

SOFTWARE MANAGEMENT
GENERAL DESCRIPTION
NETWORK SWITCHED SERVICES METHODS
NO. 3 ELECTRONIC SWITCHING SYSTEM

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NOTICE

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1. GENERAL

1.01 This section is intended to be used as an administrative guide and reference source document to aid in the management of No. 3 electronic switching system software. The primary purpose of the information contained in this section is to provide basic information on key software areas of the No. 3 electronic switching system. Throughout this section, specific references are made to other sections or documents where more detailed software information and procedures are located.

1.02 Whenever this section is reissued, the reason(s) for reissue will be given in this paragraph.

1.03 The title for each figure includes a number(s) in parentheses which identifies the paragraph(s) in which the figure is referenced.

1.04 Recommendations for any changes, additions, and/or deletions to this section should be submitted by the instructions contained in Section 000-010-015.

2. SYSTEM ORGANIZATION

2.01 Functionally, the No. 3 electronic switching system consists of three major equipment areas:

- (a) Control complex
- (b) Periphery
- (c) Power equipment.

2.02 The **control complex** consists of equipment necessary to access the system for administration, operation (call processing), and maintenance. It is the area where man-machine interface functions are accomplished.

2.03 The **periphery** consists of necessary equipment selected by the control complex to switch calls through the office and to perform various integrity checks. Upon command from the control complex, the periphery performs tasks such as scanning customer lines, connecting paths through the office network, and changing state relays of selected circuits.

2.04 The major **power equipment** consists of rectifiers, converters, inverters, fuses, and

controls necessary to supply office power requirements.

2.05 The functional areas are arranged in such a manner as to provide two control systems, each capable of assuming total office operational responsibility. System Control (SYC) (0 or 1) consists of a Control Unit (CU) and associated controllers of the periphery (Fig. 1). A CU (which is part of the control complex) consists of the 3A Central Control (3A CC), Main Store (MAS), and the System Status Panel (SSP not duplicated). The controllers located in the periphery (and referred to as peripheral controllers) include the Frame Input/Output Controller (FIOC), the Scanner Controller (SC), the Network Controller (NWC), and the Peripheral Pulse Distributor (PPD).

2.06 Each SYC is switched as a unit since the supporting components assigned to each SYC cannot be interchanged. It should be noted, however, that the active (on-line) SYC has the responsibility to update the standby (off-line) SYC memory. There are two equipment units (duplicated) which support both SYCs but which are not specifically assigned to either SYC. These are:

- (a) Teletypewriter controllers (TTYCs) 0 and 1
- (b) Tape data controllers (TDCs) 0 and 1.

2.07 Program control in a No. 3 electronic switching system is performed by the 3A CCs, which communicate with the peripheral equipment by means of an input/output channel.

2.08 The semiconductor-type main memory or MAS (part of each CU) is functionally divided into program store, translation store, and temporary (call) store areas. The temporary store portion is used by the 3A CC to store transitory data; the program store contains the generic program; and the translation store provides necessary call processing data about all lines, trunks, and peripheral equipment. Additionally, as a memory backup, the programs, translations, and office data are stored on the cartridge tape system.

3. SYSTEM SOFTWARE DESCRIPTION

GENERAL

3.01 The No. 3 electronic switching system functions as an electronic central office and per-

forms its tasks through the the use of stored program control concept. Nearly all of the system activities are determined and guided by preset, functionally grouped software programs, and instructions that are coded and stored in the switching machine's memory.

3.02 Program operation in the No. 3 electronic switching system is controlled by the 3A CC, which is a Stored Program Controlled (SPC) real-time data processing unit. (This controller/unit is also used to control other switching systems, ie, No. 2B electronic switching system.) As required, programs are read from memory and transferred to the 3A CC for execution by means of microprogram circuitry. The stored program utilizes stored (office) data which contains information pertaining to customer lines, routing, charging, etc. If changes are required to various aspects of system operation, these changes will normally be made to the stored program or office data rather than to the wiring or hardware.

3.03 The microprograms (microcode) of the 3A CC operate the stored program in its overall control of the system. These programs are separately stored in read-only memory and can be changed readily by replacing circuit packs with no changes required to wiring. Microprograms also control other nonstored program functions such as interrupt processing and portions of recovery code.

3.04 The No. 3 electronic switching system stored program consists of two parts (1) common system division and (2) application division. The common systems division includes all of the software that will be common to any electronic switching system that is equipped with a 3A CC. Applications division software includes the software that is unique to the operation of the No. 3 electronic switching system.

3.05 All of the software that comprises the No. 3 electronic switching system stored program is categorized as either *resident* or *nonresident* programs. Resident programs are stored in the write protected portion of the MAS of the 3A CC processor and include:

- All call processing programs
- Certain administrative and maintenance programs (TTY, fault detection, recovery programs).

3.06 Nonresident programs are stored on a cartridge tape and are transferred to the MAS as required. These programs consist of the software that is not used in the normal operation of the system. Types of nonresident program/data contained on the tape are:

- The administration (traffic data programs, most recent change programs)
- The maintenance — diagnostic programs
- The MAS backup memory data
- The past translation data.

3.07 Subroutines are used extensively to provide for efficient use of main storage. A subroutine is a short program which performs a specific task as requested by another program. Control is passed by the requesting program/subroutine to the call program (subroutine) until completion, at which time control is returned and normal processing continues.

GENERIC PROGRAM

3.08 The current generic issue for the No. 3 electronic switching system 3E3. The 3E3 requires a minimum of 163,840 program words. Additional memory is required depending on translations, etc. Actual equipped memory is also dependent upon which equipment version (32K versus 128K MAS modules) is installed. Each generic can process traffic from up to 15 concentrator groups or 4500 subscriber lines.

FUNCTIONAL PROGRAM CATEGORIES

3.09 Figure 2 is a functional listing of the programs that make up the No. 3 electronic switching system software. Parts 4, 5, and 6 contain a description of each program. The three categories are:

- (a) **Operational:** The operational software includes functions which control office traffic processing under normal operating conditions.
- (b) **Administrative:** The administrative software performs the functions which are related to office operations such as an automatic means for changing office parameters and initiating service orders, audits, tape handling, and TTY operation.
- (c) **Maintenance:** Software and hardware are arranged to detect service-affecting troubles

by making the appropriate call checks or by performing maintenance checks on the hardware. The maintenance programs perform the functions related to detection, diagnosis, and reaction to abnormal office operation.

4. OPERATIONAL PROGRAMS

4.01 The No. 3 electronic switching system operational software contains the programs and control functions that involve the handling of office traffic under *normal* operating conditions. In this part, the following operational software programs are generally discussed:

- Base level loop
- Interrupt
- Generic 3E3
- Call processing
- Custom calling.

4.02 Refer to Fig. 3, which can be used as a job aid, for references to other standard system documents that further detail operational program software.

A. Base Level Loop and Interrupt

4.03 The base level loop (Fig. 4) is a set of major programs which administer call processing, provide traffic information, and maintain software accuracy. In addition, required maintenance functions are performed, and nonresident software programs are scheduled to perform their functions once they are requested.

4.04 There are two types of interrupt level programs which break into the base level loop:

- (a) The first occurs on a periodic, timed basis every 10 ms. It is hardware-initiated and includes such call processing functions as immediate-start trunk scanning, digit receiving, outputting, and peripheral orders. (Fig. 5.)
- (b) The second type of interrupt occurs upon a demand basis (ie, TTY demand, fault detection). After the interrupt level has completed its allocated work, control is returned to the base level loop.

B. Base Level Loop Generic 3E3

4.05 The 3E3 base level loop (Fig. 6) for 3E3 generic has been improved to include two major changes. First, the major components of the base level loop routines are reordered so that all maintenance work is performed after normal call processing tasks have finished. Second, a new dispatcher will now control the deferrable maintenance (the multiscan functions, call processing audits, and MAS audits). The dispatcher will run these jobs in a "waste time" mode which will allow these jobs to run faster than the unconditional one-transfer-per-scan mode used in SO-2, Issue 4, generics.

General Scheduler

4.06 The general scheduler in CMMON executes out of the CBLM time monitor and controls the sequential execution of routines as defined by MMONA. The manner in which this is done is flexible and convenient since the program is designed to interface with the client programs through their TTY entry points.

4.07 The scheduler can be thought of as a system of tables since the order and conditions for the execution are all presented in tabular form. There are three levels of tables: master, major sequence, and minor sequence.

Dispatcher

4.08 The dispatcher is a real time task dispenser for the class of routines generally thought of as deferrable. The dispatcher is given control after the more critical (nondeferrable) work has completed each base level loop. The dispatcher attempts to execute the defined deferrable jobs when time remains in the base level loop and to skip them when the system is temporarily overloaded. The deferrable jobs are defined in a table called JOBADDR in MMONA which is used to run the job according to its priority and defined minimum rate of repetition. Jobs which fall behind a performance schedule are automatically given priority and may possibly be forced to execute independently of system conditions.

4.09 The jobs normally included in the deferrable class under the control of the dispatcher are all major audits and multiscan functions. While the amount of time taken by a client on each transfer is beyond the control of the dispatcher, it is assumed to be in the range of 2 to 5 msec.

Control Complex

4.10 When a demand interrupt occurs due to a fault, the trouble recovery programs are immediately initiated. Following appropriate recovery actions, the problem is passed for further resolution to the lowest priority base level maintenance programs. After the interrupt level has completed its allocated functions, control is returned to the base level loop.

Periphery

4.11 When a fault is detected by call processing programs, the recovery program is immediately given control. It performs corrective action, as required, and returns control to call processing.

C. Call Processing

4.12 The call processing software uses allocated blocks of storage to retain data associated with the junctors, lines, trunks, and service circuits during the call interval. Three of the storage blocks used in basic call processing are:

(a) **Terminal Memory Record (TMR):** The TMR is a fixed 4-word block of storage assigned to each junctor.

(b) **Transient Call Record (TCR):** The TCR is a 16-word block of storage assigned to calls in the transient state to:

- Store the state of the call
- Collect and send digits
- Record assigned service circuits
- Store progress marks which identify sections of code to perform certain functions.

(c) **Input Hoppers:** These are used to retain changes in the states of line trunks, junctors, and service circuits until the data is used by the software.

4.13 The **primary** function of the No. 3 electronic switching system is the processing and completion of telephone calls. It is important to note that calls are not processed in a continuous, uninterrupted series of actions. Instead, each call is processed in

bursts, separated by gaps in time during which other system operations occur. Many calls are processed at the same time, during which administrative and maintenance functions are also performed as time allows.

4.14 For a complete description of No. 3 electronic switching system call processing and the system functions associated with call processing, refer to Section 233-151-105.

5. ADMINISTRATIVE PROGRAMS

5.01 The No. 3 electronic switching system administrative software programs handle the functions which are related to office operations such as an automatic means for changing office parameters and initiating service orders. In this section, the following administrative programs are discussed:

- (a) Recent Change (RC) programs
- (b) System utilities programs
- (c) Tape operations
- (d) Teletypewriter functions
- (e) Traffic and plant measurements
- (f) System control
- (g) Audits
- (h) System cutover testing.

5.02 Refer to Fig. 3 for references to other standard system documents that detail administrative program software.

A. Recent Change (RC) Programs

5.03 The RC programs are used to add, change, or remove translation data from the system. The RC programs are a series of nonresident (tape storage) programs used to modify the translation data, resident and nonresident, in a particular No. 3 electronic switching system office. The RC programs also have the capability for verifying, packing, updating, and retrieving data.

B. System Utilities Programs

5.04 The system utilities programs are common systems, nonresident routines which provide

software analysis tools necessary to locate and/or correct problems in the hardware or software of the system. These programs, performed at base level or interrupt, are manually requested via the TTY. These programs include capabilities for monitoring, dumping, and loading specific locations of store. Also included are an overwrite (ie, patch other programs) and a tape utility which manipulates the tape unit.

C. Tape Operations

5.05 The programs which are not required for immediate control of system efforts are stored on magnetic tape. These programs are paged into a paging buffer which is part of the MAS. Software controls the execution of the program entered in the paging buffer.

D. Teletypewriter Functions

5.06 Primary communication with the No. 3 electronic switching system is conducted via the TTY. This communication consists of maintenance messages and commands, entering and updating of office translation data, diagnostic messages, and exercising administrative system control.

5.07 The software directing the TTY devices may be either resident or nonresident, common systems, or applications. All TTY devices operate under the control of the TTY handler program which acts as a software driver between the TTYC and application message processing.

5.08 Embedded in the associated TTY programs are program-initiated fault-handling routines which continually check the validity of the TTY input/output transmissions. When an indication of character mishandling or some other malfunction is detected, these routines take corrective and system self-protecting actions, including removing from service and isolating the malfunctioning TTYC and/or ports.

E. Traffic and Plant Measurements

5.09 The traffic (TRAFIC) program analyzes traffic information and extracts the necessary information at different scheduled times for the printing of traffic reports by the TTY or for updating a tape.

5.10 The TRAFIC program is in two main sections: traffic monitor and traffic measurements.

The traffic monitor section determines which traffic tasks should be continued or begun at a certain system time. The traffic measurements section actually increments the traffic counters.

F. System Control

5.11 The basic program structure of the No. 3 electronic switching system is a closed loop in which a set of major programs executes sequentially. This loop is the base level loop. Most call processing programs and those maintenance tasks which can be deferred are performed during base level.

G. Audits

5.12 The audit programs check all resources marked busy to ensure that they are actually busy. The audits attempt to verify that there is a record pertaining to all resources being used with an active call. When a resource without a record is found, the audit idles the resource and prints a TTY message so that the program error that caused the trouble can be located. In many cases, audits will not completely clear a call record or an invalid situation; therefore, the situation is corrected by a sequence of audits, which may result in several TTY messages for a single failure.

H. System Cutover Testing

5.13 The cutover functioning office-to-office tests have been designed to test subscriber lines from the No. 3 electronic switching system office to the connection of those lines at the existing subscriber lines served by the old office. These tests check for continuity shorts, crosses, grounds, and reversals. A program automatically performs these tests or this can be done manually, if desired, using the local test desk (14-type) or the local test cabinet (No. 3-type).

6. MAINTENANCE PROGRAMS

6.01 The No. 3 electronic switching system maintenance software programs are designed to detect service-affecting troubles. This is achieved by making periodic software and maintenance checks on the system and its hardware/equipment. Figure 2 gives a diagram of maintenance programs and the general operation associated with:

- (a) Trouble detection
- (b) Recovery

- (c) Initialization
- (d) Diagnostics
- (e) Alarm and status reporting
- (f) Programmed maintenance aids.

6.02 Refer to Fig. 3 for references to other standard system documents that give added details on maintenance program software.

6.03 Software and hardware are arranged to detect service-affecting troubles by making the appropriate call checks or by performing maintenance checks on the hardware. The maintenance programs handle the functions related to the detection, diagnosis, and reaction to abnormal office operation (Fig. 8).

A. Trouble Detection

6.04 Trouble detection is the primary means of inhibiting performance deterioration. Detection schemes are used throughout the system to facilitate identification of problem areas. These procedures utilize hardware and software operations to further ensure the integrity of the system.

Check Circuits

6.05 Self-check circuits are provided in the 3A CC, MAS, and peripheral controllers. These check circuits act as continuous monitors by which the system is notified of erroneous responses.

Call Processing Tests

6.06 During call processing, many checks are made to ensure the validity of system actions. For example, a check is made for high voltage to prevent damage to sensitive circuits associated with the customer line. Checks are also made to ensure that a customer line is ready for another origination after a previous disconnect (restore-verify check); this verifies that the line attending element was restored to the line to allow an origination.

Routine Testing

6.07 Routine testing is performed as periodic diagnostics or periodic progression.

6.08 Periodic diagnostics are tests of hardware performed automatically on a scheduled basis

(every 24 hours). These diagnostics are read in (paged) from the tape cartridge and will be performed by the standby 3A CC. The diagnostics may also be manually requested by the local or remote maintenance TTY.

6.09 Periodic progression testing is comprised of tests wherein test circuits are automatically connected to line, trunk, or service circuits in an effort to detect the latest problems. In addition, the network may also have test circuits associated with it to perform false cross and ground, power cross, and restore-verify tests which are performed on a call basis.

B. Recovery

Duplicated Units (Periphery)

6.10 Recovery programs are automatically initiated when a problem associated with the active SYC is detected. Recovery initiates a retry of the action which was being taken when the problem occurred (eg, scanner order). If the problem persists, recovery initiates an SYC switch which causes the other SYC to assume active control. A second retry of the action previously taken is initiated on the newly active SYC. If the action is taken as directed by the data accomplishes the expected results, recovery returns control to normal call processing activity.

6.11 This sequence causes the faulty peripheral controller to be removed from service. A removal from service message and an SYC switch message indicating the SYC currently active are printed out on the TTY. The appropriate lamp lights on the SSP indicating the peripheral controller is removed from service, and a major audible alarm sounds.

6.12 If the second retry does not eliminate the problem condition, the problem is located in the nonduplicated portion of the peripheral controllers. The nonduplicated portions are:

- Scanner matrix (row and column)
- Peripheral decoder (point)
- Network fabric (error analysis).

6.13 A TTY message is printed out indicating the problem area as well as the active SYC. A minor audible alarm sounds. Call processing is notified of the problem area and assumes control.

Duplicated Units (Ringing and Tone Plant)

6.14 The critical functions of the Ringing and Tone (RT) plant are duplicated. Under normal operation one RT plant would be active and the other standby. The critical functions are continuously monitored. A detected problem in the active RT plant causes the standby RT plant to become active. The SYC is not affected by the RT plant switch.

6.15 The problem indicators available for the RT plant are the RT lamp on the SSP and TTY removal from service messages. A major audible alarm sounds.

Duplicated Units (Control Complex)

6.16 The No. 3 electronic switching system processor is basically a self-checking machine. Detection of faults occurs when a failure of specific checks (error check circuits, program, or program timer) indicates that the integrity of the program system and/or data base is questionable. The detection of faults associated with the error check circuits causes one of the following:

- (a) Error interrupt—main memory will function
- (b) Unit initialization—main memory may not function
- (c) Switch and unit initialization—microcode may not function.

6.17 A problem with the active program timer (times out) will cause a switch and initialization of the standby 3A CC. A switch will not occur if the lock or force keys on the SSP are operated. A problem in the program will normally cause a 3A CC switch, depending on the type of program involved.

6.18 There are three classes of fault detection:

- (a) The first and most serious involves a fault which affects the operation of the active SYC or which might prevent the microcode of the processor from operating. Also, it may occur if the active program timer times out. Either of these results in a switch of the processors and initialization of the now active machine.
- (b) The second class is keyed by a fault (primarily MAS errors) which prevents the MAS from

functioning. This results in an initialization of the active processor with no switch of processors involved.

- (c) The third class involves peripheral errors.

Unduplicated Circuits (Periphery)

6.19 The unduplicated portion of the system includes the following circuits:

- Trunks
- Service
- Lines
- Network links
- A-links
- Test vertical
- Junctor B-links
- Wire B-links
- Scan distributor points
- Switches
- Crosspoints.

6.20 Special software routines are used to analyze failure rates in the replicate areas. If a circuit fails three consecutive times, it is removed from service. Only a set percentage of the circuits is removed from service. When this percentage is reached, the circuit is not removed from service, but a trouble report is indicated on the TTY.

Error Analysis

6.21 The error analysis resident software of the No. 3 electronic switching system is invoked by failures in call processing involving the replicated portion of the system. This software receives an error report and analyzes problems in categories by comparison. The error rate of a particular circuit is compared with the error rate of its particular group. If the comparative rate is excessive, that particular trunk, line, service circuit, junctor, A-link, or B-link is removed from service and an appropriate TTY

message is printed out, indicating a problem which must be diagnosed later.

Quick-Check

6.22 Quick-check is used to analyze problems which affect trunks, service circuits, A-links, B-links, and junctors. If three successive errors occur in a particular circuit, the circuit is automatically removed from service (if allowed), as opposed to the member group failure rate of the error analysis programs.

C. Initialization

6.23 Initialization can be caused by several hardware-detected and/or software-detected problems. Initialization can also be executed manually from the SSP. The stimulus is the failure of a check that indicates a possible fault in the integrity of the programming system and/or its data base. An initialization consists of the following:

- (a) Restoring the 3A CC to a known good state
- (b) Restoring the periphery to a known good state
- (c) Aborting certain activities
- (d) Initializing temporary data
- (e) Reloading the programs from tape.

6.24 Not all of the above are performed on every initialization. The amount of initialization can vary depending on the extent to which corrective action is required.

6.25 The five levels of initialization are as follows:

- (a) First level—partial clear
- (b) Second level—partial clear
- (c) Third level—partial clear
- (d) Fourth level—transient clear
- (e) Fifth level—stable clear.

6.26 Each level takes more drastic action. The system automatically cycles sequentially through the first four levels as required and, if necessary, ini-

tiates a bootstrap. The fourth and fifth levels can also be manually initiated from the SSP.

Bootstrap

6.27 Bootstrap provides a reload of memory only from the 3A CC preferred cartridge tape system. It is a sophisticated, selective reload of only the memory which has been destroyed. Bootstrap is a microprogram-initiated loader with three major segments: the first brings in enough of the loader to continue with a more reliable error checking loader. A second segment, in turn, loads in a more sophisticated system loader and its associated programs. A third, more sophisticated loader handles selective reloading of the 3A CC system by interaction with the 3A CC initialization programs. A bootstrap does not affect translation data. A memory reload must be executed from the SSP to accomplish a complete reloading of MAS. This will also initiate a stable clear.

6.28 The periphery will cause an initialization when a dual fault condition exists, eg, a scanner controller failure on both SYCs. Peripheral unit fault recovery will provide a suitable solution for single fault detection without invoking the initialization sequence.

D. Diagnostics

Computer Aided

6.29 Diagnostics are stored on the tape cartridge (nonresident) only and are loaded into the system by requests typed in by means of the maintenance TTY. The Input Message (IM) manual provides a listing of available diagnostic input messages.

6.30 The results of the diagnostics are printed out by the maintenance TTY in the form of numbers. These numbers are located in the appropriate Trouble-Locating Manual (TLM) and record specific circuit packs which may be responsible for the trouble.

6.31 There are three categories of diagnostics, each having a monitor program which serves as an interface between the test table data and the routines which process the table entries. These are as follows:

- (a) Processor diagnostic
- (b) Peripheral unit diagnostics
- (c) Trunk and service circuit diagnostics.

Processor Diagnostics

6.32 The processor diagnostics are programs (common systems) which employ *start-small* philosophy. A small portion of the machine is first diagnosed and, if its operation is correct, is used for further diagnosis. Essentially, each test is dependent upon the previous test(s). There are two divisions of the tests: the MAS diagnostics and the diagnostics handling the other hardware of the 3A CC. The active processor may diagnose the standby in three ways:

- (a) By the maintenance channel at the microlevel
- (b) By instructing the standby processor to run short sequences of code with the results checked by the active processor
- (c) By instructing the standby processor to run code and check its results.

Peripheral Unit Diagnostics

6.33 The peripheral unit diagnostic programs (applications) diagnose the peripheral controllers when requested. The craft person specifies either the network, peripheral pulse distributor, FIOC, or the scanner to be diagnosed. A diagnostic (DGN:) input message designates the controller to be diagnosed. A peripheral controller can be diagnosed using a restore (RST:) message in lieu of the (DGN:). The diagnostic checks the input/output port of the processor and the FIOC verifying that each is operational as it works its way to the designated controller. The output message returned states the results of the diagnostic performed. The ringing and tone plant is diagnosed in a similar manner.

Trunk and Service Circuit Diagnostics

6.34 The trunk and service circuit diagnostics are programs (applications) invoked for the maintenance of trunks, lines, and service circuits. There are three categories of these operational circuit tests: junctor, trunk, and service. Test circuits are categorized as service circuits for diagnostic purposes.

Network Fabric Diagnostics

6.35 The network fabric exercise program verifies tip-ring wiring for continuity and crosspoints for operation. It also checks for tip and ring reversals. The only crosspoints accessed in the first stage

are associated with loop-start lines. All crosspoints in the second stage are accessed. Third stage crosspoint checks depend on the network frame available.

Manual Trouble Clearing

6.36 The Trunk and Line Test Panel (TLTP) provides manual capability to test trunk, junctor, line, and service circuits. Two access trunks provide access through the network to the circuits that require testing. The access trunks are arranged for key-controlled access to voltmeter and transmission test circuitry and also voice communication facilities.

E. Alarm and Status Reporting

6.37 The alarm and status reporting programs provide a means of notifying the craft person of faults or situations which require action. These programs instantly identify, on the SSP, any system abnormality. They also maintain the current status (standby SYC) of the system as determined by various maintenance and common system programs. The SSP under the control of these programs, provides the craft person with the means for remote access to the system and for initializing the system.

Alarms

6.38 System maintenance is supported by an office alarm structure which serves as the stimulus for software-controlled diagnostics. Both visual and audible alarm indications are provided. When a particular alarm is sounded, a corresponding message is printed on the TTY indicating the category and source of the alarm. The alarm classifications are given as follows:

- (a) **CRITICAL:** This indicates that the system, or a major portion or capability of the system, is inoperable. An audible indication of the CRITICAL alarm is two continuous tones, 1/2-second apart. There is a 1-1/2 second interval before the pattern is repeated.
- (b) **MAJOR:** This indicates a partial loss of the system capability or a failure such that another similar failure could result in a critical condition. An audible indication of the MAJOR alarm is a continuous tone that sounds at 1-1/2 second intervals.
- (c) **MINOR:** This indicates a minor loss of the system capability or some other condition re-

quiring the attention of the maintenance personnel. An audible indication of a MINOR alarm is a continuous tone that is silenced after 5 seconds.

- (d) **MAJOR POWER:** This indicates a major power failure in the power equipment.
- (e) **MINOR POWER:** This indicates a minor power failure in the power equipment.
- (f) **ALARM CIRCUIT:** This indicates trouble in the office alarm circuit or in its battery supply.
- (g) **FUSE:** This indicates a blown fuse.
- (h) **SERVICE LOSS:** This indicates that recovery has taken place with the possible loss of calls approximately within the last 3 minutes.

6.39 There can be two alarm indications, ie, an alarm in classifications (d) through (h) will cause either a critical, major, or minor indication as defined in classifications (a) through (c).

6.40 Only the highest level alarm class is indicated on the SSP at any one point in time. It has priority over a lesser alarm class indication (critical over major or minor), and the lesser alarms would not be indicated until the critical alarm source was eliminated.

6.41 Visual alarm indicators associated with audible alarms remain operated until the alarm is retired. Audible alarms are on a timed interval in the alarm transfer mode (ALARM TRFR key on SSP operated) and can be disconnected manually.

6.42 The software routines related to the alarms initiate the following:

- The TTY message to be printed
- The proper alarm indications, both audible and visible, to be activated
- The proper timing for alarms.

F. Programmed Maintenance Aids

6.43 Programmed maintenance aids assist the craft person to either define a problem or verify a predetermined fault within the system. These aids are as follows:

- Station ringer test line
- Loop-around test line
- Milliwatt test line
- Short circuit
- Open circuit
- Charge test line
- Local test desk
- Trunk and line test panel.

7. SYSTEM SOFTWARE DOCUMENTATION

7.01 To obtain general, specific, and troubleshooting information on No. 3 electronic switching system software, the following documents are available to the user:

(a) **Program and Documentation Guide (PG):**

The PG is an index of the program documents associated with a given generic program/issue. It contains information such as Program Listings (PRs), Input/Output Manuals, and TLMs on a generic basis.

(b) **Input Message Manual (IM):**

The IM (IM-3H300) is a hard copy listing of all TTY input messages/codes that can be inputted and understood by the No. 3 electronic switching system. These messages and codes are used to direct the system to perform certain functions.

(c) **Output Message Manual (OM):**

The OM (OM-3H300) is a hard copy listing of the TTY output messages/codes that are automatically generated by the No. 3 electronic switching system or are the result of an input message made by a given user. The OM lists alphabetically the messages and describes the purpose of the message.

(d) **Software Subsystem Description (SSD):**

These documents are sections in the 233-151-XXX, 233-152-XXX, 233-153-XXX, 233-154-XXX, 254-340-XXX division/layers. These sections provide overall explanations of functional software areas and serve as an aid to access program listings. Refer to the appropriate BSP division index, Sections 233-000-000 and 254-000-000, for current listings of SSDs.

(e) **Trouble-Locating Manuals (TLM):** The TLMs are used primarily to identify faulty circuit packs associated with particular diagnostic failures. The TTY prints out a coded number which, when referenced in the TLM, indicates a list of possible faulty circuit packs. See Table A for a listing of the No. 3 electronic switching system TLMs.

(f) **Program Listing (PR):** The PRs are hard copy records of software programs. The PRs consist of program objectives, lists of all instructions, and any unique program data. The PR program listing is a product of the software assembly language process. Current listings of PRs are contained in the No. 3 electronic switching system PG (3H903).

(g) **Program Load Map (PK):** The PK contains a list of all programs in the system together with their starting and ending addresses. Other PKs are available dealing with No. 3 commands, network troubleshooting, maintenance reference, and miscellaneous alarms.

(h) **Program Application Instruction (PA):** The PA contains specifications for such items as office data tables layout or translations.

7.02 For a list of the No. 3 electronic switching system applicable software documentation, refer to Table B.

8. GENERIC PROGRAM CHANGES

A. General

8.01 Generic program changes are made either to correct service affecting problems or to provide new or improved call processing and maintenance features and capabilities. Generic programs are identified by issue number, and by partial issue change identifying numbers termed point issue numbers. A complete generic change is termed a **retrofit** and an issue change is termed a **restart**. Retrofits and restarts are the responsibility of Western Electric. Certain program changes that require immediate action are termed **overwrites**, and their installation is the responsibility of the Bell Operating Companies (BOCs). Overwrites are distributed to BOCs by the Western Electric Product Engineering Control Center (PECC) as **Broadcast Warning Messages (BWMs)**.

B. Broadcast Warning Messages (Overwrites) and Software Change and Notification System (SCANS)

8.02 Computerized methods for the distribution and administration of BWMs are provided by SCANS. The SCANS computer is accessed by users over dial-up connections and provides the following user features:

- (a) Urgent bulletins and information messages relating to BWMs or other pertinent maintenance data
- (b) Complete hard copies of BWMs including overwrites and symbolic code
- (c) Electronic switching system machine readable overwrites in the form of paper or magnetic tape
- (d) Tape verification allowing the user to transmit the data received back to the SCANS computer for a match of the data
- (e) Summary reports of BWMs by sequence number, date, generic issue, and miscellaneous references
- (f) Status reports of BWMs that have been completed or are scheduled for completion on an office-by-office basis.

Note: The BWMs should be inserted within 3 weeks of the SCANS entry date. Section 190-306-010 describes the operation and use of the SCANS system.

8.03 Section 190-306-010 contains guidelines for the determination that an overwrite is to be placed in a particular office.

C. Retrofits and Restarts

8.04 A generic restart is a change to a new issue of the generic program loaded in the office and contains all broadcast warning overwrites issued against the preceding issue plus other changes. A generic retrofit is where the office is upgraded from one generic program to a later generic program.

8.05 Application of generic overwrites in working offices is normally the responsibility of the operating company. However, when a generic restart,

retrofit, or turnover of a new office is involved, Western Electric installation is responsible for turning over a generic program which has all applicable overwrites installed and verified.

8.06 Although retrofits and restarts are primarily the responsibility of Western Electric installation, participation of the responsible BOC network maintenance group is required to assure that the project is completed with minimum service interruption.

8.07 In the No. 3 electronic switching system, all critical call processing equipment (ie, central processor, call store, etc) is fully duplicated. Under normal operating conditions, the office has been operating on one issue of the generic program for an extended period of time. Therefore, whenever a trouble condition arises, the most probable source of the trouble would be the hardware and not the software.

8.08 Whenever a retrofit or restart occurs, the program store memory is configured to simplex with half of the program store loaded with the original generic program and the other half of the program store loaded with the new generic program. Under this configuration, whenever a trouble condition arises, the most probable cause of trouble is the new generic program, parameter information, or operational procedures.

Retrofit/Restart Preparations

8.09 In order to resolve troubles which might occur during retrofit and restart in a fast and efficient manner, thereby decreasing the probability of total system outage, no known hardware troubles should exist. In order to reduce the probability of total system outage during a retrofit or restart, seven operations have been identified as required by the BOCs.

Note: Additional steps or methods may be required due to local conditions.

(a) Approximately 2 weeks prior to the retrofit or restart schedule date, all output messages related to critical call processing equipment (eg, program control, call store, and program store) must be closely analyzed to assure that all hardware troubles have been cleared. Typical indicators of hardware troubles would be mismatches, CU switches, nonscheduled system initiated diagnos-

tics, etc. If no known hardware troubles exist, any adverse reactions will be assumed to be a result of the retrofit or restart.

(b) All system evaluation procedures should be performed within the week prior to a retrofit or restart. The results of these tests should be made available to Western Electric installation if these tests are done in preparation for a generic retrofit.

(c) Special reviews of all maintenance-related printouts should be started at least 48 hours prior to the scheduled retrofit or restart. This review is to assure that no unexplained or intermittent troubles are present. This means no unexplained mismatches, CU switches, nonscheduled diagnostics, etc, have occurred during this 48-hour period. The retrofit or restart should be postponed until the system is able to meet this standard.

(d) Assure that all necessary trouble-locating equipment (eg, oscilloscope) is onsite and in working condition. Verify that maintenance personnel are proficient in its use. This equipment will assist in the resolution of any hardware troubles that may arise.

(e) Review and assure that all emergency recovery documents are onsite and readily available. In addition, assure that the data set for establishing TTY connections with the Electronic System Assistance Center (ESAC) is operational.

(f) If any critical call processing equipment is removed from service by the system during the retrofit or restart, all retrofit or restart operations must stop. If that equipment cannot be restored by normal maintenance procedures, backout procedures are required in order to return the No. 3 electronic switching system back to a known established configuration of hardware and software.

(g) If a piece of equipment was restored, adequate testing must be made to make sure that the trouble has been cleared. After the maintenance personnel are fully assured that the trouble has been cleared, the retrofit or restart can be reinitiated.

8.10 It is imperative that BOC maintenance people involved in restart or retrofit activities assist

in the preparation of a clear and concise Method of Procedure (MOP) covering the step-by-step operations required in the retrofit or restart.

D. Retrofit/Restart Management

8.11 The Generic Update Program (GUPD) provides the means to retrofit a generic program onsite using the current customer changes in translation store. The GUPD runs as a standalone program in the off-line Control Unit (CU). It reformats translations onto a tape cartridge that contains the new generic program.

8.12 An Engineering Change Procedure (ECP), designed specifically for working offices in conjunction with the GUPD, provides the basis for a Method Of Procedure (MOP). For generic restarts, the GUPD is not used. Instead an ECP is developed that details the copying of translation data files from the old to the new point issue tape cartridge.

9. SOFTWARE MANAGEMENT GROWTH PROCEDURES

9.01 Software growth in an existing No. 3 electronic switching office is by means of reallocation programs that can change, add, or remove translation tables. This self-growth capability in memory removes any further need for replacing translation data by the network administration program. Refer to Section 233-154-130 for reallocation procedures.

9.02 The volume of spare memory can be verified by system input and output messages. Refer to Section 233-160-100 for guidelines on software growth.

10. ELECTRONIC SYSTEMS ASSISTANCE CENTER (ESAC)

10.01 The ESAC is the corporate level organization in each BOC that is responsible for electronic switching system administration assistance and technical support not able to be provided on a local area basis. Problems that cannot be expeditiously cleared on a local or Switching Control Center (SCC) level should be referred to ESAC. Escalation of troubles to Western Electric or Bell Laboratories should be made through the ESAC whenever possible. Refer to the 190 series of Bell System Practices for escalation procedures and guidelines.

10.02 In addition to direct operational support, the ESAC will assist in the following maintenance

functions (refer to GL 78-01-057 for a complete list of ESAC functions).

(a) **Service Outage Investigation:** Follow-up investigation and reports of major service outages remain the responsibility of local office management. However, ESAC personnel should participate in all outage inquiries to lend technical expertise.

(b) **Cutovers:** The ESAC will provide technical support to line organizations responsible for first application of SPC equipment in a given company and field trials of new apparatus.

(c) **Parameter and Network Administration Reviews:** This duty is primarily the responsibility of local office switching and engineering personnel. The ESAC personnel will aid in these reviews on an *as requested* basis where applicable.

(d) **Translation Services:** The ESAC personnel will *assist* in the preparation of translation changes that are extremely lengthy or complex.

(e) **Operational Trouble Report (OTR) Review:** The ESAC will review the original copy of the OTR before it is transmitted to Western Electric.

(f) **Resident Maintenance Engineer Responsibility:** The duties of the resident maintenance engineer are as follows:

- Engineering complaints follow-up
- Change notice coordination
- Emergency hardware procurement
- Software update coordination.

11. OPERATIONAL TROUBLE REPORTS (OTRs)

11.01 The OTRs provide a means of informing Western Electric and/or Bell Laboratories Quality Assurance of important problems so that corrective action can be taken and information distributed to all electronic switching system offices which may be affected.

11.02 The OTRs should be used to report troubles concerning any aspect of the electronic

switching system—maintenance or administrative. Nonroutine troubles or unusual actions concerning hardware or software, troubles of uncertain or mixed cause, or comments on system operation and equipment arrangements should be reported by using the Stored Program Control System (SPCS) OTR, Form E-5232 (Fig. 9). The OTRs should also be submitted for any reportable occurrence relating to:

- (a) Office cutovers
- (b) Generic program changes
- (c) Total outages of 2 minutes or more
- (d) Any unexplained service affecting problems.

11.03 From time-to-time, American Telephone and Telegraph (AT&T), Bell Laboratories, or Western Electric may ask that OTRs be written to assist in gathering information on problems under investigation. ***The OTRs should not be prepared on items which are not related to the present design (ie, suggestions for system design improvements, administrative routines, human safety problems unrelated to system operating design, etc).*** These should be presented through normal channels. More detailed information concerning the OTR routine may be found in Section 790-120-260.

11.04 The OTR numbering scheme to be used is at the discretion of the operating company. However, the system should incorporate a means of serially numbering the OTR and indicating the year, ie, 03-80, on an office or SCC basis.

11.05 The OTR will be routed as shown in Fig. 10, Operational Trouble Report Flowchart. The original of all OTRs should be sent to the ESAC for review and forwarded to the Western Electric PECC.

11.06 It is not expected that a formal reply will be furnished on OTRs. Any corrective action taken will be covered by the usual notification of change. The OTR does not supercede an Engineering Complaint (EC) for items on which the telephone company requests corrective action and a final report.

11.07 The PECC will analyze, categorize, and process OTRs to identify common problems. They will then prepare summaries of recognized

problems, their service effect(s), and any service protective actions or precautions to be taken. On a regular basis, summaries will be distributed to Western Electric Regional Engineering, Bell Laboratories Quality Assurance, AT&T Engineering and Network Services, and other affected organizations. When problems are solved, the Trouble Status Report will be marked to show the issue of program, the Change Notice (CN), etc, which solved the problem.

12. ENGINEERING COMPLAINTS (ECs)

12.01 An EC is a written report covering a product furnished by Western Electric that:

- (a) Does not satisfy the purpose for which it was intended
- (b) Does not fulfill the requirement under which it was manufactured or inspected
- (c) Does not operate as it should
- (d) Does not have reasonable life
- (e) Does require excessive field maintenance
- (f) Does have possible hazards.

12.02 The ECs provide information on defective or malfunctioning products to Western Electric and the Quality Assurance Center (QAC) of Bell Laboratories. These complaints also provide an important means of checking the adequacy of quality assurance measures specified for products manufactured or inspected by Western Electric.

12.03 The No. 3 electronic switching system hardware problems that result in ECs will, in most cases, be discovered by central office maintenance or SCC forces. Software problems will be more likely to be identified as such by ESAC personnel. Whatever the origin of the complaint, the decision to escalate an OTR pertaining to a software trouble to EC status will generally be made by ESAC as described below.

12.04 The EC, Form E-5141, Fig. 11, should be used for reporting details of a defective product or program. It is called an EC because the BOC engineering department has final responsibility for determining that the complaint is valid and forwarding it to Western Electric. Instructions for completing

the form are contained in Section 010-700-010. Before an EC form is prepared, there must be reasonable certainty that the defect and related conditions meet the requirements outlined in Section 010-799-010 and that all applicable instructions for installing, operating, and maintaining the product have been applied.

12.05 Section 010-700-030 outlines the procedure established for the expedited handling of certain initially defective items of apparatus and equip-

ment which are to be returned to Western Electric. This procedure, which is commonly known as the **Pink Tag** (Form E-10118) routine, is applicable regardless of whether the items were installed by BOC personnel or Western Electric installation forces. Provision is made for return of these items for repair, replacement, or credit. The flow of information of an EC is shown in Fig. 12, and a copy of a Final Report on an EC is shown in Fig. 13.

TABLE A

**NO. 3 ELECTRONIC SWITCHING SYSTEM
TROUBLE-LOCATING MANUALS**

NUMBER	TITLE (PROGRAM MNEMONIC)
TLM-3H100	Frame I/O Controller (FIOCT)
TLM-3H101	Scanner Controller (SCNT)
TLM-3H102	Peripheral Pulse Distributor (PPDT)
TLM-3H103	Network Controller (NTCT)
TLM-3H104	Ringling and Tone Plant (RTPT)
TLM-3H105	TTY Controller (TTYT)
TLM-3H110	Overall Trunk and Service Circuit TLM
TLM-3H111	Customer Dial Pulse Receiver (CDPRT)
TLM-3H112	Superimposed Ringing Circuit (SUPRT)
TLM-3H113	Multifrequency Receiver (MFRT)
TLM-3H114	Multifrequency Transmitter (MFTT)
TLM-3H115	Test Vertical Circuit (TVCT)
TLM-1C900	Common Systems Processor Trouble-Locating Manual
TLM-1C904	Common Systems Tape Data Controller Trouble-Locating Manual

TABLE B

**NO. 3 ELECTRONIC SWITCHING SYSTEM
MISCELLANEOUS SOURCE DOCUMENTS**

NUMBER	TITLE (PROGRAM MNEMONIC)
IM-3H300	Input Message Manual
OM-3H300	Output Message Manual
PA-3H303	Office Data Tables Layout Specifications
PG-3H903	Documentation Guide for Generic 3E3
PK-1C900	Maintenance Reference Manual (Common Systems)
PK-1C901	Command Manual
PK-3H300	Load Map
PK-3H301	Network Troubleshooting Manual
PK-3H302	Miscellaneous Fixed Alarms

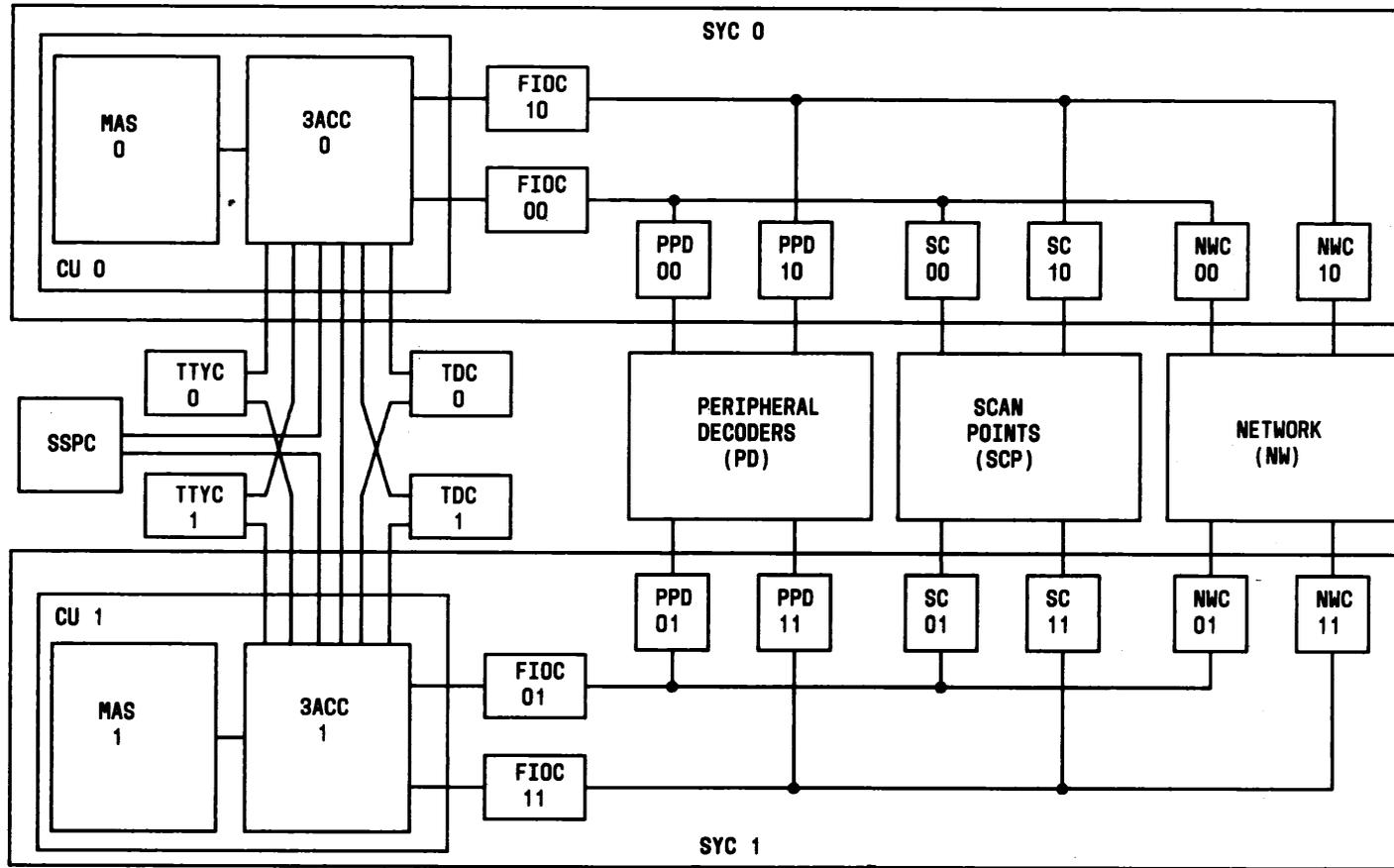


Fig. 1—System Control (SYC0, SYC1) Within No. 3 Electronic Switching System (2.05)

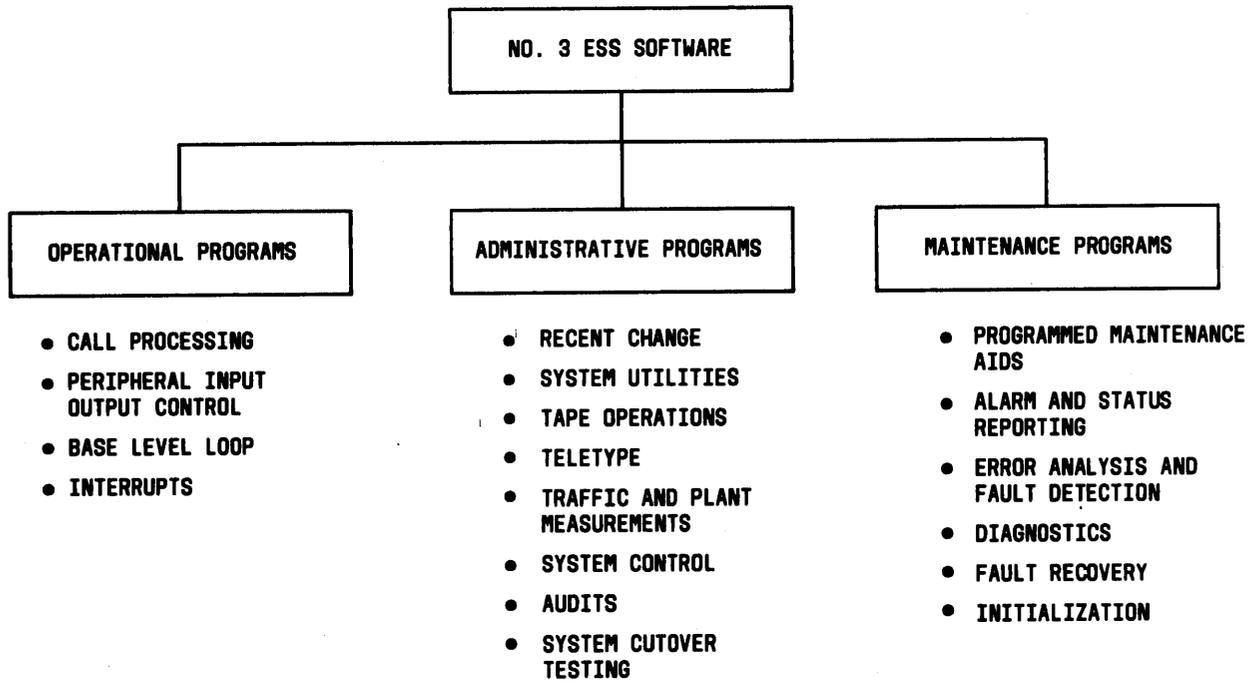


Fig. 2— No. 3 Electronic Switching System Functional Listing of Programs (3.09, 6.01)

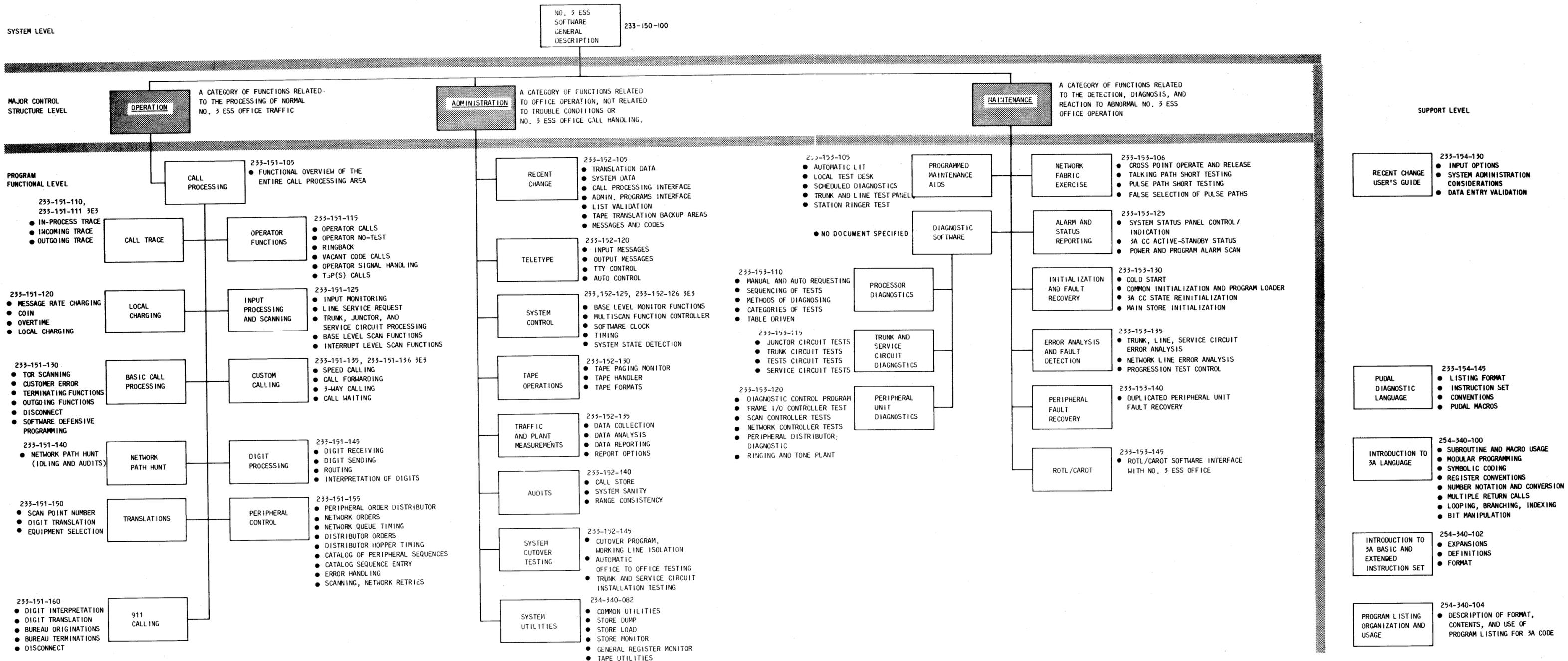


Fig. 3—Functional Organization of No. 3 Electronic Switching System Software Documentation (4.01, 5.01, 6.01)



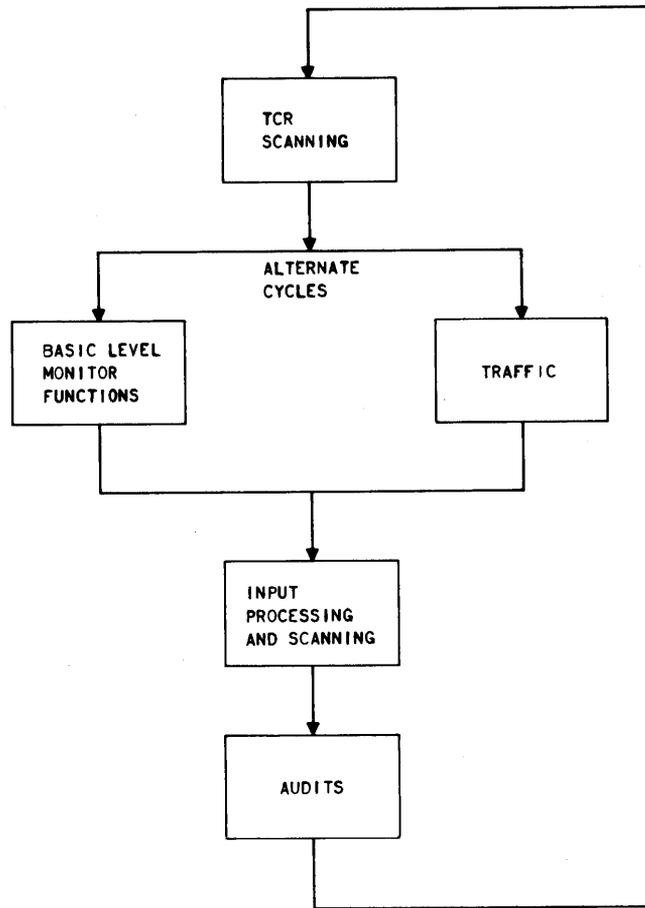


Fig. 4—Base Level Loop (4.02)

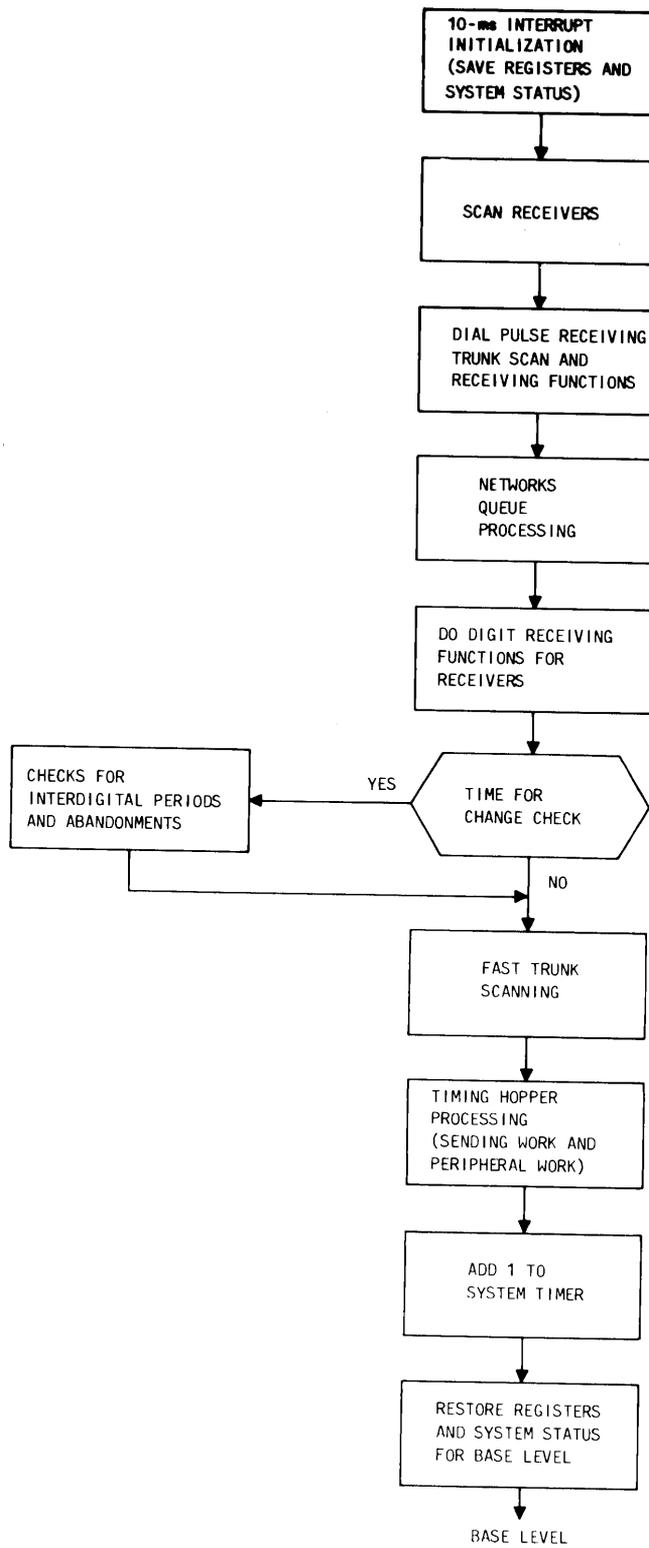


Fig. 5—Timed Interrupts (4.03)

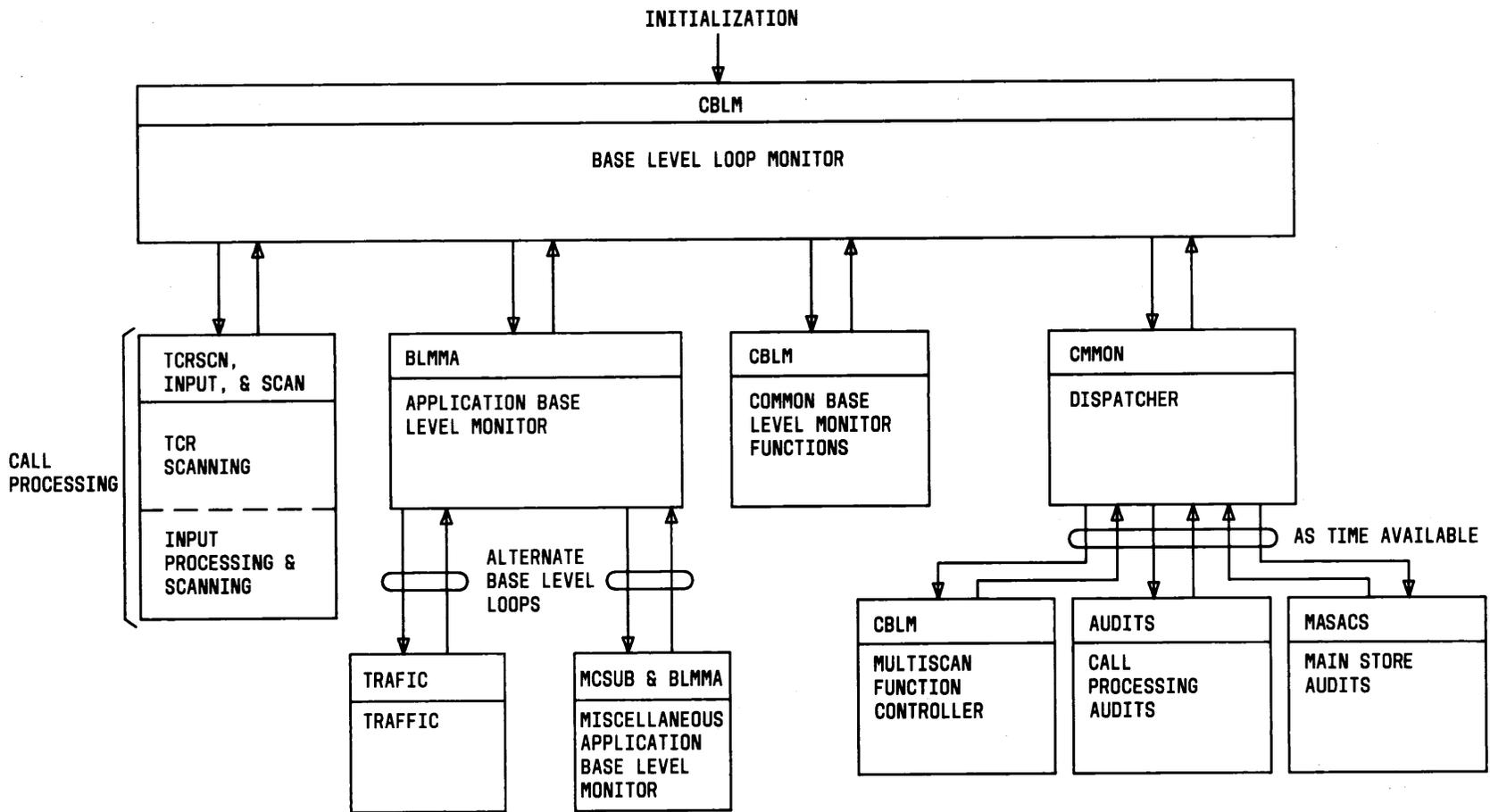


Fig. 6—Base Level Loop Generic 3E3 (4.03)

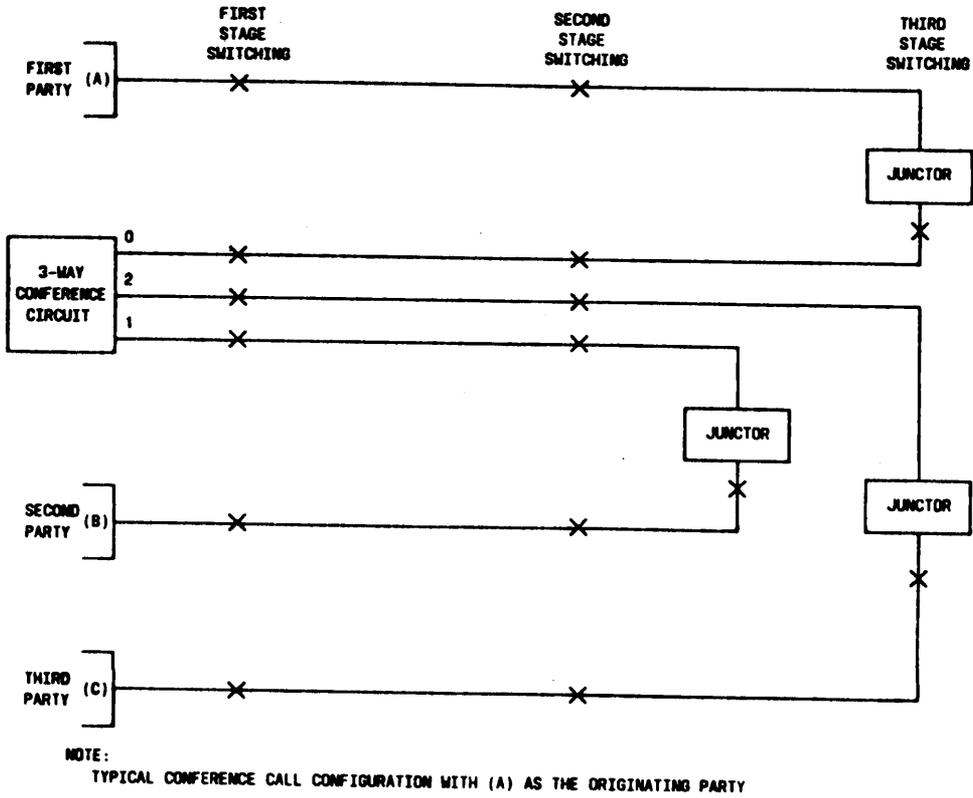


Fig. 7—Three-Way Conference Call (4.16)

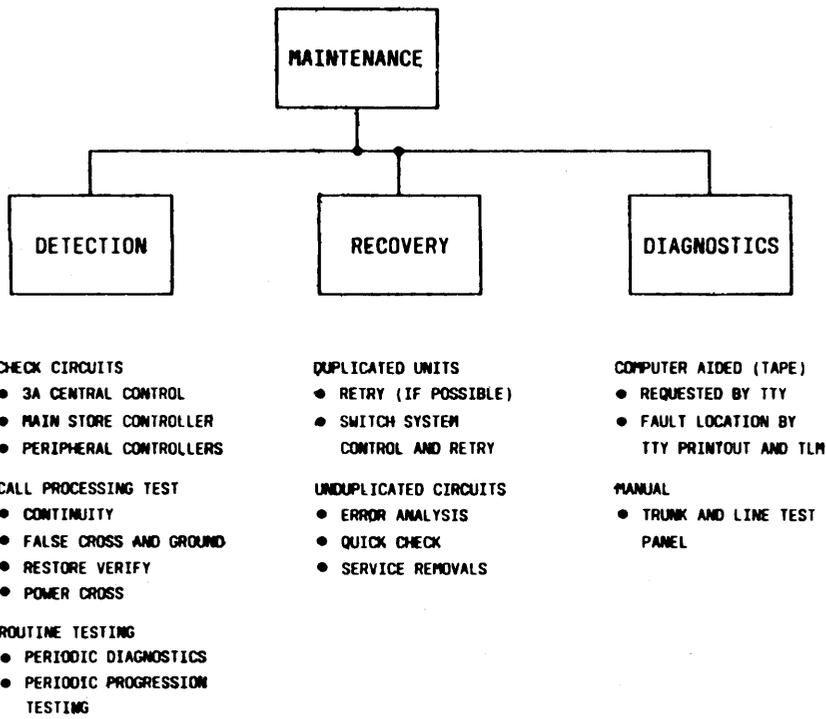


Fig. 8—No. 3 Electronic Switching System Maintenance Plan (6.02)

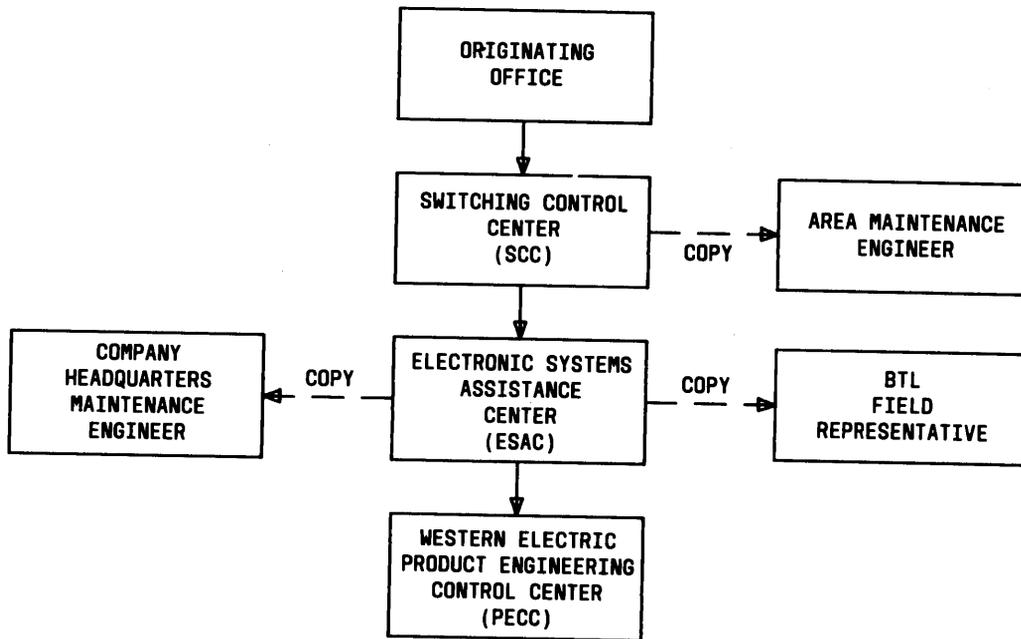


Fig. 10—Operational Trouble Report (OTR) Flowchart (11.05)

ENGINEERING COMPLAINT
(SEE REVERSE SIDE FOR INSTRUCTIONS)

		EC NO.			
PRODUCT LIABILITY	1a. CKT (BO, T, ETC. - SHOW COMPLETE NUMBER & NAME)		2. DOES EC REPORT A FIRE OR SAFETY HAZARD? <input type="checkbox"/> YES <input type="checkbox"/> NO		
			3. SYSTEM (ESS 1, LHM-2, B 12 PBX, ETC.)		
	1b. EQUIP (J, ED. - SHOW COMPLETE NUMBER & NAME)		4. WHERE WAS PRODUCT WHEN IT FAILED (C.O. NAME, PBX LOCATION, ETC.)		
	1c. SPECIFICATION (KS, AT - SHOW COMPLETE NUMBER & NAME)		5. MANUFACTURER: <input type="checkbox"/> WE <input type="checkbox"/> OTHER		
	1d. SOFTWARE DOCUMENT (PG, PD, PF - SHOW COMPLETE NUMBER & NAME)		6a. HOW MANY DEFECTIVE UNITS DOES THIS EC COVER?		
	1e. APPARATUS CODE (TEL. SET, DATA SET, ETC. - SHOW NUMBER & NAME)		6b. HOW MANY SIMILAR UNITS ARE IN SERVICE AT SAME LOCATION?		
	1f. COMPONENT APPARATUS (USED ON EQUIP OR OTHER APP - SHOW NUMBER & NAME)		7. <input type="checkbox"/> NEW <input type="checkbox"/> CLASS C		
1g. OTHER (DESCRIBE FULLY)					
8. STATEMENT OF PROBLEM (DETAILED DESCRIPTION OF TROUBLE, INCLUDING EVENTS PRECEDING FAILURE, ACTION TAKEN DURING TROUBLESHOOTING, TEST FAILED, ETC.)					
<input type="checkbox"/> ADDITIONAL MATERIAL ATTACHED					
9. WAS CONDITION CORRECTED LOCALLY? <input type="checkbox"/> YES <input type="checkbox"/> NO (IF SO, DESCRIBE BRIEFLY. ATTACH EXPLANATION) (SKETCHES, MARKED DRAWINGS, ETC.)					
<input type="checkbox"/> ADDITIONAL MATERIAL ATTACHED					
10. PROBLEM ORIGINALLY REPORTED BY:		11a. REVIEWED AND APPROVED BY:	11b. TELEPHONE NO.		
		11c. DATE			
PLANT, CUSTOMER SERVICES OR NETWORK SERVICES STAFF	12. HAS THE ABOVE INFORMATION BEEN VERIFIED THAT IT IS COMPLETE AND ACCURATE? <input type="checkbox"/> YES <input type="checkbox"/> NO		15. COMMENTS OR RECOMMENDATIONS		
	13. HAS THIS PROBLEM PREVIOUSLY BEEN REPORTED AND CORRECTED IN AREA? <input type="checkbox"/> YES <input type="checkbox"/> NO				
	14a. DO OTHER LOCATIONS IN YOUR AREA APPEAR TO HAVE SAME PROBLEM? <input type="checkbox"/> YES <input type="checkbox"/> NO <input type="checkbox"/> WAS UNABLE TO DETERMINE				
	14b. IF YES, LIST LOCATIONS AND QUANTITY DEFECTIVE AT EACH LOCATION				
<input type="checkbox"/> ADDITIONAL MATERIAL ATTACHED					
16a. REVIEWED AND APPROVED:		16b. DATE			
ENGINEERING	17. OTC REQ. NO.	18. WE ORDER NO.	26. COMMENTS OR RECOMMENDATIONS (IF POSSIBLE, DESCRIBE SERIOUSNESS OF PROBLEM, E.G., CAUSES WIDESPREAD CUSTOMER REACTION, LOSS OF REVENUE, ETC.)		
	19. TOTAL NUMBER OF UNITS FURNISHED ON ABOVE ORDER	20. HOW LONG HAS EQUIP. OR APP. BEEN IN SERVICE?			
	21a. DO OTHER LOCATIONS IN YOUR AREA APPEAR TO HAVE SAME PROBLEM? <input type="checkbox"/> YES <input type="checkbox"/> NO <input type="checkbox"/> WAS UNABLE TO DETERMINE				
	21b. IF YES, LIST LOCATIONS AND QUANTITY DEFECTIVE AT EACH LOCATION				
	<input type="checkbox"/> ADDITIONAL MATERIAL ATTACHED				
	22. ACTION DESIRED ON DEFECTIVE PRODUCT <input type="checkbox"/> CREDIT <input type="checkbox"/> REPAIR			27a. AREA CONTACT	
	RETURN MATERIAL DOCUMENT NO. DATE			27b. TEL. NO.	
23. SAMPLES <input type="checkbox"/> NONE AVAILABLE		28a. REVIEWED & APPROVED BY: (TYPE OR PRINT NAME)			
BEING HELD BY: AT:					
28. DISPOSITION DESIRED ON SAMPLES <input type="checkbox"/> JUNK <input type="checkbox"/> REPAIR & RETURN					
25. THIS APPEARS TO BE SIMILAR TO EC NO.		28b. DATE			

E-5141 (1-78)

Fig. 11—Engineering Complaint Form (12.04)

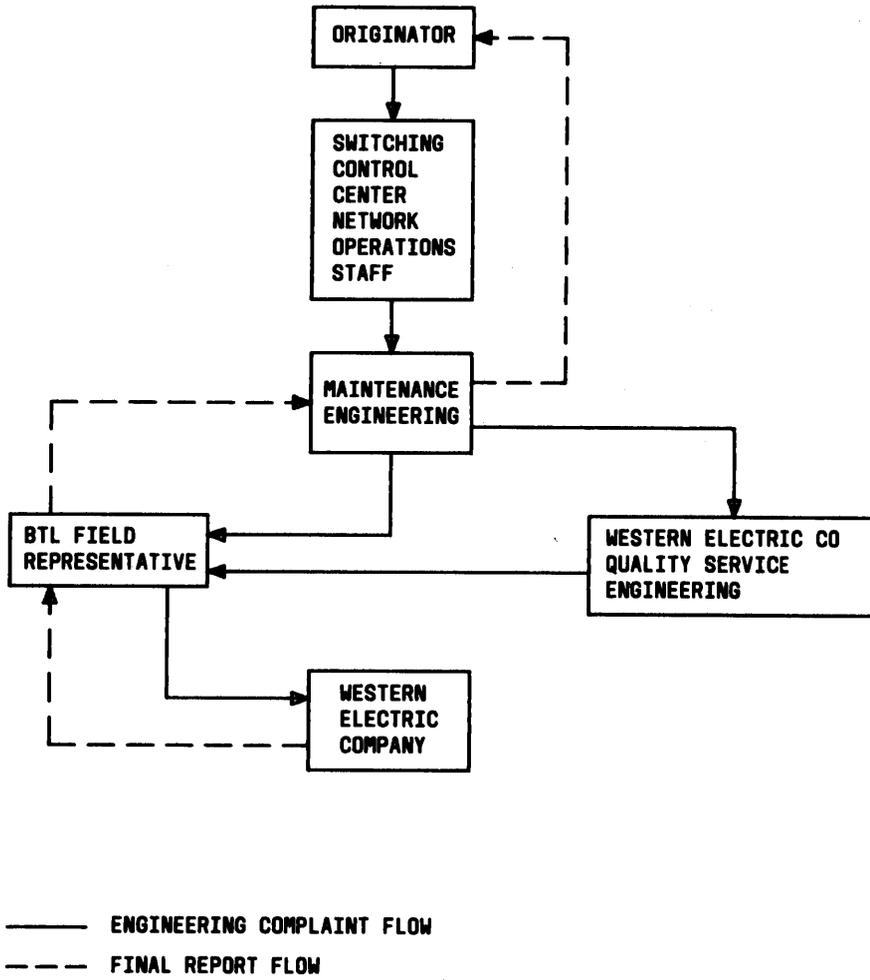


Fig. 12—Engineering Complaint Flowchart (12.05)

**CLASS 1W
ENGINEERING COMPLAINT NO.
FINAL REPORT**



WESTERN ELECTRIC

FIELD OFFICE:

DATE:

OPERATING COMPANY:

OPCO DATE:

SUBJECT:

PRODUCT IDENTITY:

COMPONENT:

REPORTED CONDITION:

ABSTRACT OF REPORT:

HAS THIS INVESTIGATION RESULTED IN A DOCUMENTATION CHANGE? YES NO

IF YES, SHOW:

**DOCUMENT
NUMBER(S)**

**ISSUE &
CLASSIFICATION**

**ESTIMATED
AVAILABILITY DATE**

REPORT OF INVESTIGATION:

Fig. 13—Final Report of Investigation of Engineering Complaint (12.05)