SWITCHING SYSTEMS MANAGEMENT
NO. 3 ELECTRONIC SWITCHING SYSTEM
SYSTEM INITIALIZATION PROCEDURES

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1. INTRODUCTION

1.01 When a No. 3 Electronic Switching System (ESS) is failing to process calls properly it should be automatically attempting to recover itself by taking automatic emergency actions. This condition should be indicated to telephone company personnel by teletypewriter (TTY) printouts. If automatic emergency actions do not restore the system to a working control unit, manual emergency actions will be required utilizing the system status panel (SSP). These automatic and manual emergency actions are termed ***initializations.***

1.02 This section describes system initialization for the No. 3 ESS. It provides the network administrator with information pertaining to the effects of initializations in such areas as call processing, the traffic work table (TWT), and traffic registers. It also indicates those areas where recovery action on the part of the network administrator is necessary.

1.03 When this section is reissued, this paragraph will contain the reason for reissue.

1.04 The title of each figure includes a number in parentheses which identifies the paragraph in which the figure is referenced.

2. INITIALIZATION PROCESS

2.01 Serious No. 3 ESS system difficulties may be caused by equipment (hardware) troubles, by difficulties in the program or translations (software), or by human error. An initialization is an attempt to regain system sanity by restarting the program at some fixed location and proceeding in an orderly manner to the beginning of the call processing monitor cycle.

STIMULUS FOR INITIALIZATION

2.02 A system initialization may be performed as a result of any one of the following conditions:

- Program timer time-out
- Error detection
- Control system switch request via the maintenance channel
- Power turn on
- Manual initialization request from the SSP.

2.03 When an initialization is triggered in the No. 3 ESS, the 3A Central Control (CC) and periphery will be restored to a known good state and certain activities will be aborted. This ensures that the equipment is in condition to run the software initialization. Selected bits of data are loaded into a dedicated area of memory known as the "postmortem" area. This loading is done early enough in the initialization process to be useful during that initialization attempt. Temporary data in the main store memory (MAS) may then be zeroed or otherwise initialized and resident generic programs or translations reloaded into write protected MAS memory from the magnetic tape backup. Not all of these functions are performed on every initialization. The severity of the problem will determine the action required.

MEMORY FACILITIES

2.04 In order for the network administrator to understand the No. 3 ESS initialization process it is necessary to understand the software and memory facilities which are utilized. The three memory facilities utilized by the No. 3 ESS are:

(1) main store

(2) tape cartridge

(3) microprogram store.

2.05 The main store is an electrically alterable semicondutor memory and serves as the storage medium for generic program instructions, translations, and call handling information. It also serves as the temporary memory used to store the call processing and administrative information required for system operation such as transient call records (TCRs), terminal memory records (TMRs), traffic registers, etc. MAS is the only No. 3 ESS memory facility which can experience a loss or alteration of stored data as a result of an initialization. Barring a system failure, concern afforded by the network administrator to an initialization should be due to the loss or alteration of pertinent data in MAS.

2.06 The tape cartridge facility provides a backup image of all the generic program, parameter, and translation data residing in MAS. It also contains other programs which are infrequently used and are loaded into MAS only as required. Additional information stored on the tape cartridge includes tape loading instructions, generic program patch files, and back dated copies of office translations. If the accuracy of some area of MAS memory containing generic or translation data is in question, an operation known as a "bootstrap" is capable of reloading that area of MAS using the image stored on the tape cartridge.

2.07 Microprogram store is a hardwired (diode array) memory and can only be changed by changing memory circuit hardware. The microprogram store facility provides most of the complex controls and sequencing operations required for implementing the system instructions. An instruction stored in MAS is used to address a microinstruction in the microprogram store. This begins a microsequence composed of microinstructions used to perform the function specified by the instruction in MAS. Many complex control functions including a portion of the initialization function are stored in the microprogram store.

INITIALIZATION STAGES

2.08 When an initialization occurs in a No. 3 ESS, it will proceed in the following stages:

(1) Hardware

(2) Microcode

(3) Main memory.

A. Hardware Initialization

2.09 As stated earlier, instructions in MAS are used to trigger microsequences stored in microstore, and one such microsequence serves the purpose of initialization. In order for this microcode initialization to occur, the address of that microsequence must appear in the microstore address register (MAR) in the 3A CC microprogram control and the microprogram control must be allowed to perform the microsequence. This is the purpose of the hardware stage of system initialization. It jams the address of the initialization microcode into the MAR and and initialized enough hardware to allow the microcontrol to sequence.

B. Microcode Initialization

2.10 The second stage of initialization is performed by the initialization microprogram. Predetermined system states are first stored to direct the machine to a return point upon successful completion of initialization. The microprogram then sequences through to determine which one of three possible paths is indicated. The result will be one of the actions below.

- Stop and switch to other Central Control
- Reload main memory from tape (Bootstrap)
- Go to main memory initialization.

2.11 If a stop and switch occurs, the initialization will be terminated and the other central control will be placed on-line. The other central control will then be initialized.

2.12 If a memory reload occurs, the bootstrap operation will determine what areas of MAS are in question and will reload those areas using the image on the tape cartridge as a source. Control will then be passed on to the main memory initialization program for the main memory stage of initialization.

C. Main Memory Initialization

2.13 Primarily, main memory initialization is executed cooperatively by the common system initialization program (CINIT) and the application portion of the initialization program (INITA). CINIT, as its name implies, is a program common to 3A processors in several other applications. INITA is necessary to make CINIT applicable to the No. 3 ESS. During main store initialization, control will be passed back and forth a number of times between CINIT and INITA.

2.14 As stated earlier, the loss or alteration of data in MAS may affect the network administrator. To what extent will depend upon the severity of the initializing action. For example, a given initialization may zero some or all temporary data in MAS, ie, TMRs, TCRs, traffic data, etc. An initialization process which cleared and restored all MAS and restored the entire network would be effective in solving the problem at hand but would seriously disrupt call processing. A more desirable approach is to perform the initialization in levels, and after each level to allow call processing to resume. If call processing were then to continue normally for some probationary period it could be assumed that the problem was corrected or isolated. If call processing were to falter, a higher level of initialization would be attempted. The escalation is encoded in the level number, which is incremented by CINIT just prior to its passing control to INITA for the first time during each main memory initialization. The higher the level number, the more drastic should be the response. The level count is zeroed after 1000 base level scans have successfully elapsed since the last initialization sequence (3 minutes, 20 seconds), or when the level count has reached its maximum of 4.

2.15 It is well to mention at this time that if an initialization attempt is terminated prior to CINIT passing control to INITA for the first time during the main memory stage of the initialiation, the initialization level counter may not be incremented. If, under these circumstances, the system fails to recover, a second initialization will be attempted. This second initialization will, however, pursue some path mentioned in 2.10 different from that pursued by the earlier initialization attempt.

2.16 Most of the clearing action performed on the temporary MAS data will be under the control of INITA. Those areas cleared by CINIT make up only a small part of the temporary data and will not affect the network administrator. INITA on the other hand is capable of clearing the remaining temporary data in MAS and as such it relies heavily on the initialization level to determine what clearing is to be accomplished.

2.17 Figure 1 lists the types and level count of system initializations along with a synopsis of the effect that each has on call processing. An additional initialization, not shown in Fig. 1, is the TTY initialization. The TTY initialization is intended to be used when it is felt that the TTY is in trouble but there is still network action indicating that call processing is taking place. The TTY initialization, which can be triggered manually at the SSP or any TTY, causes clearing of the TTY memory area, and does not interrupt call processing.

3. INITIALIZATION LEVELS

3.01 The following paragraphs discuss the clearing action performed by INITA during the main memory stage of initialization. Items which are of special importance to the network administrator are indicated in italics.

Minimal Clear Initialization (Level 1)

3.02 A minimal clear initialization is the first level of initialization and will occur when the following conditions exist:

(a) The initialization level is one

(b) No emergency action keys are depressed at the SSP

(c) MAS translation data has not been altered by a bootstrap operation

(d) A good copy of temporary MAS is available.

3.03 Registers in the post-mortem area are first examined. When the register points to a TCR, this TCR is put in the failure state so that it will be removed when call processing resumes. Also the hold/get stack is analyzed, and any TCR found active at a higher level than the level experiencing the error interrupt is marked for processing by failure routines when call processing resumes.

3.04 The following temporary store will then be cleared:

Audit control

Base level scratch area

Translation error buffer

Camp-on buffer

Peripheral diagnostic request buffer

Ringing and tone plant data

Ringing and tone plant count

Error analysis—quick check entries

Quick check control

Line origination hopper overflow count

Network audit map

Error analysis input buffer

Hold/get counter

Hold/get area

Call trace input message buffer

Trunk and service circuits maintenance aids programs input buffer

Miscellaneous power status

24 Volt power status

Nonresident generic program active timer

Recent change status of translation store

Resident directory for tape handler

Network controller recovery buffer.

The last-look and ignore bits of miscellaneous scan points are initialized to their expected values. This provides for reporting all off-normal indicators (such as alarms) following the initialization. The peripheral controllers are then initialized and the ringing and tone plant counter is set to all ones.

3.05 The clearing action of a level 1 initialization will cause an imperceptible delay in call processing. One or two calls, in a transient state, may be set back to an off-hook condition. No action is required on the part of the network administrator.

Partial Clear Initialization (Levels 2 and 3)

3.06 A partial clear initialization will be initiated when the following conditions exist:

(a) The initialization level is two or three

(b) No emergency action keys are pushed at the SSP

(c) MAS translation data has not been altered by a bootstrap

(d) A good copy of temporary MAS is available.

3.07 Four additional tasks (in addition to those done during partial clear—level 1) are performed. First, the hold/get stack is analyzed, and any TCR found active at a higher level than the level experiencing the error interrupt is marked for processing by failure routines when call processing resumes. Second, all TCRs containing MAINT or MTC_NW progress marks are marked for failure processing, because these are under control of multiscan functions which were aborted by CINIT. Third, the following additional temporary store is cleared.

Levels 2 and 3

Maintenance status table

Cassette tape handling I/O buffer

Line scan status

Resident-nonresident interface

Administrative control common areas

Recent change reallocation status

Alarm unit lamp counter

Alarm block

Automatic line insulation test data

Station ringer test data

Local test desk table

Mini multiscan function task status block

Building alarm status word

Routine diagnostic data

Level 3 Only

Maintenance known fault list

Path hunt data word

Application utility routine data

Miscellaneous flags

Calling line identification table for trace

Fourth, the off-line processor peripheral controllers are removed from service during a level 3 initialization.

3.08 The clearing action of a level 2 or level 3 initialization will cause an imperceptible delay in call processing. A number of calls in the transient state may be set back to the off-hook condition. In addition, ***Dynamic Service Protection (DSP) will automatically be placed in the inhibited state by a level 3 initialization or above.*** The network administrator has a joint responsibility with Network Maintenance for executing DSP. DSP may be allowed or denied via either the maintenance or network administration TTY.

Transient Call Clear Initialization (Level 4)

3.09 A transient call clear initialization can be initiated either manually or automatically. A transient clear is initiated by operating the ENABLE and EXECUTE keys on the system status panel. If a level 4 initialization is reached, a transient clear is initiated automatically.

3.10 During transient clear, the additional temporary store is cleared.

Error analysis table

Error analysis line entries

Transient call records

Maintenance TCR

Last base level loop start time

All TTY temporary store

Fault list hourly report data

System timer

Trunk dial pulse receiver hopper

Network queues

Receiver status area

Timing hopper

Test vertical status

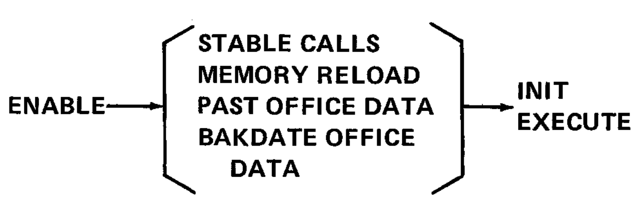
3.11 Transient clear must tear down all transient network connections and idle all circuits involved in transient connections while leaving stable calls untouched. The initialization level is then set to zero, causing the next initialization, if required, to be a level 1. This ensures that a stable clear is not invoked automatically via initialization level count.

3.12 The result of a transient call clear initialization is that all calls which have not yet reached the talking stage will be set back to the off-hook condition where they must rebid for dial tone. DSP will automatically be placed in the inhibited state.

Stable Call Clear Initialization (Level 5)

3.13 A stable call clear initialization will occur when one of the following conditions exist.

(a) Emergency action keys on the system status panel are operated in the following sequence:



Note: These keys may be active in any pattern.

(b) A processor switch occurs where the on-line processor has an out-of-date store and no access is available to the other processor store; a stable clear occurs automatically because all the temporary store is lost.

3.14 The first task is to zero the following temporary store in addition to that which was cleared at lower levels.

Trunk and service circuit out-of-service counters

List of plugged up lines

Network map

Terminal memory records

Trunk/junctor input hopper

Interrupt input hopper

Line origination hopper

Line and junctor status lists

Trunk and service circuit status bits

Software clock

Auto connect line circuit status

Network link out-of-service list

Power cross failure time record

ODA assignable area

Traffic data

Maintenance measurements

The remainder of the stable clear zeros all peripheral pulse distributor relays, opens all network crosspoints, opens all line cutoffs, and then closes all line cutoffs.

3.15 The result of a stable call clear initialization will be that all calls in progress in the office will be set back to the off-hook condition. Also,

a stable call clear initialization will result in the loss of all traffic data with no possibility of recovery. DSP will be automatically placed in the inhibited state.

4. BOOTSTRAPPING

Introduction

4.01 Bootstrapping a processor consists of loading writable memory from an external source and using the processor as the controlling device. In a system using a volatile memory, software may not exist to aid in the reload. Therefore, a reload mechanism is designed into the processor which will enable it to retrieve a program from an outside source and load it into memory. Since the 3A CC is a microprogrammed processor, a small sequence of microcode is dedicated to the reload mechanism.

4.02 The external device that will supply the 3A CC with data during bootstrap is a 4-track tape cartridge. Each 3A CC has access to its own bootstrap dedicated tape unit with the facility to utilize the other 3A CC tape unit at the appropriate time if required.

4.03 The primary use of the tape medium by the 3A processor is that of backup for the system program and system data tables, commonly known as translation in ESS applications. Secondary system benefits are derived from an extension of memory such as the creation of historical system performance files. However, the layout of the information on the tape is engineered for the bootstrap operation.

4.04 The system program and system translation are the most important items stored on the tape and must be given the best chance of recovery. The two inner tracks (1 and 2) of the tape cartridge are used to store the program and translation backup. The system program resides on track 1 and is write-protected. This protection will prevent an inadvertent overwrite of the system program which would place the system in a precarious state. Since the translation is subject to frequent change, it will reside on track 2 which will remain writable.

4.05 Three copies of all translation data are maintained on each of the duplicated nonresident tapes. Copy 1 is updated automatically every 24 hours (can be updated manually as often as desired). Thus, copy 1 will not differ from the translation in memory (including any recent changes) by more than 24 hours. Copies 2 and 3 are maintained under the control of the operating company. When an update is made on these copies, the older of the two copies is updated. The update is done directly from memory; therefore, at times two of the copies will have the same information.

4.06 Any one copy of translation data may be loaded into MAS during a manual bootstrap depending on the actions taken at the SSP. The MEMORY RELOAD button on the SSP is used to load memory from copy 1. The PAST OFFICE DATA button is used to load memory from the more current of the other two copies. The BACKDATE OFFICE button is used to load the oldest version from tape to memory.

4.07 Since the 3A processor is a duplicated system, both tape units will contain the same program and translation-related data.

Tape Format

4.08 The bootstrap program and its central core of system programs are placed at the beginning of tape on tracks 1 and 2 (Fig. 2). The bootstrap microsequence is programmed to read from the start of the write-protected track and to sequence to track 2 if it encounters difficulty in reading track 1.

4.09 Positioned immediately at the end of this file is the file containing all the checksums for the main store information. This file is placed on track 2 for update as changes are made to either the system program or translations. A virgin copy of this file exists on track 1 for recovery purposes.

4.10 Immediately following the checksums, the system program will be stored in logical segments of 4096 words on track 1. Each 4096-word boundary will begin on a new block within the file, and each unit will end with a specially marked block.

4.11 The start of translation data will be on track 2, following the completion of the system program file on track 1. Any overflow of translations will be accomodated on track 3 of the tape. Following the translation on either track 2 or track 3, the file of system program patches will be stored.

4.12 Finally, the last file associated with the bootstrap function is the application translation backdate files. This is the earliest stored translation that the system may need to recover from an error in the current copy of translation.

Bootstrap Sequence

4.13 After an initialization of the 3A CC occurs, the microstore initialization program determines whether a software mutilation has taken place and whether a reload attempt is required. The tape unit associated with the 3A CC in trouble is initialized and rewound to the beginning of tape. The microcode starts the tape to read. It unloads the first 128 words that come off the tape and stores them in MAS. The microprogram then transfers control to the location of the first executable word read off the tape.

4.14 The first segment of the bootstrap sequence consists of 122 executable words. This sequence must be capable of continuing to unload program from tape until the second segment is completely loaded into memory. The bootstrap programs are duplicated on tracks 1 and 2 so that an attempt to recover mutilated data can be made without disturbing the other tape device. This is only true for the bootstrap and checksum files. If the duplicated data is bad also, a time-out occurs, resulting in a reboot. The cyclic check mechanism is used to determine if a block of data has been mutilated.

4.15 Program control is passed to the second segment to complete the loading of the bootstrap program, system initialization programs, and checksum data. This sequence of bootstrapping utilizes the same recovery process as the first sequence.

4.16 Successful completion of the second segment of the bootstrap sequence ensures that the common system initialization program (CINIT) is properly loaded. Control will be passed to CINIT at this time for execution of hardware initialization and disabling of the other CC before further bootstrap action occurs in this machine.

4.17 A bootstrap sequence may occur automatically or may be manually initiated from the SSP. An automatic bootstrap sequence will only load generic data into MAS and this reloading will be done on a selective basis, ie, only areas suspect will be reloaded. ***Translation data can only be loaded into MAS by a manually initiated bootstrap and this will be a total reload of that copy selected at the SSP*** (see 4.06). Also, ***manually initiated bootstrap sequences will trigger a stable clear initialization.***

Recent Changes

4.18 Tape translations are updated automatically every 24 hours only. It is possible therefore to loose recent change translation data as a result of a manual bootstrap. Dialed in changes to speed calling list and changes to the TWT will be part of the data lost. Tape translations may be updated manually via the maintenance teletypewriter and this would avoid the loss of recent changes. However, since the translations in MAS are being replaced it may be assumed that they are in some way deficient and manually updating would only place them, along with any deficiencies, on one of the tape copies. This may or may not be desired depending upon the circumstances surrounding the bootstrap operation and local company practices for bootstrap operations. It is recommended that the network administrator be aware of the contents of tape translation copies and that both network maintenance and network administration agree on any course of action involving bootstrapping of translation data.

5. TTY PRINTOUTS

5.01 The No. 3 ESS is designed for the unattended community dial office environment. As such it will permit the performance of most maintenance and administrative tasks from remote located TTYs. Normally the network administrator's only indication that an initialization has taken place will be a network administation TTY located some distance from the No. 3 ESS switching machine. The indication will be the ***EA Counter*** which is printed as part of each traffic report. The EA counter keeps a record of system initializations which occur during the measurement period of the schedule. The counter contains the identity of the level of initialization which occurred during the measurement period and the time at which it occurred. For example, if the H-schedule is collected from 2 to 3 pm, the EA counter which appears on the H-schedule would identify an emergency action which took place between 2 and 3 pm and the time at which it ocurred.

5.02 The EA counter will identify only one level of initialization occurring during the measurement period. If more than one level takes place during the measurement period, the ESS will use the following procedure to determine which level is reported. If the level is not one which clears measurement registers and if the level is equal to or greater than any previously occurring level, then it is reported on the EA counter (highest level to occur is reported). If the level is one which clears measurement registers, it is reported on the EA counter whether it is the highest level to occur or not (most recent level to occur is reported). The EA counter will not count initialization attempts which do not increment the level counter.

6. EXECUTION TIMES

6.01 Approximate execution times for the initialization levels are as follows:

Partial clear—30 milliseconds

Transient call clear—60 seconds for 15 concentrator groups

Stable call clear—100 seconds for 15 concentrator groups

Bootstrap with stable call clear—2 minutes, 30 seconds.

7. SUMMARY

General

7.01 An initialization is an attempt to regain system integrity by restarting the program at some fixed location and proceeding in an orderly fashion to the beginning of the call processing monitor cycle. Selected data are stored in a protected area of call store and these data along with a count of the number of initialization attempts incurred during a given time are used to progressively clear out areas of call store and initialize physical equipment.

7.02 There are 5 levels of system initialization, including bootstrap operations, with clearing action becoming more extensive at each higher level. Level 5 initializations which reload translation data into MAS must be triggered manually from the SSP but all other initializations can occur automatically.

Effect on Call Processing

7.03 Call processing may be affected to some extent by any level of initilization. Although the network administrator should be aware (via the network administration TTY) of occurring initializations, no recovery action is required until the count reaches level 3.

7.04 Initialization of level 3 and above will automatically place DSP in the inhibited state. Network administration or network maintenance should determine action to be taken in this situation.

Effect on TWT and Traffic Data

7.05 Level 5 initializations will clear all traffic data with no possibility of recovery.

Effect on Translation Data

7.06 Translation data may only be altered by a manually triggered bootstrap (level 5). Network administration and network maintenance should agree on the steps taken when bootstrapping translation data.

8. REFERENCES

Bell System Practices

Section 233-153-130, No. 3 Electronic Switching System—Initialization and Processor Fault Recovery Software Subsystem Description

Dial Facilities Management Practices

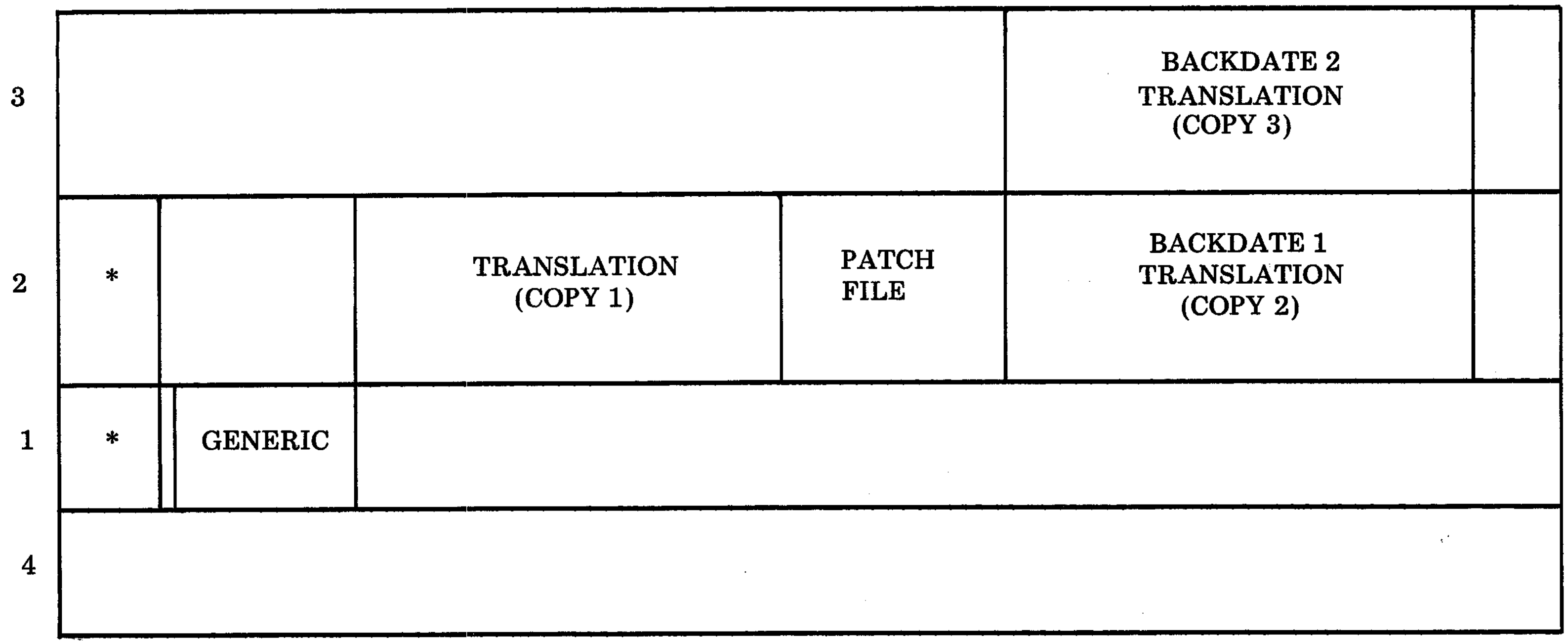
Division H, Section 11a, No. 3 Electronic Switching System—System Description

Division H, Section 11c(2), No. 3 Electronic Switching System—Dynamic Service Protection

Division H, Section 11h, No. 3 Electronic Switching System—Network Administration and Maintenance Measurements

TYPE INITIALIZATION	SOURCE REQUESTED	LEVEL COUNT	EFFECT ON CALL PROCESSING
Normal	Automatic	1	• Mark selected TCRs for failure processing • Clear selected areas of temporary store • Initialize miscellaneous scan points • Initialize peripheral controllers • Initialize ringing and tone plant counter • Bootstrap selected areas of generic data if required
Partial	Automatic	2	Same as 1 plus: • Clear additional areas of temporary store
		3	Same as 2 plus: • Clear additional areas of temporary store • Remove off-line processor peripheral controllers from service
Transient	Automatic and Manual	4	Same as 3 plus: • Clear additional areas of temporary store • Restore all circuits associated with transient calls • Set initialization level count to zero
Stable	Automatic and Manual	5	Same as 4 plus: • Clear all areas of temporary store • Zero all peripheral pulse distributer relays • Open all network crosspoints • Open then close all line cutoffs
Memory Reload Bootstrap	Manual	5	• Reload translations from tape using current copy • Perform stable call clear initialization
Past Office Data Bootstrap	Manual	5	• Reload translations from tape using older copy • Perform stable call clear initialization
Backdate Office Data Bootstrap	Manual	5	• Reload translations from tape using oldest copy • Perform stable call clear initialization

Fig. 1—System Initilization (2.17)



*Duplicate Bootstrap and Checksum Files

Fig. 2—Tape Format (4.08)