically analyzed. An error rate is determined; and when a circuit exhibits an excessive rate, it is removed from service. Notification of these faults is also provided by a teletypewriter (TTY) printout for maintenance purposes.

2. FAULT DETECTION

A. General Peripheral Control Processing

2.01 The No. 3 ESS call processing programs interface with the hardware of the switching networks by means of the peripheral order programs. All network controller and distribute orders and many scan orders are developed and issued by these programs. Most of the test procedures used for fault detection are also part of the peripheral order sequences initiated by peripheral programs. Sequences are initiated by call processing programs when a request is made by the peripheral action (PACT) macro, which calls the POINT program.

2.02 The POINT program executes PCAT which consists of a list of data words defining various peripheral activities. The fault detection tests are part of this catalog. The number and type of tests to be run depend on the sequence selected. Catalog (PCAT) sequences are identified by the peripheral progress mark (PPM) which is furnished to the POINT program by the PACT macro. The PPM is recorded in the transient call record (TCR) and serves to mark where the sequences start. Peripheral sequences start during base level and continue to completion in subsequent interrupt levels.

2.03 During the peripheral activities, the processing of errors and fault detection procedures depends on the type of error reported and whether the peripheral error return (PERTN) bit in the TCR is set. The PERTN bit is set by the PACT macro when control is to be returned to the call processing program regardless of a peripheral error. When the bit is not set, the error reporting and analysis procedures are conducted by general purpose error subroutines. If the bit is set, the user call processing program has error codes returned and performs the necessary processing.

B. Fault Detection Peripheral Error Return Bit Not Set (PERTN=0)

2.04 After a PACT macro is issued, the peripheral sequences are initiated and fault detection

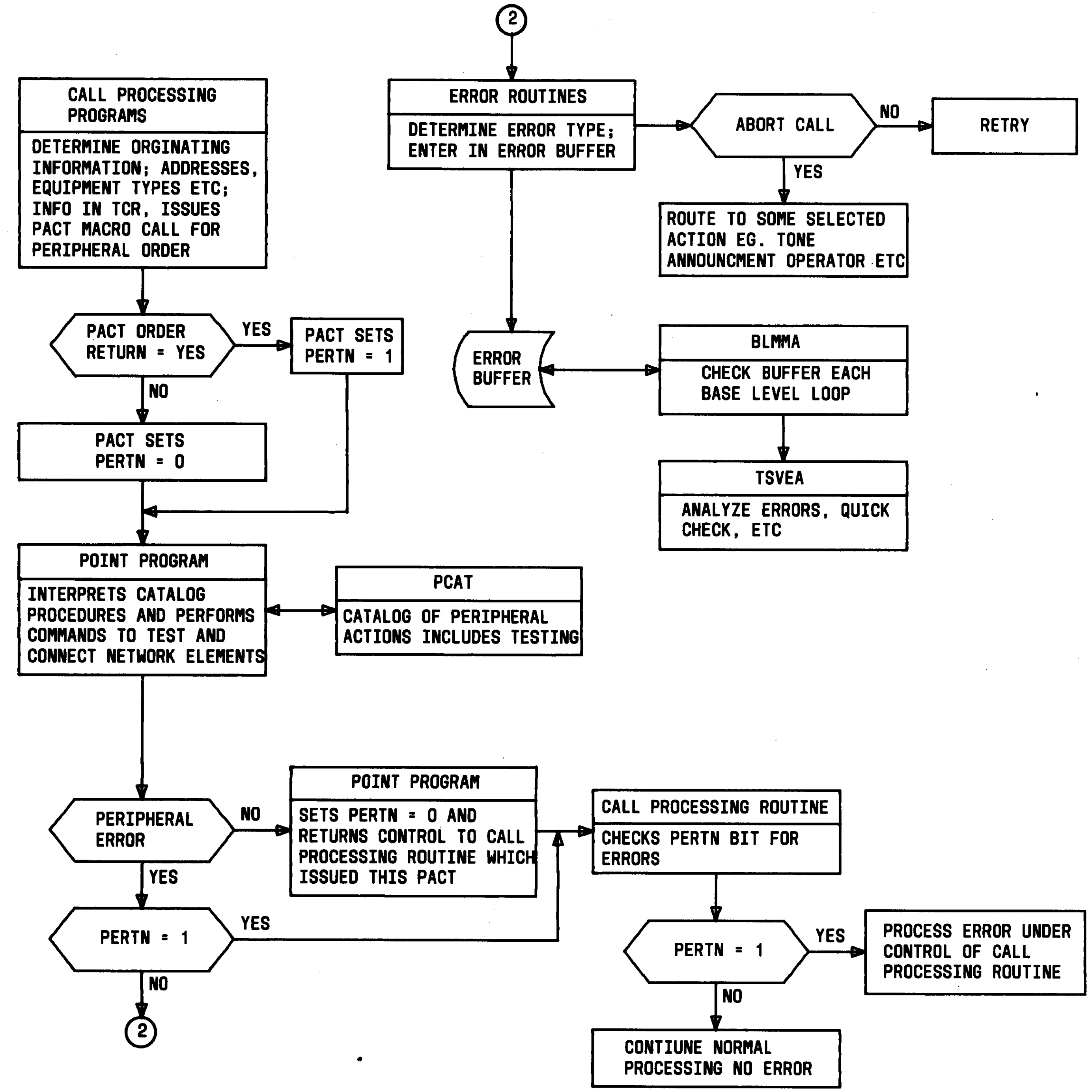

Fig. 1—Fault Detection

tests may be performed as part of the required sequences. Some of the fault detection tests are as follows:

- Continuity checks
- False cross and ground (FCG) tests
- Power cross (PWX) tests.

2.05 Continuity is tested by scanning for off-hook at the appropriate scan points (Fig. 2). If the test is successful, continuity is assumed to be good and the next catalog item is executed. Failure (scan point appearing on-hook) indicates that current is not flowing in a tip-ring loop formed partly by a path in the network. The problem may be in the network or in the circuit connected to the network completing the current loop.

2.06 Failure causes several more continuity checks to be made. After the last attempt, a failure code is loaded into the TCR, and a branch is made to an error entry point in the POINT program. When the PERTN bit is not set, a failure code is stored in the TCR, the base level progress mark (BASEPM) is set to peripheral error recovery (PEER), and the peripheral progress mark (PPM) and interrupt progress mark (INTPM) are zeroed. Control of the TCR is then returned to base level.

2.07 During the next base level loop, the PEER subroutine in the POINT program is entered. The POINT program calls a peripheral error analysis routine (PEA) in program POPS which determines the type of error and returns an error code. The error code denoting a continuity failure causes a branch to a peripheral error continuity failure analysis subroutine in the peripheral operations subroutines (POPS) program. This subroutine tests to determine whether the error is caused by a line. A nonline error results in a call to the peripheral error subroutine in the POPS program which makes an entry in the error analysis buffer (EA_BUF). Line faults cause the rescan-and-analyze indeterminate continuity failure subroutine to be called. The line is disconnected and rescanned. An on-hook is interpreted to mean the customer has hung up. The path is idled, and the TCR is cleared. An off-hook indicates a continuity error. An error code is returned to the peripheral error continuity failure analysis subroutine. An entry is made in the error buffer and the TCR is failed.

2.08 The FCG test is used to ensure the integrity of the network fabric which establishes a connection. The test is made by connecting a path with the second- and third-stage crosspoints closed, the junctor in the bypass state, and the test circuit connected through either the circuit or wire test vertical. (Only one configuration is illustrated in Fig. 3.) In the FCG test state, the test circuit supplies -dc to tip and +dc to ring; any current flow will indicate a cross or ground in the network fabric and will be detected by the test circuit.

2.09 Power cross (PWX) tests check for the presence of hazardous voltages existing on a network terminal; it is actually a test of the incoming line rather than of the network fabric itself. Also, while FCG tests can be made on a stand-alone basis, a PWX test is never made unless preceded by an FCG test. If any abnormal voltage is present, it must not be allowed to affect other portions of the network while the test is performed. The PWX test (Fig. 4) is made with a connection similar to the one used for the FCG test except that the first-stage crosspoint on the side of the terminal being tested is closed. Any voltage above the level of the office battery will be detected by the test circuit.

2.10 These tests may be performed several times during a sequence. A successful return causes the sequence to continue. Failure of either the false cross and ground or power cross test causes a branch to an error subroutine in the POINT program. This subroutine will:

(a) Release the network test circuit

(b) Load the error buffer with an appropriate failure code (EA_FCG, EA_PWRX, etc)

(c) Store the failure code in the TCR.

2.11 Processing is similar to that done for a continuity error. The exception is that neither the peripheral error continuity failure analysis nor the indeterminate continuity failure subroutine is used.

C. Fault Detection Peripheral Error Return Bit Set (PERTN=1)

2.12 The processing of failures when the peripheral error return bit is set (PERTN=1) is accomplished in the same manner as described in

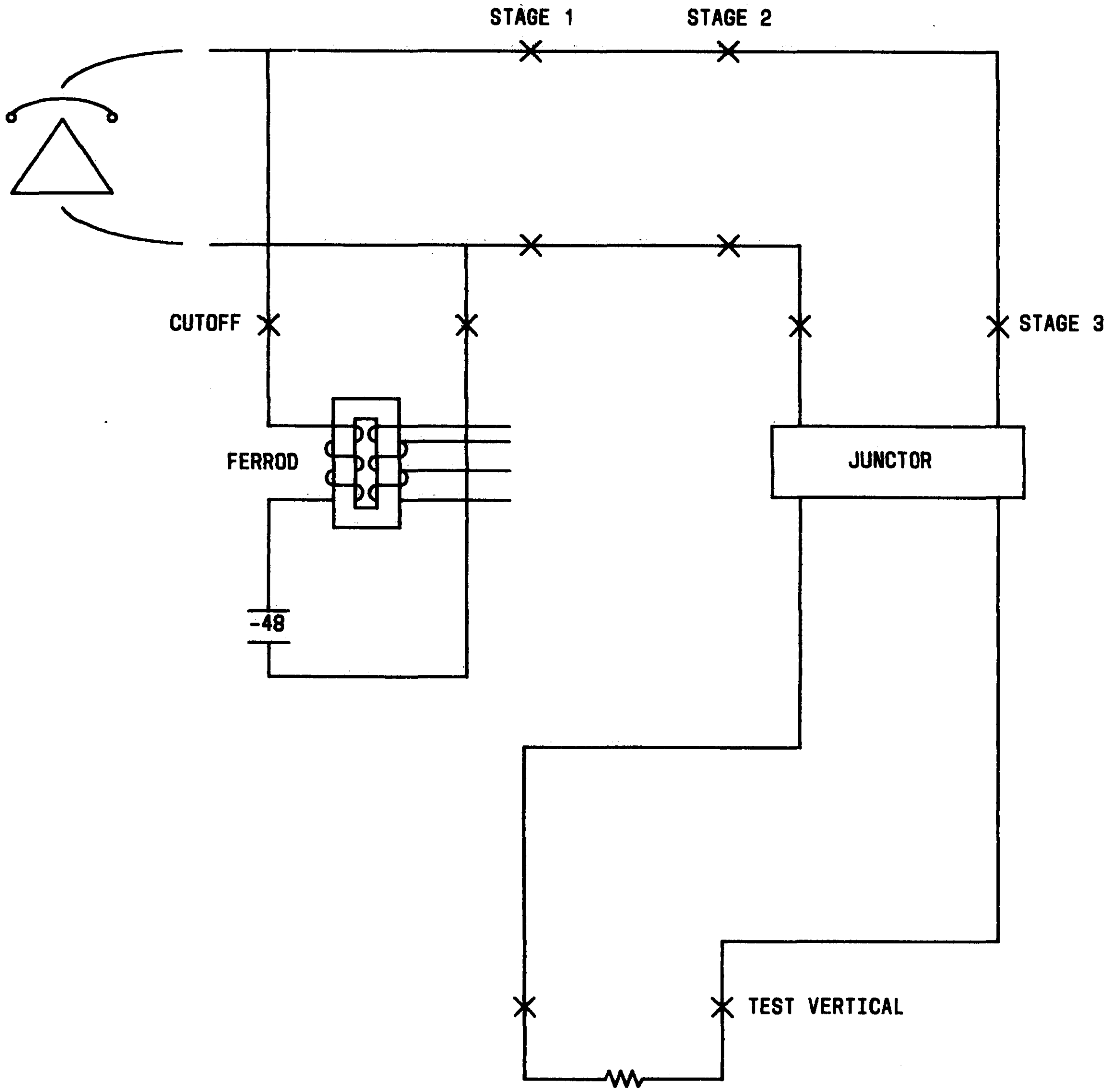

Fig. 2—Restore-Verify Test Toward Line

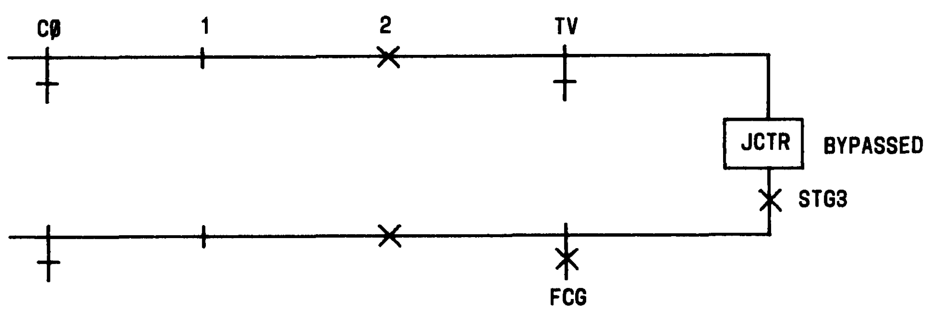

Fig. 3—FCG Test Connection

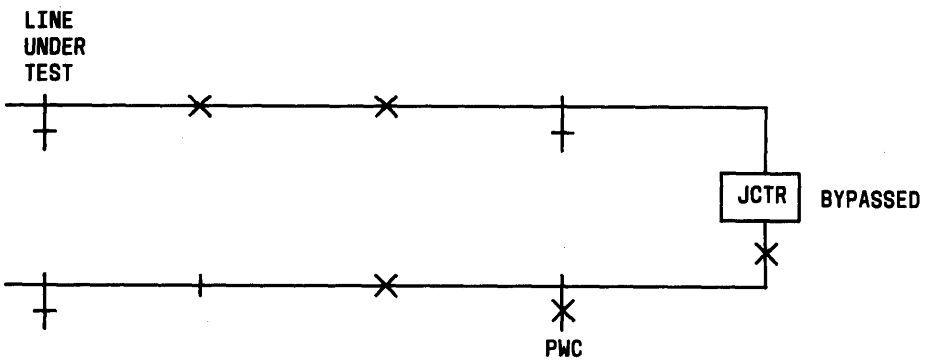

Fig. 4—PWC Test Connection

2.04, 2.05, and 2.06 for continuity failures and 2.08, 2.09, and 2.10 for FCG or PWX failures up to setting the base level action (BACTION) bit in the TCR. When PERTN is set, the BASEPM is zeroed instead of being set to the peripheral error recovery progress mark. This returns control to the call processing program that issued the PACT macro.

2.13 The call processing program tests for a peripheral error and, when an error code is present in the TCR, the peripheral error analysis subroutine in program POPS is called to perform error analysis. Three different return codes may be generated by the peripheral error analysis subroutine (PEA). PEA generates a code for the FCG errors and another code for the continuity errors, but assigns the same code for all other errors.

2.14 Continuity errors are processed as previously described, ie, reporting the error and processing by peripheral error continuity failure analysis or the indeterminate continuity failure subroutine for nonline or line errors, respectively. The appropriate call processing program then branches to a reorder subroutine in the customer error (CUSTER) program. The reorder subroutine attempts to reestablish a path to complete the call. If the call cannot be completed in 30 seconds, the calling party either is placed in a "high-and-wet" state or is routed to a permanent signal routine.

2.15 All other types of errors are routed to the POINT program for error determination. Normally, a TTY message is printed for software-type errors and is not printed for network errors. The FALTCR program is called and places both parties in the high-and-wet state and clears the TCR. For power cross failures, additional processing is performed to determine the bad terminal. That terminal is placed in a high-and-dry state (out-of-service) and the TCR is cleared.

D. Direct Detection During Call Processing

2.16 Call processing programs also initiate tests directly. Failure may or may not abort the call, and the error report is entered directly into the error buffer. The following list contains some of the errors which are processed in this manner:

- Ringing continuity failure—EA_RC
- Network controller failure—EA_NWC
- Low leakage resistance failure—EA_LLR
- Line cutoff failure—EA_LCO
- TOUCH-TONE® receiver error—EA_TTRCV
- MF receiver error—EA_MFRCV
- Excessive dial pulses error—EA_EDP
- No-coin control—EA_NCOIN
- Stuck coin control—EA_SCOIN.

3. ERROR ANALYSIS

A. Error Analysis Input Buffer

3.01 The error analysis input buffer (Fig. 5) is loaded by call processing when an error occurs and is unloaded within one scan by the error analysis program. Errors that occur while the buffer is full are ignored. Call processing furnishes the error by setting the error-type bits in the buffer. The remaining information in the buffer is determined by the type of error.

3.02 The error analysis routines are entered once each base level loop via a call from the base level application monitor (BLMMA) program to the error entry point in the TSVEA program. The error input buffer is checked and, if there is an entry, the circuits involved are analyzed.

3.03 The TSVEA program initial analysis determines the type of paths involved and identifies the links, junctors, and connecting circuits of the particular path analyzed.

3.04 Initial analysis specifically identifies the paths and circuits by using the appropriate terminal equipment numbers (TENs), scan point numbers (SPNs), or junctor switch numbers. After initial analysis, one or more of the following analytical subroutines may be called:

- Trunk and service circuit analysis subroutines
- Network path analysis subroutines (includes x-half-path, y-half-path, junctor B-link only, or wire B-link only)
- Line analysis subroutine.

B. Error Analysis Procedures

3.05 The error analysis subroutines use the TEN and SPN to perform translations which determine the group and member number as well as other identifying circuit features. Error analysis is then performed by the error analysis subroutines.

3.06 Error analysis determines when the error rate of a circuit is greater than that of other circuits of the same type. All circuit types of the same class (ie, trunks, service circuits, etc) are divided into groups. Within the group, each circuit is assigned a member number which uniquely identifies it. Probability theory is used to calculate a number of values for two parameters, GROUP COUNT and MEMBER COUNT, which are functions of the actual group size and selected so that there is a low probability of falsely detecting an error rate. These parameters are located in an error parameter table and are used by the error analysis subroutine to determine when a circuit fails more often than others in the same group. For trunks and service circuits, the group size is variable and is found in the office (translation) data. Other circuit classes have fixed group sizes.

(a) Lines are grouped per concentrator and the average size is taken as 140.

(b) A-links are grouped per concentrator and the size is 64.

(c) Junctor B-links are grouped per concentrator group and the size is 32.

(d) Wire B-links are grouped per concentrator group and the size is 32.

3.07 When any circuit (ie, trunk, service circuit, line, or network link) is suspected of causing an error, it is passed to the error analysis subroutine. The first error from a circuit causes a new entry in the error analysis table (Fig. 6). The subroutine first hunts through the error analysis entries (Fig. 6) in an attempt to match the specified error type, circuit class, and group number. When a match is found, the subroutine attempts to match member numbers. When this match is made, the entry

15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
BSY	ERROR TYPE			VARIABLE DEPENDS ON ERROR				JUNCTER SW NUMBER							
		LINE	X PATH SPN OR TEN												
		LINE	Y PATH SPN OR TEN												

Fig. 5—Error Buffer Format

will be moved to the end of the table. When no match is found before the end of the table, a new entry is developed and added to the end of the table. The top entry (oldest) is discarded if the table is already full. Error analysis must then determine the group size. When the circuits are variable (ie, trunks, service circuits, etc), the appropriate translation routines are used to secure the group size data. The proper group number and member number are selected from the error parameter table and entered into the error entry (Fig. 6). For fixed size circuits, the group number and member number are entered directly from the parameter table based on the size.

3.08 When a match is made, it indicates subsequent errors from a previously entered circuit, and the error analysis subroutine causes the MEMBER COUNT (Fig. 6) to be decremented for that entry and decrements the GROUP COUNT for all others with the same group number. Errors from other circuits in the same group cause this entry's GROUP COUNT to be decremented. When the GROUP COUNT reaches zero, the entry is deleted. When the MEMBER COUNT reaches zero before the GROUP COUNT, the circuit is detected as having a high error rate and a failure indication is returned. Thus, the error rate of a particular circuit is compared to the error rates of similar circuits of the same group.

3.09 A high error rate return results in the following actions.

(a) Trunks and service circuits are removed from service unless there are already too many circuits of a particular type out of service. The out-of-service limit is one-eight of the assigned circuits. A TTY trouble report is printed.

(b) Network links (A-B) are removed from service to a limit of one-eighth per group. (A-links are also limited to two per input switch.)

(c) Line errors are counted and a TTY report is printed. The line is not removed from service.

3.10 A continuity failure may involve a full path between two connected circuits or, in the case of a supervision continuity failure, may be only a half-path between a junctor and connected circuit. The continuity analysis subroutine in the TSVEA program identifies the proper circuit, path, network link, or line; then calls the appropriate analysis subroutine such as trunk or service circuit analysis, link analysis, or line analysis. In general, these subroutines identify the specific address of the item and then call the error analysis subroutine which performs analyses as described in 3.06 and 3.07. When a line is involved in a continuity failure, it is given special treatment. Since it may be a "showering line," it is left in the high-and-wet state by call processing. If the line passes error analysis (ie, no high error rate), it is placed in the in-service idle state. If the line fails (ie, high error rate), it is placed out of service for 30 seconds, then returned to the high-and-wet state. After error analysis and removals, if any, path hunting is changed to relocate the preferred links to a different portion of the network to randomize link selections when peripheral network errors are occurring.

C. Errors Not Requiring Analysis

3.11 A line circuit restore-verify failure results in an immediate TTY error message, specifying the terminal equipment number and telephone number of the affected line.

3.12 When a power cross test fails during a peripheral operation, the line is idled, then retried. When it fails the retry, a known open is established between the test circuit and line, and the test circuit is rescanned. When the fault indication (a saturated ferrod) is still present, the test circuit is bad. The test failure subroutine in

ERROR TYPE						CKT CLASS		GROUP NUMBER							
MEMBER NUMBER								GROUP COUNT				MEM COUNT			
15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0

Fig. 6—Error Analysis Table

the POINT program is called. The test failure subroutine releases the test circuit and loads the error buffer. When the test circuit scan point is active, the circuit is bad. The test circuit status is updated and a return is made to continue the call. If the test circuit tests inactive, the line is faulted. The test failure subroutine loads a failure peripheral progress mark (PPM) (XFAIL) and failure code into the TCR. The PPM initiates routines to idle and records the path. The process is then returned to base level with the peripheral error recovery base level progress mark set. On the next base level scan, the peripheral error recovery subroutine in the POINT program is called, identifies the faulted party, and calls the FALTCR program. The FALTCR program performs disconnect and idling, and prepares to clear the TCR. When the error buffer is accessed during a base level loop and when a power cross failure code is present, the power cross subroutine in the TSVEA program is called. The subroutine will test to determine if the error is a faulty test circuit. If so, the test circuit is removed from service and a removal message is printed out. When it is not a test circuit, the TSVSUB program is called to place the line out of service for a short period, then restore it and retry a complete power cross test using the PPM (MRST). When the retry fails, the line is removed from service and a removal message is printed out. When a retry is successful, the line is left in service and the power cross error routine exits to base level.

D. Quick-Check Activities

3.13 When a trunk, service circuit, junctor, or A-link is reported as being involved in an error but passes error analysis, the scan point number is passed to the quick-check error subroutine in the TSVEA program. This subroutine retains the error indication for quick-check purposes. If the SPN is already in the quick-check table, the error bit of that entry (Fig. 7) is set to show that the circuit is suspected of causing an error and the error type is retained in the second word of the entry. In the event that the scan point number does not appear in the table and the table is not full, a new quick-check entry (Fig. 7) is begun with the error count set to zero and the error type in word 2. In addition, the quick-check activity bit in the camp-on buffer (Fig. 8) is set in order to monitor traffic uses of all trunks, service circuits, and links.

3.14 When a trunk service circuit or network path is idled, the appropriate camp-on subroutine (ie, TSV_CMP, LINK_CMP, etc) is called to determine if the element is being camped-on (3.15). The camp-on control bits in the camp-on buffer (Fig. 8) are checked to determine which routines are active. When quick-check is active, the scan point number of the element is passed to the proper subroutines (TSV_QCHK, LINK_QCK). These subroutines establish the identity of the links or trunks with the appropriate TENs, SPNs, etc, then call the quick-check subroutine which searches the quick-check table. The quick-check table is searched until the SPN is matched. When the error bit in the table entry (Fig. 7) is not set, it indicates that the circuit has been used successfully and that the entry is deleted. When the error bit is set, the circuit has encountered an error. The error bit is then reset, and the error count is incremented by one. When the error count reaches three, the circuit has encountered three errors consecutively without a success. A failure indication is returned, the entry is deleted from the table, and the circuit is removed from service. The three reasons for failing the circuit are retained in word 2 of the quick-check entry. These error types are furnished for a TTY printout.

3.15 In addition to the quick-check activity described in 3.14, camp-on activities are used in circuit

<table>
<tr><td>E
R
R
O
R</td><td colspan="2">ERROR COUNT</td><td colspan="13">QUICK CHECK SPN</td></tr>
<tr><td></td><td colspan="5">PREVIOUS ERROR TYPE</td><td colspan="5">PREVIOUS ERROR TYPE</td><td colspan="5">LAST ERROR TYPE</td></tr>
<tr><td>15</td><td>14</td><td>13</td><td>12</td><td>11</td><td>10</td><td>9</td><td>8</td><td>7</td><td>6</td><td>5</td><td>4</td><td>3</td><td>2</td><td>1</td><td>0</td></tr>
</table>

Fig. 7—Quick-Check Entry

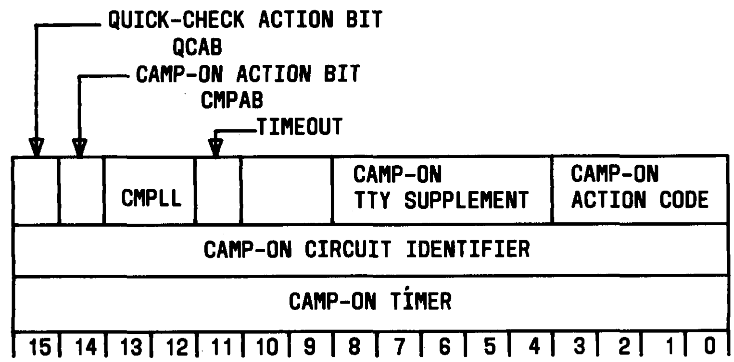

Fig. 8—Camp-On Buffer

removal actions. When one of the removal subroutines (RMV_TSV_EA, RMV_ALNK_EA, RMV_BLNK_EA) in the TSVEA program is called to remove a circuit from service, either as the result of error analysis or in response to a TTY removal message, the subroutines attempt to remove the requested circuit. When the requested circuit is in service and active at the time the request is received, it cannot be removed from service until it becomes idle. In this event, the circuit will be camped-on for a short period (approximately 20 seconds for an automatic request or 5 minutes for a manual request) until it becomes idle. The removal subroutine performs a branch to an appropriate camp-on subroutine in the TSVEA program. These subroutines load the camp-on buffer (Fig. 8) with control bits, circuit identification, and the time the circuit is to be camped-on. As circuits become idle, the camp-on subroutines check the camp-on buffer. If a match is found between the just idled circuit and one in the buffer, control is passed to each active subroutine as defined by the control bits. If these subroutines find a match, some action is taken (ie, quick-check, removal, etc).

4. GLOSSARY

4.01 The following terms pertain to this section.

A-Path—Connects the first party (A-party) to the second party (A-service) through the A-junctor and is commonly referred to as the customer dial pulse receiver (CDPR) or receiver path. It may be normal or reversed.

B-Path—Connects the first party (B-party) to the second party (B-service) through the B-junctor and is commonly referred to as the ringing path. It may be normal or reversed.

Base Level Loop—Major software loop which includes all functions not performed during interrupt level. High-priority tasks which cannot be deferred are performed during interrupts of the base level loop.

Camped-On—The function of waiting for a designated circuit to become idle before performing a required action (ie, quick-check, removal, etc).

False Cross and Ground (FCG) Test—Consists of monitoring for current in an open-ended loop that contains the tip and ring conductors of the test vertical.

Macro—A sequence of operations called by an abbreviated notation. A macro can generate different sequences of code, depending on the parameters supplied in the macro call.

SPN—Scan point number of a line, trunk, or service circuit. A 13-bit number which specifies the point, row, and scanner.

T-Path—The talk path defined by the A-party TEN, the T-junctor, and the B-party TEN.

TCR—Transient call record. A 16-word record which contains all pertinent information concerning the call in progress.

TEN—Terminal equipment number [same as OE (office equipment)]. A 13-bit number specifying the network controller, concentrator group, concentrator, switch group, switch, and level.

X-Party—The party in the network path closer to the junctor.

Y-Party—The party in the network path separated from the junctor by the third-stage switch.