HEWLETT hp PACKARD

MAINTENANCE MANUAL

30115A

NINE-TRACK (NRZI-PE) MAGNETIC TAPE SUBSYSTEM

(FOR HP 3000 COMPUTER SYSTEMS)

Manual Part No. 30115-90001
Microfiche Part No. 30115-90004

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Printed-Circuit Assemblies:

30215-60002
30215-60006

Note

All references in this manual to part number 30215-60001 mag tape controller PCA are valid for application of part number 30215-60006 mag tape controller PCA.

Options Covered

This manual covers the basic subsystem and subsystem options –100, –200, –300, and –400.

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PREFACE

This manual provides subsystem-level coverage for the HP 30115A Nine-Trace (NRZI-PE) Magnetic Tape Subsystem, a part of the HP 3000 Computer System mass storage I/O facilities. The manual is effective for the overall basic subsystem and subsystem options -100, -200, -300, and -400.

This manual is intended for use by Hewlett-Packard Customer Engineers trained on the HP 3000 Series II or pre-Series II Computer Systems.

Contents of the manual include:

a. A physical description of equipment and a subsystem parameter listing (Section I).

b. HP 3000 Computer System control parameters for the magnetic tape subsystem (Section II).

c. Subsystem theory of operation (Section III).

d. Subsystem servicing and troubleshooting information (Section IV).

Refer to the following HP 3000 Series II or pre-Series II Computer System documentation for information on related hardware and software. The related documentation common to all HP 3000 Computer Systems includes the following:

a. HP 7970B Digital Magnetic Tape Unit Operating and Service Manual, part no. 07970-90383.

b. HP 7970E Digital Magnetic Tape Unit Operating and Service Manual, part no. 07970-90765.

c. HP 13194A Multiunit Cable Accessory Kit Installation Manual, part no. 13194-90003.

The related documentation for the HP 3000 Series II Computer System includes the following:

a. HP 3000 Series II Computer System Service Manual, part no. 30000-90018.

b. HP 3000 Series II Computer System Signal and Power Distribution Manual, part no. 30000-90021.

c. Stand-Alone HP 30115A Nine-Track Magnetic Tape Subsystem Diagnostic Manual, part no. 30115-90014.

d. System Support Log, part no. 03000-90117.

e. HP 3000 Series II Computer System Installation Manual, part no. 30000-90019.

The related documentation for the pre-Series II HP 3000 Computer System includes the following:

a. HP 30035A Multiplexer Channel Maintenance Manual, part no. 30035-90001.

b. HP 30001A Central Processor Unit/Input-Output Processor Maintenance Manual, part no. 30001-90003.

c. HP 30005A/30006A Memory Subsystem Maintenance Manual, part no. 30005-90001.

d. HP 30390A Cabinet Installation and Maintenance Manual, part no. 30390-90001.

e. HP 30350A Auxiliary Control Panel and HP 30352A Hardware Maintenance Panel Operator's Manual, part no. 30352-90001.

f. HP 3000 Manual of On-Line Diagnostics, On-Line HP 30115A Magnetic Tape Test, part no. 30115-90003.

g. Systems Support Log, part no. 03000-90117.

h. HP 3000 Computer System Installation Manual, part no. 03000-90032.

i. Detailed Diagrams Manual, set numbers DD607 and DD608, Manual part no. 03000-90021.

j. Illustrated Parts Breakdown Manual, part no. 03000-90021.

CONTENTS

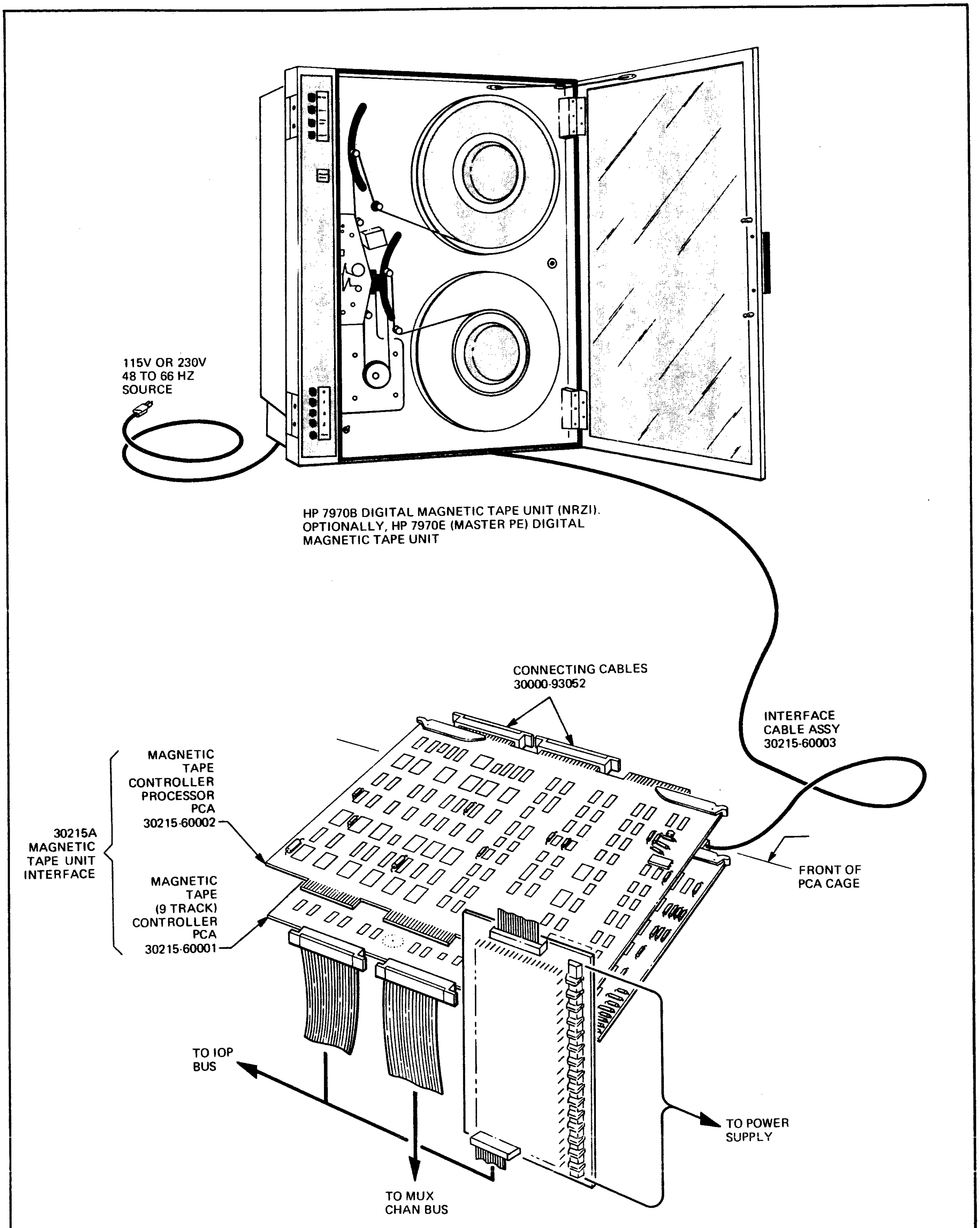
CONTENTS (Continued)

CONTENTS (Continued)

ILLUSTRATIONS

ILLUSTRATIONS (Continued)

TABLES



2180-4

Figure 1-1. HP 30115A Nine-Track (NRZI-PE) Magnetic Tape Subsystem Using a Single Tape Unit

GENERAL INFORMATION

1-1. INTRODUCTION.

1-2. This section describes important functional and physical features of the HP 30115A Nine-Track (NRZI-PE) Magnetic Tape Subsystem. Information on equipment components and options is included. Specifications and equipment identification data are also provided.

1-3. GENERAL DESCRIPTION.

1-4. The magnetic tape subsystem provides mass storage backup facilities to record and play back HP 3000 Computer System code and data segments to and from nine-track digital magnetic tape. An additional function of the magnetic tape subsystem is to provide the capability to cold-load the HP 3000 Computer System from magnetic tape. The non-return-to-zero-invert (NRZI) technique is used for subsystems utilizing HP 7970B Digital Magnetic Tape Units. The phase-encoded (PE) recording technique is used for subsystems using HP 7970E Digital Magnetic Tape Units. The HP 7970E Digital Magnetic Tape units are also capable of using a master-slave configuration. The above mentioned subsystems may be configured using a mix of these units. Certain constraints are imposed on configurations as outlined later in this section and in the maintenance section. Maximum data transfer rate is 36,000 bytes-per-second (18,000 words-per-second) when using NRZI tape units. The data transfer rate with phase-encoded recording units on-line is 72,000 bytes-per-second (36,000 words-per-second). Tape, reels, and recording format are in accordance with USA Standard (USAS) X3.22-1967, Recording Magnetic Tape for Information Interchange (800 cpi, NRZI) with NRZI recording. Phase-encoded recording is ANSI and industry compatible. Recording format and commands for the magnetic tape subsystem are discussed in Section II.

1-5. BASIC SUBSYSTEM.

1-6. Equipment for the basic HP 30115A Nine-Track (NRZI-PE) Magnetic Tape Subsystem, shown in figure 1-1, consists of:

a. HP 7970B Digital Magnetic Tape Unit (NRZI), hereafter referred to as the tape unit.

b. HP 30215A Magnetic Tape Unit Interface, hereafter referred to as the interface.

c. This subsystem manual.

1-7. Each of the items listed above for the basic magnetic tape subsystem is comprised of a number of parts as outlined below.

a. The HP 7970B Digital Magnetic Tape Unit (NRZI) consists of the tape unit proper and:

(1) Tape unit power cable assembly, approximately 8 feet (2.4 meters), part no. 8120-1395.

(2) Tape reel (empty), 10-1/2 inches (267 mm) diameter, part no. 1490-0738.

(3) Tape reel (with approximately 2400 feet (731 meters blank tape), 10-1/2 inches (267 mm) diameter, part no. 9162-0025.

(4) Tape unit extender printed-circuit assembly (PCA) part no. 07970-60420 (not shown in figure 1-1).

(5) Head cleaner (not shown in figure 1-1).

(6) Mounting accessories (not shown in figure 1-1).

(7) *HP 7970B Digital Magnetic Tape Unit Operating and Service Manual,* part no. 07970-90383 (applicable for the HP 7970B).

b. The HP 30215A Magnetic Tape Unit Interface consists of:

(1) Magnetic tape (nine-track) controller printed-circuit assembly (PCA), part no. 30215-60001, hereafter referred to as the tape controller PCA.

(2) Magnetic tape controller processor printed-circuit assembly (PCA), part no. 30215-60002, hereafter referred to as the controller processor PCA.

(3) Connecting cable assembly, 1-1/2 inches (38 mm), part no. 30000-93052 (two required).

(4) Interface cable assembly, approximately 20 feet (6 meters), part no. 30215-60003.

c. The magnetic tape subsystem manual data (not shown in figure 1-1) includes this maintenance manual, part no. 30115-90001, and Detailed Diagram sets, DD607, part no. 30215-90001, and DD608, part no. 30215-90003, for the *HP 3000 Computer System Detailed Diagrams Manual,* part no. 03000-90023.

1-8. SUBSYSTEM OPTIONS.

1-9. There are four option classifications to the basic magnetic tape subsystem. Note that the basic magnetic tape subsystem includes a single nine-track NRZI tape unit. Subsystem option—100 is effective if a single nine-track PE tape unit is installed instead of the NRZI unit. Option—100 consists of the HP 7970E Digital Magnetic Tape Unit (PE) Master proper and the following items:

a. Tape unit power cable assembly, approximately 8 feet (2.4 meters), part no. 8120-1395.

b. Tape reel (empty), 10-1/2 inches (267 mm) diameter, part no. 1490-0738.

c. Tape reel (with approximately 2400 feet (731 meters) blank tape), 10-1/2 inches (267 mm) diameter, part no. 9162-0025.

d. Tape unit extender PCA, part no. 07970-60420.

e. Head cleaner.

f. Mounting accessories.

g. *HP 7970E Digital Magnetic Tape Unit Operating and Service Manual,* part no. 07970-90765 (applicable for the HP 7970E.

1-10. The HP 30115A Nine-Track (NRZI-PE) Magnetic Tape Subsystem may also be operated from a 230-Vac source. The computer system power control module (PCM) will distribute 230-volt, single-phase power to plug mold strips within the HP 30390A Cabinet in this case. The HP 7970B or HP 7970E Digital Magnetic Tape Units plug into the plug mold carrying 230 volts *after* the slide switch on the respective tape unit power module is moved to the 230-Vac position. (These steps are taken when the system is configured, and this data is included here for additional servicing information.) Power distributed to the HP 30215A Magnetic Tape Unit Interface PCA's from the HP 30310A Power Supply Modules remains unchanged. Instructions for 230-volt operation of the HP 30310A Power Supply Modules are contained in the *HP 30310A Power Supply Module Maintenance Manual,* part no. 30310-90003.

1-11. ADDITIONAL TAPE UNITS. Provisions for additional tape units (up to four units can be driven from the same interface) are included under options -200, -300, and -400. The options are described below. Appropriate tape unit operating and service manuals are included as options are adopted. Note that the tape controller PCA may drive a mix of HP 7970E and HP 7970B Digital Magnetic Tape Units on a sequenced basis. The phase-encoded tape units can be master and slave configurations provided that the slave units are driven by a master unit. Some representative connections are shown in figure 1-2. A total of 24 different option configurations are possible as explained in section IV. The HP 13194A or HP 13194A-001 Multiunit Cable is required when additional units are connected with options as outlined below. Note that the HP 13194A-001 Multiunit Cable is used only from a Master HP 7970E Digital Magnetic Tape Unit to a Slave HP 7970E Digital Magnetic Tape Unit.

a. Option -200 adds one HP 7970B Digital Magnetic Tape Unit (NRZI) to the magnetic tape subsystem. With the basic magnetic tape subsystem installed, this option may be added three times (total of four tape units on one tape controller PCA). The HP 7970B Digital Magnetic Tape Unit (NRZI) must be the first unit from the interface if it is used in a mix configuration. The option includes:

(1) HP 7970B Digital Magnetic Tape Unit (NRZI).

(2) HP 13194A Multiunit Cable, approximately 20 feet (6 meters).

(3) Tape unit power cable assembly, approximately 8 feet (2.4 meters), part no. 8120-1395.

(4) Tape reel (empty), 10-1/2 inches (267 mm) diameter, part no. 1490-0738.

(5) Tape reel (with 2400 feet (731 meters) blank tape), 10-1/2 inches (267 mm) diameter, part no. 9162-0025.

(6) Mounting accessories.

b. Option -300 adds one HP 7970E Digital Magnetic Tape Unit to the magnetic tape subsystem. With the basic magnetic tape subsystem installed, this option may be added three times (total of four tape units on one tape controller PCA). In a mix configuration, HP 7970E Digital Magnetic Tape Units must be connected last in the series if HP 7970B Digital Magnetic Tape Units are used. If slave HP 7970E Digital Magnetic Tape Units (PE) are used they must follow the master unit in the series. The option includes:

(1) Master HP 7970E Digital Magnetic Tape Unit (PE).

(2) HP 13194A Multiunit Cable, approximately 20 feet (6 meters).

(3) Tape unit power cable assembly, 8 feet (2.4 meters), part no. 8120-1395.

(4) Tape reel (empty), 10-1/2 inches (267 mm) diameter, part no. 1490-0738.

(5) Tape reel (with 2400 feet (731 meters) blank tape), 10-1/2 inches (267 mm) diameter, part no. 9162-0025.

(6) Mounting accessories.

c. Option -400 adds one slave HP 7970E Digital Magnetic Tape Unit (PE) to the magnetic tape subsystem. This phase-encoded slave tape unit may only be used in conjunction with the master HP 7970E Digital Magnetic Tape Unit (PE). For example; if the basic magnetic tape subsystem includes Option -100, this option can be added three times. The option includes:

(1) Slave HP 7970E Digital Magnetic Tape Unit (PE).

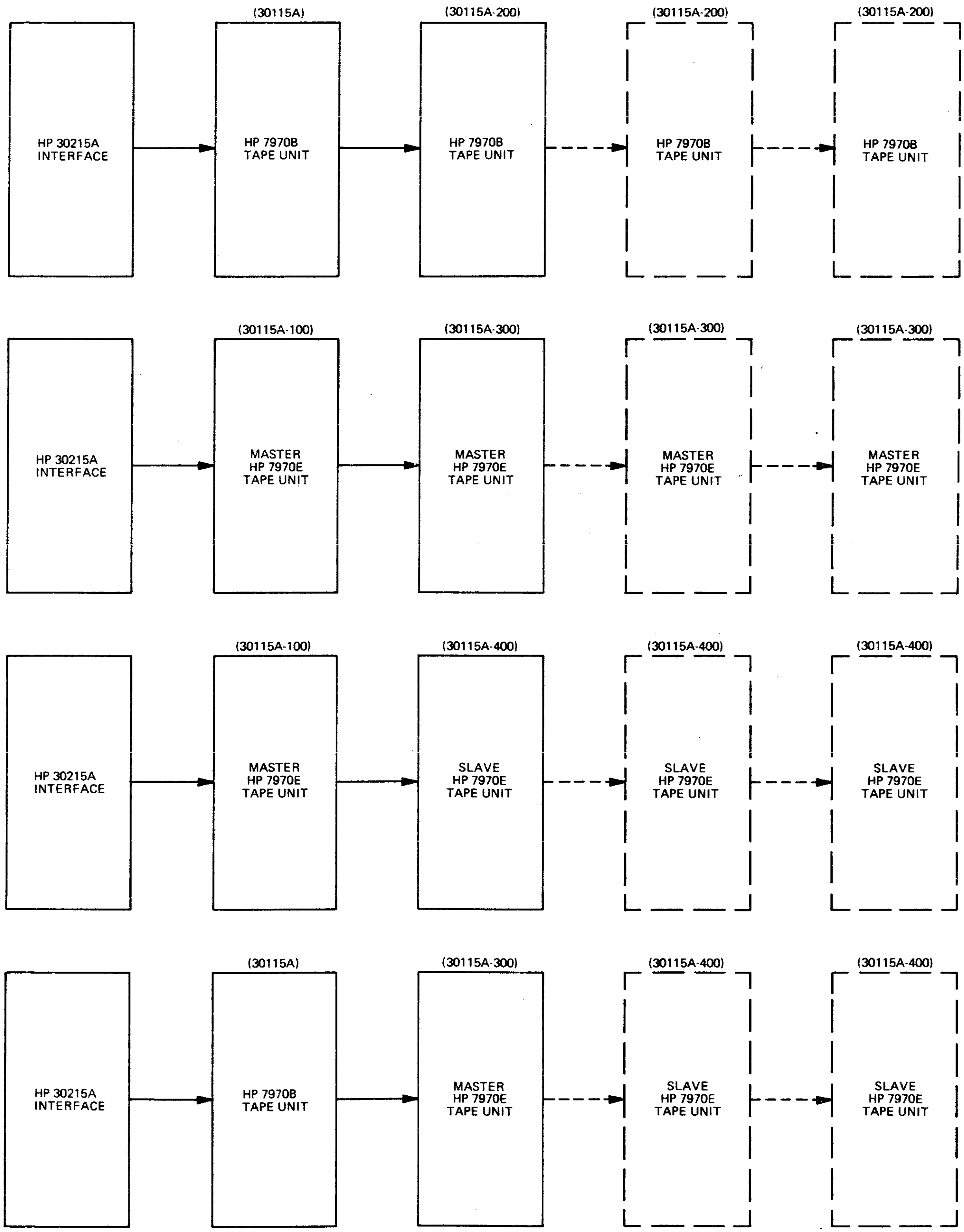
(2) HP 13194A-001 Multiunit Cable, approximately 20 feet (60 meters).

(3) Tape unit power cable assembly, 8 feet (2.4 meters), part no. 8120-1395.

(4) Tape reel (empty), 10-1/2 inches (267 mm) diameter, part no. 1490-0738.

(5) Tape reel (with 2400 feet (731 meters) blank tape), 10-1/2 inches (267 mm) diameter, part no. 9162-0025.

(6) Mounting accessories.



NOTES:

1. FROM TWO TO FOUR TAPE UNIT MAY BE USED IN ANY OF THE ABOVE CONFIGURATIONS
2. CRITERION IS THAT IF A HP 7970B IS USED IT MUST BE THE FIRST UNIT FROM THE HP 30215A INTERFACE ON THE SERIES.
3. NUMBERS IN PARENTHESIS ABOVE BLOCKS INDICATE OPTIONS.

2180-20A

Figure 1-2. Example Subsystem Option Configuration Connections

1-12. ADDITIONAL INTERFACES. Additional interfaces may be included if it is necessary to split control of two or more tape units. These consist of only an HP 30215A Magnetic Tape Unit Interface. Contents of this interface are described in paragraph 1-7, step b.

1-13. EQUIPMENT DESCRIPTION.

1-14. The following paragraphs describe the peripheral devices, printed-circuit assemblies, and cables of the HP 30115A Nine-Track (NRZI-PE) Magnetic Tape Unit Subsystem.

1-15. HP 7970B DIGITAL MAGNETIC TAPE UNIT (NRZI).

1-16. The HP 7970B used in the basic magnetic tape unit subsystem has the specific options listed in steps below. Subsystem related details of the tape unit are condensed in the specifications paragraph. Refer to the tape unit operating and service manual for individual option identification numbers.

a. Nine-track, read-after-write heads.

b. Unit-select capability.

c. Factory-wired for 800 characters-per-inch (cpi), (approximately 315 characters-per-centimeter) NRZI recording density.

d. Forty-five (45) inches-per-second (114 centimeters-per-second) read only/read-after-write speed.

1-17. The HP 7970B Digital Magnetic Tape Unit is physically comprised of the tape transport proper, read assembly, write assembly, control and status assembly, and power assemblies. The fast-forward feature of the tape unit is not used when under system control. The unit may be operated off-line to facilitate maintenance. All manual operating controls and indicators for the magnetic tape subsystem are located on the tape unit. The system Auxiliary Control and Hardware Maintenance Panels are used to control the subsystem from the system. Refer to part I of the *HP 7970B Digital Magnetic Tape Unit Operating and Service Manual* for additional descriptions of the unit.

1-18. MASTER HP 7970E DIGITAL MAGNETIC TAPE UNIT (PE).

1-19. The master HP 7970E Digital Magnetic Tape Unit has the specific options listed below. Other details of the tape unit are condensed in the paragraph 1-30, Specifications. Refer to the *HP 7970E Digital Magnetic Tape Unit Operating and Service Manual* for the individual option identification numbers. The specific options are as follows:

a. Nine-track, read-after-write heads.

b. Unit-select capability.

c. Phase-encoded recording density 1600 characters-per-inch (cpi), (630 characters-per-centimeter).

d. Master read module.

e. Forty-five inches-per-second (ips) (114 centimeters-per-second) read/write speed.

1-20. The HP 7970E assemblies are described in the *HP 7970E Digital Magnetic Tape Unit Operating and Service Manual.* This tape unit has more control over the actual read only/read-after-write operation, as far as error correcting capabilities are concerned, than does the HP 7970B. For that reason less control from the interface is necessary.

1-21. SLAVE HP 7970E DIGITAL MAGNETIC TAPE UNIT (PE).

1-22. The slave HP 7970E tape unit has specific options that are essentially the same as those for the HP 7970E master tape unit. The difference is that the slave tape unit contains a slave read module rather than a master read module. The *HP 7970E Digital Magnetic Tape Unit Operating and Service Manual* also describes the slave tape unit features. Refer to that manual for further details. Note that the HP 13194A-001 Multiunit Cable is used to connect slave units and that different connectors in the tape units are used. Further details are included in section IV, Maintenance, of this manual.

1-23. HP 30215A MAGNETIC TAPE UNIT INTERFACE.

1-24. The HP 30215A Magnetic Tape Unit Interface is comprised of two printed-circuit assemblies (see table 1-1) that mount in a computer system PCA cage, two connecting cables between the printed-circuit-assemblies, and the interface cable between the printed-circuit-assemblies and tape unit. The basic functions of the interface are to supervise and control all operations called for by the computer system. The interface also signals the computer system if specific interrupt or error conditions occur. In the idle state, no Start Input/Output (SIO) program going on, the interface keeps monitoring the ready status of all tape units connected to it. Each PCA is described below.

1-25. MAGNETIC TAPE (NINE-TRACK) CONTROLLER PCA. The tape controller PCA interfaces the HP 3000 Computer System with the selected tape unit. The PCA contains integrated-circuit packs, components, and transistors grouped as follows:

a. Bus interface logic and jumpers to interface and configure the subsystem with the HP 3000 Computer System. Printed-circuit assembly jumper position options and requirements are discussed in section IV, Maintenance.

b. Tape unit interface logic to receive status, and to pass commands, data read from tape, data to be written on tape, to and from the selected tape unit.

c. Status logic to check, register, and report subsystem conditions and signal status.

d. Read-Only-Memory (ROM) integrated-circuit (I.C.) packs that contain the subsystem micro-program to control all subsystem functions.

e. Controller processor interface logic to pass and receive commands and data to and from the controller processor PCA.

f. PCA control logic, exercised by the controller processor, to control all tape controller PCA logic.

1-26. MAGNETIC TAPE CONTROLLER PROCESSOR PCA. The controller processor PCA controls overall subsystem operation by implementing instructions of the micro-program read from the tape controller PCA ROM I.C. packs. The PCA contains integrated-circuit packs, a transistor, and components grouped as follows:

a. The internal clock logic and 9.216-MHz crystal that control overall subsystem timing.

b. The 12-bit ROM address register (RAR) logic used to implement read-out of instructions from the ROM integrated-circuit packs on the tape controller PCA.

c. The ROM output register (ROR) logic to hold and distribute 20-bit instruction words received from the ROM integrated-circuit packs.

d. Decoding logic to decode instructions of the microprogram.

e. Flag logic to initiate branching in the microprogram.

f. Counter-register logic under control of microprogram instructions.

g. Six general purpose and two dedicated (save and holding) registers. The registers are all used to implement instructions of the microcode. All control words and data handled by the subsystem pass through designated general purpose registers.

h. The arithmetic and logic unit (ALU) performs functions as directed by the microprogram to control operation of the subsystem.

i. The shift-rotate logic follows the ALU and performs directed functions for subsystem control.

j. The PCA control logic to gate and enable all other controller processor PCA logic.

1-27. CABLES. The two short connecting cable assemblies supplied are 50-pin flat-ribbon types, part no. 30000-93052, that connect directly between the two PCA's of the HP 30215A Magnetic Tape Unit Interface as shown in section IV. The 20-foot (6 meter) cable, part no. 30215-60003, has one hooded connector on one end and three marked, hooded connectors on the other end. The single connector connects to the interface and the three connectors attach to the tape unit as shown in section IV.

1-28. STANDARD ACCESSORIES AND SERVICE ITEMS.

1-29. An I/O PCA extender supplied with the HP 3000 Computer System maintenance equipment is used for servicing PCA's of the HP 30215A Magnetic Tape Unit Interface. Accessories and service items supplied with the tape unit are described in the operating and service manual for the particular tape unit. Additional requirements for checkout and troubleshooting are described in section IV, Maintenance.

1-30. SPECIFICATIONS.

1-31. Pertinent specifications for the magnetic tape subsystem are listed in table 1-1.

1-32. IDENTIFICATION NUMBERS AND CODES.

1-33. Identification tag locations and codes used on the tape unit are described in the appropriate tape unit operating and service manual. Assembly and revision numbers for the PCA's of the HP 30215A Magnetic Tape Unit Interface are located on the outside corner of each board. Cable part numbers appear on hooded connectors.

Table 1-1. Magnetic Tape Subsystem Specifications

ITEM	SPECIFICATION
Recording Method	NRZI (with HP 7970B) Phase-Encoded (PE) (with HP 7970E). Read-after-write heads
Recording Channels	Eight data, one parity
Transfer Rates	36,000 bytes-per-second between interface and HP 7970B (max) 18,000 words-per-second between interface and system using HP 7970B (max) 72,000 bytes-per-second between interface and HP 7970E master or slave (max) 36,000 words-per-second between interface and system using HP 7970E master or slave (max)

Table 1-1. Magnetic Tape Subsystem Specifications (Continued)

ITEM	SPECIFICATION
Tape Packing Density	800 characters-per-inch (cpi) (315 characters-per-centimeter) with HP 7970B 1600 characters-per-inch (cpi) (630 characters-per-centimeter) with HP 7970E
Character Type	Binary or ASCII
Tape	Certified 800 bits per-inch (bpi) (NRZI) Certified 3200 flux reversals per inch (frpi) (PE) Width: 0.5 in. (12.7 mm) Thickness: 1.5 mils
Tape Format	ANSI (USAS X3.22-1967) and industry compatible (800 cpi NRZI) ANSI- and industry compatible (1600 cpi PE)
Tape Start Time (Read)	8.33 milliseconds (max)
Tape Start Time (Write)	10.1 milliseconds (max)
Tape Stop Time	8.33 milliseconds (max)
Start Tape Travel (Read)	Approximately 0.187 in. (4.76 mm)
Start Tape Travel (Write)	Approximately 0.267 in. (6.8 mm)
Stop Tape Travel	Approximately 0.187 in. (4.76 mm)
Modes of Operation	
Forward Write	45 inches-per-second (ips) (114 centimeters-per-second)
Forward Read	45 ips (114 centimeters-per-second)
Reverse Read	45 ips (114 centimeters-per-second)
Rewind	160 ips (406 centimeters-per-second)
Load Point, beginning-of-tape (BOT) Search	Approximately 20 ips (50 centimeters-per-second)

Table 1-1. Magnetic Tape Subsystem Specifications (Continued)

ITEM	SPECIFICATION
Recording Accuracy Verification Methods	Read-after-write character dropout detection (single-track error, self-correcting in PE tape unit) in read only mode Odd, lateral read/write parity Cyclic redundancy check (CRC) during read only and read-after-write modes (NRZI only)
Storage Capacity	Standard 10-1/2 in. (267 mm) diameter reels. Absolute max 2,500 ft (762 m) tape storage. Normal load 2,400 ft (731 m). Approximately 20 Megabyte storage capacity per reel. Actual value depends on record lengths, number of tape marks, etc.
Power Requirements	
Tape Units	115 or 230 (± 10%) Vac, 48 to 66 Hz, single phase. 400 volt-amperes (VA) maximum each
Controller Processor PCA	+ 5 volts, 6 amperes
Tape Controller PCA	+ 5 volts, 4 amperes
Common-Return Provisions	
Tape Units	Through three-prong power connector
Printed-Circuit Assemblies	Through power bus, power supplies, and system PCM
Environmental Requirements	
Operating Temperature	-5° to 55°C
Non-operating Temperature	-20° to 65°C
Relative Humidity	90% at 40°C (non-condensing)

Table 1-1. Magnetic Tape Subsystem Specifications (Continued)

ITEM	SPECIFICATION
Cooling Provisions	
Tape Units	Case vent holes
Printed-Circuit Assemblies	HP 3000 Computer System Cabinet Blowers
Heat Dissipation	
Tape Units	1365 BTU/hr (344 Kilo-calories-per-hour)
Printed-Circuit Assemblies	153 BTU/hr (38 Kilo-calories-per-hour)
	Cabinet cooling equipment should be capable of handling approximately 1500 BTU/hour (378 Kilo-calories-per-hour) additional heat output for basic subsystem.
Weights	
Tape Units	130 pounds (59 Kilograms)
Controller Processor PCA	24 ounces (680 Grams)
Tape Controller PCA	22-1/2 ounces (635 Grams)
Dimensions	
Tape Units	24 in. (610 mm) high 19 in. (483 mm) wide 12 in. (305 mm) deep
	Note: Tape units require 26-1/4 in. (667 mm) vertical mounting space which includes a 2-1/4 in. (57 mm) space below unit for blank panel.
Printed-Circuit Assemblies	1/16 in. (0.6 mm) thick 11-1/2 in. (292 mm) deep 13-11/16 in. (346 mm) wide

Table 1-1. Magnetic Tape Subsystem Specifications (Continued)

ITEM	SPECIFICATION
Miscellaneous	
Controller Processor Crystal Frequency	9.216 MHz (for 45 ips, 114 centimeters-per-second) tape travel.
Record Protection Method	Write-enable Ring
Subsystem Tape Unit Capacity	Four tape units from one tape controller subject to constraints of connection noted in maintenance section.
PCA Mount Facilities	HP 3000 Computer System PCA Module
Interface Cable Length	Approximately 20 ft (6 m)
Tape Unit Mount Facilities	HP 3000 Computer System Cabinet within 20 ft (6 m) cable length of tape controller PCA.
Acetate/Polyester Tape Environmental Conditions:	
Temperature	15.5° to 26.6°C (60° to 80°F)
Relative Humidity	40 to 60%

Note: Unless otherwise indicated, specifications are applicable for the subsystem using 1600-cpi phase-encoded or 800-cpi NRZI tape units.

OPERATING PARAMETERS SECTION II

2-1. INTRODUCTION.

2-2. The scope of this section includes the following.

a. An overview of HP 3000 Computer System I/O program control of the magnetic tape subsystem.

b. Definitions of HP 3000 Computer System control and status parameters for the magnetic tape subsystem.

c. Definitions of magnetic tape format and specifications.

2-3. I/O PROGRAM CONTROL.

2-4. Operation of the magnetic tape subsystem is closely tied to that of the computer system input/output processor (IOP) and multiplexer channel. For that reason, a brief discussion of subsystem related details of HP 3000 Computer System operation is presented in the following paragraphs. For detailed explanations of CPU/IOP and multiplexer channel operation, refer to the appropriate manuals. Details of software operating procedures may be found in system software documentation. Only a summary of the cold load and cold dump is presented in this manual. Microprogramming carried on within the magnetic tape subsystem interface is not directly under control of the computer system I/O program. However, commands to the subsystem may cause branching within the microprogram. Microprogramming is discussed in sections III and IV.

2-5. MAGNETIC TAPE SUBSYSTEM CONTROL METHODS.

2-6. All operating controls and indicators for the magnetic tape subsystem proper are on the tape unit. These are described in the applicable operating and service manual for the tape unit. HP 3000 Computer System controls that influence the magnetic tape subsystem in normal operation are located on the HP 30350A Auxiliary Control Panel Assembly. These controls are described in software procedures manuals. The tape units may also be operated in an off-line mode. This procedure is also described in the applicable tape unit and test accessory operating and service manuals. Parameters involved in single- and multiple-unit selection are described in paragraph 2-22. Information on the driver for the magnetic tape subsystem will be found in HP 3000 Computer System software documentation. Diagnostics for the subsystem are discussed in section IV. Information on the cold load and cold dump control methods is presented in paragraphs 2-7 through 2-12. The magnetic tape subsystem is also used for batch processing with up to four tape units driven by the HP 30215A Magnetic Tape Unit Interface.

2-7. COLD LOAD SEQUENCE. Cold load may be performed from tape unit number 0 (push button select) only. The switch register setting on the system auxiliary control panel should be as described below:

a. Switch Register (0 through 7) := 6 (RDR Command Code),

b. Switch Register (8 through 15) := Device Number.

2-8. For an explanation of magnetic tape subsystem commands refer to paragraph 2-22. Manually pushing the COLD LOAD push button (after pushing I/O RESET and CPU RESET) causes the CPU to generate an I/O Read program around the DRT entry for the magnetic tape subsystem, i.e.:

(Device Number) *4 ——→	*+1	SIO program pointer,
	Octal 40000	Control Order,
	6	RDR (from switch register),
	Octal 77740	Read of octal 40 words,
	*+1	Address pointer,
	→	First word transferred by subsystem

2-9. After setting up the I/O program, the CPU issues the Start Input/Output (SIO) command. The subsystem transfers 32 words read from block I on tape. These words further bootstrap the I/O program to read more blocks from tape. Thus any amount of core can be filled with data.

2-10. COLD DUMP SEQUENCE. The cold dump operation dumps the contents of system core in 4096-word blocks onto magnetic tape. This operation may be performed only on tape unit number 0 (pushbutton select) provided the tape reel has a write-enable ring in it. The switch register setting on the system auxiliary control panel should be as follows:

a. Switch Register (0 through 7) := 4 (WRR Command Code),

b. Switch Register (8 through 15) := Device Number.

CAUTION

A tape that is known to be good must be used for cold dumps. There will normally be only one chance for a dump. If the dump is not successful all information in the system may be lost.

2-11. Manually pushing the COLD DUMP button (after pushing I/O RESET and CPU RESET) causes the CPU to generate an I/O Write program around the DRT entry for the magnetic tape subsystem, i.e.:

(Device Number) *4 ——→	*+1	SIO program pointer,
	Octal 40000	Control Order,
	4	WRR (from switch register),
	Octal 60000	Write of 4096 words,
	0	Starting Address.

2-12. After setting up the I/O program, the CPU issues an SIO command and the subsystem starts writing a block. The CPU monitors the SIO OK bit of the subsystem status word to determine whether a block is written or not. After completion of a block, the CPU updates the starting address and SIO program pointer to write the next block of 4096 words. The CPU also monitors the memory module interrupt to decide how much core the system actually has. When the cold dump is complete, the tape comes to a halt. The tape unit should be switched off line and rewound in the local mode to bring it to the load point.

2-13. SIO MODE CONTROL.

2-14. The magnetic tape subsystem operates in Start Input/Output (SIO) mode only. In this mode, the CPU executes an SIO instruction that transfers control of the I/O operation to the Input/Output Processor (IOP). The IOP controls the functions of the magnetic tape subsystem via the HP 30035A Multiplexer Channel. The multiplexer channel allows a total of 16 devices (subsystems) to operate simultaneously. The magnetic tape subsystem is one of the 16 devices served by the applicable multiplexer channel.

2-15. The I/O programs for this subsystem, as with other subsystems, are executed as a series of "double-words". That is, each command to control the subsystem is contained in appropriate portions of two sixteen-bit words. The first word is referred to as the Input-Output Command Word (IOCW). The second word is called the Input-Output Address Word (IOAW). Initial orders to the I/O structure and bus logic are contained in the IOCW. Read, write, and motion control function command words for the magnetic tape subsystem are contained in the IOAW. Figure 2-1 illustrates the IOCW/IOAW format.

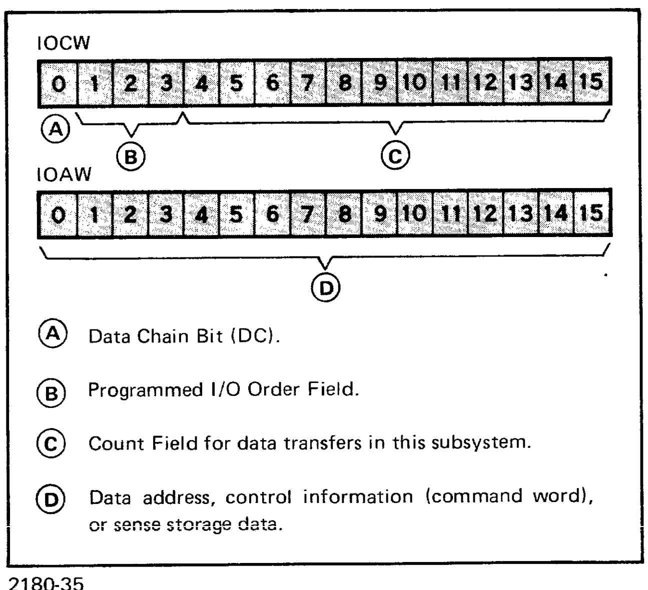


Figure 2-1. IOCW/IOAW Format

2-16. PROGRAMMED I/O ORDERS. Programmed I/O order bit patterns related to the magnetic tape subsystem are shown in table 2-1 and explained in table 2-2. These programmed I/O orders are contained in the IOCW. They are used by the multiplexer channel to control data transfers of the subsystem. The multiplexer channel issues appropriate strobes to the magnetic tape subsystem to control the read, write, and status acquisition functions based on receipt of these programmed I/O orders. The programmed I/O orders and the magnetic tape subsystem command words, described in paragraph 2-17, are issued on the 16-line I/O Data (IOD) bus. The orders and command words issued in the doublewords of an I/O program enable data transfer between memory and the magnetic tape subsystem of from one (minimum of two characters) to 4096 words without data chaining. With data chaining (bit 0 high) there is no limitation on the maximum number of words transferred except the length of tape on the reel and, during read operations, the amount of inter-block gap recorded. Additional discussions of the tape format and specifications are included in a later paragraph.

Table 2-1. Programmed I/O Order Bit Patterns

FIELD BIT PATTERN			PROGRAM I/O ORDER
1	2	3	
0	0	0	Jump
0	0	1	Return Residue
0	1	0	Interrupt
0	1	1	End
1	0	0	Control
1	0	1	Sense
1	1	0	Write
1	1	1	Read

Note: Field bit pattern numbers coincide with IOCW/IOAW bit position numbers that in turn coincide with IOD bus bit position numbers.

Table 2-2. Programmed I/O Order Definitions

PROGRAMMED I/O ORDER	DEFINITION
JUMP	Orders multiplexer channel (MUX CHAN) to jump to a memory address given in the second part of I/O program doubleword (IOAW) for a program. A conditional jump (bit 4 high) is treated as an unconditional jump (bit 4 low) in this subsystem.
RETURN RESIDUE	Causes the MUX CHAN to return word count residue, from a data transfer, to the CPU. Residue count is returned in the IOAW.

Table 2-2. Programmed I/O Order Definitions (Continued)

PROGRAMMED I/O ORDER	DEFINITION
INTERRUPT	Orders the subsystem (via MUX CHAN) to interrupt the CPU.
END	Notifies MUX CHAN of end of I/O program. If bit 4 is high, subsystem also interrupts CPU in addition to MUX CHAN. Subsystem status is returned to CPU in IOAW.
CONTROL	Notifies MUX CHAN that the following 16-bit word on the IOP data bus is a control word (in IOAW) for the magnetic tape subsystem. Count field in IOCW is stored in MUX CHAN.
SENSE	Orders magnetic tape subsystem, via MUX CHAN to output 16-bit status word on the IOP data (IOD) bus. Status is returned to CPU in the IOAW.
WRITE	Orders magnetic tape subsystem, via MUX CHAN, to transfer a block of data from memory to magnetic tape. Number of words to be transferred is contained in the COUNT field of the IOCW. MUX CHAN recognizes information in IOAW as starting address to get data.
READ	Orders magnetic tape subsystem, via MUX CHAN, to transfer a block of data from magnetic tape to memory. Number of words to be transferred is contained in the COUNT field of the IOCW. MUX CHAN recognizes information in IOAW as the starting data storage address.

2-17. DIRECT I/O COMMANDS. The subsystem will respond to the direct I/O command bit patterns shown in table 2-3. Table 2-4 explains the commands. These direct commands are issued by the CPU/IOP on a three-line bus directly to device controllers and to the multiplexer channel and are not in the IOCW/IOAW format even though the commands appear to be similar.

2-18. The direct I/O command TIO, shown in tables 2-3 and 2-4, may be issued at any time regardless of whether or not the magnetic tape unit interface is busy with other operations. The direct I/O command CIO, is also used to generate a programmed master clear (PMC) of the magnetic tape subsystem and for programmed clearing of an interrupt request from the magnetic tape subsystem. A particular data word bit pattern is expected to accomplish each of these operations. For example, a direct CIO command with a data word of 100000_8, will generate a PMC in the subsystem, i.e.:

if (S) := 100000 (octal),

and (S–K) := Device Number (S refers to the Stack pointer), then by issuing (CIO K), a PMC pulse is generated that forces the magnetic tape subsystem ROM microprogram to address 0000_8 (the START routine).

Table 2-3. Direct I/O Command Bit Patterns

CODE LINE BIT PATTERNS			MNEMONIC	DIRECT I/O COMMAND
2	1	0		
0	0	0	SIN	Set Interrupt
0	0	1	RESET INT	Reset Interrupt
0	1	0	SIO	Start Input Output (I/O)
0	1	1	SMSK	Set Mask
1	0	0	CIO	Control Input Output (I/O)
1	0	1	TIO	Test Input Output (I/O)

NOTES:
1. Since Direct Write I/O (110) and Read I/O (111) commands are not used by the magnetic tape subsystem, these commands are not listed.
2. Field bit pattern numbers coincide with bit position numbers on the direct I/O command bus (part of the overall IOP bus).

Table 2-4. Direct I/O Command Definitions

MNEMONIC	DEFINITION
SIN	Commands magnetic tape subsystem to interrupt the CPU. See command word definitions for interrupt conditions.
RESET INT	Commands magnetic tape subsystem to clear interrupt logic.
SIO	Performs a TIO on magnetic tape subsystem, then transfers control from CPU to IOP. Starts I/O program doubleword fetch.
SMSK	Outputs 16-bit word on top-of-stack (TOS) as a mask word to the subsystem. The mask word alerts each subsystem in same mask group.
CIO	Outputs 16-bit word on top-of-stack (TOS) as a control word to the subsystem. (See text for further data on CIO).
TIO	Commands magnetic tape subsystem to return a 16-bit status word to TOS via IOP data bus.

2-19. When the START routine is entered, the selected tape unit will stop motion immediately and all interface PCA elements will be cleared. Any tape units that were rewinding will continue to the load point (BOT). Any non-selected tape units that were in the write mode will remain in that mode. The PMC will put the subsystem in tape-unit-number-zero mode.

2-20. A direct I/O command with a data word of 40000_8 will clear an interrupt request generated by the subsystem, i.e.:

if (S) := 40000 (octal),
and (S–K) := Device number,
then by issuing (CIO K), the interrupt request (bit 2 of the Status Word) is cleared.

2-21. A power failure will force the magnetic tape subsystem to the CLEAR mode. Following a power failure, only a REW, RST, or BSR command word (in the IOAW) should be initially issued to the subsystem for each tape unit.

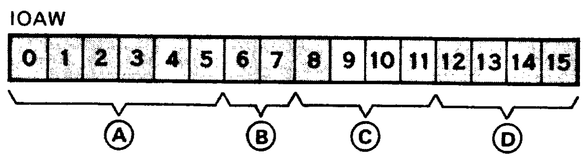
2-22. SUBSYSTEM COMMANDS.

2-23. The format of the IOAW for the magnetic tape subsystem is shown in figure 2-2. Table 2-5 shows the bit code patterns for the unit select field. Table 2-6 shows the bit code patterns for the command code field. The command code field carries the command words for the subsystem. Note that there are two commands that are used only for diagnostics and that there are three reserve codes. These are shown in table 2-7 and explained in table 2-9. The subsystem IOAW command code field entries are defined in table 2-8. Command words are grouped into three categories in the tables. These are:

a. Read forward type: RDR, FSR, FSF and RDC.

b. Read backward type: BSR, BSF.

c. Write (forward only): WRR, WFM, GAP and WRZ.



(A) Field not used for nine-track magnetic tape subsystem control. Bits can be high or low.

(B) Unit Select Field. Used with Select command word only.

(C) Field not used for nine-track magnetic tape subsystem control. Bits should all be low. Invalid codes may cause improper operation but will not cause a command word to be rejected.

(D) Command Word Code Field. Only an invalid code in bits 12 through 15 will cause a command word to be rejected (see Reject status).

2180-36

Figure 2-2. Magnetic Tape Subsystem IOAW Format

2-24. The Rewind, Rewind and Reset, and Select command words are also included in table 2-8. If a command word in an I/O program follows a command word in one of the same groups (previously listed) within 103 microseconds, tape motion will continue, interblock gap will be spaced over or written, and the new command word will be executed. If a command word follows one from a different group, tape motion will cease before the new command word is executed. In general, the system and I/O structure will not respond with a new command (of either groups mentioned) within 103 microseconds and tape motion will cease. If a tape unit is not ready and a command word other than a Select is issued, the new command word will be rejected.

Table 2-5. Unit Select Field Bit Patterns

FIELD BIT PATTERNS		MNEMONIC	FUNCTION
6	7		
0	0	CS0	Select unit number 0
0	1	CS1	Select unit number 1
1	0	CS2	Select unit number 2
1	1	CS3	Select unit number 3

NOTE: Field bit pattern numbers coincide with IOAW bit position numbers which in turn coincide with IOD bus bit position numbers.

Table 2-6. Command Code Field Bit Patterns

FIELD BIT PATTERNS				COMMAND WORD MNEMONIC	FUNCTION
12	13	14	15		
0	0	0	0	SEL	Select
0	1	1	0	RDR	Read Record
0	1	1	1	FSR	Forward Space Record
1	1	1	1	FSF	Forward Space File
1	0	1	0	BSR	Back Space Record
1	0	1	1	BSF	Back Space File
0	1	0	0	WRR	Write Record
1	1	0	1	WFM	Write (File) Tape Mark
0	1	0	1	GAP	Write Gap
1	0	0	0	REW	Rewind
1	0	0	1	RST	Rewind and Reset

NOTES: 1. Field bit pattern numbers coincide with IOAW bit position numbers which in turn coincide with IOD bus bit position numbers.

2. Bits 13 and 14 determine the command word group.

Table 2-7. Command Code Field Bit Patterns, Diagnostic and Reserved Commands

FIELD BIT PATTERNS				COMMAND WORD MNEMONIC	FUNCTION
12	13	14	15		
1	1	0	0	WRZ	Write Record With Zero Parity (800 cpi only)
1	1	1	0	RDC	Read Record With CRCC (800 cpi only)
0	0	0	1	–	Reserved code
0	0	1	0	–	Reserved code
0	0	1	1	–	Reserved code

NOTES: 1. Field bit pattern numbers coincide with IOAW bit position numbers which in turn coincide with IOD bus bit position numbers.
2. Bits 13 and 14 determine the command word group.

Table 2-8. Magnetic Tape Subsystem Command Code Definitions

MNEMONIC	
SEL	The Select command is used to select the tape unit that will recognize all succeeding commands. Any commands following the SEL command will perform operations on the selected tape unit unless the command is rejected. A new tape unit may be selected at any time in an I/O program. Bits 6 and 7 of the IOAW are decoded only in this command. These bits are ignored in all other commands.
RDR	The Read Record command establishes the necessary conditions for a read operation on the selected tape unit. The order following the RDR command word must be a programmed I/O Read order. Forward motion of magnetic tape is not initiated until a programmed I/O Read order is encountered in the I/O program. The subsystem expects to receive at least two characters from tape, separated by no more than a 10.2 character spacing, within 25 ft (7.62 m) of tape. This must occur in order for the magnetic tape unit interface to treat the characters as part of a data block or tape mark. One character is considered noise and the magnetic tape unit interface begins searching for a data block starting from the noise character. If no data block or tape mark is encountered within 25 ft (7.62 m) of tape, the Tape Runaway encoded error (indicating an attempt to read blank tape) of the status word will be set and an interrupt will be generated.

Table 2-8. Magnetic Tape Subsystem Command Code Definitions (Continued)

MNEMONIC	DEFINITION
RDR (continued)	If the character count of a data block read is odd, the Byte Count bit of the status word will be set. The right byte (bits 8 through 15) of the last word transferred to memory will be packed with zeros. If a tape mark is encountered, the corresponding status bit will be set and a following Return Residue Programmed I/O Order (if any) will indicate to the programmer that no data has been transferred. If data chaining (DC) is used with the read order (in the IOCW) for the RDR command and the data block is shorter than the programmed word count, a Command Reject encoded error of status will occur. The reason this will happen is that the magnetic tape unit interface expects a Control Programmed I/O Order after finishing reading a data block whereas the incoming order will be a Read. To avoid this problem, data chaining in the read mode should be used only when the block length on tape is well defined. Parity checks are made on each character and the CRCC is computed from the recovered characters. At the end of a data block the CRCC is read from tape and compared against the computed one. A good comparison ensures a good data block (800 cpi only). 1600-cpi read electronics is self-correcting if a single track is in error. The data block is considered good as long as the tape unit does not indicate a Multiple Tracks in Error status.
FSR	The Forward Space Record (block) command spaces the tape forward until a tape mark or data block is found and passed. If a tape mark is read, the Tape Mark status bit is set. No parity checks are made. If no data block or tape mark is found within 25 ft (7.62 m) of tape, the Tape Runaway encoded error of the status word is set and an interrupt is generated.
FSF	The Forward Space File command spaces the tape forward until a tape mark is encountered and passed. No parity checks are made. The Tape Mark bit of the status word is set after spacing over a tape mark. If no tape mark or record is encountered within 25 ft (7.62 m) of tape, the Tape Runaway encoded error of the status word is set and an interrupt is generated.

Table 2-8. Magnetic Tape Subsystem Command Code Definitions (Continued)

MNEMONIC	DEFINITIONS
BSR	The Back Space Record command spaces the tape backward over a data block or tape mark until an interblock gap or beginning of tape (BOT) reflective marker is found. If a tape mark is back-spaced over, the Tape Mark bit of the status word will be set. No parity checks are made. If the tape is at the load point (BOT), the command will be ignored. If a backspace is performed after a write operation, the tape will move forward and 0.15 in. (3.81 mm) of tape will be erased before turning off the write current in the tape unit heads and initiating backward motion. This is done to avoid writing a noise character in the immediate gap when write current is switched off. During back-spacing, if a single character is found (no other character within 10 character spacings of it) it is considered a noise character. Tape motion continues in the reverse direction to search for a valid data block, tape mark, or load point (BOT) whichever comes first.
BSF	The Back Space File command will cause the tape to move backwards until a tape mark or BOT reflective marker, whichever comes first, is encountered and passed. No parity checks are made. The Tape Mark bit of the status word will be set if tape mark status is confirmed by the interface. If the tape is at the load point, (BOT) the command will be ignored. If a back-space is performed after a write operation, the tape will move forward and 0.15 in. (3.81 mm) of tape will be erased before current in the tape unit write heads is turned off and tape goes into reverse motion. This is done to avoid writing a noise character in the immediate gap when current in write heads is switched off.
WRR	The Write Record command establishes the necessary conditions for a write operation on the selected tape unit. Forward tape motion is not initiated until a programmed I/O Write order is encountered in the I/O program. If the tape is at the load point (BOT) a WRR operation will be automatically preceded by writing a 3.75 in. (95 mm) initial gap for 800-cpi tapes or writing a 2-in. (50 mm) identification burst followed by a 3.75-in. (95 mm) gap for 1600-cpi tapes.

Table 2-8. Magnetic Tape Subsystem Command Code Definitions (Continued)

MNEMONIC	DEFINITION
WRR (continued)	Since the I/O system is word oriented, the number of characters written on tape will always be even. When the end of the block is written on tape, the subsystem will request another command from the multiplexer channel and coast for 103 microseconds. If a new command of the same subgroup (WRR, WRZ, (800 cpi only) WFM, or GAP) is encountered during the coast the subsystem will space over the interblock gap and execute the new command. Any other command causes tape motion to halt first. The new command will be then acted upon. The coast time is short compared to system response time therefore, the tape motion will halt. The system cannot deliver the next command in time. Read-after-write parity checks are made on each character. The cyclic redundancy check character (CRCC) is computed from the recovered characters. The CRCC is compared with the CRCC read from the tape at the end of a data block. A good comparison ensures that the data block on tape is good (800 cpi only). Read-after-write operation in WRR command word execution also looks for two or more character dropout cases. One character dropout may go unnoticed because the magnetic tape standards allow 50% to 200% variation in the single character spacing. When character dropout is detected, the write operation is terminated; the tape is moved by a distance of the read/write head spacing, 0.15 in. (3.81 mm), before stopping. The Tape Error encoded error of the status word is set, and an interrupt is generated. There is no hardware restriction on minimum block length. Without data chaining (DC) in the I/O program, data block length may vary from one to 4096 words. With data chaining, there is no upper limit on data block length in the subsystem.
WFM	The Write (File) Tape Mark command establishes the necessary write conditions on the selected tape unit and causes a tape mark to be written on the tape. (Refer to the tape mark format information in text). The Tape Mark bit of the status word is set after the read-after-write operation confirms that a tape mark was indeed written on the tape. If the read-after-write operation does not confirm the validity of the tape mark, the Tape Error encoded error of the status word is set.

Table 2-8. Magnetic Tape Subsystem Command Code Definitions (Continued)

MNEMONIC	DEFINITION
GAP	The Write Gap command causes 3.75 in. (95 mm) of tape to be erased. Read-after-write operation during execution of this command will ensure that the erasure is noise-free. If the Tape Error encoded error of the status word is set during execution of the GAP command, it indicates that there was some noise left in the gap. An interrupt is generated. A reentry is not recommended because the back-spacing operation may skip over the noise character and move the tape past a good data block. The good data block may consequently get erased by the execution of the next GAP command.
REW	The Rewind command causes the selected tape unit to rewind and halt at the load point (BOT). Once this command is issued, the interface may select and command other tape units even before completion of the rewind operation on the commanded tape unit. If a new command is issued to a rewinding tape unit, the subsystem will reject the command and generate an interrupt (the exception is the SEL command which will not be rejected). When no SIO is going on, the interface monitors the status of the rewinding tape unit and generates an interrupt when the rewind operation is complete.
RST	The Rewind and Reset command is the same as the REW command, but in addition will cause the tape unit to go off-line (Local-not ready). When the rewind operation is complete there will be no interrupt because the tape unit is "not-ready". A manual intervention is required to bring the tape unit on-line and ready.

Table 2-9. Diagnostic Command Code Definitions

MNEMONIC	DEFINITIONS
RDC	The Read Record With CRCC command is used in 800-cpi operation only The command is like the RDR command with the addition that at the end of a data block transfer, the Cyclic Redundancy Check Character (CRCC), as read from the tape, will also be transferred to memory. The CRCC transferred will be nine bits arranged in the data word as follows: Bits 0 through 7-CRCC (0 = MSB), Bit 8-Parity of CRCC, Bits 9 through 15-packed with zeros.

Table 2-9. Diagnostic Command Code Definitions (Continued)

MNEMONIC	DEFINITION
RDC (continued)	To get this CRCC, the programmer must program for this extra word in the "word count" field of the IOCW. The Byte Count status information does not include the CRCC and refers only to the character count (odd or even) in the data block. In normal operation of the subsystem this command is not used. It is used in the on-line diagnostic environment.
WRZ	The Write Record With Zero Parity command is also used in 800-cpi operation only. The command is like the WRR command except while writing on tape, the parity of each character will be forced to logical 0. This feature enables the programmer to simulate character dropouts, error cases, or variable length gaps on tape in the diagnostic environment. In normal operation of the subsystem this command is not used.
RESERVED COMMAND CODES	There are three unused codes. Programming any one of these will cause the command to be rejected.

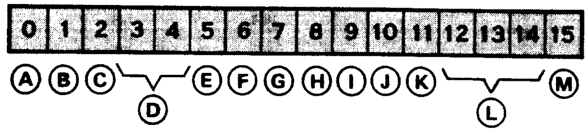
2-25. SUBSYSTEM STATUS.

2-26. Subsystem status is returned in the IOAW as a result of the Sense or End programmed I/O order or returned on the IOD bus because of a TIO, direct I/O command. Figure 2-3 illustrates the format of the status word. Table 2-10 explains the status word fields. The status word is a combination of tape controller PCA and tape unit status. "High" as mentioned in tables and figures refers to a high voltage level, (i.e., logic 1 condition) of the particular bit or bits mentioned, at the subsystem tape controller PCA Status Register input, (i.e., input pins of integrated circuit packs U166 and U167).

2-27. The tape unit status information, represented by all fields of the status word except the SIO OK, Interrupt Request, and the Error Code fields, is valid for the particular tape unit number represented by the unit select field. Table 2-11 defines the unit select field bit patterns. During the idle state, when no SIO program is being executed, the magnetic tape unit interface continuously selects one tape unit after the other to look for the Ready status. Thus, the tape unit status bits may be continuously changing as the selected tape unit field changes.

2-28. The SIO OK, Interrupt Request, and Error Code encoded error field represent the tape controller status. These fields of the status word are indicative of what happened in the last tape controller operation. The three bits of the encoded Error Code field represent:

IOAW



Ⓐ SIO OK.

Ⓑ Byte Count.

Ⓒ Interrupt Request.

Ⓓ Unit Select Field.

Ⓔ End of Tape (EOT).

Ⓕ File Protect.

Ⓖ Ready.

Ⓗ Load Point (BOT).

Ⓘ 800/1600 cpi.

Ⓙ Write Status.

Ⓚ Tape Mark.

Ⓛ Error Code Field.

Ⓜ Tape Unit Tracks Designation Bit. Bit is always logical 0 in the HP 30115A Magnetic Tape Subsystem, indicating nine tracks. (A logical 1 indicates seven-track subsystem.)

2180-37

Figure 2-3. Magnetic Tape Subsystem Status Word Format

a. A normal case.

b. An error-free interrupt.

c. Five different error-interrupt cases.

d. One reserved code.

2-29. All error codes cause the subsystem to terminate the I/O program in progress and cause an interrupt. The entire field is cleared when a new command is given. To handle two or more interrupt conditions, a priority scheme is incorporated. The lowest octal value of the code (in bits 12, 13, 14) has the highest priority. Thus, Transfer Error (octal 1) has higher priority than Tape Error (octal 5) but lower priority than Unit

Interrupt (octal 0). In an instance where the tape controller detects both Timing Error (octal 4) and Tape Error (octal 5) the error code will indicate Timing Error. Thus, the error-interrupt code should be intepreted with the possibility of multiple errors.

2-30. Certain combinations like Tape Runaway and Tape Error should never occur. The former implies reading a blank tape while the latter can happen only if there is a tape with some data block information on it. All these error codes are cleared to the normal state (octal 7) whenever a new SIO program is issued. Each Error Code bit pattern is shown in table 2-12. Each code is explained in table 2-13.

Table 2-10. Subsystem Status Word Field Definitions

FIELD	DEFINITIONS
SIO OK	Field represents tape controller status. If bit 0 is high it indicates that SIO is permitted and currently there is no I/O program in progress.
BYTE COUNT	Field represents tape unit status. Bit 1 is high if an odd number of characters are read from a block on tape and transferred to memory with the lower half (bits 8 through 15) of the last word packed with zeros. The bit is low if an even number of characters are read from the tape. In the case of writing a block on tape, this bit will always be low. If an RDC command (800 cpi only) is executed, this status bit refers to the number of characters in the data block and does *not* include the CRC Character in the count. If part of the block is read, this bit will always be low since an even number of characters are read from the tape and transferred to memory. The bit goes low when a new command is issued.
INTERRUPT REQUEST	Field represents tape controller status. When bit 2 is high it indicates that in the last operation, the subsystem encountered an interrupt condition. One of the following constitutes an interrupt condition: a. A tape unit, not ready before, has become ready. b. Transfer Error is detected. c. Last SIO order is rejected. d. An attempt is made to read a blank reel of tape. e. Timing Error is detected. f. Tape Error is detected. Interrupt conditions b through f are error interrupts representing a malfunction. The only case of error-free interrupt condition is shown in a. Particular condition information is obtained from the Error

Table 2-10. Subsystem Status Word Field Definitions (Continued)

FIELD	DEFINITIONS
INTERRUPT REQUEST (continued)	Code encoded error field. The Interrupt Request bit is cleared by a Manual I/O Reset, a Programmed Master Clear, i.e., a direct CIO with a data word of 40000_8, a programmed clear-interrupt, or Interrupt Active signal (indicating processing of an interrupt).
UNIT SELECT	Field represents tape unit status. The pattern of the bit 3 and 4 field indicates which of four possible tape units is currently selected. The rest of the tape unit status fields are valid only for that tape unit.
END OF TAPE	Field represents tape unit status. When bit 5 is high it indicates that the End-of-Tape (EOT) reflective marker was encountered during forward motion. The bit goes low only when the reflective marker is sensed and passed during reverse or rewind operations.
FILE PROTECT	Field represents tape unit status. When bit 6 is high it indicates that no write operation may be performed on the selected tape unit, i.e., the write enable ring is off the tape reel. The bit is low if the write enable ring is on the tape reel, indicating a write operation can be performed. The Write command will be rejected if a write operation is programmed when bit 6 of the status word is high.
READY	Field represents tape unit status. When bit 7 is high it indicates that the selected tape unit is on-line and ready. Attempting to command a tape unit that is not ready will cause the command to be rejected. A rewinding tape unit is in the not-ready state. The Ready status bit may be monitored by the I/O program to indicate whether or not a rewind operation is complete.
LOAD POINT (BOT)	Field represents tape unit status. When bit 8 is high it indicates that the selected tape unit is at the load point reflective marker (BOT) and ready to accept commands.
800/1600 BPI	Field represents tape unit status. Bit 9 indicates the read/write density capability of the selected tape unit. If this bit is low, it indicates 800 bits-per-inch, in a single track, or characters-per-inch (cpi), entire width of tape, density. If this bit is high, it indicates 1600 cpi density.

Table 2-10. Subsystem Status Word Field Definitions (Continued)

FIELD	DEFINITIONS
WRITE STATUS	Field represents tape unit status. When bit 10 is high it indicates that the last operation performed by the selected tape unit was a write operation. Current in the write heads is still on. The bit becomes low whenever a command other than that belonging to the Write group i.e., WRR, WFM, GAP, and WRZ is given to the subsystem.
TAPE MARK	Field represents tape unit status. If bit 11 is high it indicates that a tape mark was detected and passed during the last operation, which must have been a BSR, BSF, FSR, FSF, RDR, RDC or WFM. A new command will clear the EOF flip-flop making this test bit low at the Status Register.
ENCODED ERROR FIELD	Field represents tape controller status. Combinations of bits 12 through 14 represent five error states, one error-free (normal) state, one error-free interrupt case, and one reserved code.
TRACK DESIGNATION	Field represents drive status. Bit 15 is always low in HP 30115A Magnetic Tape Subsystem operation indicating nine-track tape units. A high represents a seven-track subsystem.

NOTE: Low/high levels refer to the level present at the input to the tape controller PCA status register, U166, U167.

Table 2-11. Unit Select Field Status Bit Patterns

FIELD BIT PATTERNS		FUNCTION
3	4	
0	0	Unit Number 0 Selected
0	1	Unit Number 1 Selected
1	0	Unit Number 2 Selected
1	1	Unit Number 3 Selected

NOTES:
1. Levels of status bits are shown at input to subsystem tape controller PCA Status Register.
2. Field bit pattern numbers also coincide with IOAW bit position numbers which in turn coincide with IOD bus bit position numbers.

Table 2-12. Encoded Error Field Bit Patterns

FIELD BIT PATTERNS			FUNCTION
12	13	14	
0	0	0	Unit Interrupt (error free-highest priority)
0	0	1	Transfer Error
0	1	0	Command Reject
0	1	1	Tape Runaway
1	0	0	Timing Error
1	0	1	Tape Error (lowest priority)
1	1	0	Reserved Code
1	1	1	Error free (normal)

NOTES:
1. Status valid only for selected tape unit.
2. Priority scheme, highest to lowest, is shown above. Scheme resolves priority for two or more errors occurring in one operation.
3. Reserved code should never occur.
4. Field bit pattern numbers coincide with IOAW bit position numbers which in turn coincide with IOD bus bit position numbers.

Table 2-13. Encoded Error Field Definitions

ERROR	DEFINITION
UNIT INTERRUPT	The Unit Interrupt is the only case where an interrupt is generated without an error condition existing. In the idle state (no SIO program going on), the magnetic tape unit interface continuously scans the status of the tape units. The tape unit "ready/not ready" information is stored in an internal register and keeps getting updated as the tape units go "not-ready" (because of removed tape reels or for rewinding operations), or become ready (rewind completed or new tape mounted). In the latter case an interrupt is generated, status bits 12 through 14 all go low (000), and the Unit Select field contains the information as to which tape unit just became ready, and selected.
TRANSFER ERROR	This error indicates that the system has detected a parity error going to or from memory or an out of bounds address. The subsystem will look for this error during each word transferred to the memory in the read mode. If a system parity error is detected, the subsystem will stop any data transfer to memory, stop the tape in the inter-block gap, clear the I/O interface logic, (to cause the SIO OK bit to

Table 2-13. Encoded Error Field Definitions (Continued)

ERROR	DEFINITION
TRANSFER ERROR (continued)	go high), and generate an interrupt. Information, as to where in the SIO program chain this error was encountered, can be obtained by looking at the absolute memory address given by: ABSOLUTE (4* DEVICE NO.)–2.
COMMAND REJECT	This error code indicates that the current SIO program can not be executed for one of the following reasons: a. A write type command was issued to a unit with a protected reel of tape (i.e., no write enable ring installed) (check File Protect status). b. An invalid command code in the IOAW, following a Control programmed I/O order (in the IOCW) was issued to the subsystem. c. An attempt has been made to command a not-ready or non-existing tape unit. A not-ready tape unit may, however, be issued a Select command. Check the ready status bit associated with the particular tape unit number (Unit Select field) in question. d. An I/O Read order has been encountered when the subsystem was expecting a Write or Control order (check I/O program). e. An I/O Write order has been encountered when the subsystem was expecting a Read or Control order (check I/O program). f. An I/O Control order has been encountered when the subsystem was expecting a Read or Write order. (check I/O program). g. A case has occurred where data chaining is programmed in a Read order and the block length on tape happens to be less than or equal to the word count present in all but the last Read order. When a command is rejected, the SIO program is terminated and an interrupt is generated. The absolute memory address of the rejected programmed I/O order is given by: ABSOLUTE (4* DEVICE NO.) –2.
TAPE RUNAWAY	The magnetic tape recording standards specify that the maximum length of a gap on tape should be 25 ft (7.6 m). Tape Runaway error code status is present when, in a read forward operation, no block or tape mark is encountered for 25 ft (7.6 m) or more of tape. In this interface a one character block is considered a noise character and not a part of gap. The tape unit travel will be 25 ft (7.6 m) provided there is no noise character found. If a noise

Table 2-13. Encoded Error Field Definitions (Continued)

ERROR	DEFINITION
TAPE RUNAWAY (continued)	character is encountered, the interface attempts to find a valid block or tape mark within 25 ft (7.6 m) starting from the noise character. This error code indicates that the reel of tape being read is probably blank. The current I/O program will be terminated and an interrupt will be generated after setting the Tape Runaway status.
TIMING ERROR	This error code status is present when the I/O structure cannot service the subsystem at the data transfer rate of the magnetic tape subsystem. This can happen if certain high priority devices pre-empt the bandwidth required to service the magnetic tape subsystem. This error code status is present only after completing a read or write operation. The data transferred may not be valid. An interrupt is generated at the end of a read or write operation.
TAPE ERROR	This is the most common form of error code encountered during various operations of the subsystem. An interrupt is generated and the current I/O program is terminated for any of the conditions listed below. The reason for having only one status code representing all these types of errors is that the action taken by the programmer (re-trying, skipping over bad blocks, etc) can be the same for all cases. During WRR and WRZ command word execution: a. A vertical parity error has been detected during read-after-write operation. b. The Cyclic Redundancy Check Character (CRCC) read from tape does not compare with the CRCC computed by recovering all read characters. A good compare ensures that the data block written on tape is good. (800 cpi only).. c. Dropout of two or more adjacent characters is detected during read-after-write (800 cpi only). Dropout of one character may go unnoticed in this check mode (it will be caught by CRCC comparison) because the magnetic tape standards allow the single character spacing on tape to vary from 50% to 200% of the nominal spacing. The detection of character dropout while writing is important so that an undesired gap is not created in the same record. If the dropout is big enough, it can be mistaken for a valid interrecord gap and the reference of tape position is lost.

Table 2-13. Encoded Error Field Definitions (Continued)

ERROR	DEFINITION
TAPE ERROR (continued)	d. On a 1600-cpi tape a single track or multiple tracks are found to be in error. The 1600-cpi tape unit read electronics is self-correcting if one of the nine tracks is found to have errors. It is possible to encounter a single-track error during writing or reading while the data transferred is good. In this subsystem the tape error code is set if a single-track error during write is encountered. This ensures that the tapes generated by this subsystem will be error-free in all nine tracks. During WFM command word execution: After writing the tape mark, the read-after-write operation tries to confirm the validity of the tape mark. The Tape Error code is set if a valid tape mark did not go on tape. During GAP command word execution: A noise character (or block in 1600-cpi operation) is detected in the 3.75-in. (95 mm) erased gap just written. A re-try is not recommended because during back-spacing, a tape may get positioned beyond a valid record (after skipping the noise character) and the execution of the GAP command may erase that record. During RDR and RDC command word execution: a. A vertical parity error is detected in the record. b. The Cyclic Redundancy Check Character (CRCC) read from the tape does not match with the CRCC computed from read characters in the record (800-cpi only). c. In 1600 cpi, multiple tracks are found to be in error. A single track error is not indicated because the data transferred is valid. d. While reading only part of a record (word count < block length), cases a through c are still applied to the whole data block. There is no way to guarantee whether data transferred to memory is error-free or not.
RESERVED CODE	This code should never occur in any operation under any circumstances. The occurrence of this code implies a subsystem tape controller PCA malfunction.

Table 2-13. Encoded Error Field Definitions (Continued)

ERROR	DEFINITION
ERROR FREE CODE	This code represents normal subsystem operation during the last SIO program. The code also indicates, in the microprogram idle state, that no tape unit has become ready. An error-free operation will have octal 7 (code 111) present at the tape controller PCA Status Register input.

2-31. MAGNETIC TAPE FORMAT.

2-32. The magnetic tape specifications and format for the HP 30115A Magnetic Tape Subsystem are discussed in the following paragraphs and shown in figures 2-4 through 2-7.

2-33. TAPE FORMAT FOR 800-CPI TAPE UNITS.

2-34. Figure 2-4 represents the usable tape area and the constraints imposed for 800 cpi, NRZI tape unit operation. These constraints are set up to ease the interchangeability problems with tapes generated by different systems. The BOT and EOT reflective markers indicate the logical beginning and end of the recording area on tape. With this magnetic tape interface, a gap of 3.75 inches (95 mm) is written near the BOT.

2-35. TAPE FORMAT FOR 1600-CPI TAPE UNITS.

2-36. The physical characteristics of 1600-cpi tape, figure 2-5, are the same as those for 800-cpi tape. To distinguish between the two types, an identification burst (IDB) of 2 inches (51 mm) followed by a gap of 3.75 inches (95 mm) is written near the BOT marker. The IDB consists of consecutive flux reversals for the parity bit (1600 flux reversals-per-inch of tape) with all other tracks in the reference flux state. Thus, alternating logical 1's and 0's are written for 2 inches (51 mm) of tape in track 4.

2-37. In the read-after-write mode, the magnetic tape unit interface checks that the selected tape unit has 1600-cpi electronics and that the tape is at the BOT before writing the 2-inch (51 mm) IDB followed by a 3.75-inch (95 mm) gap.

2-38. TAPE MARK FORMATS.

2-39. Figure 2-6 shows the patterns of tape mark blocks for 800- and 1600-cpi tapes. Tape marks may be written any number of times on tape, subject to the constraints imposed by the tape mark command words and programmers choice. In 800-cpi operation, a tape mark record consists of writing octal 23 (bits 3, 6, 7) which goes on tape as logical 1's in tracks 2, 3 and 8. The remaining tracks are in the reference flux state. The tape mark LRC character occurs 8 bit spaces later.

2-40. The tape mark for 1600-cpi tape consists of a written block of 80 flux reversals in tracks 1,2,4,5, 7,8 (octal 247) with other tracks in the reference flux state. A tape mark cannot be mistaken for a data block since all tracks have flux reversals in a valid data block.

2-41. BLOCK ORGANIZATION ON TAPE.

2-42. Magnetic tape recording has no restriction as to the length of data that can be written on tape except the physical length of tape. A typical tape may have variable-length records separated by a 0.5-inch nominal (±0.1 inch) inter-block gap. In this subsystem, without data chaining, minimum data block length is 2 characters, maximum is 8198 characters. With data chaining continuous characters are written, until the END programmed I/O order, with no gaps between 8198 character blocks. Figure 2-7 illustrates data block format for 800-cpi and 1600-cpi tapes as transferred by the interface.

2-43. In 800-cpi operation a block on tape consists of the data block (information from the computer) plus a Cyclic Redundancy Check Character (CRCC) four character spaces later and a Longitudinal Redundancy Check Character (LRCC) four character spaces away from the CRCC. The CRCC is a unique character that is a function of the characters present in the data block. Its generation is explained in section III. The LRCC is written on tape by giving a write reset pulse to the tape unit. This makes the write amplifiers to go to a clear state. Each bit in the LRCC represents an even parity for that particular track's bits.

2-44. In 1600-cpi operation, a block on tape consists of the data block (information from the computer) preceded by a preamble and followed by a postamble (see figure 2-7). The preamble consists of 40 consecutive logical-0 characters (in all nine tracks) followed by a single, all-logical-1's character. The postamble consists of a single, all-logical-1's character followed by 40 consecutive logical-0 characters (in all nine tracks). In reverse tape motion, the postamble looks like the preamble and vice-versa.

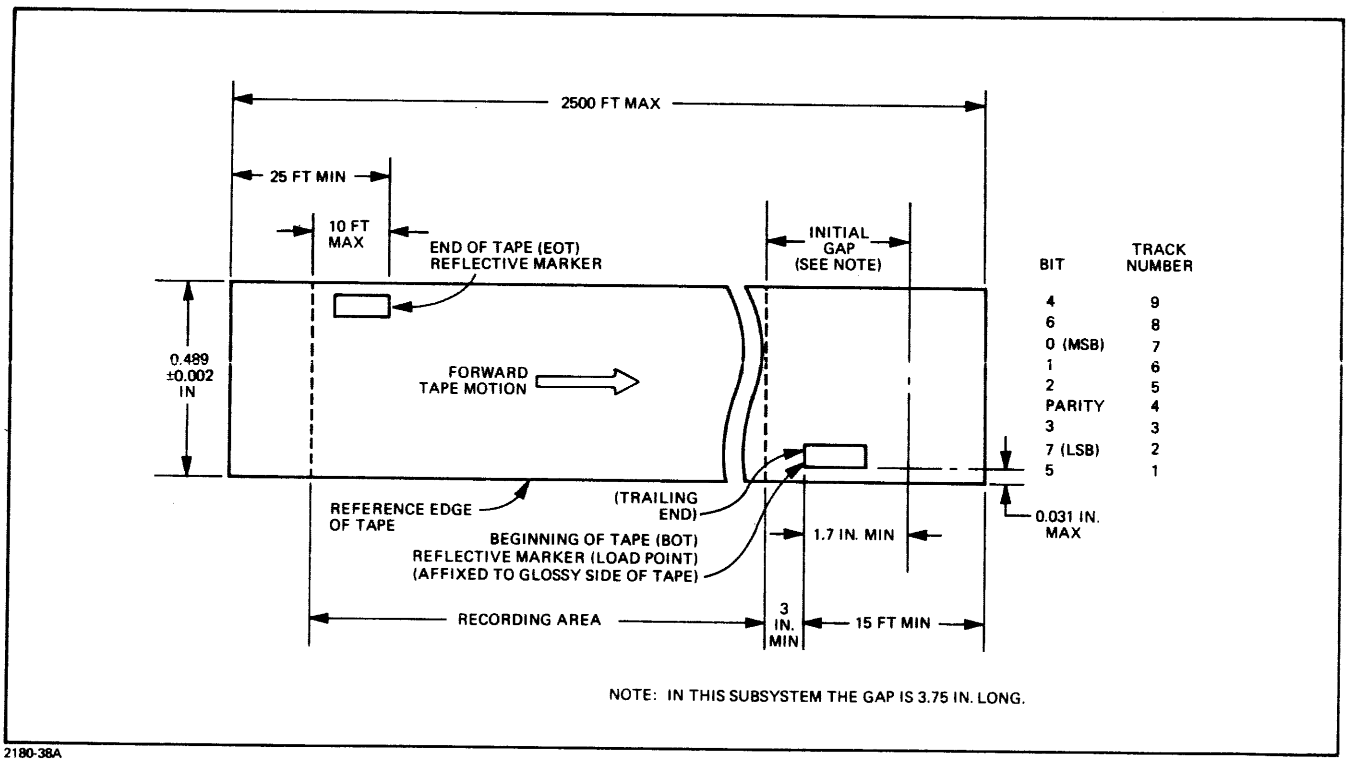


Figure 2-4. Tape Format for 800-cpi Tape

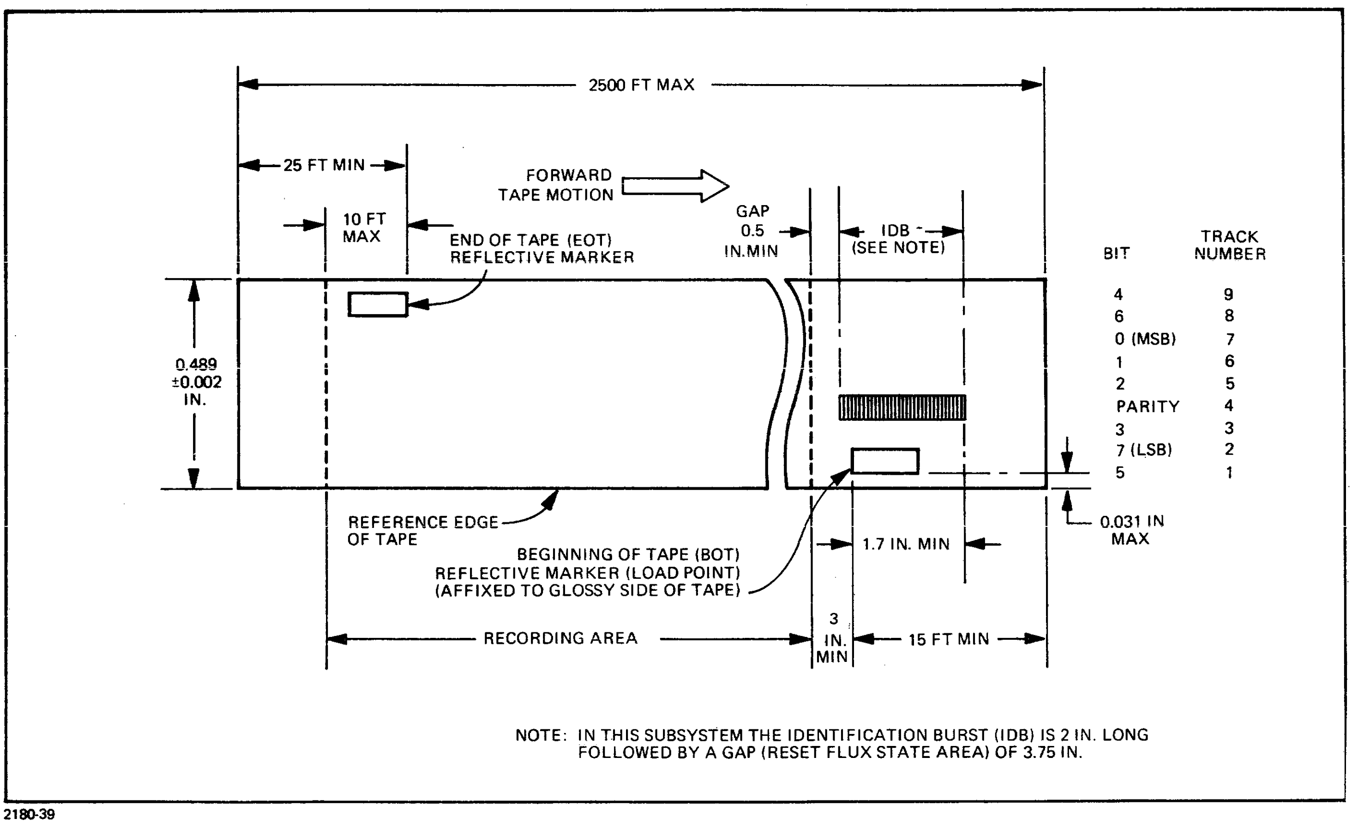


Figure 2-5. Tape Format for 1600-cpi Tape

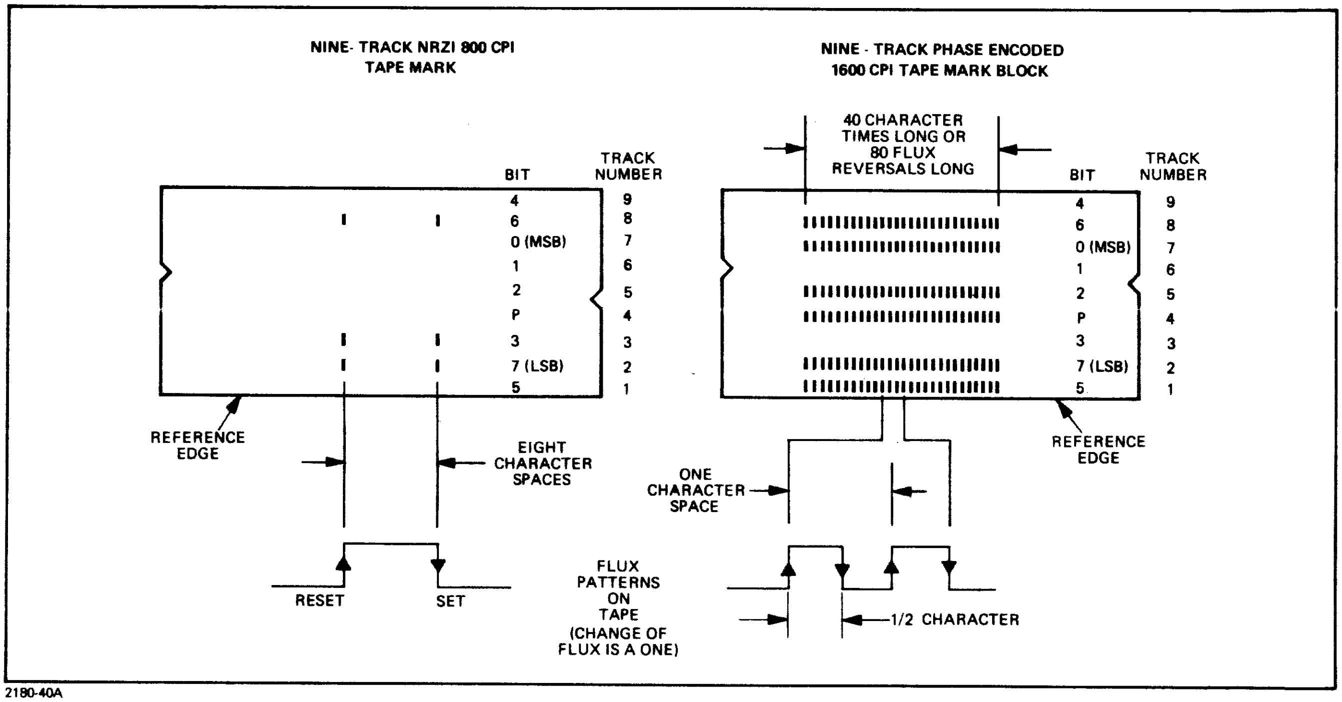


Figure 2-6. Tape Mark Formats, 800-cpi and 1600-cpi Tapes

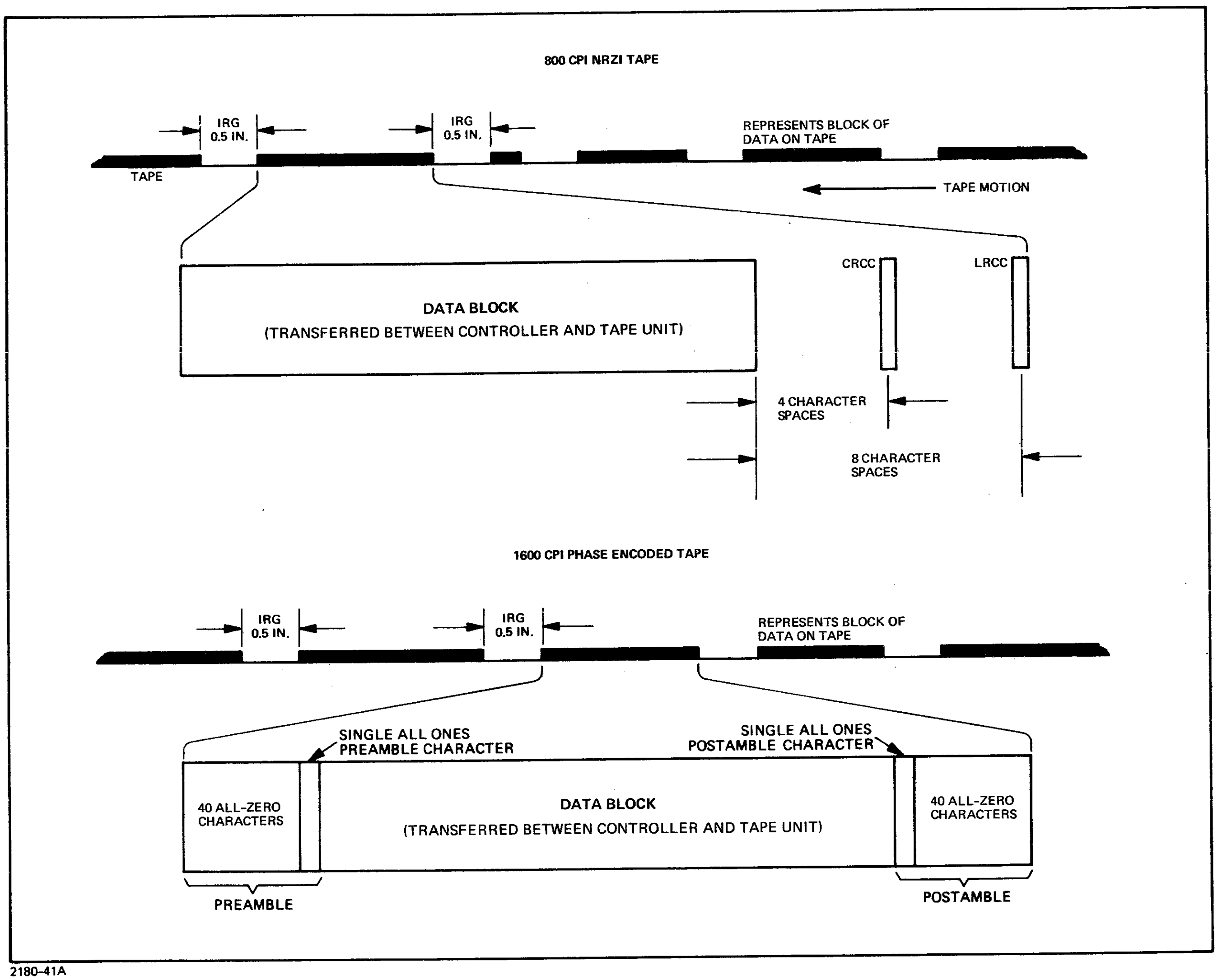


Figure 2-7. Tape Data Block Organization, 800-cpi and 1600-cpi Tapes

SECTION III THEORY OF OPERATION

3-1. INTRODUCTION.

3-2. This section includes an overall block diagram discussion of the magnetic tape subsystem and discussions of the interface printed-circuit assemblies (the tape controller PCA and controller processor PCA). In general, the basic magnetic tape subsystem is discussed (i.e., the interface and the nine-track NRZI tape unit). The interface discussion comprises the major portion of information. Applicable differences between phase encoded and NRZI operation are noted. The theory of operation for the NRZI tape unit will be found in the *HP 7970B Digital Magnetic Tape Unit Operating and Service Manual.* Theory of operation for the master and slave, phase-encoded tape units will be found in the *HP 7970E Digital Magnetic Tape Unit Operating and Service Manual.*

3-3. Detailed microprogram flow charts, the microprogram listing, and timing diagrams discussed in this section are located in the maintenance section. This separation has been implemented to facilitate troubleshooting and maintenance of the subsystem.

3-4. SUBSYSTEM FUNCTIONAL SECTIONS.

3-5. The function of the magnetic tape subsystem is to provide the HP 3000 Computer System with a means to read and write system data to and from nine-track magnetic tape. The major sections of the subsystem that perform this function are the interface and the tape unit. These sections perform the following operations.

a. Control movement of the magnetic tape through the selected tape unit.

b. Unpack system data words passed to the magnetic tape subsystem and cause eight-bit parallel blocks of data to be written on magnetic tape in a selected tape unit.

c. Read and pack data from magnetic tape into 16-bit parallel words for transmission to the HP 3000 Computer System.

d. Cause appropriate checks to be made to ensure accurate recording and recovery of data from the magnetic tape.

e. Cause appropriate identifying tape marks and gaps to be written on and read from the magnetic tape in response to I/O program commands.

f. Report subsystem status to the system upon command.

3-6. An overall block diagram of the magnetic tape subsystem is shown in figure 3-1. The basic magnetic tape subsystem, using an NRZI tape unit, is shown as an example. A phase-encoded tape unit could just as well have been used. A single, additional tape unit, added as an option, is shown parallel-connected from unit 0. Up to four phase-encoded and NRZI tape units may be connected to the interface in any mix, subject to the constraints outlined in section I and shown in section IV. For simplicity, only a single additional unit is shown.

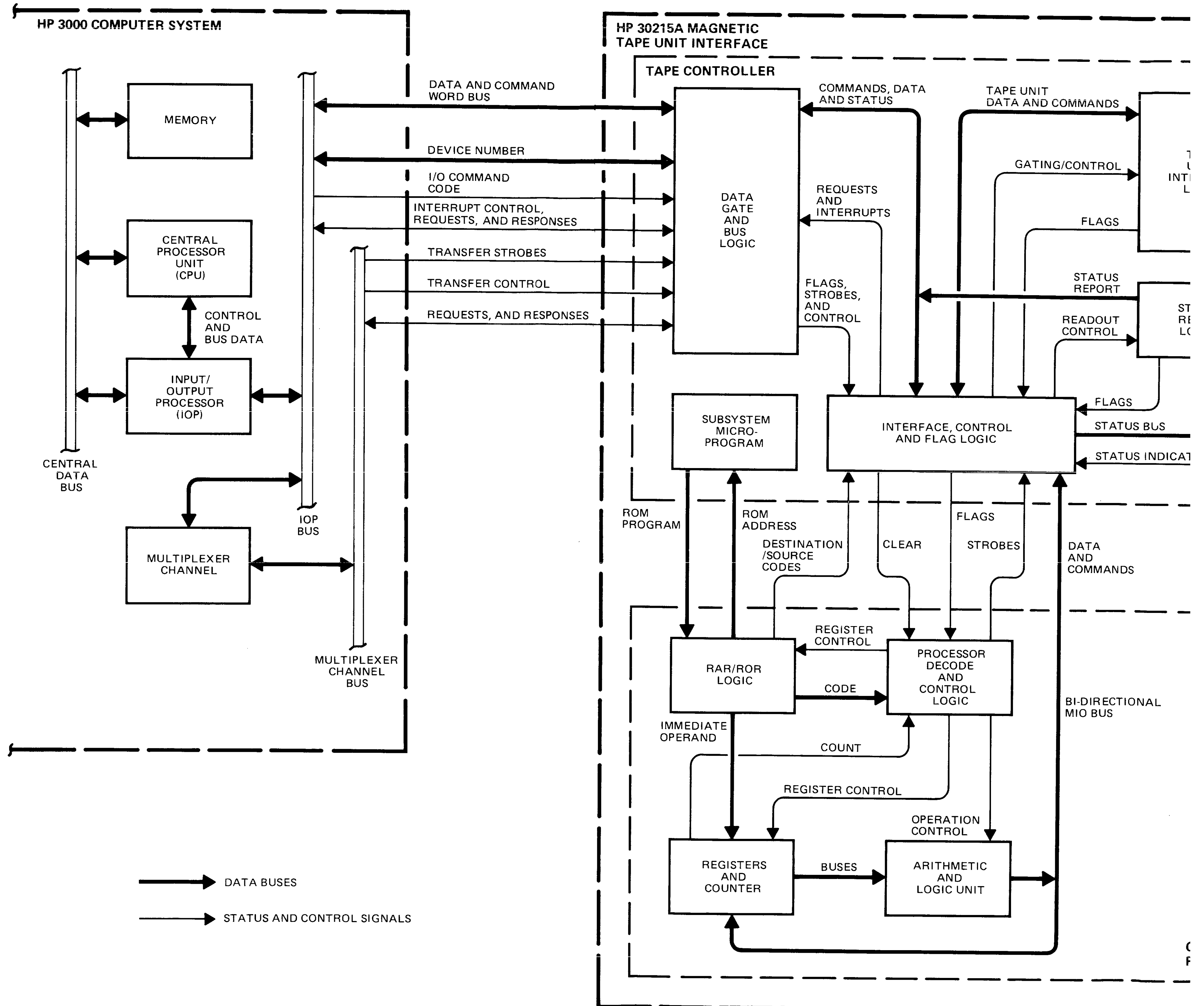
3-7. A discussion of the magnetic tape subsystem may be approached by identifying major logic portions and signal interface requirements. This is the case in the following paragraphs. First, the interface with the computer system is discussed. Secondly, interface between the tape unit and the tape controller PCA is discussed. The logic sections of the HP 30215A Magnetic Tape Unit Interface are then defined in paragraph 3-12.

3-8. COMPUTER SYSTEM INTERFACE SIGNALS.

3-9. Operation of the magnetic tape subsystem requires transfer of commands, data, and status information between the magnetic tape subsystem and the input/output processor (IOP) and multiplexer channel of the computer system. The magnetic tape subsystem is classed as a low-speed I/O device as far as I/O structure capability is concerned. Hence, control of data transmission is exercised by the multiplexer channel. The data gate and bus logic of the tape controller PCA in the interface provides all interface with the IOP and multiplexer channel via three major buses. These are the multiplexer channel (MUX CHAN) bus, IOP bus, and the power (PWR) bus. In the hardware, portions of the IOP bus signal grouping will be found mixed in the power bus grouping. Interface with the computer system is shown at the left in figure 3-1. Note in the diagram that only the IOP and multiplexer channel buses are shown. The data and command word bus, device number bus and the $\overline{\text{IODPRTY}}$ signal are in the IOP bus information group of signals. The I/O command code bus, shown in figure 3-1, is in the IOP bus control group of signals. All remaining signals for the IOP bus are grouped in the interrupt control, requests, and responses line shown on the diagram, which comprises the system status, and request responses groups of signals. IOP bus signals that are routed with the power bus grouping, as mentioned above, are shown here interfacing with the IOP bus in the interrupt control, requests, and responses bidirectional line. All interface shown with the computer system IOP bus is explained in more detail in table 3-1. All interface with the multiplexer channel bus is explained in more detail in table 3-2. Multiplexer channel bus signal groups shown in the diagram coincide with groups listed in table 3-2. The computer system buses contain more signals than listed in tables 3-1 and 3-2, but only signals used by the magnetic tape subsystem are listed. Sequences of signal occurrences are explained in the HP 30215A Magnetic Tape Unit Interface discussion.

3-10. TAPE UNIT INTERFACE SIGNALS.

3-11. Data, commands, and signals exchanged between the tape unit and interface are all exchanged via the subsystem interface cable. Routing is from the tape controller PCA, tape unit interface logic and the status report logic, as shown in figure 3-1, to three connectors that attach to the tape unit write, read, and motion control logic. The motion control logic controls forward, reverse, and rewind operations of the


HP 3000 COMPUTER SYSTEM
MEMORY
CENTRAL PROCESSOR UNIT (CPU)
CONTROL AND BUS DATA
INPUT/ OUTPUT PROCESSOR (IOP)
CENTRAL DATA BUS
MULTIPLEXER CHANNEL
IOP BUS
MULTIPLEXER CHANNEL BUS
DATA AND COMMAND WORD BUS
DEVICE NUMBER
I/O COMMAND CODE
INTERRUPT CONTROL, REQUESTS, AND RESPONSES
TRANSFER STROBES
TRANSFER CONTROL
REQUESTS, AND RESPONSES
HP 30215A MAGNETIC TAPE UNIT INTERFACE
TAPE CONTROLLER
DATA GATE AND BUS LOGIC
COMMANDS, DATA AND STATUS
REQUESTS AND INTERRUPTS
FLAGS, STROBES, AND CONTROL
TAPE UNIT DATA AND COMMANDS
GATING/CONTROL
FLAGS
STATUS REPORT
READOUT CONTROL
FLAGS
STATUS BUS
STATUS INDICAT
SUBSYSTEM MICRO-PROGRAM
INTERFACE, CONTROL AND FLAG LOGIC
ROM PROGRAM
ROM ADDRESS
DESTINATION /SOURCE CODES
CLEAR
FLAGS
STROBES
DATA AND COMMANDS
REGISTER CONTROL
RAR/ROR LOGIC
CODE
PROCESSOR DECODE AND CONTROL LOGIC
BI-DIRECTIONAL MIO BUS
IMMEDIATE OPERAND
COUNT
REGISTER CONTROL
OPERATION CONTROL
REGISTERS AND COUNTER
BUSES
ARITHMETIC AND LOGIC UNIT
DATA BUSES
STATUS AND CONTROL SIGNALS
2180-1

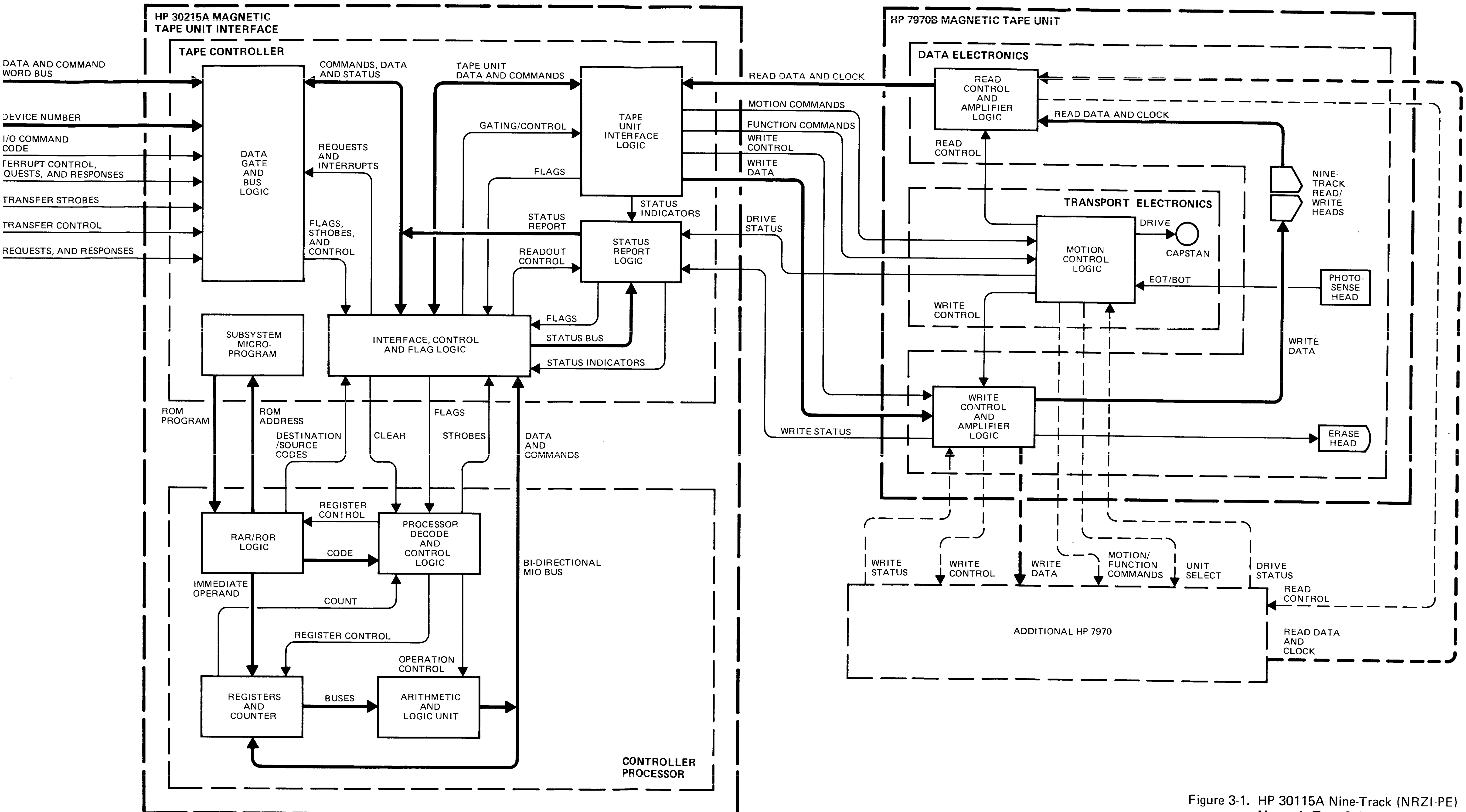


Figure 3-1. HP 30115A Nine-Track (NRZI-PE) Magnetic Tape Subsystem Block Diagram

tape unit upon command received from the tape controller. The read control and amplifier logic of the tape unit receives frames of data read by the heads and sends this data and a clock pulse to the tape controller. The write control and amplifier logic receives data and control signals from the tape controller for NRZI or PE recording on the tape via the write heads. Table 3-3 lists in more detail, and defines bus and signal lines routed between the tape controller and tape unit. Control of additional tape units is from the interface through the first tape unit. Additional tape units are parallel connected. See section IV for PE master-slave type connection details.

Table 3-1. Magnetic Tape Subsystem IOP Bus Interface Signals

NAME	MNEMONIC	DESCRIPTION
	INFORMATION GROUP	
IOP DATA BUS	$\overline{\text{IOD 00:15}}$	Sixteen-bit bi-directional bus. Inbound(to memory) active to IOP with $\overline{\text{SI}}$ signal low. Outbound (to subsystem) active with $\overline{\text{SO}}$ signal low. Bus carries: a. All I/O data. b. Program command words to subsystem (in the IOAW). c. Subsystem status to IOP (in the IOAW). d. DRT address (device number) from magnetic tape subsystem to memory for I/O program execution.
DEVICE NUMBER BUS	$\overline{\text{DEVNO 00:07}}$	Eight-bit bi-directional bus. Carries address (device number) of the subsystem that must interpret outbound commands and process data appearing on the IOP Data Bus. Bus also carries device interrupt number (address) for interrupt processing.
DRT ADDRESS ODD PARITY	$\overline{\text{IODPRTY}}$	Signal line to IOP carrying odd parity for DRT address transfer.
	CONTROL GROUP	
COMMAND OUT BUS	$\overline{\text{IOCMD 00:02}}$	Three-bit bus. Carries Direct I/O commands to subsystem. Six of the eight direct I/O commands are used by the subsystem. These are: a. Set Interrupt. b. Reset Interrupt. c. Start I/O. d. Set Mask. e. Control I/O. f. Test I/O.

Table 3-1. Magnetic Tape Subsystem IOP Bus Interface Signals (Continued)

NAME	MNEMONIC	DESCRIPTION
INTERRUPT CONTROL, REQUEST, AND RESPONSE GROUP		
INTERRUPT REQUEST	$\overline{\text{INT REQ 1}}$	Subsystem request to IOP for system software program interruption. IOP responds by causing the interrupt Poll to go high.
INTERRUPT ACKNOWLEDGE	$\overline{\text{INT ACK}}$	Subsystem response to Interrupt Poll with IOP with a low level signal. Subsystem interrupt number (address) is sent to IOP on device number bus simultaneously with this signal.
INTERRUPT POLL	INT POLL IN and INT POLL OUT	Interrupt Poll from IOP (in the Power Bus Grouping). Initiated in response to an Interrupt Request. Subsystem must cause the $\overline{\text{INT ACK}}$ signal to go low and gate its device interrupt number to the device number bus if the subsystem is requesting interrupt, or it must let the poll propagate. IOP accepts highest priority.
SERVICE OUT	$\overline{\text{SO}}$	Signal from the IOP (in the Power Bus Grouping) used as a direct I/O command validity signal for: a. Command Out Bus. b. Device Number Bus. c. IOP Data Bus. In initialization sequence, $\overline{\text{SO}}$ causes magnetic tape subsystem to accept and respond to the data on the Command Out Bus and its device number. The magnetic tape subsystem will send a request for service to the multiplexer channel. $\overline{\text{SO}}$ is also used as IOP Data bus outbound validity signal.
SERVICE IN	$\overline{\text{SI}}$	Subsystem acknowledge signal (in the Power Bus Grouping) to IOP for receipt of programmed strobes from the multiplexer channel.
SYSTEM STATUS GROUP		
POWER ON	PWR ON	Signal from Power Bus Grouping indicates HP 3000 Computer System Power Supplies ready. Enables Tape Unit Select Logic on tape controller PCA of interface.

Table 3-1. Magnetic Tape Subsystem IOP Bus Interface Signals (Continued)

NAME	MNEMONIC	DESCRIPTION
SYSTEM STATUS GROUP (Cont.)		
I/O RESET	IO RESET	Signal in Power Bus Grouping from I/O RESET button in HP 3000 Computer System. Acts as master clear for subsystem logic. Also sent at system power-up time.
NOTE: Only the signals used by the HP 30115A Magnetic Tape Subsystem are listed.		

Table 3-2. Magnetic Tape Subsystem Multiplexer Channel Bus Interface Signals

NAME	MNEMONIC	DESCRIPTION
TRANSFER CONTROL GROUP		
CHANNEL SERVICE OUT	$\overline{\text{CHAN SO}}$	Signal from multiplexer channel. Indicates multiplexer channel now receiving service for the subsystem from the IOP after subsystem has requested service from the multiplexer channel. Accompanied by SR line pulled low and $\overline{\text{DEVNO DB}}$ strobe during initilization.
CHANNEL ACKNOWLEDGE	$\overline{\text{CHAN ACK}}$	Signal from multiplexer channel. Acknowledges receipt of Device End signal from subsystem.
SIO ENABLE	$\overline{\text{SIO ENABLE}}$	Signal level (low) from multiplexer channel necessary to permit subsystem initialization and communication with the system
TOGGLE SERVICE REQUEST	$\overline{\text{TOGGLE SR}}$	Signal from multiplexer channel to clear Service Request after initialization sequence is complete. Signal also sets and clears Service Request during DRT Fetch operations.
TOGGLE SIO OK	TOGGLE SIO OK	Signal from multiplexer channel at the end of an entire SIO program. Puts subsystem into idle state ready for next I/O program
TOGGLE IN TRANSFER	TOGGLE IN XFER	Signal from multiplexer channel to prepare subsystem for sequence of data transfers to the system from magnetic tape. Clears the subsystem of the read mode at the end of each data transfer sequence *if* data chaining is not

Table 3-2. Magnetic Tape Subsystem Multiplexer Channel Bus Interface Signals (Continued)

NAME	MNEMONIC	DESCRIPTION
TRANSFER CONTROL GROUP (Cont.)		
TOGGLE IN TRANSFER (Cont.)	TOGGLE IN XFER (Cont.)	in effect. Signal clears the read mode at the end of the entire data chaining transfer sequence if data chaining is in effect.
TOGGLE OUT TRANSFER	TOGGLE OUT XFER	Signal from multiplexer channel to prepare subsystem for a sequence of data transfers from memory to magnetic tape. Clears the subsystem write mode at end of each data transfer sequence *if* data chaining is not in effect. Signal clears the subsystem write mode at the end of the entire data chaining transfer sequence in this case.
END OF TRANSFER	$\overline{\text{EOT}}$	Signal from multiplexer channel, not used in the subsystem although received in the interface.
REQUEST AND RESPONSE GROUP		
SERVICE REQUEST	SR	Signal to multiplexer channel, one of 16 priority lines selected by jumper in the subsystem. Signal goes high for following conditions: a. When subsystem completes execution of last I/O Program Control Word. b. When subsystem has data for transfer to memory or requires more data from memory. c. When transfer has ended. d. After first I/O Program Control Word is received. Service request line is pulled low by the multiplexer channel and Channel Service Out signal is sent to subsystem in answer to high Service Request signal to allow programmed strobes to be gated into subsystem.
REQUEST	$\overline{\text{REQ}}$	Signal to multiplexer channel for SIO operation initialization. Generated once at the start of SIO. Subsystem is in priority line for service (priority is established by SR signal). Multiplexer channel generates Service-in signal to IOP and puts multiplexer channel in the DRT Fetch mode for this subsystem RAM address.

Table 3-2. Magnetic Tape Subsystem Multiplexer Channel Bus Interface Signals (Continued)

NAME	MNEMONIC	DESCRIPTION
REQUEST AND RESPONSE GROUP (Cont.)		
ACKNOWLEDGE SERVICE REQUEST	$\overline{\text{ACK SR}}$	Signal from multiplexer channel acknowledging receipt of a Service Request signal. Clears Device Service Request condition in the subsystem.
DEVICE END	$\overline{\text{DEV END1}}$	Signal to multiplexer channel causes termination of read operation for the subsystem at the multiplexer channel. Sent from subsystem as a result of end of data being processed.
TRANSFER ERROR	$\overline{\text{XFER ERROR}}$	Signal from memory through multiplexer channel due to one or more of the following: a. Parity error. b. Illegal address. c. System error.
TRANSFER STROBE GROUP		
DEVICE NUMBER DATA BASE	$\overline{\text{DEVNO DB}}$	Strobe from multiplexer channel at time of Channel Service Out and cancelled Service Request returned signals. Causes subsystem to gate DRT address to the IOP Data Bus. Multiplexer channel goes to DRT fetch phase for this subsystem RAM address and Service In is sent to the IOP.
PROGRAM COMMAND ONE	$\overline{\text{P CMD 1}}$	Strobe from multiplexer channel to strobe in the first I/O program Control Word for control of a subsystem. Occurs when the multiplexer channel decodes an I/O program word Control order and it is in the first I/O program word (IOCW) fetch phase. For this subsystem, the first I/O program word (IOCW) does not contain a Control Word, therefore, the subsystem simply returns a Service-In signal to the IOP and requests multiplexer channel service.
PROGRAMMED CONTROL STROBE	$\overline{\text{P CONT STB}}$	Strobe from multiplexer channel. Indicates contents of IOAW (on the IOP Data Bus) is an operation Control Word for the subsystem. The Control Word is gated into subsystem data register. Strobe is a result of the multiplexer channel being in the second I/O program word

Table 3-2. Magnetic Tape Subsystem Multiplexer Channel Bus Interface Signals (Continued)

NAME	MNEMONIC	DESCRIPTION
TRANSFER STROBE GROUP (Cont.)		
PROGRAMMED CONTROL STROBE (Cont.)	$\overline{\text{P CONT STB}}$ (Cont.)	(IOAW) fetch phase and decoding the I/O program word Control order.
PROGRAMMED WRITE STROBE	$\overline{\text{P WRITE STB}}$	Strobe from multiplexer channel. Indicates data on the IOP Data Bus is data to be written on magnetic tape by the subsystem. Data is gated into subsystem data register. Strobe results from multiplexer channel being in Data Transfer Phase, with a decoded I/O program word Write order, and not having a Device End condition present.
PROGRAMMED READ STROBE	$\overline{\text{P READ STB}}$	Strobe from multiplexer channel. Indicates data to be placed on the IOP Data Bus that has been read from magnetic tape by the subsystem. Data is strobed onto IOP Data Bus. Strobe results from multiplexer channel being in the Data Transfer Phase, with a decoded I/O program word Read order, and not having a Device End condition present
PROGRAMMED STATUS STROBE	$\overline{\text{P STAT STB}}$	Strobe from multiplexer channel to obtain output from subsystem status register as IOAW (Status word) on the IOP Data Bus. Strobe is a result of the multiplexer channel decoding an I/O program word Sense or End order and being in the Fetch Second I/O Program Word (IOAW) phase.
SET INTERRUPT	$\overline{\text{SET INT}}$	Strobe from multiplexer channel to place subsystem in interrupt state. Strobe is a result of multiplexer channel being in the Fetch Second I/O Program Word (IOAW) phase and decoding an I/O program word End order with bit four of the IOCW set to cause an interrupt. Enables the subsystem to inform the IOP/CPU that operation has ended.

Table 3-3. Interface-to-Tape Unit Signals

NAME	MNEMONICS	DESCRIPTION
		WRITE GROUP
WRITE DATA BUS	$\overline{\text{WD 0:7}}$	Data levels to write module of tape unit. The logical state of each write data line of the bus at Write Clock time defines the character to be written on tape. For NRZI tape units, a low level on a write data bus line causes a change of flux to occur. (A logical 1 is written.) A high level on a write data bus line causes no change of flux on tape. (A logical 0 is written.) The state of erased NRZI tape flux is the same as the reference flux state. For PE tape units, a low level on a write data bus line is represented on tape as a flux change in the direction opposite to the sense of inter-block gap flux. (A logical 1 is written.) A high level on a write data bus line causes a flux change in the direction of inter-block gap flux. (A logical 0 is written.) Erased tape is represented by no flux change after the tape is brought to the inter-block gap flux state. (Reference flux state.)
WRITE DATA PARITY	$\overline{\text{WDP}}$	Data level to write module of tape unit. Same characteristics as Write Data Bus lines.
WRITE CLOCK	$\overline{\text{WC}}$	Pulse to write module of tape unit. A low causes flux polarity to be written on tape corresponding to the logical state of the individual write data lines and the write parity line for NRZI. Tape unit must be in the write condition. This pulse should be at least two (2) microseconds duration.
WRITE RESET	$\overline{\text{WRS}}$	Signal level to write module of tape unit. A transition to a low level causes longitudinal redundancy check (LRC) character to be written on tape provided the tape unit is in Write mode. This signal is not used in phase-encoded tape units. This pulse should be at least two (2) microseconds duration.
		READ GROUP
READ DATA BUS	$\overline{\text{RD 0:7}}$	Data levels from read module of tape unit. The bus transmits detected characters read from the tape.
READ DATA PARITY	$\overline{\text{RDP}}$	Data level from read module of tape unit. Same characteristics as Read Data Bus lines.
READ CLOCK	$\overline{\text{RC}}$	Pulse from read module of tape unit. Indicates that a character has been read from tape and is present on the Read Data Bus. The pulse is at least two (2) microseconds duration.
		FUNCTION COMMANDS
SELECT COMMAND	$\overline{\text{CS 0:3}}$	Four individual lines to motion control module of tape unit. Low level selects a particular on-line tape unit from a group connected to a common interface cable when subsystem options are used. Otherwise $\overline{\text{CS0}}$ selects only tape unit 0.

Table 3-3. Interface-to-Tape Unit Signals (Continued)

NAME	MNEMONIC	DESCRIPTION
		FUNCTION COMMANDS (Cont.)
OFF-LINE COMMAND	$\overline{CL}$	Signal level to motion control module of tape unit. A low level of this signal clears the write condition and terminates the on-line condition of the selected tape unit.
SET WRITE COMMAND	$\overline{WSW}$	Signal level to motion control module of tape unit. Transition to a low level of the $\overline{WSW}$ signal enables the setting of the selected and on-line tape unit's write condition, provided the tape unit is ready and write-enabled. High state of the signal enables the clearing of the tape unit's write condition.
		MOTION COMMANDS
FORWARD COMMAND	$\overline{CF}$	Signal level to motion control module of tape unit. Providing the tape unit is selected and ready, this command causes tape to be driven in the forward direction.
REVERSE COMMAND	$\overline{CR}$	Signal level to motion control module of tape unit. When at a low level, clears the Write condition and causes the tape to be driven in the reverse direction, provided that the tape unit is selected and ready. Load point status inhibits the response to this command.
REWIND COMMAND	$\overline{CRW}$	Signal level to motion control module of tape unit. Clears the Write command on the selected tape unit and initiates a rewind operation, provided that the tape unit is ready and not at load point. Tape is positioned at load point at the end of this operation.
		STATUS
WRITE STATUS	$\overline{SW}$	Signal level from write module of tape unit. Indicates that the selected tape unit is write-enabled and current is flowing in the write and erase heads. Tape flux is of inter-block gap polarity until a Write Clock pulse is received (NRZI).
READY STATUS	$\overline{SR}$	Signal level from motion control module of tape unit. Indicates that the tape unit is selected, is on-line, the initial loading sequence is complete, and the tape unit is not rewinding.

Table 3-3. Interface-to-Tape Unit Signals (Continued)

NAME	MNEMONIC	DESCRIPTION
		STATUS (Cont.)
LOAD POINT STATUS	$\overline{\text{SLP}}$	Signal level from motion control module of tape unit. A low level indicates that the tape unit is selected, is on-line, and the tape is positioned at the load point reflective marker.
FILE PROTECT STATUS	$\overline{\text{SFP}}$	Signal level from motion control module of tape unit. A low level indicates that the selected, and on-line unit is not write-enabled (write enable ring is not present in the tape reel).
END OF TAPE STATUS	$\overline{\text{SET}}$	Signal level from motion control module of tape unit. Indicates that an End-of-Tape reflective marker was detected by the photosensitive head of a selected and on-line tape unit. A low level is maintained until cancellation of the End-of-Tape condition by the passage of the reflective marker in the reverse direction.
PHASE ENCODED STATUS (800/1600 cpi)	$\overline{\text{SD16}}$	Signal level from tape unit. Indicates 800- or 1600-cpi density recording for the subsystem. Interface cable pin not connected at HP 7970B Digital Magnetic Tape Unit. Line tied high at input to tape controller PCA provides low input to tape controller status register when 800-cpi tape unit is selected. Line pulled low at tape controller PCA for 1600-cpi tape unit selected.
END OF BLOCK	$\overline{\text{EOB}}$	Pulse line from tape unit. Interface cable pin not connected at NRZI tape unit. For PE tape unit, indicates that a data block, tape mark or identification burst has been read. Strobes these signals to tape controller PCA. This pulse is at least two microseconds duration.
TAPE MARK	$\overline{\text{TM}}$	Signal level line from tape unit. Interface cable pin not connected at NRZI tape unit. For PE tape unit, indicates that block just read was tape mark if signal is low. This signal is valid only during the EOB pulse time.
IDENTIFICATION BURST	$\overline{\text{IDB}}$	Signal level line from tape unit. Interface cable pin not connected at NRZI tape unit. For PE tape unit, indicates that block just read from tape was an identification burst block if signal is low. Valid only during EOB pulse time.
MULTIPLE TRACK ERROR	$\overline{\text{MTE}}$	Signal level line from tape unit. Interface cable pin not connected at NRZI tape unit. For PE tape unit, if signal is low, indicates that an uncorrectable error situation was detected and the black must be re-read. Valid only during EOB pulse time.

Table 3-3. Interface-to-Tape Unit Signals (Continued)

NAME	MNEMONIC	DESCRIPTION
STATUS (Cont.)		
SINGLE TRACK ERROR	$\overline{\text{STE}}$	Signal level line from tape unit. Interface cable pin not connected at NRZI tape unit. Used only for PE. If signal is low, indicates single-track error condition was detected. If MTE is not low at EOB time in a read only mode, error condition was correctable. Block need not be re-read. Valid only during EOB pulse time.

NOTES:

1. Signals not routed to HP 30115A Magnetic Tape Subsystem from tape unit are not listed.
2. All signals are exchanged between tape controller of HP 30215A Magnetic Tape Unit Interface and selected tape unit.

3-12. HP 30215A MAGNETIC TAPE UNIT INTERFACE LOGIC SECTIONS.

3-13. The HP 30215A Magnetic Tape Unit Interface portion of the magnetic tape subsystem, controls and processes all signal and data exchanges between the HP 3000 Computer System and the selected tape unit. The interface is comprised on the tape controller and controller processor printed-circuit-assemblies. The tape controller may be viewed as the data logic portion of the interface, while the controller processor can be viewed as the interface control logic.

3-14. The major logic sections of the tape controller PCA, shown in figure 3-1, are the:

a. Data gate and bus logic.

b. Interface, control, and flag logic.

c. Tape unit interface logic.

d. Status report logic.

e. Magnetic tape subsystem microprogram (ROM integrated-circuit packs).

3-15. The major logic sections of the controller processor PCA, shown in figure 3-1, are the:

a. Register and counter.

b. Arithmetic and Logic Unit (ALU).

c. RAR/ROR logic.

d. Decode and control logic.

3-16. Certain groups of signals are exchanged between the tape controller and controller processor to accomplish subsystem control and data handling. The signal groups, shown in figure 3-1, of the controller processor that are used in the HP 30115A Magnetic Tape Subsystem are the:

a. Twenty-bit ROM program word bus.

b. Twelve-bit ROM address word bus.

c. Sixteen Flag lines to the controller processor.

d. Five Destination/Source code control lines.

e. Three strobe lines to the tape controller.

f. Sixteen-bit bi-directional MIO bus.

g. Clear line from the tape controller to the controller processor.

3-17. All timing and control for tape motion, reading, and writing operations in the magnetic tape subsystem is under supervision of the subsystem microprogram read out from the subsystem microprogram ROM IC packs. Readout of 20-bit ROM program words to the ROM Output Register (ROR) in the RAR/ROR logic normally occurs sequentially as directed by 12-bit ROM address words applied to the ROM IC packs from the ROM Address Register (RAR) in the RAR/ROR logic. The microprogram branches to appropriate subroutines or addresses, in response to magnetic tape I/O program commands from the HP 3000 Computer System, or sensed conditions on the Flag lines, to accomplish the desired results. Magnetic tape subsystem command words and the formats are explained in section II.

3-18. Figure 3-1 shows that all I/O program commands to the magnetic tape subsystem, and all data transferred through the subsystem is exchanged through the data gate and bus logic, and the interface logic of the interface, control, and flag logic blocks in the tape controller via the 16-bit data and command word buses. Data and commands incoming on the bus are routed to the controller processor registers via the 16-bit bi-directional MIO bus on the controller processor.

3-19. The commands or data are examined or operated on and passed through the registers or counter, see figure 3-1 controller processor portion, and the Arithmetic and Logic Unit (ALU) back to the MIO bus. The bus structure, registers, and ALU in the controller processor are so arranged that the lower or upper byte, or the entire 16 bits of the information may be utilized. Information on the MIO bus may be incoming to the controller processor, or may be output to the tape controller, or may be routed back to the registers or counter for storage, or information may be routed back for further operations to be performed depending upon the microprogram instructions.

3-20. Outgoing data from the HP 3000 Computer System, in the form of 16-bit words, is passed through tape controller PCA logic and unpacked to form two 8-bit bytes to be written on tape. The unpacking operation takes place in the controller processor under direction of the microprogram. Unpacked data is then passed from the controller processor to the tape unit via the upper byte of the 16-bit MIO bus and through the tape controller PCA interfacing logic. Data from the tape unit, inbound to the HP 3000 Computer System, is routed through tape controller and interface logic, via the lower byte of the MIO bus into the controller processor registers. Here two 8-bit frames read from tape are packed into a single 16-bit word in the controller processor registers by operations performed through the Arithmetic and Logic Unit. The 16-bit word is then routed through the ALU to the MIO bus and into tape controller interface logic as a full 16-bit word. This information from magnetic tape is input to the system upon receipt of appropriate commands and strobes.

3-21 The subsystem status report logic, located on the tape controller PCA holds the coded conditions of appropriate tape unit and tape controller PCA status signals. The 16-bit status word is continuously available for readout on the Data and Command word bus upon command from the HP 3000 Computer System. Format and field explanations of the status word are discussed in section II.

3-22. The operations described in a general nature in preceding paragraphs are all implemented through registers and gates that are controlled by the control logic distributed throughout both HP 30215A Magnetic Tape Unit Interface printed-circuit-assemblies. As previously mentioned, all control logic is activated by the microprogram. Destination/source lines, and strobes from the controller processor, and additional strobes and commands from the HP 3000 Computer System, described in table 3-1, are all fed to the tape controller PCA to perform the desired operations. The exact nature and sequence of these "desired operations" is described in the tape controller PCA paragraphs. Generally, on the tape controller PCA, the signals involved in control operations are shown in figure 3-1 as the following lines. (See the tape controller in figure 3-1 and note the sources and destinations of these control signal groups.)

a. Requests.

b. Interrupts.

c. Flags.

d. Strobes.

e. Control signals.

f. Gating signals.

g. Readout Control signals.

3-23. The controller processor control logic decodes fields of the ROM program words output from the ROR. Timing of all control functions is under the influence of the crystal oscillator in the decode and control logic section of the controller processor. General groupings of the control signals on the controller processor PCA are shown in figure 3-1 as the following lines. (See the controller processor in figure 3-1 and note the sources and destinations of these control signal groups.)

a. Register Control signals.

b. Code bus.

c. Immediate Operand bus.

d. Count.

e. Operation Control signals.

3-24. Once the logic and the signals of the interface are defined, the operation of the entire subsystem can be more easily understood by examining the microprogram. The prerequisite is an understanding of the controller processor microinstruction and word format repertoire, and commands for HP 30115A Magnetic Tape Subsystem control. As previously mentioned, further details on the microprogrammed operation of the subsystem are presented in the following paragraphs.

3-25. INTERFACE.

3-26. The HP 30215A Magnetic Tape Unit Interface is functionally comprised of the tape controller and controller processor printed-circuit-assemblies, and the two flat-ribbon connector cables from J2-to-J2 and from J3-to-J3 on the respective PCA's. The controller processor may be considered a "black-box" that provides "holding" type logic to implement commands and to process data through the tape controller. Flags to the controller processor from the tape controller; and strobes and destination codes to the tape controller from the controller processor cause subsystem operation to be carried out according to the microprogram held in the ROM integrated-circuit packs. The ROM integrated-circuit packs are physically located on the tape controller.

3-27. All logic used in the interface printed-circuit-assemblies is positive-true. The detailed diagrams manual contains information on the integrated-circuit packs, used in the interface, that should be referenced to understand simplified and detailed diagrams for the printed-circuit assemblies. Simplified logic diagrams that support the presentations and tables of tape controller and controller processor operation will be found in the simplified logic diagrams manual. The detailed logic diagrams will be found in the detailed diagrams manual. Logic conventions used in the tape units are described in the tape unit operating and service manuals. The following paragraphs describe the operation of the tape controller and controller processor in relation to the magnetic tape subsystem microprogram.

3-28. TAPE CONTROLLER PCA.

3-29. The functional operation of the magnetic tape subsystem is best described in the flow chart presentation of overall operation in paragraph 3-30. The microprogram for the subsystem resides in the ROM integrated-circuit packs physically present on the tape controller PCA. Flip-flops and registers on the tape controller PCA that are controlled by the microprogram are listed in table 3-3A. Where set and clear information is provided, the logic diagrams should also be referenced for clock signal information and additional source signal data. Accurate movement of tape and read/write gating of information written on or read from tape is the key to successful operation of the magnetic tape subsystem. Timing and tape movement is discussed in paragraphs 3-36 through 3-37. References to information in sections II and IV are made when appropriate.

3-30. TAPE CONTROLLER MICROPROGRAM. The overall subsystem operation is described in the general flow charts of figure 3-2. These flow charts, and the detailed flow charts of the listing mentioned later, are applicable for nine-track, 800-cpi (NRZI) and 1600-cpi (PE) tape units. As seen in the flow charts the tape controller is capable of driving a mix of up to four 800-cpi and 1600-cpi tape units.

3-31. Sheet one of the general flow charts shows the overall subsystem operation from the power-on or I/O reset initialization sequence that starts at ROM address 0000_8, through the command word decode sequences. Sheets two through seven show the scan, read forward 800 cpi and 1600 cpi, write forward 800 cpi and 1600 cpi, and read reverse sequences in general form. Sheet eight shows the stop sequence, reject and interrupt sequence, and algorithm to compute the CRCC. Most of the tape controller time is spent in the main (idle) loop. Note that less control from the interface is necessary with 1600-cpi (PE) operation due to the fact that the phase-encoded tape unit exercises more control over the tape than does the NRZI tape unit. Mnemonics for command words shown are defined in section II.

3-32. Detailed Flow Charts. Detailed flow charts of the microprogram discussed above are located in section IV, figure 4-10. Refer to figure 4-9A and table 4-1A for conventions and definitions of terms and symbols used in the detailed flow charts. The detailed flow charts fully describe the microprogram listing, table 4-4, which is discussed in paragraph 3-33. In addition, keep in mind the following when using the detailed flow charts.

a. The list of flip-flops and registers in table 3-3A should also be used to understand PCA operation.

b. Specific flip-flop setting or clearing is generally shown in the flow charts by indicating the flip-flop name, stage going to, and mode of that state. For example:

IN/OUT MODE FF ← 0 (OUT)

means that the flip-flop named In/Out Mode is being cleared and in the clear state it is in the "Out" mode.

c. Controller processor general purpose registers RG0 through RG5, and the counter, are repeatedly assigned as temporary registers to perform particular functions such as: the unit history register, read CRCC register (CRCR), write CRCC register, status report register, character storage register, etc. These register names are effective only for the particular current function, thus, these names do not appear in table 3-3A.

d. Bits are considered as bit "0" left, reading left (MSB)-to-right (LSB). When a single bit is of interest, for example, it is designated thus: "bit 15."

3-33. Listing. Introductory material for the listing is included in the first seven pages of the listing. The constants shown on page one are octal quantities that may be directly converted to the bit pattern shown in the applicable portion of the 20-bit ROM word. Whether the quantity is loaded into the upper or lower byte must also be considered. The binary quantity is loaded from the immediate operand into the controller processor counter or designated register, as applicable. The actual operation of the counter is to increment but because the sense of the MIO bus is reversed, the overall function of the counter logic is decrementing. Decrementing the counter towards all logical 1's with a quantity stored, provides the desired timing delays. Further information on timing calculation appears in table 4-1A. All logical zero's is the largest number the decrementing counter in the controller processor can hold. Tape controller command word codes are also shown on page one of the listing. The constants shown for the command words are in octal. These may be converted directly to binary to obtain the bit pattern for bits 12 through 15 of the IOAW, which carries the tape controller command word. For example: the Command RST is #11 thus bits 12 through 15 of the IOAW will be 1001. In the listing, quantities preceded by the number symbol (#) are octal quantities. Tape controller command words are all explained in section II of this manual along with their binary patterns. The Reference Coding Sheet for the controller processor shown on page two of the listing is included for reference only. Use the controller processor microcoding sheet, figure 4-11, and word format figure 3-13 included in the controller processor PCA description for complete information. Pages three through five of the listing provide reference tables for tape controller card pins and signals of jacks J1 through J3. Note that J2-36 (ROM Enable) and J3-49 (Run) are used only for maintenance. The Run signal is not used at all in the nine-track magnetic tape subsystem. Additional data, cabling, and maintenance information is included in section IV of this manual.

3-34. The destination and source codes shown on page six of the listing are octal numbers that may be converted to binary to obtain the bit pattern on the destination/source lines (ROR7 through 11). The code from the controller processor to the tape controller is valid at output or input strobe time. Consider, for example, a destination code of D03 for output. The bit pattern for ROR 7:11 presented at the destination/ source decoder in the tape controller will be "00011," respectively. At output strobe time this will be decoded to gate the write register. The destination/source codes are used in IOC and OTI instructions. To easily find which registers, gates, and/or flip-flops are activated at the appropriate strobe time, refer to the coding sheet on page seven of the listing and to table 3-3A. The detailed logic diagrams must be used to locate the wiring and logic activated.

Table 3-3A. Magnetic Tape Controller PCA Flip-Flops and Registers

NAME	REFERENCE DESIGNATION	DESCRIPTION
FLIP-FLOPS		
BYTE CNT (Byte Count)	U161B	Status report logic JK FF. Provides tape odd/even byte count in bit 1 of subsystem status word. Set by MIO bus bit M9 for odd bytes. Cleared by MIO bus bit M8 for even bytes.
CMD ENB (Command Enable)	U94B	Flag logic JK FF. Provides flag signal F17 to microprogram. Flag low indicates programmed I/O order has been received (FF set). "Set CMD ENB FF" in microprogram indicates flag is high (FF cleared). Set by $\overline{\text{P CONT STB}}$ from MUX CHAN. Cleared by D1x (ROR bit 8) and UOS or LOS.
Data FF	U84A	Flag logic JK FF. Provides flag signal F14 to microprogram. Flag high indicates data taken by system or provided to the subsystem. Set by $\overline{\text{P READ STB}}$ or $\overline{\text{P WRIT STB}}$ from MUX CHAN. Cleared by MIO bus bit M0 and UOS.
DEV END (Device End)	U182A	Bus logic interface logic JK FF. Provides Device End ($\overline{\text{DEV END}}$) Signal to MUX CHAN. Clear state is active state. Set by Acknowledge Service Request or Clear Interface Logic, or Master Reset signals. Cleared by MIO bus bit M4 and DO2 (ROR bit 10), and UOS.
DEV END (B) (Device End Buffer)	U16 B/C	Control logic gate FF. Provides signal to gate device address to IOD bus at end of SIO operation. Set by Device End (DEV END) signal from DEV END FF. Cleared by MUX CHAN signals.
DSR (Device Service Request)	U74B	Bus logic interface logic JK FF. Provides signal to issue Service Request to MUX CHAN for additional commands. Set by D2x (ROR 7) and either output strobe (UOS or LOS). Cleared by Acknowledge Service Request, or Clear Interface Logic, or Master Reset signals.

Table 3-3A. Magnetic Tape Controller PCA Flip-Flops and Registers (Continued)

NAME	REFERENCE DESIGNATION	DESCRIPTION
FLIP-FLOPS (Cont.)		
EOB FLAG FF (End of Block Flag)	U83B	Flag logic D FF. Provides flag signal F07 to microprogram. Flag high indicates 1600 cpi tape unit has sent End of Block ($\overline{EOB}$) signal. Set by EOB O.S. (one shot). Cleared by D1x (ROR bit 8) and UOS or LOS.
EOF (End of File)	U161A	Status report logic JK FF. Provides Tape Mark, bit 11, of subsystem status word. Set by MIO bus bit M10 to indicate tape mark found. Cleared by MIO bus bit M15.
ESR (Enable Service Request)	U26B	Request logic D FF. Flip-flop used to initiate Service Request to MUX CHAN. Set by decoded SIO command. Cleared by Clear Interface Logic ($\overline{CLRIL}$) signal.
FWD (Forward)	U142B	Tape unit control interface logic JK FF. Sends Forward ($\overline{CF}$) command to selected tape unit. Set by MIO bus bit M10. Cleared by MIO bus bit M9.
F0 (Flag Zero)	U182B	Flag logic JK FF. Provides flag signal F00 to microprogram. Used in microprogram as a memory element. Set by MIO bus bit M2. Cleared by MIO bus bit M3.
F1 (Flag One)	U162A	Flag logic JK FF. Provides flag signal F01 to microprogram. Used in microprogram as a memory element. Set by MIO bus bit M11. Cleared by MIO bus bit M10.
F2 (Flag Two)	U162B	Flag logic JK FF. Provides flag signal F02 to microprogram. Used in microprogram as a memory element. Set by MIO bus bit M9. Cleared by MIO bus bit M8.
In-Out	U172A	PCA control logic JK FF. Provides control signal for in or out parity reading and 1600 cpi tape unit status signal reading. Set by MIO bus bit M15 for in mode. Cleared by MIO bus bit M14 for out mode.

Table 3-3A. Magnetic Tape Controller PCA Flip-Flops and Registers (Continued)

NAME	REFERENCE DESIGNATION	DESCRIPTION
FLIP-FLOPS (Cont.)		
INT ACT (Interrupt Active)	U55A	Interrupt logic D FF. Provides Interrupt Active ($\overline{\text{INT ACK}}$) signal to IOP and PCA interrupt logic when interrupt pending. Set by controller requesting interrupt. Cleared by decoded Reset Interrupt Logic ($\overline{\text{RIL}}$) command (4).
Interrupt Request	U114A	Bus logic interface logic D FF. Provides Interrupt Request, bit 2, of subsystem status word and Interrupt Request ($\overline{\text{INT REQ}}$) signal to interrupt logic, and Interrupt, bit 3, for internal status word. Set by high signal from error status decoder (when any error condition occurs) and clocked by destination code D02, UOS, and MIO bus bit M7 or set by decoded Set Interrupt ($\overline{\text{SET INT}}$) command. Cleared by Reset Interrupt ($\overline{\text{RESET INT}}$) signal or Master Reset.
INT LATCH (Interrupt Latch)	U24D	Interrupt logic D FF. Stops Interrupt Poll and provides device address gating signal when set by Interrupt Active or Interrupt Request signals. Cleared by reverse of above conditions.
IN-XFER (In Transfer)	U86B	Flag logic JK FF. Provides flag signal F16 to microprogram. Flag high indicates system taking data from subsystem. Toggled by In Transfer signal from MUX CHAN and clocked by IOP and MUX CHAN. Cleared by Master Reset or Clear Interface Logic signals.
Mask	U55B	Interrupt logic D FF. Allows subsystem to respond or not respond to interrupts depending upon mask word from IOP. Set by proper bit connected through mask jumper and clocked by Set Mask from IOP. Cleared by Master Reset or Programmed Master Clear.
Odd/Even Parity	U152A	Tape unit write interface logic JK FF. Causes write parity generator to provide odd or even parity for write operation. Set by MIO bus bit M15 for odd parity. Cleared by MIO bus bit M14 for even parity.

Table 3-3A. Magnetic Tape Controller PCA Flip-Flops and Registers (Continued)

NAME	REFERENCE DESIGNATION	DESCRIPTION
FLIP-FLOPS (Cont.)		
Off-Line	U153B	Tape unit control interface logic JK FF. Sends Off-Line ($\overline{CL}$) command to selected tape unit when set. Set by MIO bus bit M6. Cleared by MIO bus bit M7.
OUT-XFER (Out Transfer)	U86A	Flag logic JK FF. Provides flag signal F12 to microprogram. Flag high indicates system sending data to subsystem. Toggled by Out Transfer signal from MUX CHAN and clocked by IOP and MUX CHAN. Cleared by Master Reset or Clear Interface Logic signals.
PAR ENB (Parity Enable)	U172B	Tape unit control interface logic JK FF. Enables parity to be written when set. Provides constant "0" in parity track when clear. Set by MIO bus bit M13 to enable parity (odd parity). Cleared by MIO bus bit M12 to suppress parity.
PAR ERR (Parity Error)	U83A	Flag logic D FF. Provides flag signal F11 to microprogram. Flag low indicates bad read parity. Set by read parity checker and clocked by read clock one shot. Cleared by Master Reset signal.
RD CLK FLAG (Read Clock Flag)	U84B	Flag logic JK FF. Provides flag signal F10 to microprogram. Flag high indicates read clock received from tape unit. Clocked to set by read clock one shot. Cleared by D04, $\overline{D03}$ and UOS or LOS.
RD PARITY (Read Parity)	U114B	Tape unit read interface logic D FF. Used to store the state of the read parity bit for use by flag F06. Clocked by Read Clock one shot.
Reject	U181A	Status report logic JK FF. Provides reject command status data to error status decoder for status error field bits 12, 13, 14 of subsystem status word. Set by MIO bus bit M14. Cleared by MIO bus bit M15.

Table 3-3A. Magnetic Tape Controller PCA Flip-Flops and Registers (Continued)

NAME	REFERENCE DESIGNATION	DESCRIPTION
FLIP-FLOPS (Cont.)		
REV (Reverse)	U142A	Tape unit control interface logic JK FF. Sends Reverse ($\overline{CR}$) command to selected tape unit. Set by MIO bus bit M11. Cleared by MIO bus bit M9.
REW (Rewind)	U153A	Tape unit control interface logic JK FF. Sends Rewind ($\overline{CRW}$) command to selected tape unit. Set by MIO bus bit M5. Cleared by MIO bus bit M7.
SIO OK	U96B	Service logic JK FF. Indicates SIO operation state. Set by decoded SIO direct command. Cleared by clear Interface Logic or Master Reset signals. Toggled by MUX CHAN Toggle SIO OK signal.
SR (B) (Service Request Buffer)	U26A	Service logic D FF. Indicates to controller logic that service request has been sent to MUX CHAN. Clocked by card control logic. Cleared by Programmed Master Clear or I/O Reset signals.
SR (Service Request)	U96A	Request logic JK FF. Initiates controller service request after receipt of SIO direct command. Set by decoded SIO direct command. Toggled by Toggle SR signal from MUX CHAN and clocked by card control logic. Cleared by Clear Interface Logic or Master Reset signals.
Tape Error	U171B	Status report logic JK FF. Provides tape error status data to error status decoder for status error field bits 12, 13, 14 of subsystem status word. Set by MIO bus bit M11. Cleared by MIO bus bit M15.
Tape Runaway	U181B	Status report logic JK FF. Provides tape runaway status data to error status decoder for status error field bits 12, 13, 14 of subsystem status word. Set by MIO bus bit M13. Cleared by MIO bus bit M15.

Table 3-3A. Magnetic Tape Controller PCA Flip-Flops and Registers (Continued)

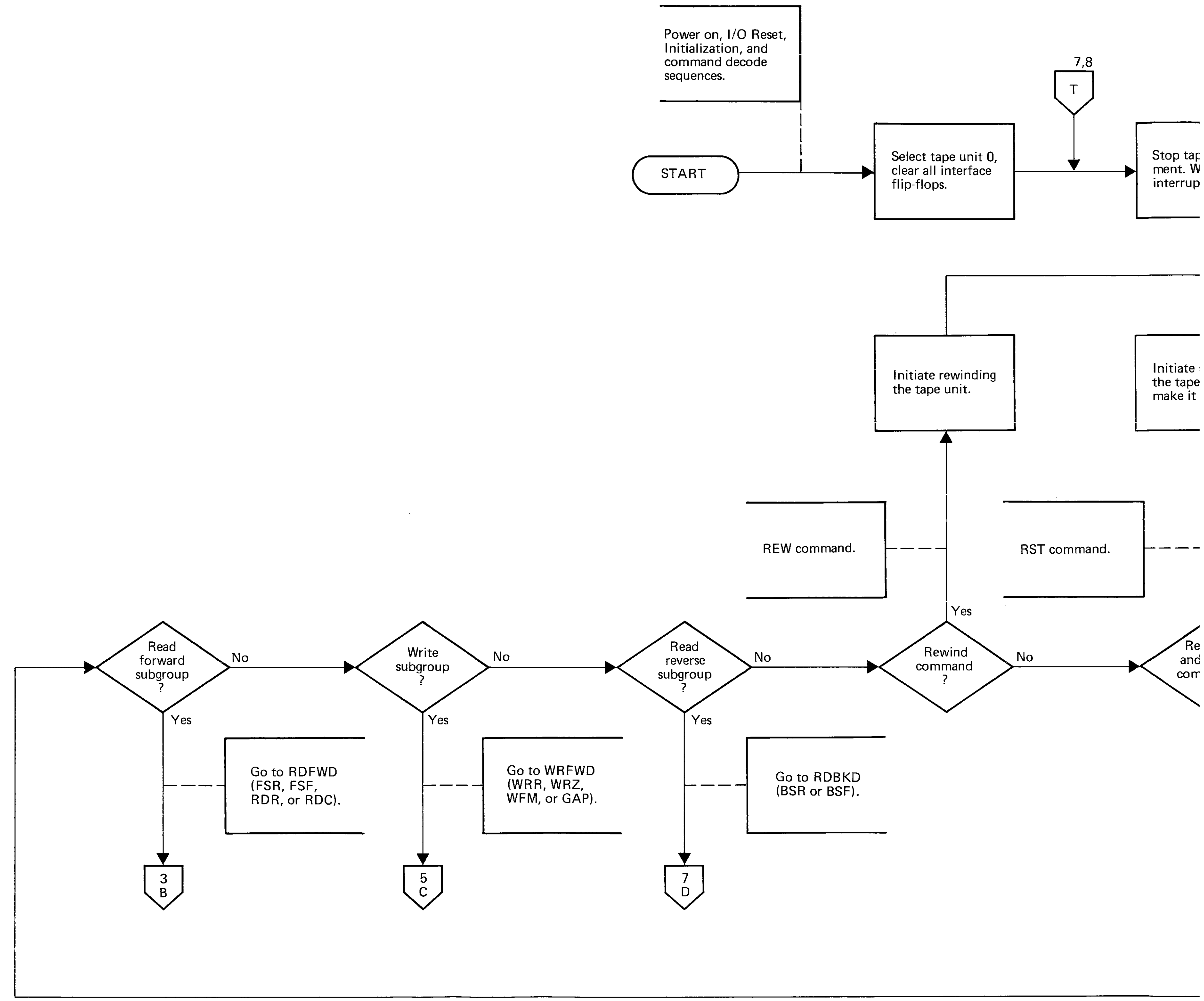
NAME	REFERENCE DESIGNATION	DESCRIPTION
FLIP-FLOPS (Cont.)		
Timing	U171A	Status report logic JK FF. Provides timing status data to error status decoder for status error field bits 12, 13, 14 of subsystem status word. Set by MIO bus bit M12. Cleared by MIO bus bit M15.
UNIT INT (Unit Interrupt)	U173A	Status report logic JK FF. Provides unit ready status to error status decoder for status error field bits 12, 13, 14 of subsystem status word. Set by MIO bus bit M1. Cleared by MIO bus bit M5.
UNIT SEL 1 (Unit Select One)	U151B	Unit select logic JK FF. Provides unit select internal status data, select decoder data, and unit select status bit 4 of subsystem status word. Set by MIO bus bit M6. Cleared by MIO bus bit M4.
UNIT SEL 2 (Unit Select Two)	U151A	Unit select logic JK FF. Provides unit select internal status data, select decoder data, and unit select status bit 3 of subsystem status word. Set by MIO bus bit M7. Cleared by MIO bus bit M5.
Write	U152B	Tape unit control interface logic JK FF. Sends Write ($\overline{WSW}$) command to selected tape unit. Set by MIO bus bit M13. Cleared by MIO bus bit M12.
XFER ERROR (Transfer Error)	U74A	Status report logic JK FF. Provides transfer error status data to error status decoder for status error field bits 12, 13, 14 of subsystem status word and signal to clear interrupt logic. Set by Transfer Error signal from MUX CHAN and clocked by Clock Transfer Error signal. Cleared by Master Reset signal.

Table 3-3A. Magnetic Tape Controller PCA Flip-Flops and Registers (Continued)

NAME	REFERENCE DESIGNATION	DESCRIPTION
	ONE-SHOTS (O.S.)	
EOB (End of Block)	U22A	Tape unit status interface logic one shot. Provides 1.25 microsecond pulse to clock EOB FLAG FF for flag F07 and clocks 1600 cpi Status Latch Register. Triggered by $\overline{\text{EOB}}$ signal from 1600 cpi tape unit.
RD CLK (Read Clock)	U22B	Tape unit read interface logic one shot. Provides 1.25 microsecond pulse to clock RD PARITY FF then PAR ERR FF and Read Data Register. Triggered by $\overline{\text{RD CLK}}$ signal from selected tape unit.
WRT CLK (Write Clock)	U143A	Tape unit write interface logic one shot. Provides 2.58 microsecond $\overline{\text{WC}}$ pulse to selected tape unit. Triggered by MIO bus bit M2, D00, and UOS.
WRT RESET (Write Reset)	U143B	Tape unit write interface logic one shot. Provides 2.58 microsecond $\overline{\text{WRS}}$ pulse to selected tape unit. Triggered by MIO bus bit M3, D00, and UOS.
	REGISTERS	
AUX Status (Auxiliary Status)	U13	Processor interface logic inverting gates acting as internal status register. Provides microprogram status on upper byte MIO bus bits as follows: M0 $\overline{\text{IDB}}$ (1600 cpi tape unit). M1 $\overline{\text{TM}}$ (1600 cpi tape unit). M2 $\overline{\text{MTE}}$ or $\overline{\text{STE}}$ (1600 cpi tape unit). M3 INT ACTIVE or Interrupt Request. M4 $\overline{\text{SIO OK}}$. M5 $\overline{\text{SFP}}$ (from tape unit). M6 and M7 (Tied low). Note: See Status Latch Register also for M0, M1, M2. Gated to bus by source codes D22 or D26 (ROR bits 10 and 7) and Input Strobe (INP STB).

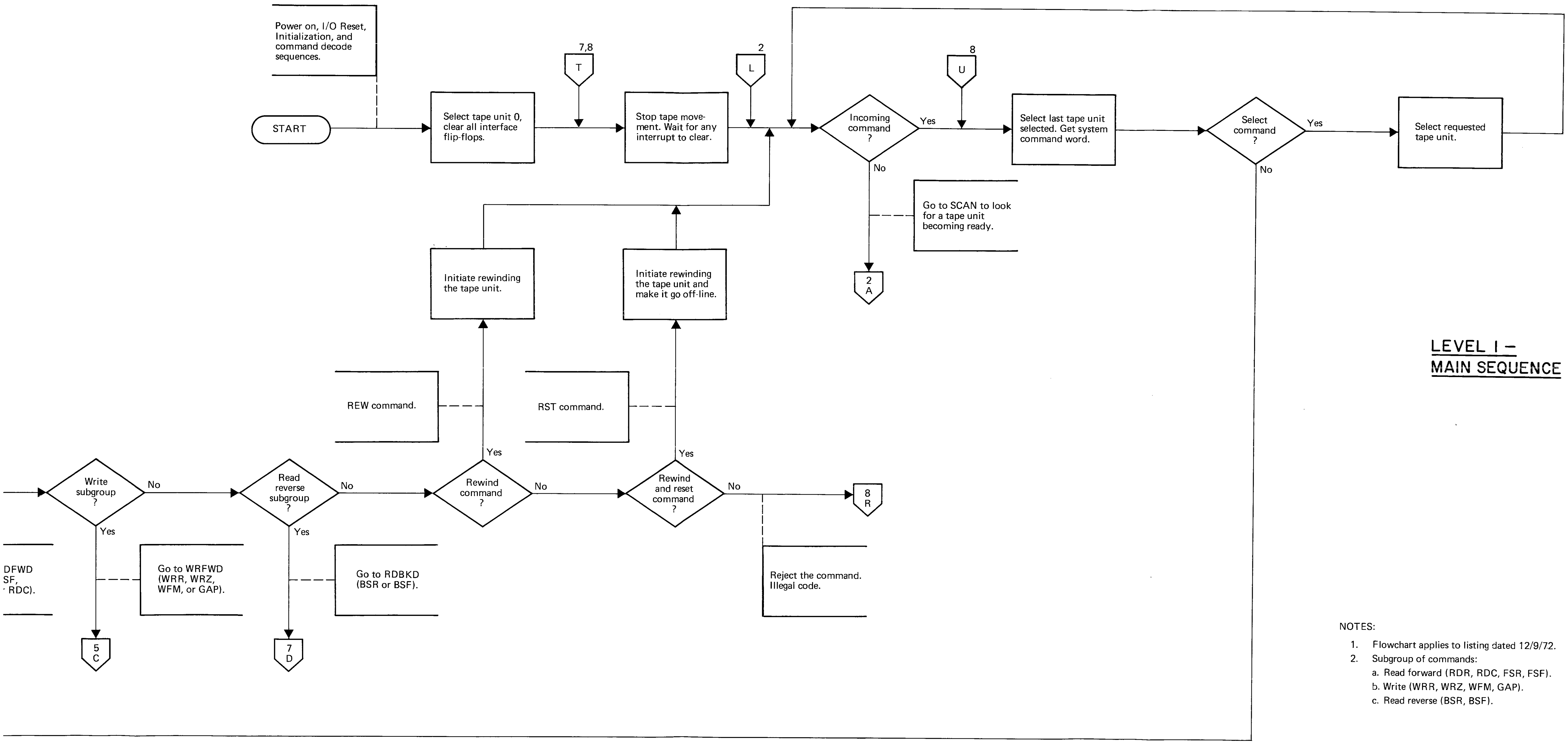
Table 3-3A. Magnetic Tape Controller PCA Flip-Flops and Registers (Continued)

NAME	REFERENCE DESIGNATION	DESCRIPTION
REGISTERS (Cont.)		
Data In	U184 U186	Processor interface logic upper (U186), lower (U184) byte latch registers. Hold 16-bit data word for input to system. Data latched in by D07 and UOS/LOS.
Data Out	U135 U165	Bus logic interface logic upper (U135), lower (U165) byte latch registers. Holds data and command words output from system. Data latched in by $\overline{\text{P CONT STB}}$ or $\overline{\text{P WRIT STB}}$.
Read Data	U21	Tape unit read interface logic latch register. Holds eight bit byte received from tape unit read data lines. Byte latched in by Read Clock and one shot output.
Status Latch	U24	Tape unit status interface logic latch register. Holds 1600 cpi tape unit status for output to AUX status gates. Status latched in by pulse from EOB one shot.
Status	U166 U167	Status report logic gates that act as system status word register. See section II for status word bit and field definitions. Status gated by $\overline{\text{P STAT STB}}$ or $\overline{\text{D STAT STB}}$ signals.
Unit Status	U33	Processor interface logic gates that act as internal unit select status register. Status gated to MIO bus by D20 or D24 source code.
Write Data	U53	Tape unit write interface logic latch register. Holds eight bit byte to be sent to selected tape unit for writing on tape. Byte latched in by destination code D03.



Power on, I/O Reset, Initialization, and command decode sequences.
START
Select tape unit 0, clear all interface flip-flops.
7,8
T
Stop tap
ment. W
interrup
Initiate rewinding the tape unit.
Initiate
the tape
make it
REW command.
RST command.
Read forward subgroup ?
No
Yes
Write subgroup ?
No
Yes
Read reverse subgroup ?
No
Yes
Rewind command ?
Yes
No
Re
and
com
Go to RDFWD (FSR, FSF, RDR, or RDC).
Go to WRFWD (WRR, WRZ, WFM, or GAP).
Go to RDBKD (BSR or BSF).
3 B
5 C
7 D

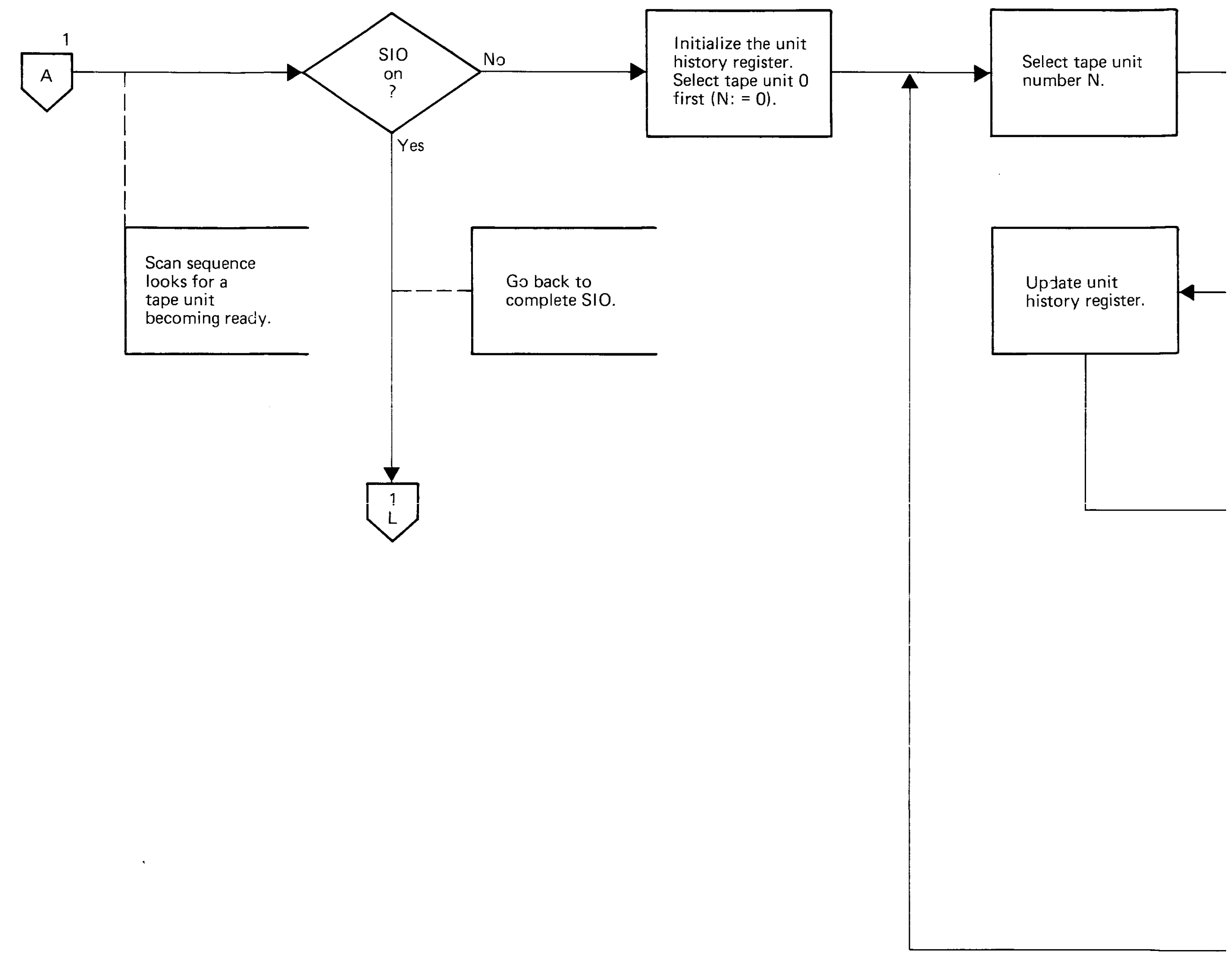
2180-42B



NOTES:

1. Flowchart applies to listing dated 12/9/72.
2. Subgroup of commands:
   a. Read forward (RDR, RDC, FSR, FSF).
   b. Write (WRR, WRZ, WFM, GAP).
   c. Read reverse (BSR, BSF).

Figure 3-2. Tape Controller Overall Operation Flowchart (Sheet 1 of 8)



A
1
SIO on ?
No
Yes
Initialize the unit history register. Select tape unit 0 first (N: = 0).
Select tape unit number N.
Scan sequence looks for a tape unit becoming ready.
Go back to complete SIO.
Update unit history register.
1 L

2180-50A

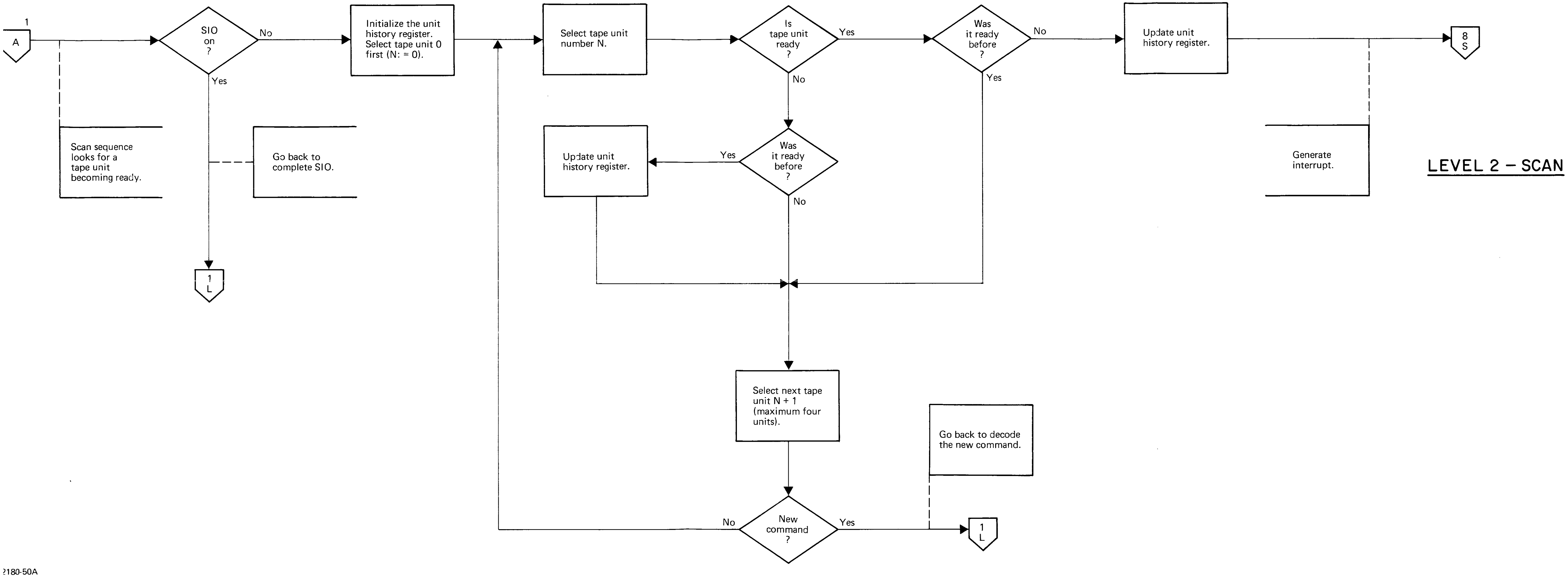
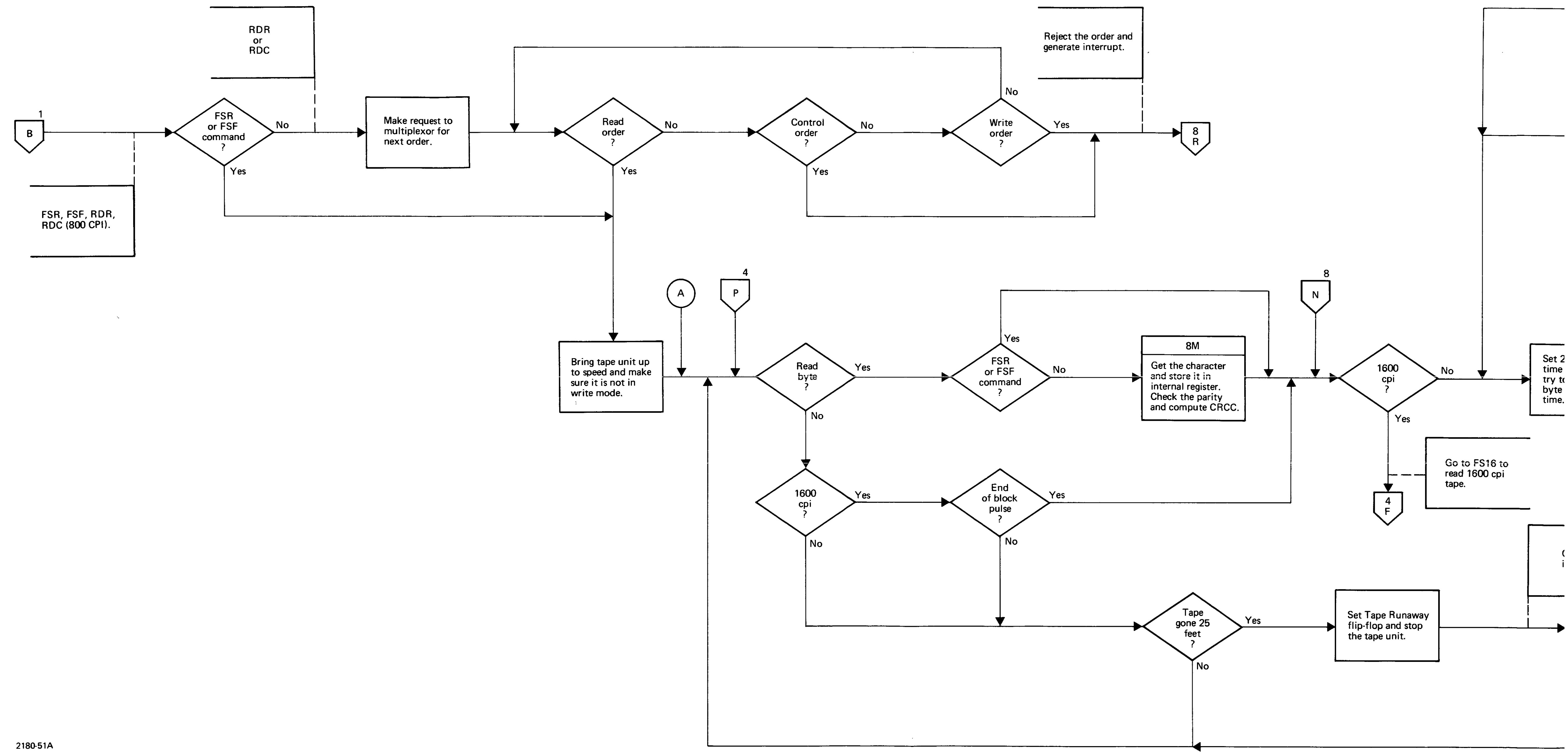
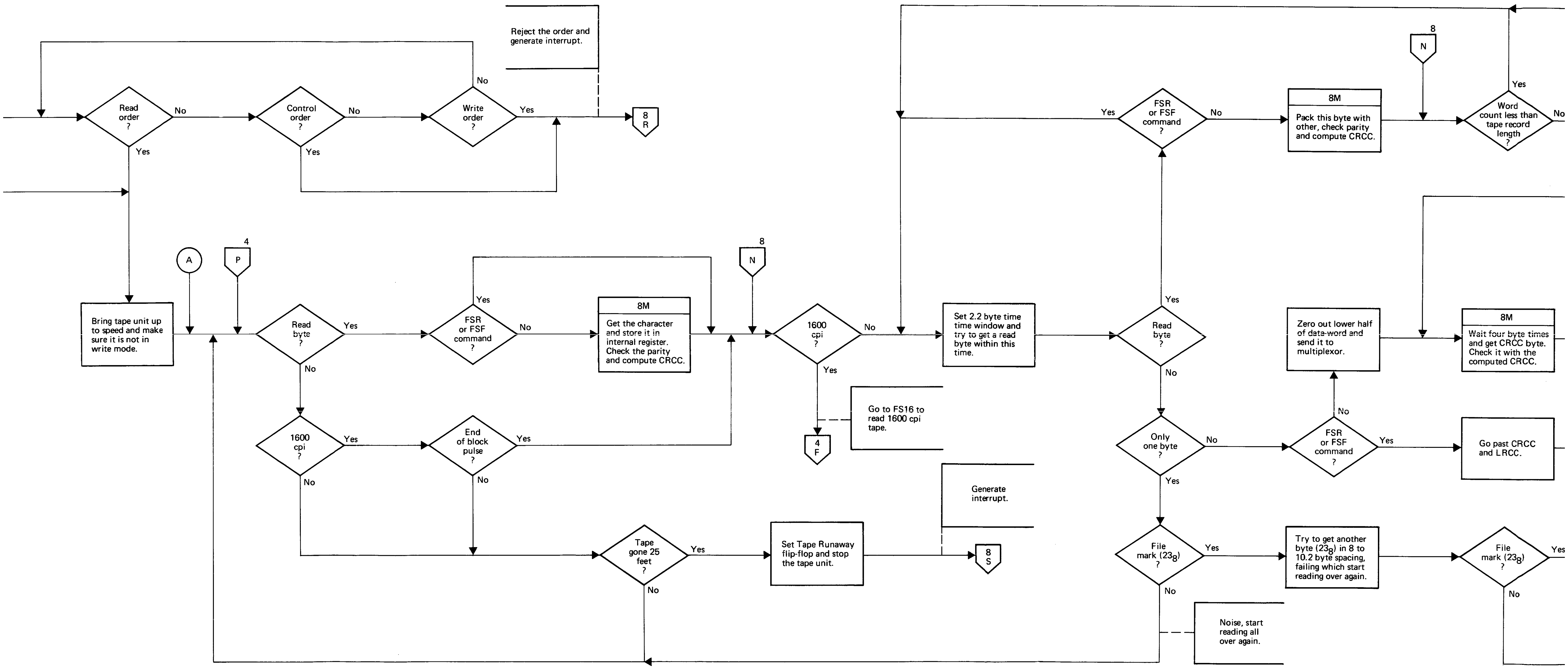


Figure 3-2. Tape Controller Overall Operation Flowchart (Sheet 2 of 8)


RDR or RDC
FSR, FSF, RDR, RDC (800 CPI).
B
1
FSR or FSF command ?
No
Yes
Make request to multiplexor for next order.
Read order ?
Control order ?
Write order ?
Reject the order and generate interrupt.
8 R
Bring tape unit up to speed and make sure it is not in write mode.
A
4 P
Read byte ?
FSR or FSF command ?
8M
Get the character and store it in internal register. Check the parity and compute CRCC.
8 N
1600 cpi ?
Go to FS16 to read 1600 cpi tape.
4 F
End of block pulse ?
Tape gone 25 feet ?
Set Tape Runaway flip-flop and stop the tape unit.
Set 2
time
try t
byte
time.
2180-51A



Read order ?
No
Yes
Control order ?
No
Yes
Write order ?
No
Yes
Reject the order and generate interrupt.
8 R
Bring tape unit up to speed and make sure it is not in write mode.
A
4 P
Read byte ?
Yes
No
FSR or FSF command ?
Yes
No
8M
Get the character and store it in internal register. Check the parity and compute CRCC.
8 N
1600 cpi ?
No
Yes
Go to FS16 to read 1600 cpi tape.
4 F
1600 cpi ?
Yes
No
End of block pulse ?
Yes
No
Tape gone 25 feet ?
Yes
No
Set Tape Runaway flip-flop and stop the tape unit.
Generate interrupt.
8 S
Set 2.2 byte time time window and try to get a read byte within this time.
Read byte ?
Yes
No
FSR or FSF command ?
Yes
No
8M
Pack this byte with other, check parity and compute CRCC.
8 N
Word count less than tape record length ?
Yes
No
Only one byte ?
No
Yes
FSR or FSF command ?
No
Yes
Zero out lower half of data word and send it to multiplexor.
8M
Wait four byte times and get CRCC byte. Check it with the computed CRCC.
Go past CRCC and LRCC.
File mark (23_8) ?
Yes
No
Try to get another byte (23_8) in 8 to 10.2 byte spacing, failing which start reading over again.
File mark (23_8) ?
Yes
No
Noise, start reading all over again.

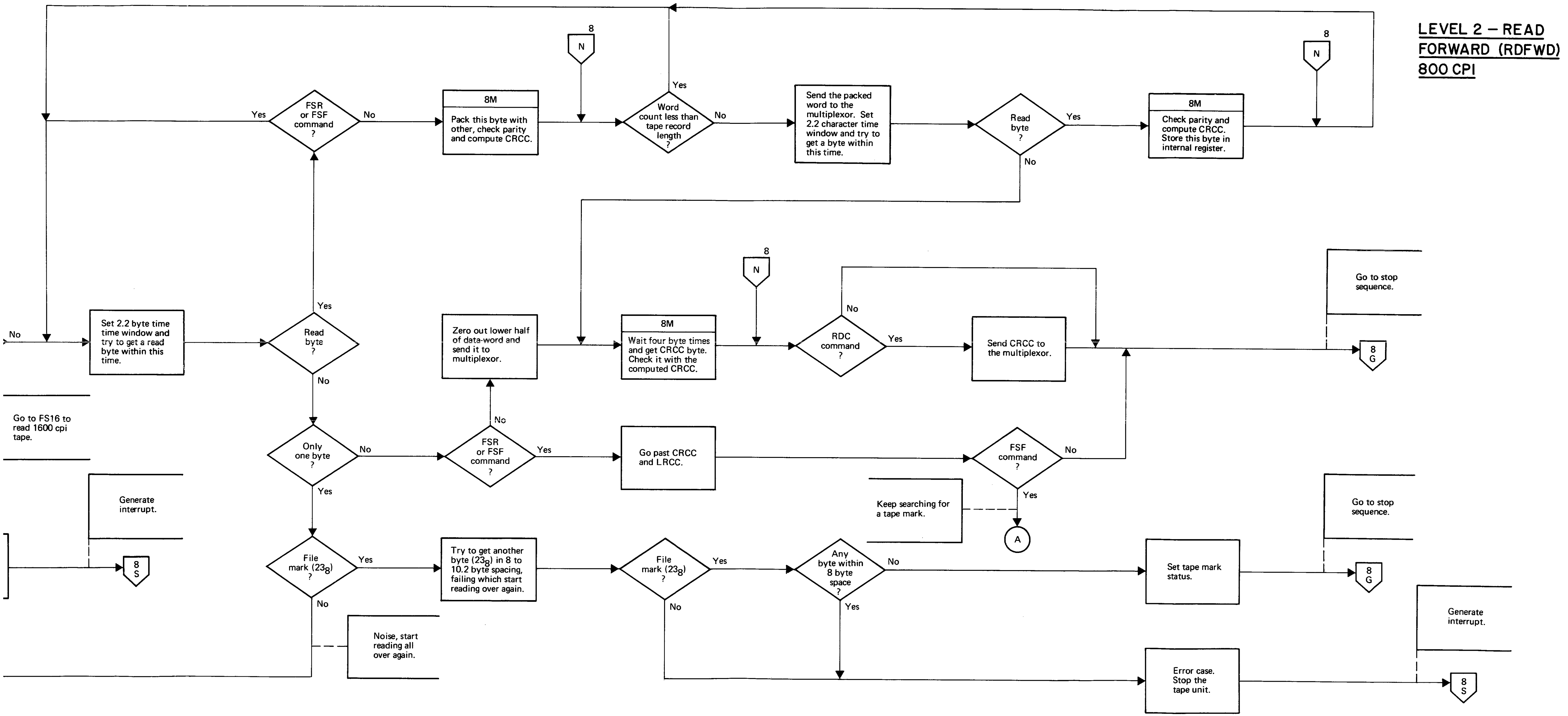
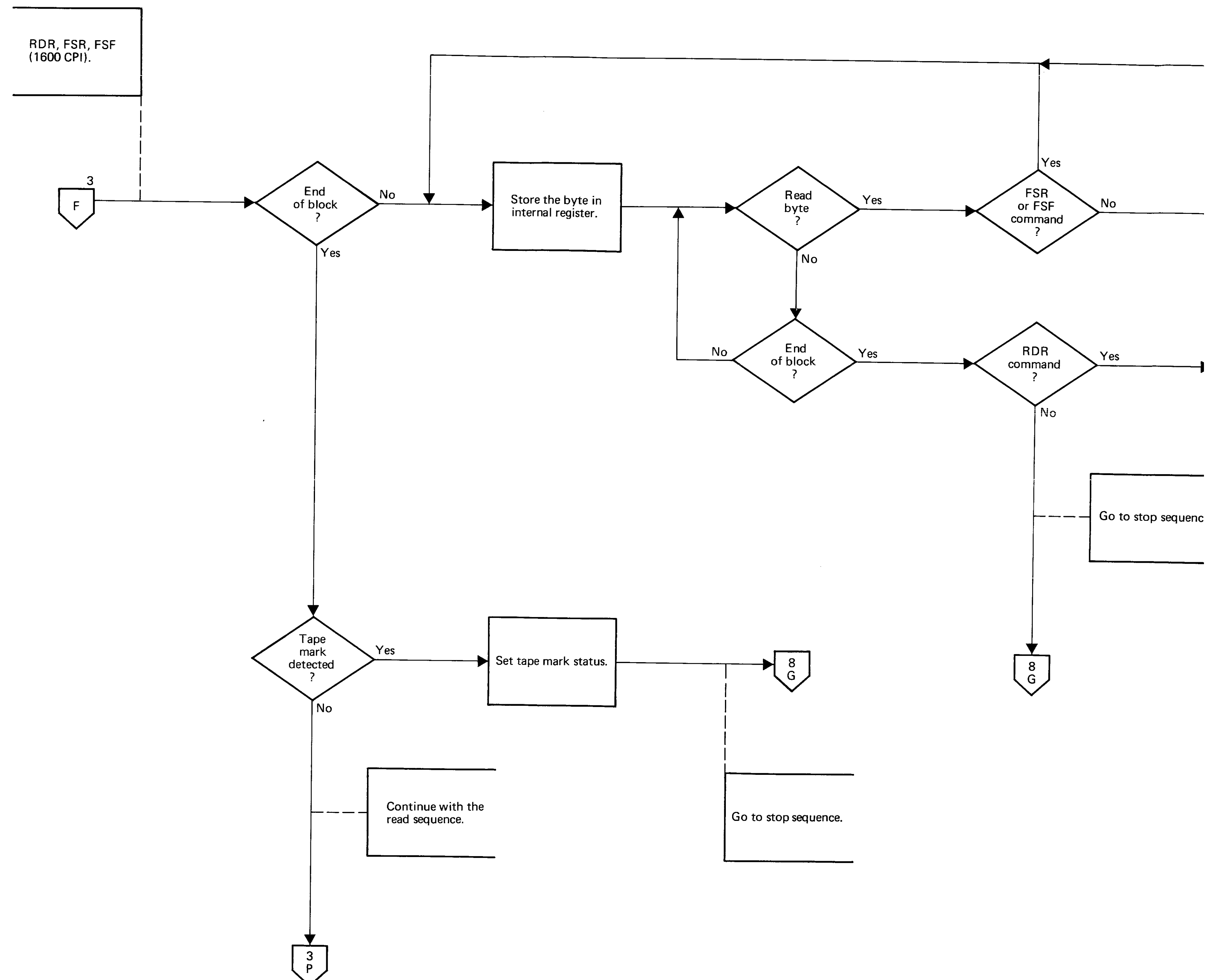


Figure 3-2. Tape Controller Overall Operation Flowchart (Sheet 3 of 8)


RDR, FSR, FSF (1600 CPI).
3
F
End of block ?
No
Yes
Store the byte in internal register.
Read byte ?
Yes
No
FSR or FSF command ?
Yes
No
End of block ?
No
Yes
RDR command ?
Yes
No
Go to stop sequenc
8
G
Tape mark detected ?
Yes
No
Set tape mark status.
8
G
Continue with the read sequence.
Go to stop sequence.
3
P

2180-52A

LEVEL 2—FS16.
READ FORWARD
1600 CPI.

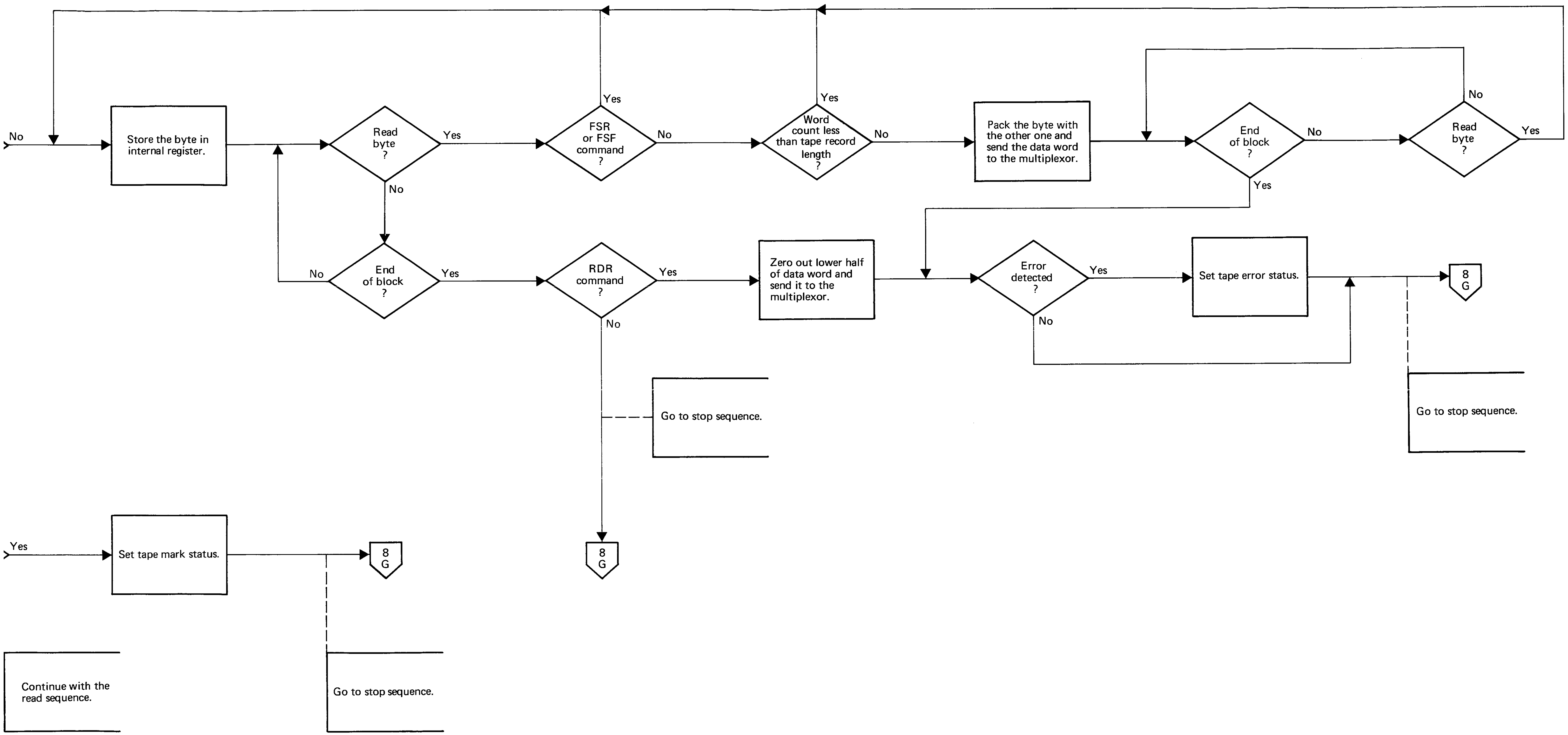
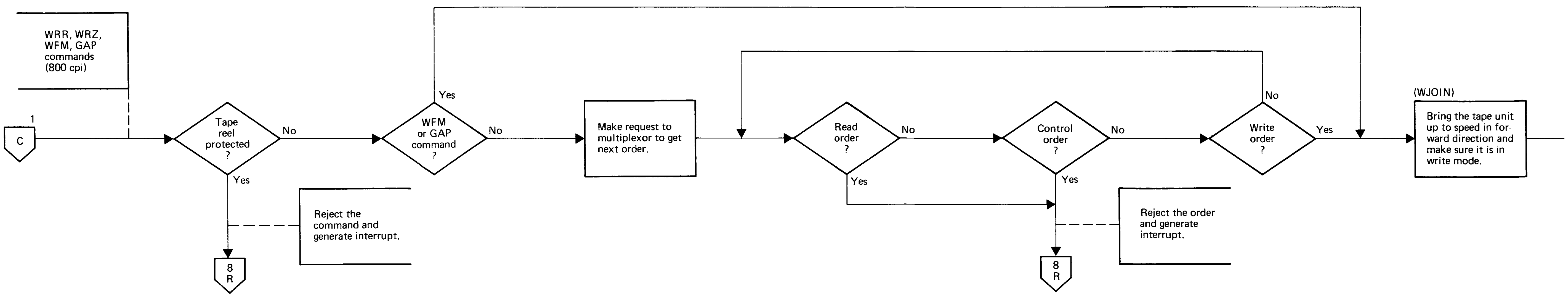
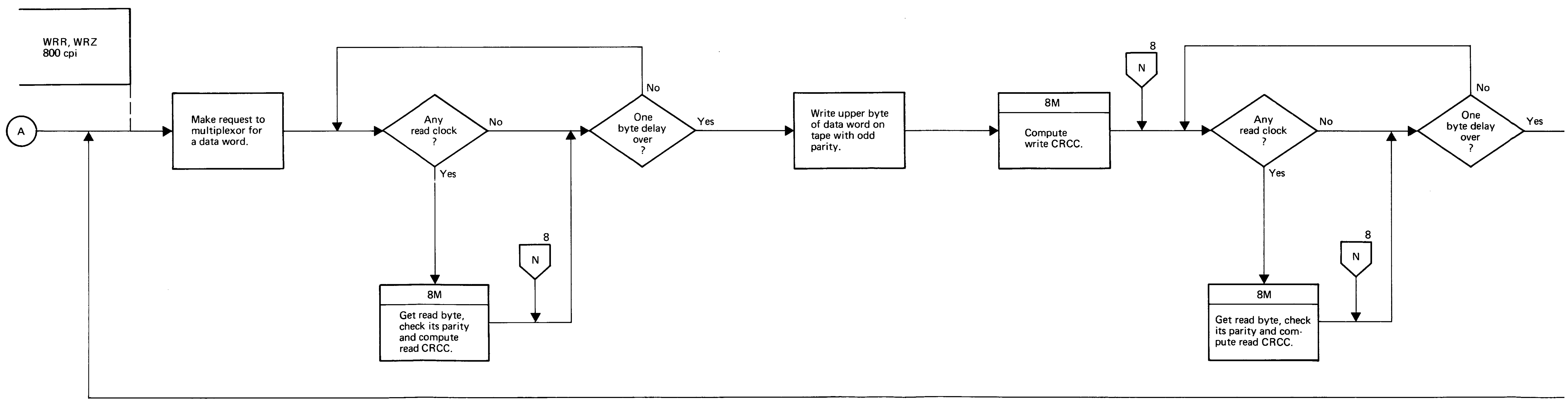


Figure 3-2. Tape Controller Overall Operation Flowchart (Sheet 4 of 8)

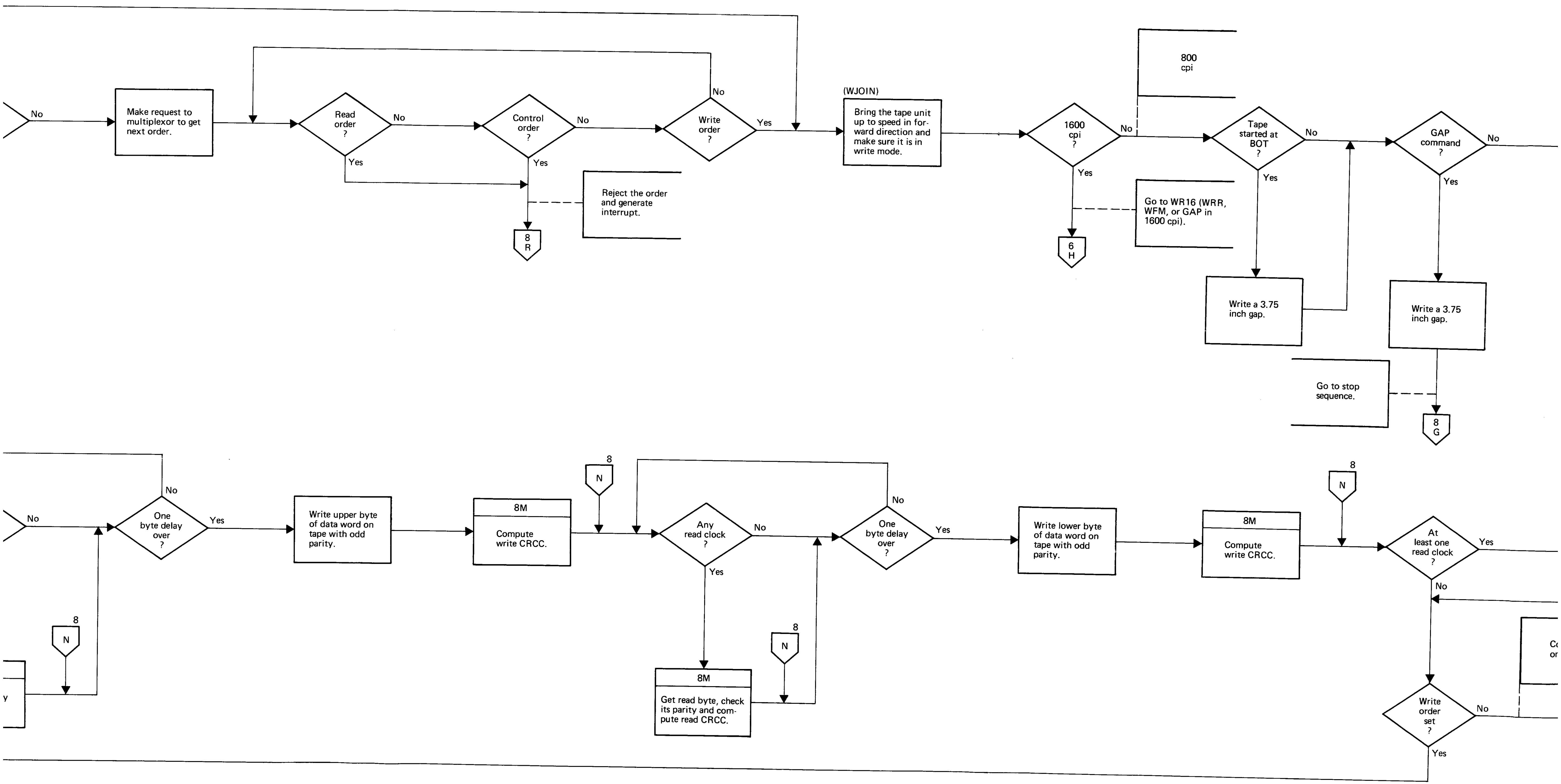


WRR, WRZ, WFM, GAP commands (800 cpi)
1
C
Tape reel protected ?
No
Yes
Reject the command and generate interrupt.
8 R
WFM or GAP command ?
Yes
No
Make request to multiplexor to get next order.
Read order ?
No
Yes
Control order ?
No
Yes
Reject the order and generate interrupt.
8 R
Write order ?
No
Yes
(WJOIN)
Bring the tape unit up to speed in forward direction and make sure it is in write mode.



WRR, WRZ 800 cpi
A
Make request to multiplexor for a data word.
Any read clock ?
No
Yes
8M
Get read byte, check its parity and compute read CRCC.
8
N
One byte delay over ?
No
Yes
Write upper byte of data word on tape with odd parity.
8M
Compute write CRCC.
8
N
Any read clock ?
No
Yes
8M
Get read byte, check its parity and compute read CRCC.
8
N
One byte delay over ?
No
Yes

2180-53A



No
Make request to multiplexor to get next order.
Read order ?
No
Yes
Control order ?
No
Yes
Write order ?
No
Yes
Reject the order and generate interrupt.
8 R
(WJOIN)
Bring the tape unit up to speed in forward direction and make sure it is in write mode.
1600 cpi ?
No
Yes
800 cpi
Go to WR16 (WRR, WFM, or GAP in 1600 cpi).
6 H
Tape started at BOT ?
No
Yes
Write a 3.75 inch gap.
GAP command ?
No
Yes
Write a 3.75 inch gap.
Go to stop sequence.
8 G
No
One byte delay over ?
No
Yes
8 N
Write upper byte of data word on tape with odd parity.
8M
Compute write CRCC.
8 N
Any read clock ?
No
Yes
8M
Get read byte, check its parity and compute read CRCC.
8 N
One byte delay over ?
No
Yes
Write lower byte of data word on tape with odd parity.
8M
Compute write CRCC.
8 N
At least one read clock ?
Yes
No
Write order set ?
No
Yes

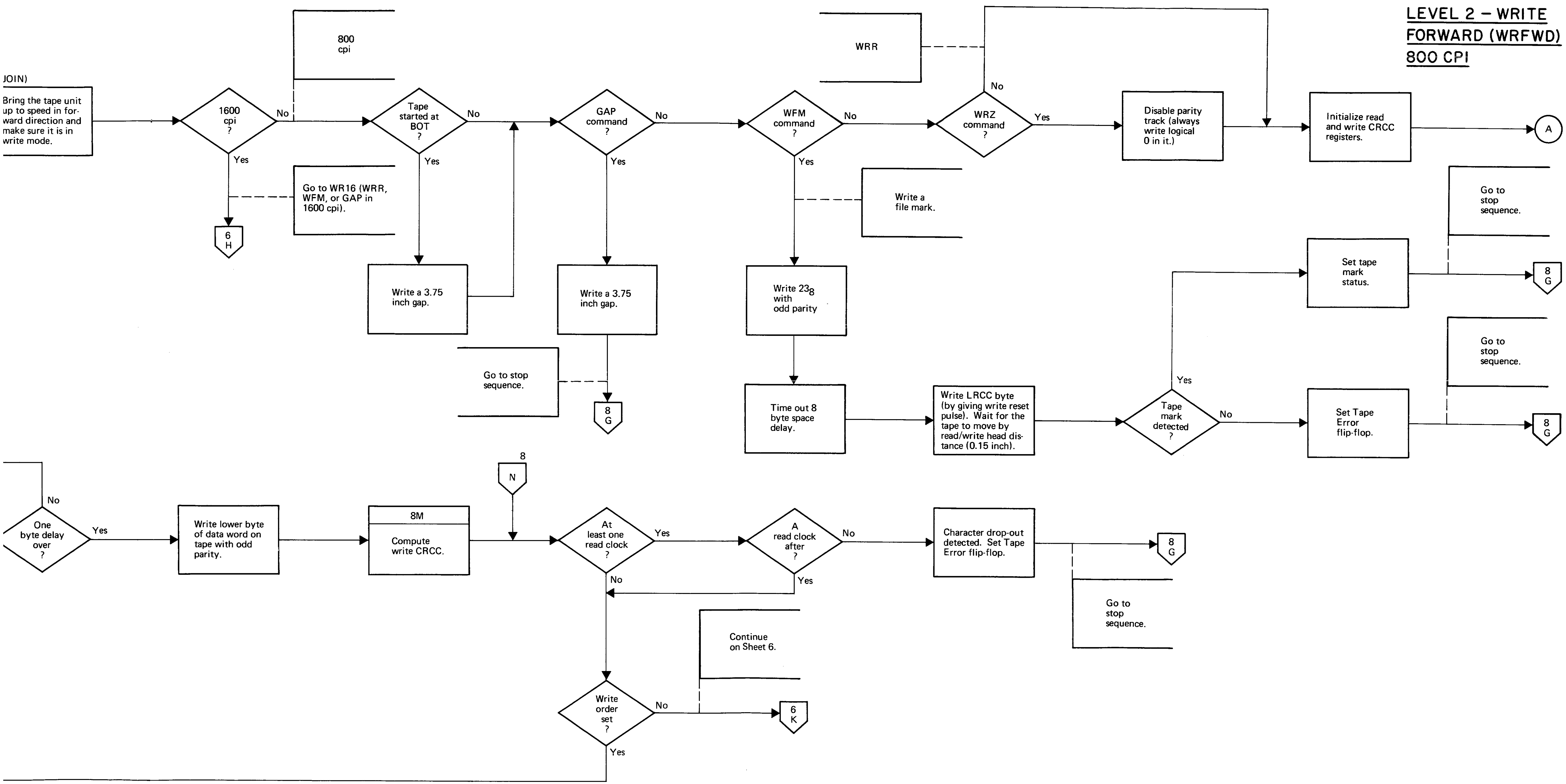
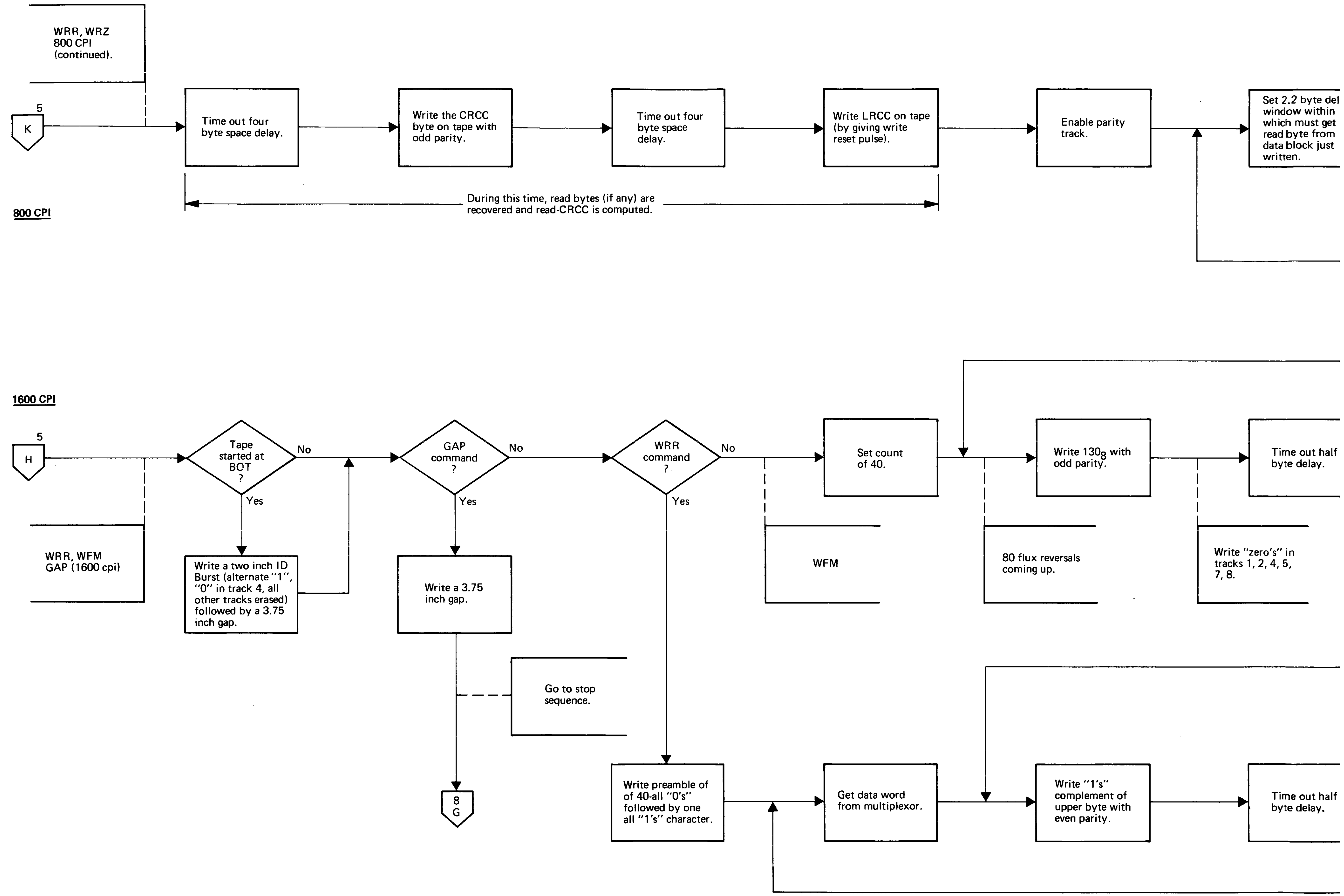
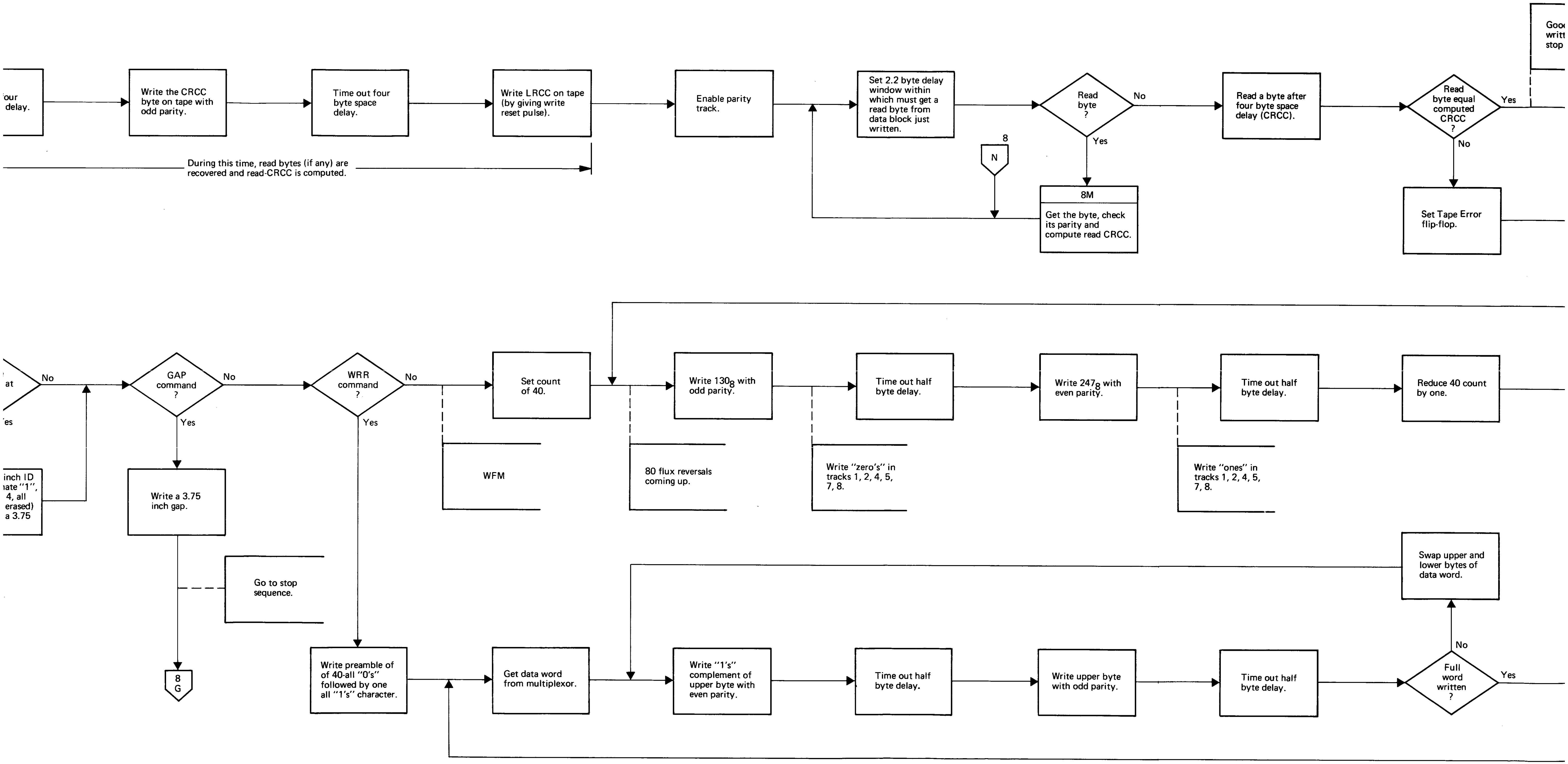


Figure 3-2. Tape Controller Overall Operation Flowchart (Sheet 5 of 8)



WRR, WRZ
800 CPI
(continued).
5
K
Time out four byte space delay.
Write the CRCC byte on tape with odd parity.
Time out four byte space delay.
Write LRCC on tape (by giving write reset pulse).
Enable parity track.
Set 2.2 byte del window within which must get read byte from data block just written.
During this time, read bytes (if any) are recovered and read-CRCC is computed.
800 CPI
1600 CPI
5
H
WRR, WFM
GAP (1600 cpi)
Tape started at BOT ?
No
Yes
Write a two inch ID Burst (alternate "1", "0" in track 4, all other tracks erased) followed by a 3.75 inch gap.
GAP command ?
No
Yes
Write a 3.75 inch gap.
Go to stop sequence.
8
G
WRR command ?
No
Yes
WFM
Set count of 40.
80 flux reversals coming up.
Write 130₈ with odd parity.
Write "zero's" in tracks 1, 2, 4, 5, 7, 8.
Time out half byte delay.
Write preamble of of 40-all "0's" followed by one all "1's" character.
Get data word from multiplexor.
Write "1's" complement of upper byte with even parity.
Time out half byte delay.

2180-54A



four delay.
Write the CRCC byte on tape with odd parity.
Time out four byte space delay.
Write LRCC on tape (by giving write reset pulse).
Enable parity track.
Set 2.2 byte delay window within which must get a read byte from data block just written.
Read byte ?
No
Yes
Read a byte after four byte space delay (CRCC).
Read byte equal computed CRCC ?
Yes
No
Good writ stop
During this time, read bytes (if any) are recovered and read-CRCC is computed.
8 N
8M
Get the byte, check its parity and compute read CRCC.
Set Tape Error flip-flop.
at
No
Yes
GAP command ?
No
Yes
WRR command ?
No
Yes
Set count of 40.
Write 130₈ with odd parity.
Time out half byte delay.
Write 247₈ with even parity.
Time out half byte delay.
Reduce 40 count by one.
WFM
80 flux reversals coming up.
Write "zero's" in tracks 1, 2, 4, 5, 7, 8.
Write "ones" in tracks 1, 2, 4, 5, 7, 8.
inch ID ate "1", 4, all erased) a 3.75
Write a 3.75 inch gap.
Go to stop sequence.
8 G
Swap upper and lower bytes of data word.
Write preamble of of 40-all "0's" followed by one all "1's" character.
Get data word from multiplexor.
Write "1's" complement of upper byte with even parity.
Time out half byte delay.
Write upper byte with odd parity.
Time out half byte delay.
Full word written ?
No
Yes

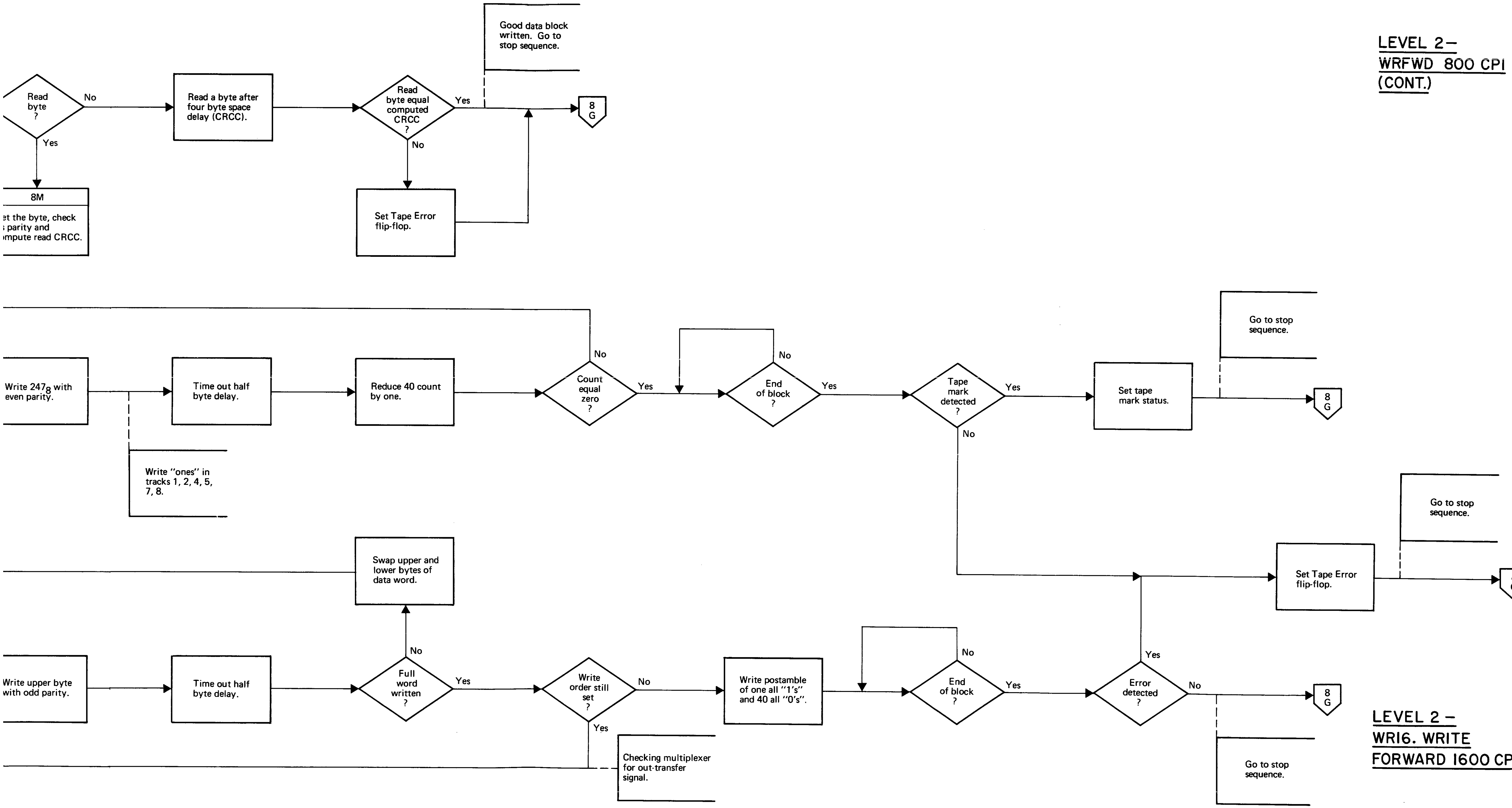
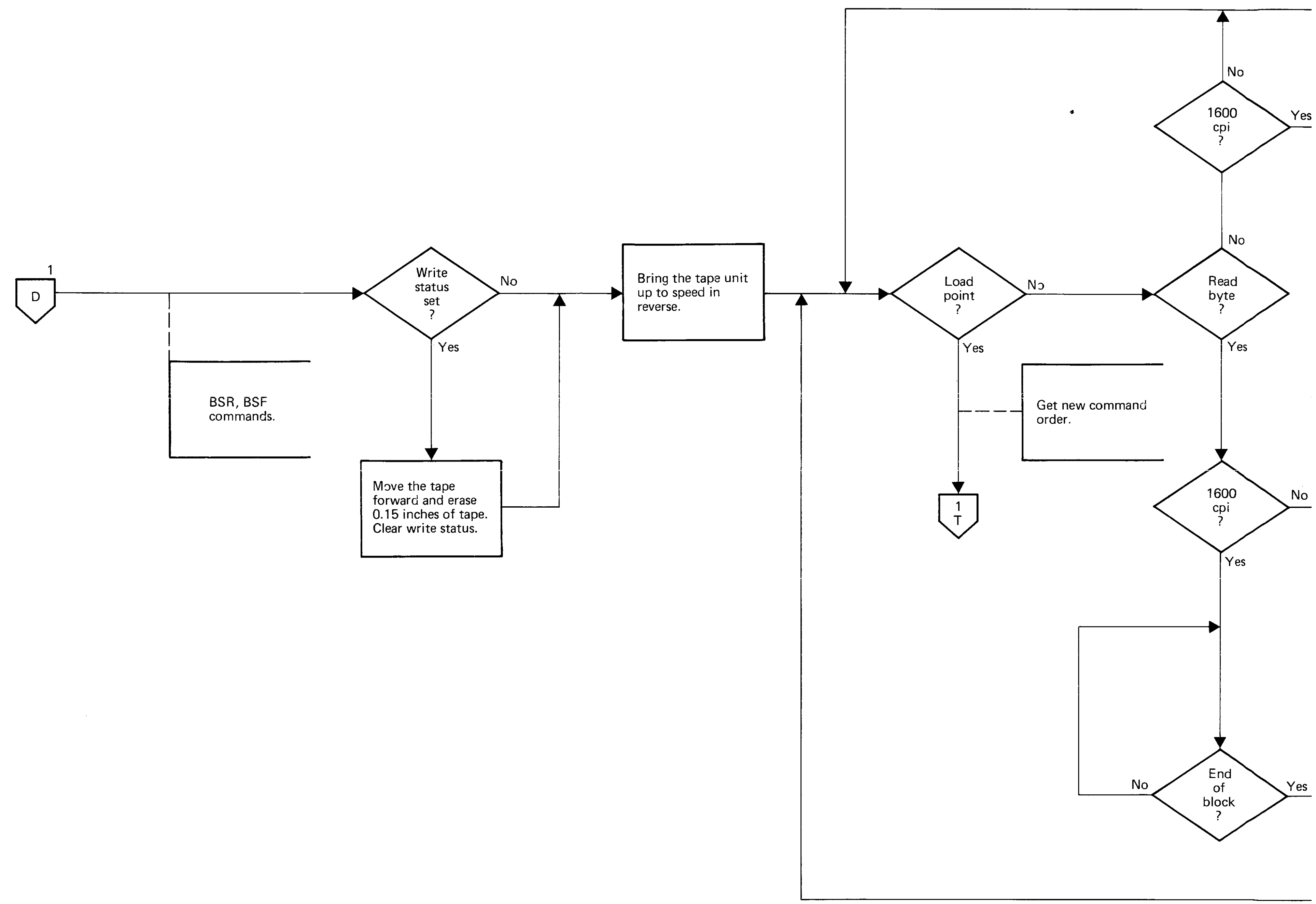


Figure 3-2. Tape Controller Overall Operation Flowchart (Sheet 6 of 8)


1
D
Write status set ?
No
Yes
BSR, BSF commands.
Move the tape forward and erase 0.15 inches of tape. Clear write status.
Bring the tape unit up to speed in reverse.
Load point ?
No
Yes
Get new command order.
1
T
Read byte ?
No
Yes
1600 cpi ?
No
Yes
1600 cpi ?
No
Yes
End of block ?
No
Yes

2180-55B

LEVEL 2 – READ REVERSE (RDBKD)

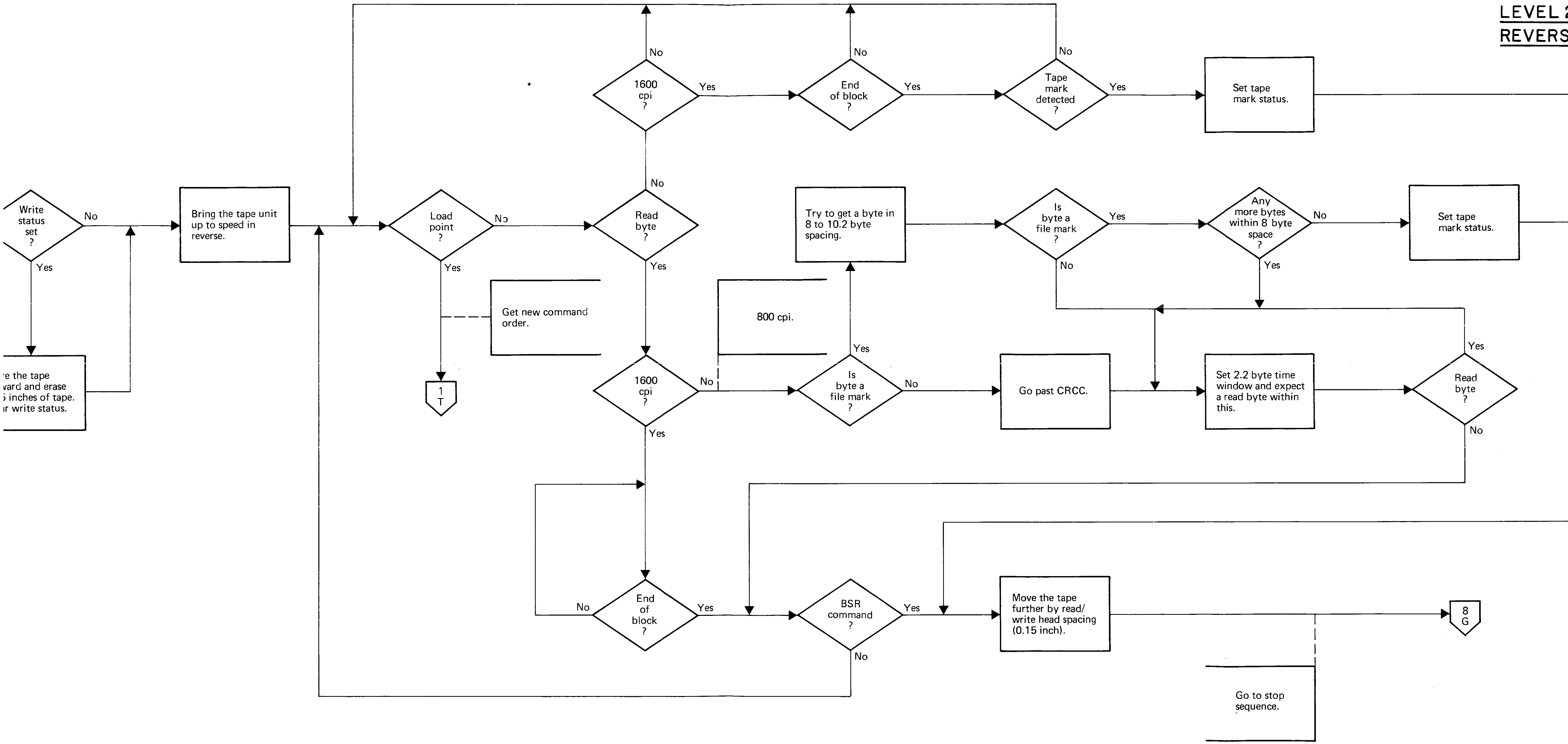
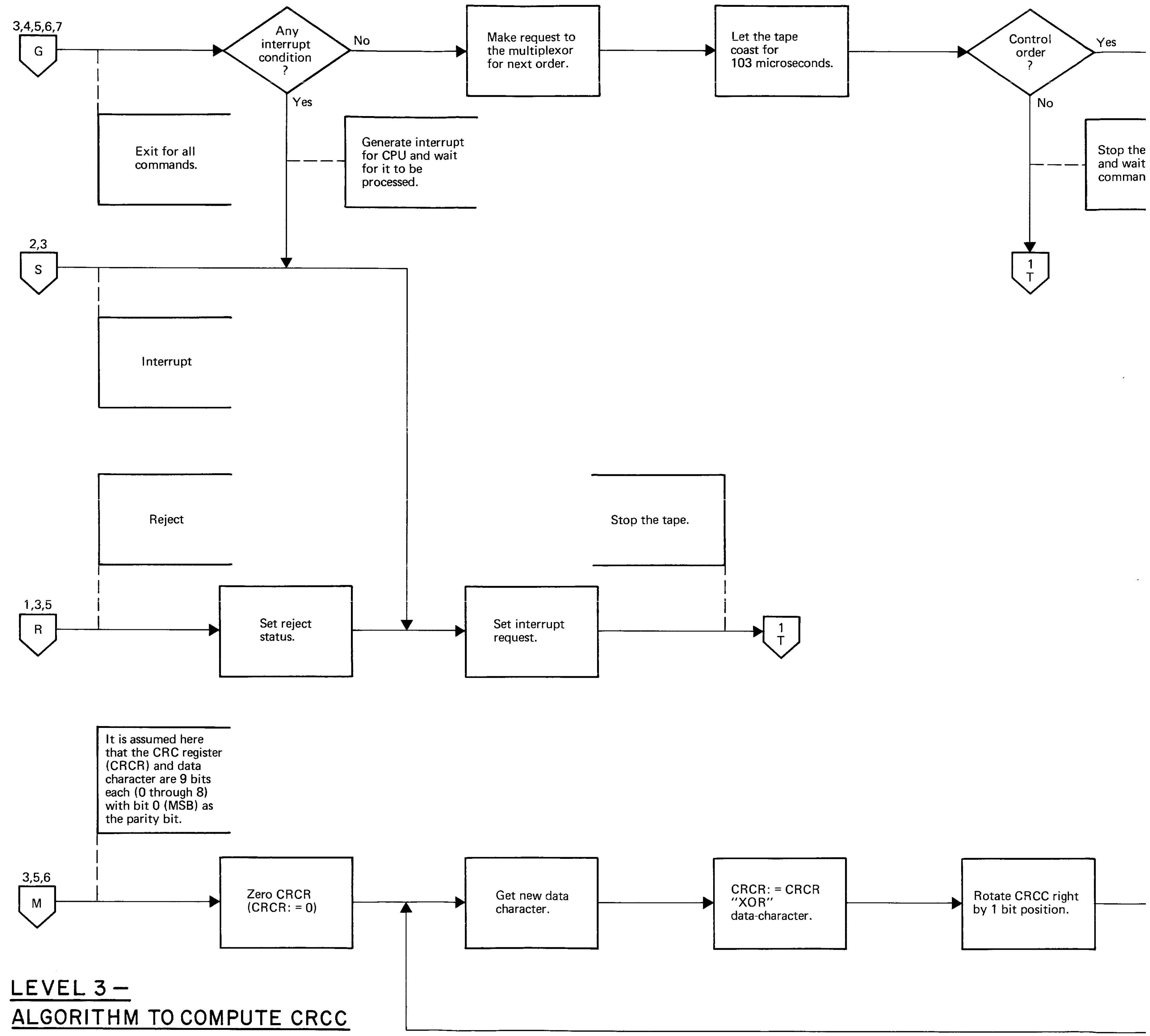


Figure 3-2. Tape Controller Overall Operation Flowchart (Sheet 7 of 8)

LEVEL 2 – STOP



LEVEL 3 – ALGORITHM TO COMPUTE CRCC

2180-56B

LEVEL 2– STOP

REJECT AND INTERRUPT

CCRC

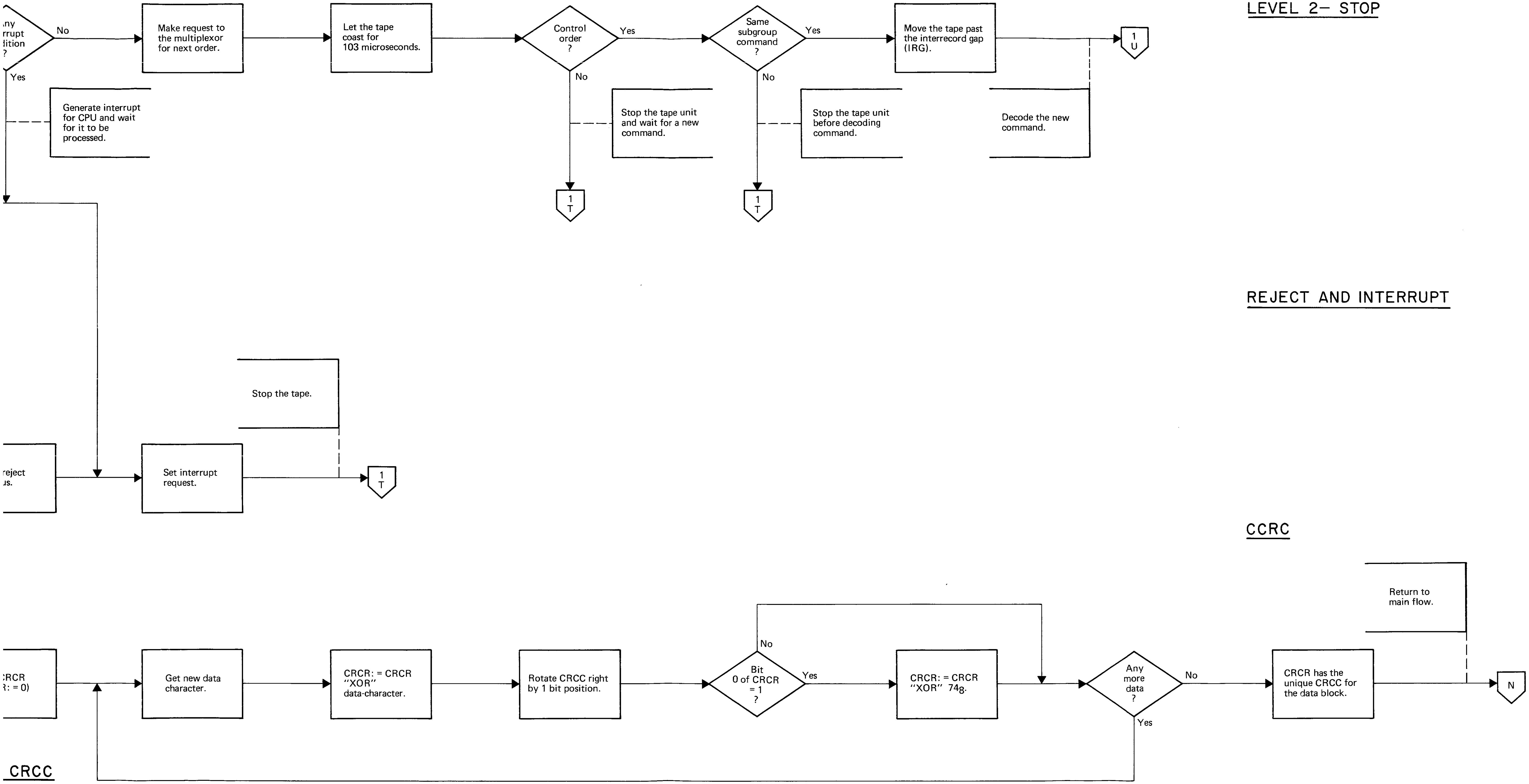


Figure 3-2. Tape Controller Overall Operation Flowchart (Sheet 8 of 8)

3-35. The actual microprogram begins at page eight of the listing. In the listing, the first group of numbers (reading left-to-right) are the sequence numbers (in decimal). These are followed by the ROM address numbers (in octal), which are followed by the 20-bit ROM data word (in binary). Labels for routines and subroutines appear next (reading left-to-right). Labels are a maximum of six symbols long. The operation code (three letters) appears next. All operation codes and their meanings are listed in the controller processor PCA discussion. Operation codes indicate one of six word format types for field decoding. Applicable field mnemonics, references, and constants (if used) are listed next. Octal numbers shown are preceded by the number symbol (#). Remarks are shown last in the listing. If a line begins with an asterisk (*) the entire line is a comment. The comments, remarks, and flowcharts for the microprogram provide adequate information for understanding the overall operation of the subsystem.

3-36. TAPE CONTROLLER TIMING AND TAPE MOVEMENT. Figure 4-12 in section IV is an overall tape controller timing diagram for a typical write operation. Figure 4-13 shows a typical read operation. Both these diagrams illustrate NRZI writing as an example. Also, the following conditions apply to data transfers between the interface and the tape unit.

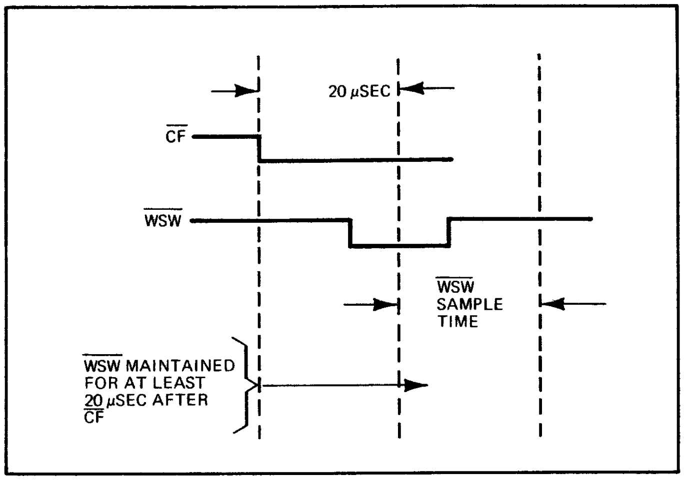
a. For the write mode, the levels of the write data bus and write parity line ($\overline{\text{WD 0:7}}$ and $\overline{\text{WDP}}$) at the input to the tape unit receiver gates in the tape unit should be settled for 500 nanoseconds before and after the Write Clock ($\overline{\text{WC}}$) is received from the tape controller.

b. For the read mode, the levels of the read data bus and read parity line ($\overline{\text{RD 0:7}}$ and $\overline{\text{RDP}}$) should be settled by the transition time (drop to low) of the Read Clock ($\overline{\text{RC}}$), and the levels remain settled until one microsecond (maximum), before the next Read Clock.

c. The time for the following edge of the Read Clock ($\overline{\text{RC}}$) pulse to drop to a low is two microseconds minimum, three microseconds maximum.

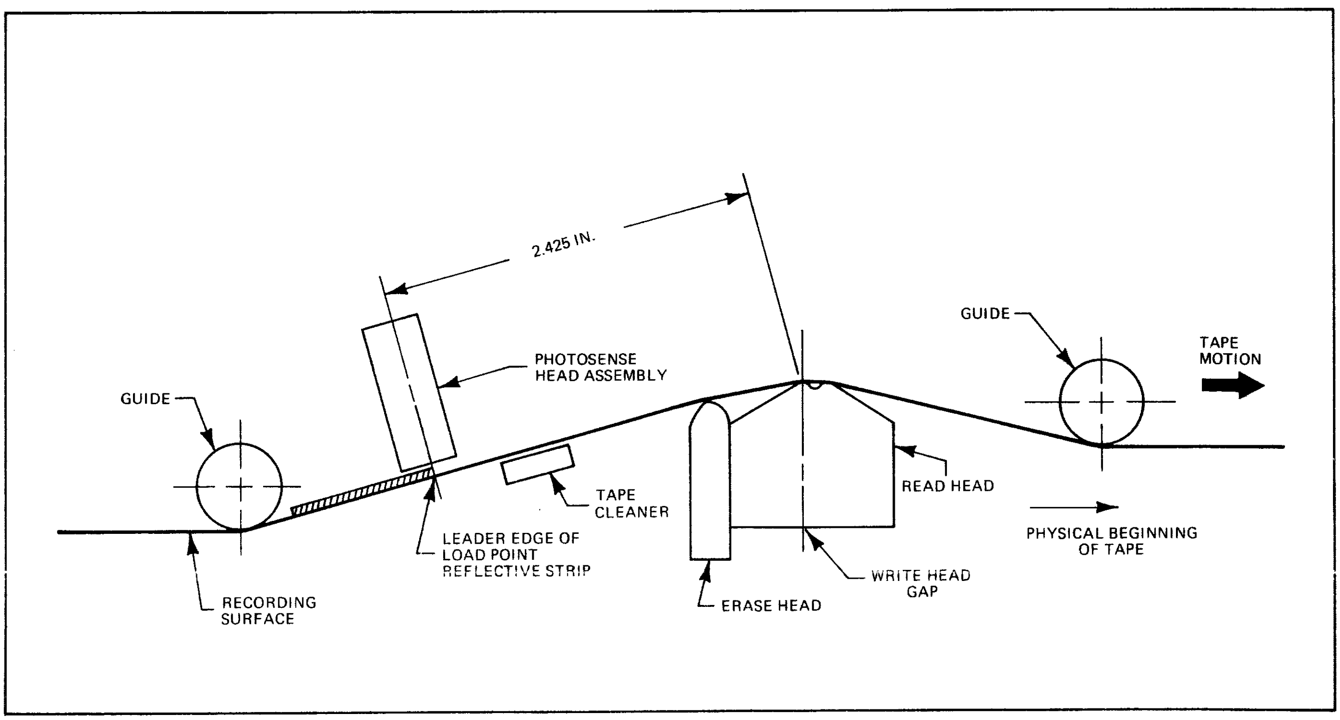
d. When the Forward ($\overline{\text{CF}}$) command is issued to the tape unit, the Set Write ($\overline{\text{WSW}}$) command is sampled by the tape unit following a 20-microsecond maximum delay period. The tape controller maintains the $\overline{\text{WSW}}$ command at a low level for not less than 20 microseconds after it issues $\overline{\text{CF}}$ to the tape unit. See figure 3-3.

3-37. Figure 3-4 represents the general physical orientation of tape unit transport heads and the photosense assembly. The orientation is the same for NRZI and PE tape units. Figures 3-5 through 3-7 represent typical tape movement past the heads during write and read operations, and for character drop-out detection. The diagrams generally represent NRZI and PE operations.



2180-43

Figure 3-3. WSW, CF Sequencing



2180-44

Figure 3-4. Orientation of the Erase, Write, Read, and Photosense Head Assemblies

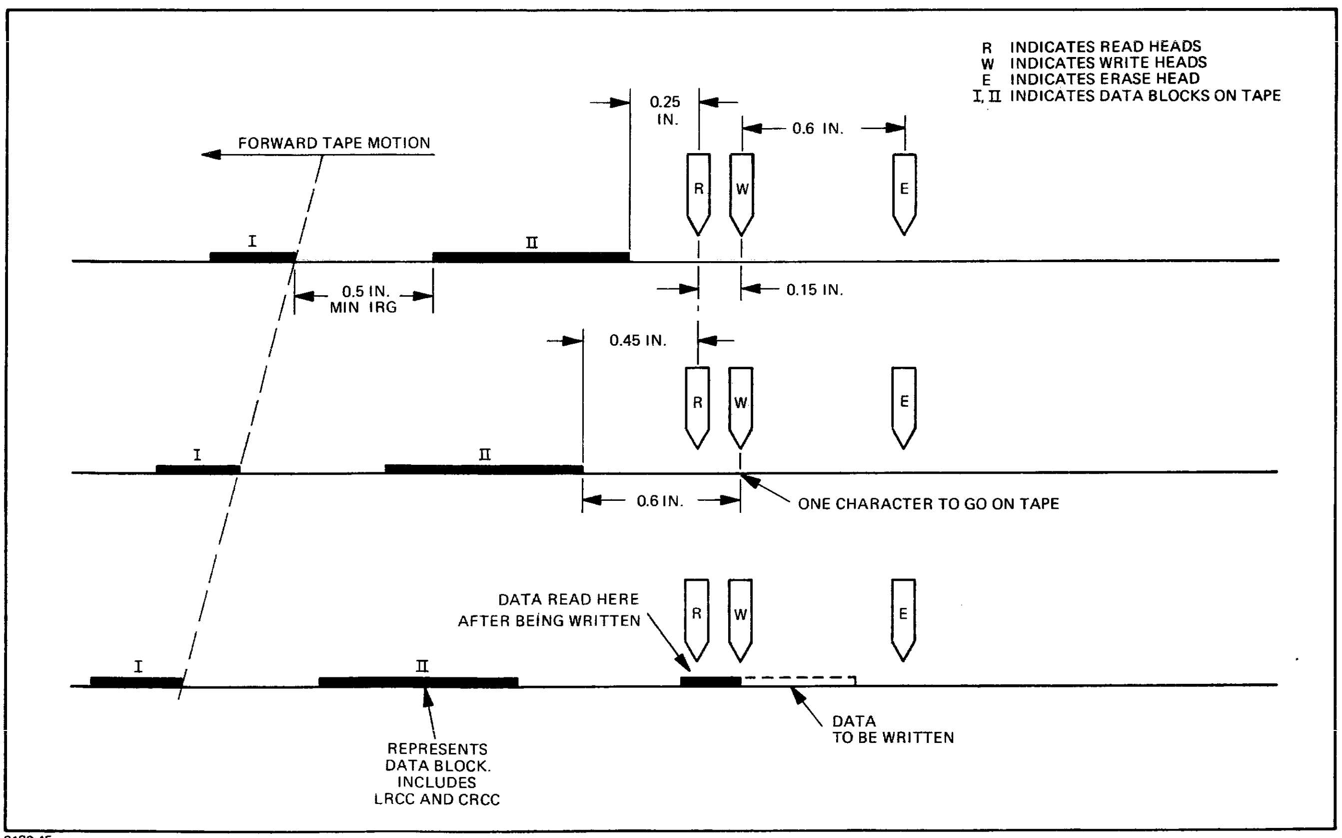


Figure 3-5. Typical Write Operation, Tape Movement Diagram

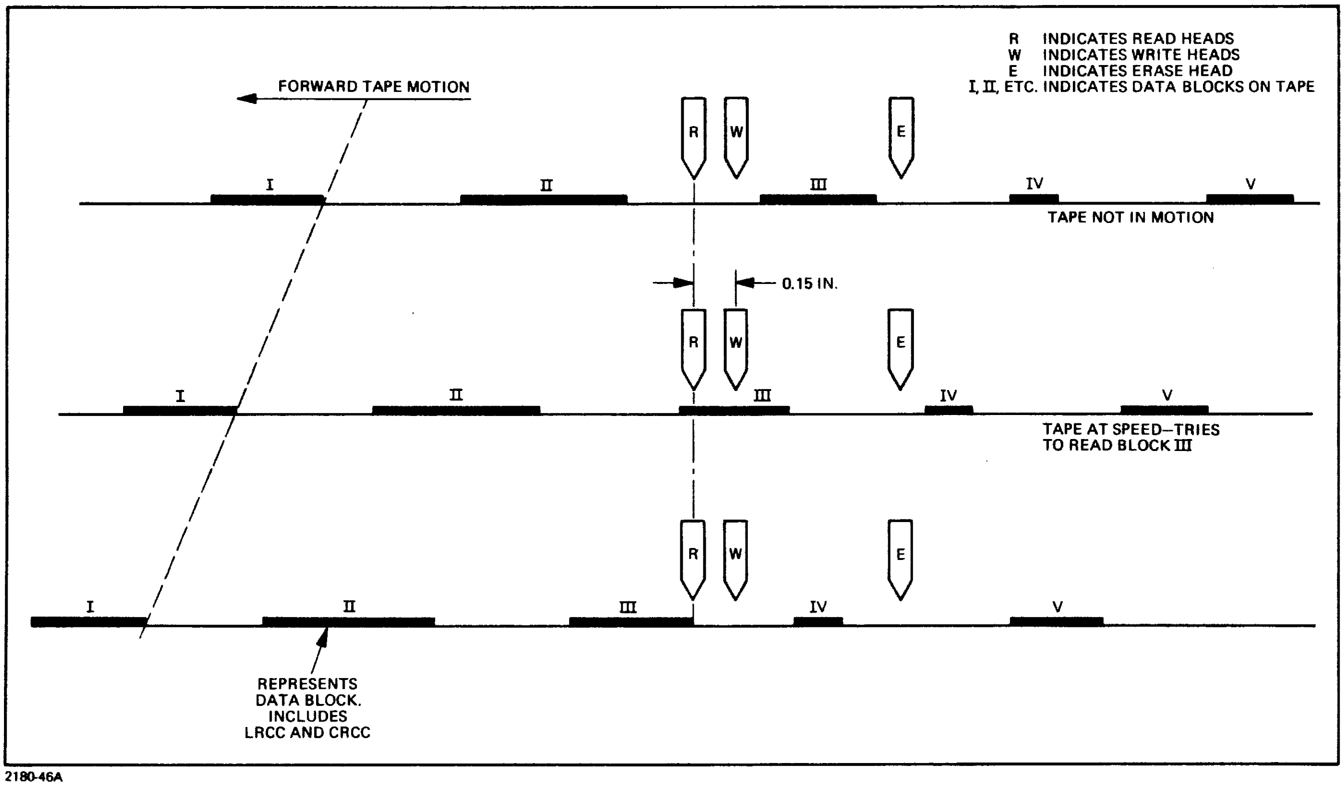
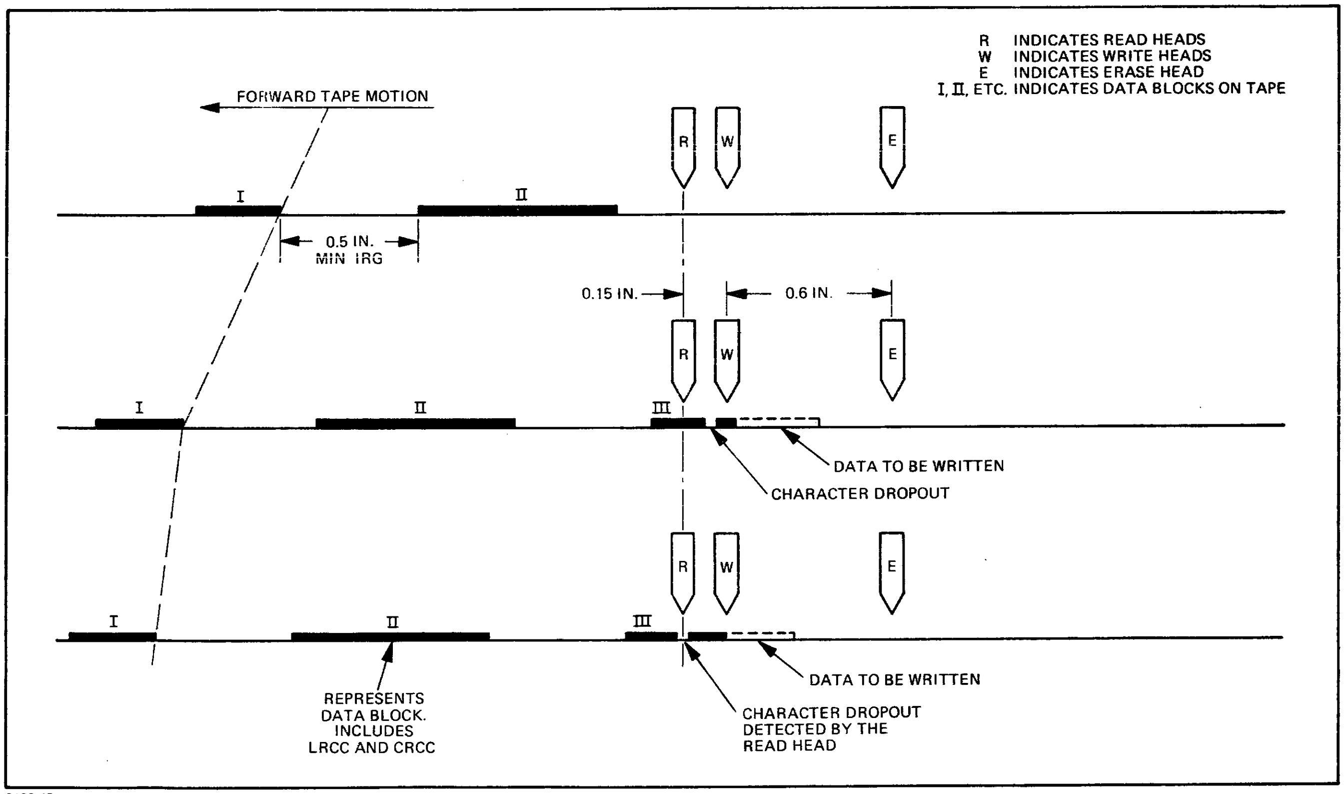


Figure 3-6. Typical Read Operation, Tape Movement Diagram



2180-47

Figure 3-7. Detection of Character Dropout During Write Operation Tape Movement Diagram

3-38. CONTROLLER PROCESSOR PCA.

3-39. In order to understand the details of the microprogram for the subsystem, it is necessary to understand logical sections and functional operating particulars of the controller processor PCA. Paragraphs 3-40 through 3-55 define the logical portions of the PCA. Paragraphs 3-56 through 3-69 describe the most important aspects of operation. The word formats and field definitions are primary points in the discussion. Refer also to the consolidated microcoding sheet and the timing diagram in section IV to fully understand controller processor operation.

3-40. CONTROLLER PROCESSOR LOGICAL SECTIONS. The overall block diagram of the controller processor PCA is shown in figure 3-8. The primary function of the controller processor is to implement the microprogram for the subsystem. As shown in the diagram, four major logic sections of the PCA, listed below, accomplish this. They are:

a. The RAR/ROR logic.

b. Processor decode and control logic.

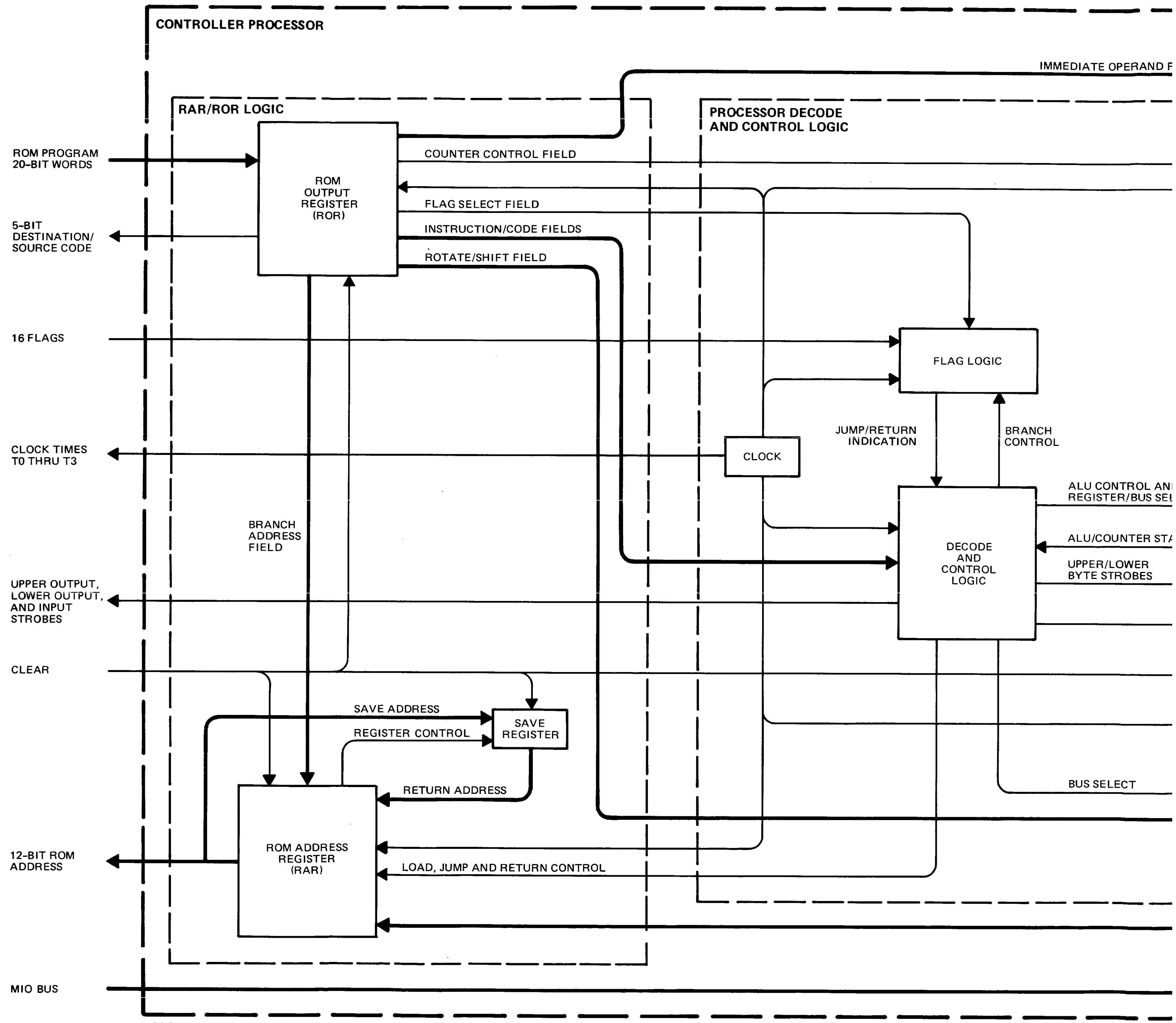
c. Registers and counter.

d. Arithmetic and Logic Unit (ALU).

3-41. Note that all programmed command input and data to and from the controller processor is routed via the MIO bus. Input data is loaded into the selected general purpose register. As directed by the microprogram, the data is processed through the ALU, via the A and B buses back to the MIO bus. The A bus is driven by the Immediate Operand field, the counter, and three of the general purpose registers. The B bus is driven by four of the general purpose registers. One register is common to both buses. The MIO bus is used for input/output and as the return path to the general purpose registers. The controller processor microinstruction set contains arithmetic and logical instructions and conditional branching microinstructions that control the ALU and rotate shift logic. Sixteen flag lines that permit selective branching on external conditions are also provided. Direct branching is possible by testing one of the 16 flag lines. All of the controller processor internal buses have the capability of being partially selected. That is, the option of selecting the upper byte, lower byte, or the whole word is provided. Also available is an external register select line which may be used to select an external register in place of any of the general purpose registers. This feature is not utilized in this subsystem, however.

3-42. Five destination/source bits are provided to select the source or destination desired when executing an input/output instruction.

3-43. The RAR/ROR logic addresses and controls the ROM readout, from the tape controller, to the ROR. The majority of ROR field readout in the controller processor is to the processor decode and control logic. The exception is the Immediate Operand field which is passed to the registers and counter section. The major sections of the controller processor may be subdivided into the logical blocks listed below. See figure 3-8, the overall block diagram. Descriptions of these logic blocks are contained in the following paragraphs.



CONTROLLER PROCESSOR
RAR/ROR LOGIC
PROCESSOR DECODE AND CONTROL LOGIC
IMMEDIATE OPERAND F
ROM PROGRAM 20-BIT WORDS
5-BIT DESTINATION/ SOURCE CODE
16 FLAGS
CLOCK TIMES T0 THRU T3
UPPER OUTPUT, LOWER OUTPUT, AND INPUT STROBES
CLEAR
12-BIT ROM ADDRESS
MIO BUS
ROM OUTPUT REGISTER (ROR)
COUNTER CONTROL FIELD
FLAG SELECT FIELD
INSTRUCTION/CODE FIELDS
ROTATE/SHIFT FIELD
FLAG LOGIC
CLOCK
JUMP/RETURN INDICATION
BRANCH CONTROL
DECODE AND CONTROL LOGIC
ALU CONTROL AN
REGISTER/BUS SE
ALU/COUNTER ST
UPPER/LOWER BYTE STROBES
BRANCH ADDRESS FIELD
SAVE ADDRESS
REGISTER CONTROL
SAVE REGISTER
RETURN ADDRESS
ROM ADDRESS REGISTER (RAR)
LOAD, JUMP AND RETURN CONTROL
BUS SELECT

2180-8

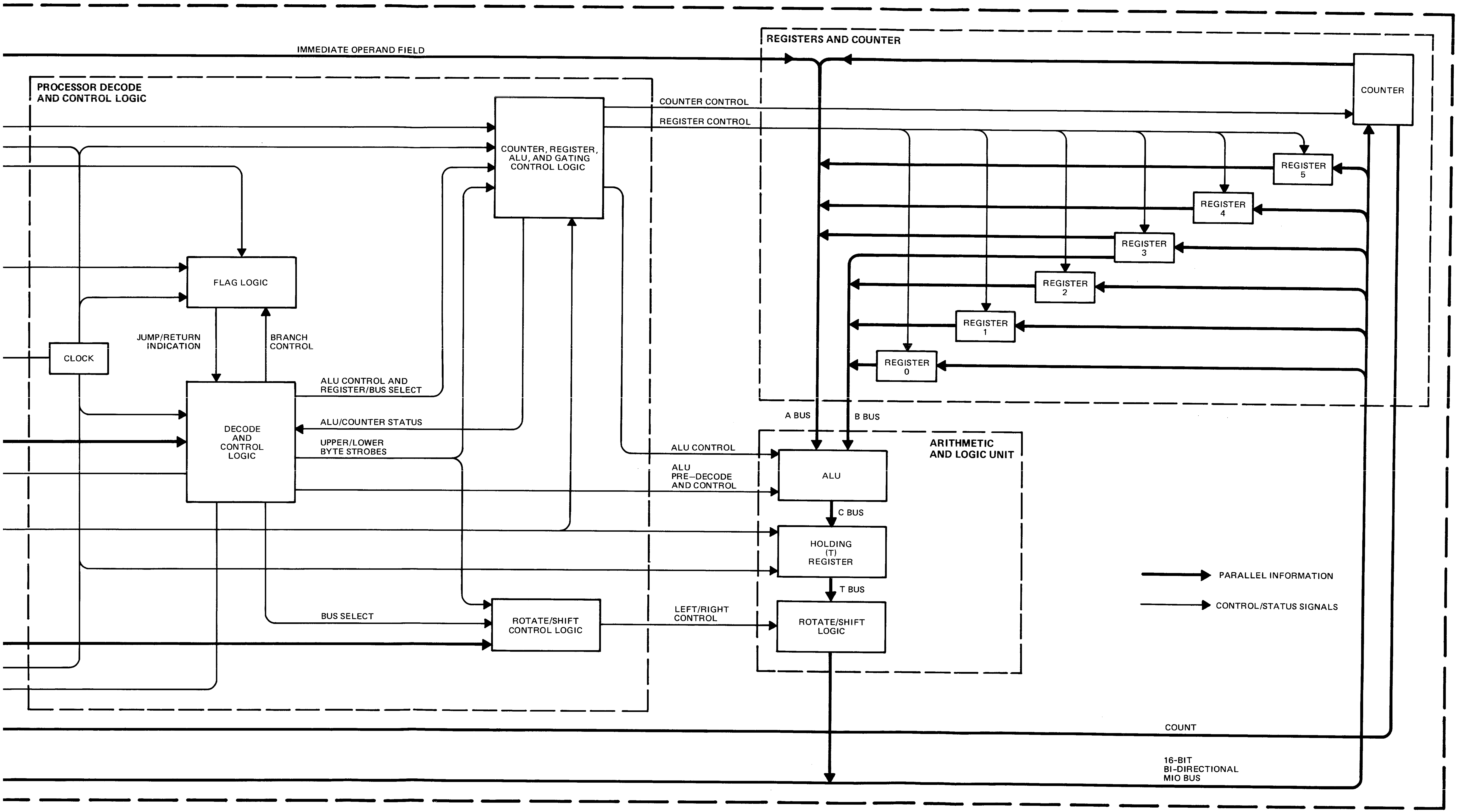


Figure 3-8. Controller Processor Overall Block Diagram

a. Registers and counter.

(1) Six general purpose registers, RG0 through RG5.

(2) Counter.

b. Arithmetic and Logic Unit.

(1) ALU.

(2) Holding (T) Register.

(3) Rotate/shift logic.

c. RAR/ROR logic.

(1) ROM Address Register (RAR).

(2) Save Register.

(3) ROM Output Register (ROR).

d. Processor decode and control logic.

(1) Flag logic.

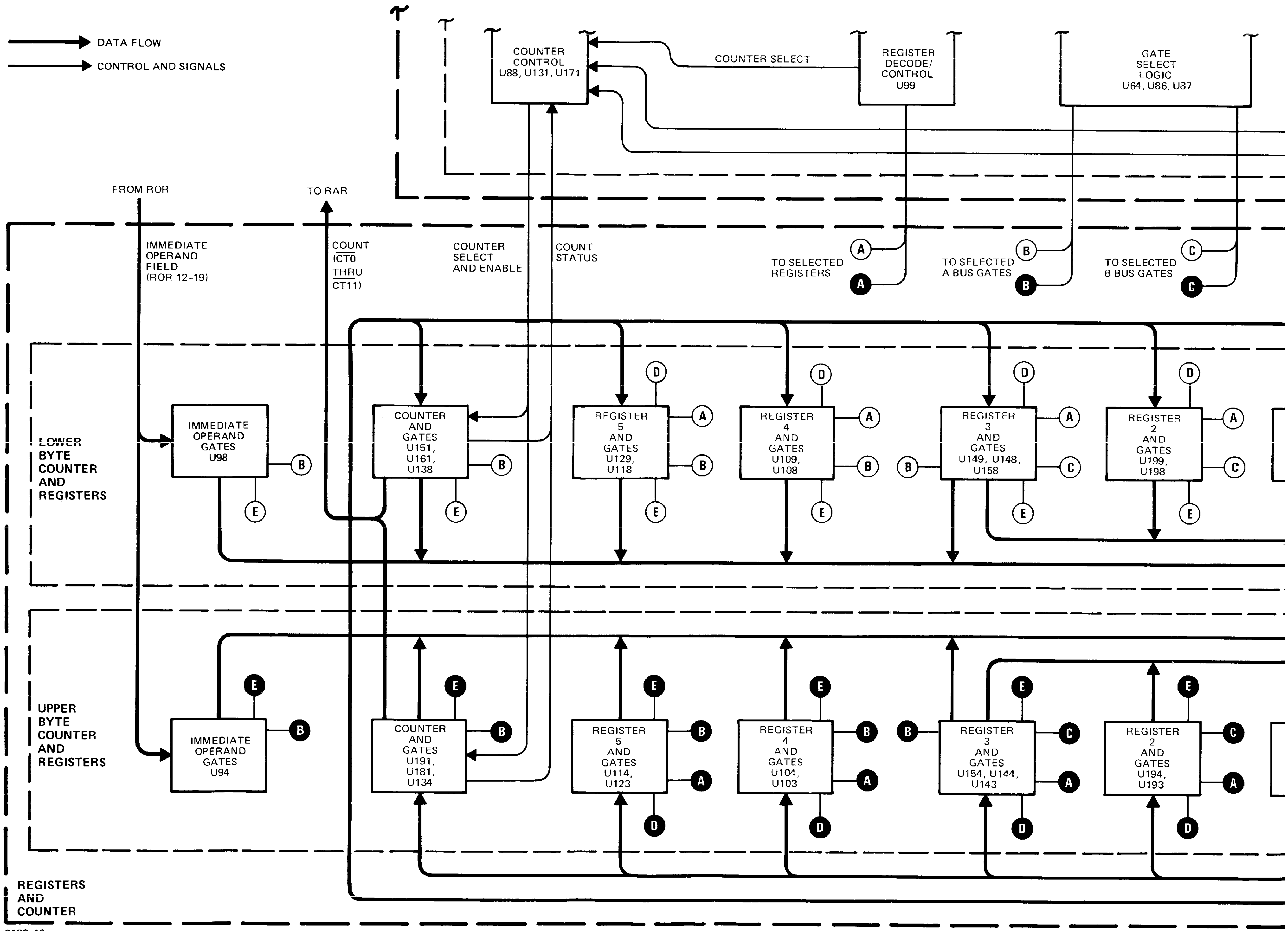
(2) Clock.

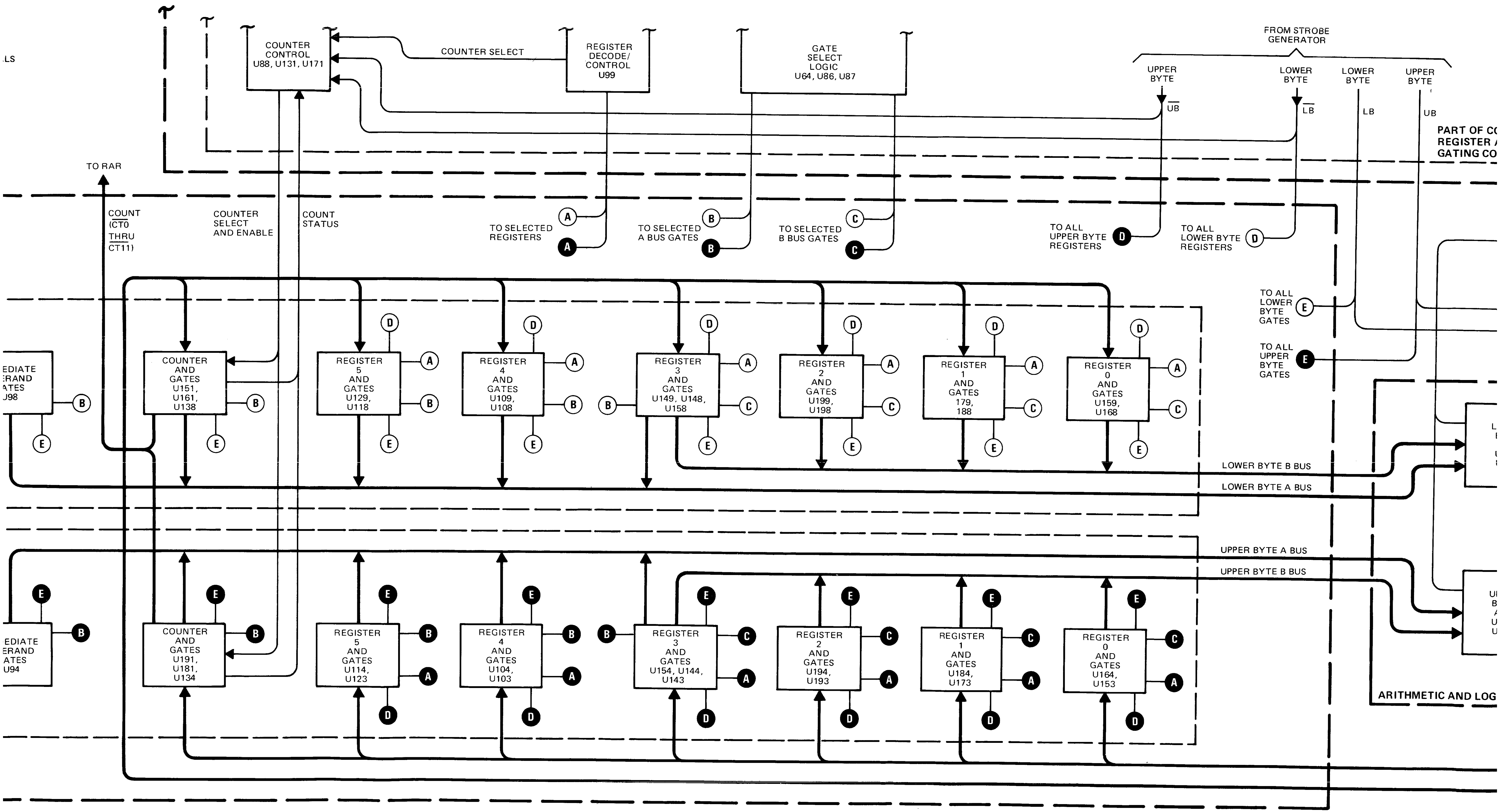
(3) Rotate/shift control logic.

(4) Decode and control logic.

(5) Counter, register, ALU, and gating control logic.

3-44. Registers and Counter. There are six, 16-bit general purpose registers designated, RG0 through RG5. See the detailed block diagram, figure 3-9. Each register can be loaded from the MIO bus, and can drive the A and/or B bus. That is, it is possible to write into any one of the registers from the MIO bus while placing the contents of two registers onto the A bus and/or B bus. Registers RG0 through RG3 are connected to the B bus, while registers RG3 through RG5 are connected to the A bus. Register RG3 is connected to both buses. It should be noted here that the data being written into the registers may be from any source connected to the MIO bus. It is also possible to write into, or read from, the upper or lower byte independently from one another.


DATA FLOW
CONTROL AND SIGNALS
COUNTER CONTROL U88, U131, U171
COUNTER SELECT
REGISTER DECODE/ CONTROL U99
GATE SELECT LOGIC U64, U86, U87
FROM ROR
TO RAR
IMMEDIATE OPERAND FIELD (ROR 12-19)
COUNT (CT0 THRU CT11)
COUNTER SELECT AND ENABLE
COUNT STATUS
TO SELECTED REGISTERS
TO SELECTED A BUS GATES
TO SELECTED B BUS GATES
LOWER BYTE COUNTER AND REGISTERS
IMMEDIATE OPERAND GATES U98
COUNTER AND GATES U151, U161, U138
REGISTER 5 AND GATES U129, U118
REGISTER 4 AND GATES U109, U108
REGISTER 3 AND GATES U149, U148, U158
REGISTER 2 AND GATES U199, U198
UPPER BYTE COUNTER AND REGISTERS
IMMEDIATE OPERAND GATES U94
COUNTER AND GATES U191, U181, U134
REGISTER 5 AND GATES U114, U123
REGISTER 4 AND GATES U104, U103
REGISTER 3 AND GATES U154, U144, U143
REGISTER 2 AND GATES U194, U193
REGISTERS AND COUNTER
2180-12



COUNTER CONTROL U88, U131, U171
COUNTER SELECT
REGISTER DECODE/ CONTROL U99
GATE SELECT LOGIC U64, U86, U87
FROM STROBE GENERATOR
UPPER BYTE
LOWER BYTE
LOWER BYTE
UPPER BYTE
UB
LB
LB
UB
PART OF CO
REGISTER A
GATING CO
TO RAR
COUNT (CT0 THRU CT11)
COUNTER SELECT AND ENABLE
COUNT STATUS
TO SELECTED REGISTERS
TO SELECTED A BUS GATES
TO SELECTED B BUS GATES
TO ALL UPPER BYTE REGISTERS
TO ALL LOWER BYTE REGISTERS
TO ALL LOWER BYTE GATES
TO ALL UPPER BYTE GATES
EDIATE ERAND ATES U98
COUNTER AND GATES U151, U161, U138
REGISTER 5 AND GATES U129, U118
REGISTER 4 AND GATES U109, U108
REGISTER 3 AND GATES U149, U148, U158
REGISTER 2 AND GATES U199, U198
REGISTER 1 AND GATES 179, 188
REGISTER 0 AND GATES U159, U168
LOWER BYTE B BUS
LOWER BYTE A BUS
UPPER BYTE A BUS
UPPER BYTE B BUS
EDIATE ERAND ATES U94
COUNTER AND GATES U191, U181, U134
REGISTER 5 AND GATES U114, U123
REGISTER 4 AND GATES U104, U103
REGISTER 3 AND GATES U154, U144, U143
REGISTER 2 AND GATES U194, U193
REGISTER 1 AND GATES U184, U173
REGISTER 0 AND GATES U164, U153
ARITHMETIC AND LOG

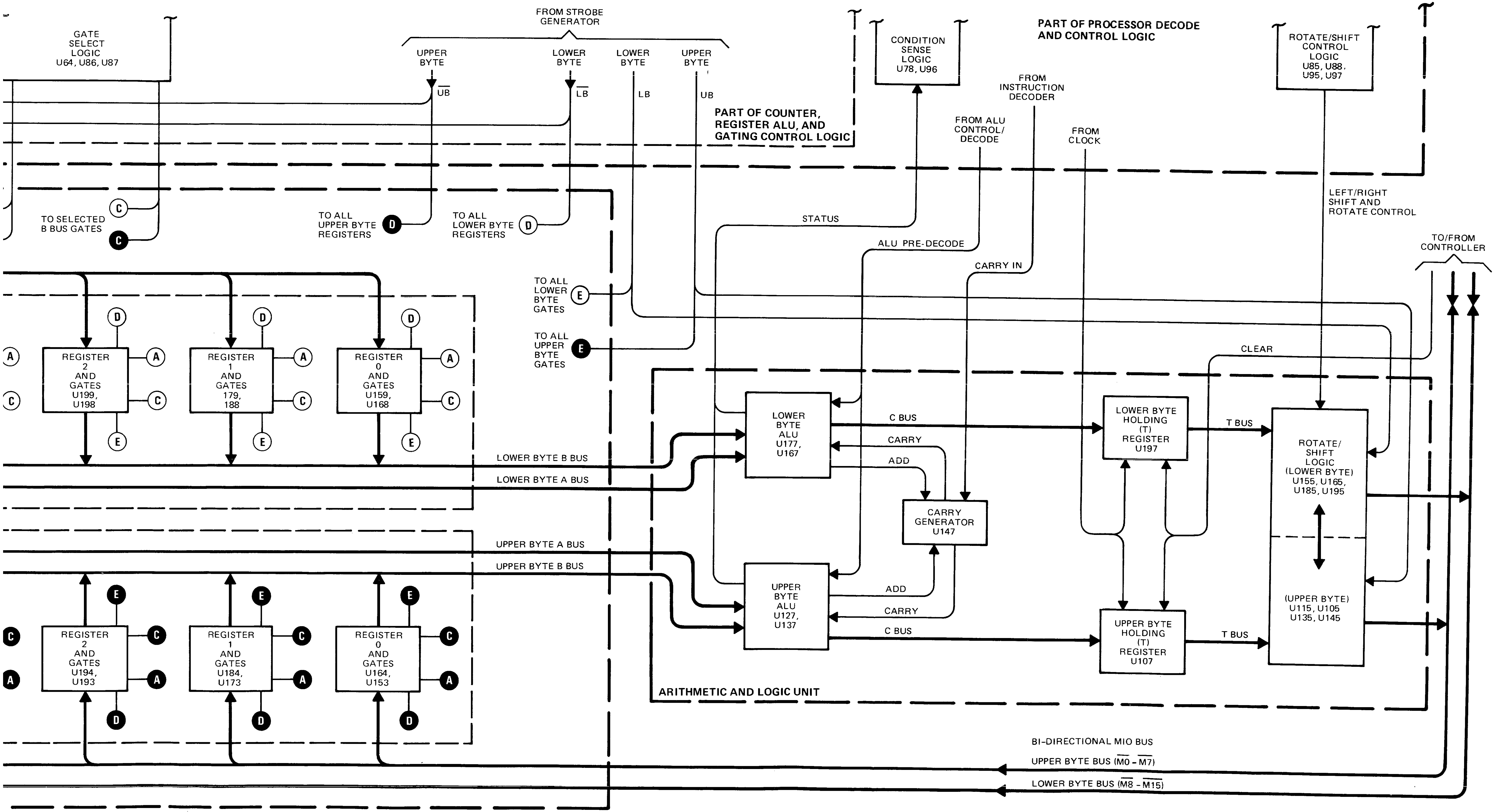


Figure 3-9. Counter, Registers, and ALU

3-45. The 16-bit binary counter is capable of being preset from the MIO bus, counted down, and gated onto the A bus. The counter may be decremented in every microinstruction. The counter can be used as a seventh register when it is not in use as a counter. It is possible to branch to the contents of the counter, thus, computed addressing is possible (described later). The counter can be decremented until a zero state is reached. It will then remain in the zero state until initialized again.

3-46. Arithmetic and Logic Unit. The Arithmetic and Logic Unit (ALU) is shown in the detailed block diagram, figure 3-9. The two inputs to the ALU are the A and B buses. The buses are driven only by the internal general purpose registers, the counter, and the Immediate Operand and are not directly accessed by the tape controller. The ALU is capable of performing the functions listed in table 3-4. Mnemonics and functions are explained in later paragraphs. Since the Rotate/shift logic follows the T-register, described next, any of the functions listed in table 3-4 may be performed, then the results shifted or rotated.

Table 3-4. ALU Functions

FUNCTION	MNEMONIC
A PLUS B	ADD
$A \cdot B$	AND
$A + B$	IOR
$A \oplus B$	XOR
A MINUS B	SUB
$\overline{A}$	CMA
$\overline{B}$	CMB
A	PSA
B	PSB
(IMMEDIATE OPERAND) PLUS B	ADI
(IMMEDIATE OPERAND) $\cdot$ B	ANI
(IMMEDIATE OPERAND) + B	IOI
(IMMEDIATE OPERAND) $\oplus$ B	XOI
(IMMEDIATE OPERAND)	PSI

3-47. The output of the ALU is latched into a holding (T) register, which serves to hold data for output on the MIO bus or for storage in a general purpose register. The T-register is a 16-bit latch. It serves as the master for the general purpose registers which act as slaves during recirculate instructions. It is also the output register for output instructions. The output of this holding register is fed into the rotate/shift logic.

3-48 The rotate/shift logic makes it possible to rotate or shift the data left one bit, right one bit, or left four bits. The rotate microinstructions are applicable to full 16-bit words only. When no rotate or shift operation is performed, data passes straight through the rotate/shift logic. The output of the rotate/shift logic is put onto the MIO bus.

3-49. <u>RAR/ROR Logic</u>. The ROM Address Register (RAR) is a 12-bit register that is incremented at $\overline{T0}$. See the detailed block diagram in figure 3-10. It can also be preset to the desired address from one of four sources during $\overline{T1}$, $\overline{T2}$. These are:

a. The decrementing counter.

b. The Save Register.

c. The Branch field in the instruction word from the ROR.

d. The address selected on the maintenance panel when it is connected.

3-50. The RAR feeds an address directly into the Read Only Memory (ROM), effective at $\overline{T3}$, to read out the desired word which is latched in the ROR at $\overline{T0}$. The ROM is contained on the tape controller PCA of the subsystem. The ROM memory is organized on a modular basis in three blocks of 256 words for this subsystem. (Addresses 0000 thru 0377, 0400 thru 0777, and 1000 thru 1400.) Readout from the ROM chips normally takes about 100 nanoseconds.

3-51. The 12-bit save register, shown in the detailed block, figure 3-10, saves the current address +1, at the end of $\overline{T0}$, on a call to subroutine instruction, thus providing single level jump to subroutine capability. Both the RAR and save registers are under control of the RAR/save register control logic. A return is made to the address in the save register on return from subroutine instructions.

3-52. The ROM Output Register (ROR) is a 20-bit register that holds the current word from the ROM. See the detailed block diagram in figure 3-11. At the beginning of each cycle ($\overline{T0}$) the new ROM word is clocked into the register. The output fields are directed into the following logic of the decode and control logic in the processor decode and control logic section.

a. Instruction decoder.

b. ALU control decode.

c. Counter/register select.

d. Word decode/control.

e. Condition sense.

f. Strobe generator.

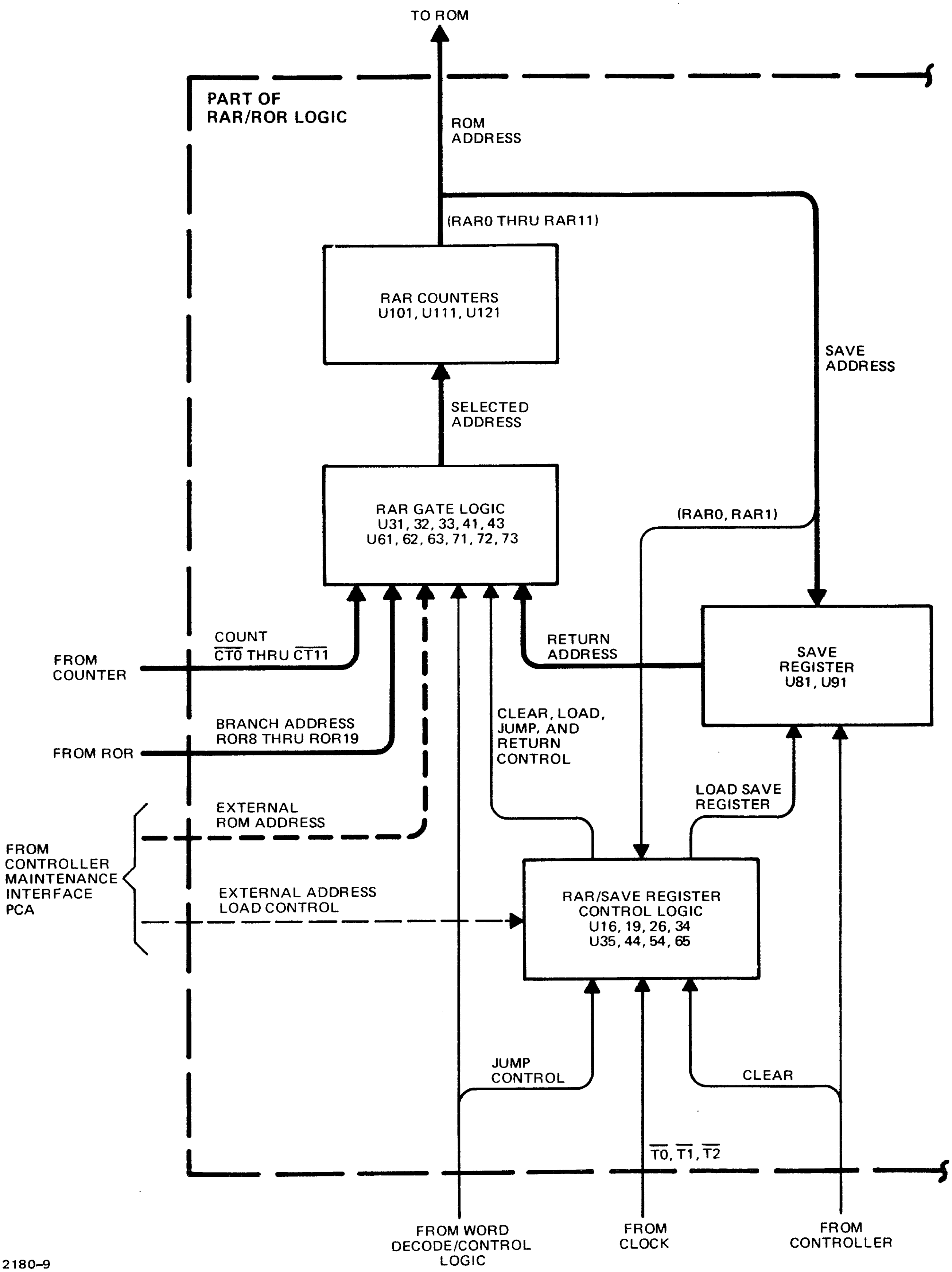
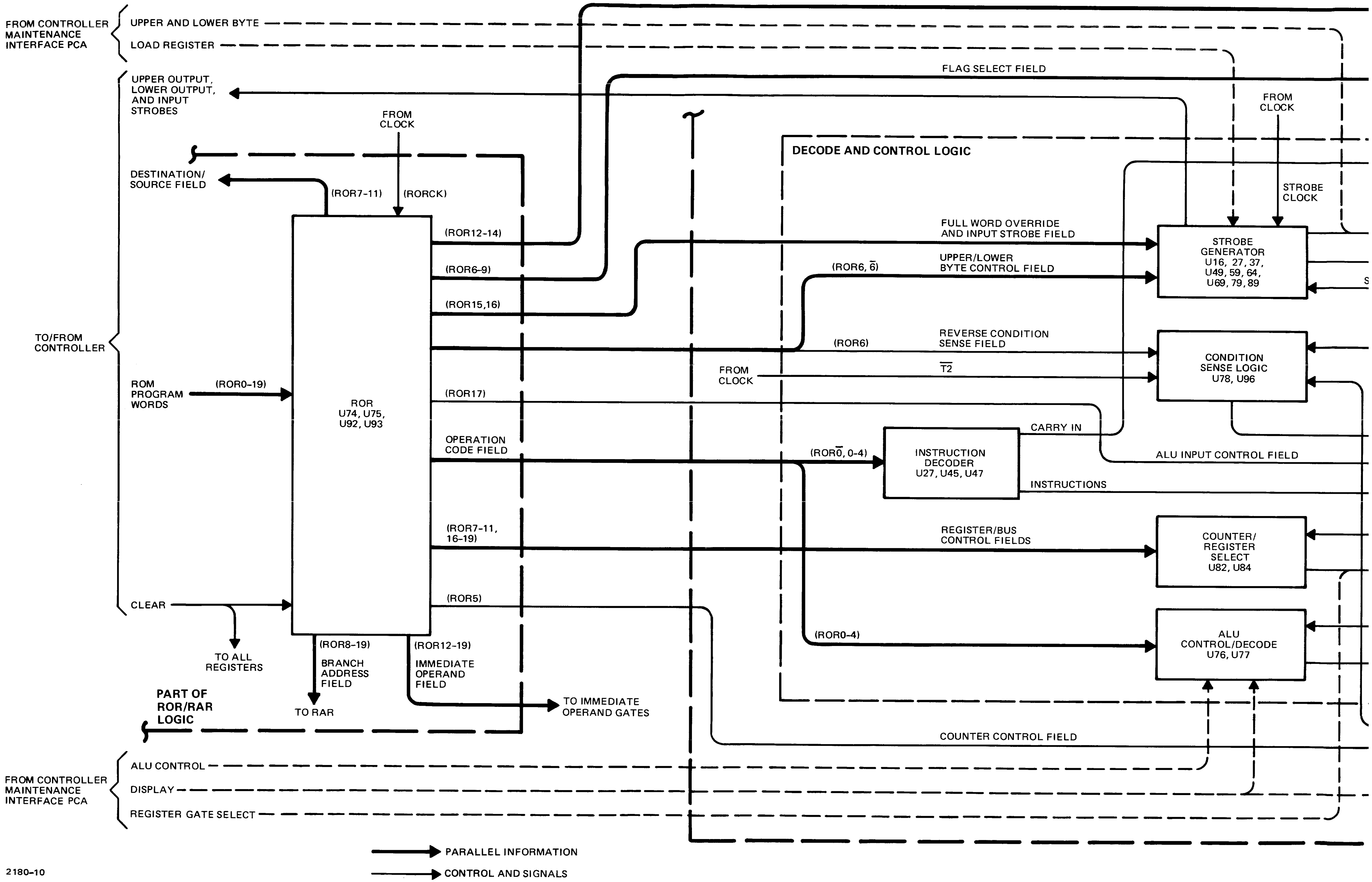


Figure 3-10. Controller Processor RAR/Save Logic, Detailed Block Diagram


FROM CONTROLLER MAINTENANCE INTERFACE PCA
UPPER AND LOWER BYTE
LOAD REGISTER
FLAG SELECT FIELD
UPPER OUTPUT, LOWER OUTPUT, AND INPUT STROBES
FROM CLOCK
DECODE AND CONTROL LOGIC
DESTINATION/ SOURCE FIELD
(ROR7-11)
(RORCK)
STROBE CLOCK
FULL WORD OVERRIDE AND INPUT STROBE FIELD
(ROR12-14)
(ROR6-9)
UPPER/LOWER BYTE CONTROL FIELD
(ROR6, 6̄)
STROBE GENERATOR U16, 27, 37, U49, 59, 64, U69, 79, 89
(ROR15,16)
TO/FROM CONTROLLER
(ROR6)
REVERSE CONDITION SENSE FIELD
CONDITION SENSE LOGIC U78, U96
T̄2̄
ROM PROGRAM WORDS
(ROR0-19)
ROR U74, U75, U92, U93
(ROR17)
CARRY IN
OPERATION CODE FIELD
(RORŌ, 0-4)
INSTRUCTION DECODER U27, U45, U47
ALU INPUT CONTROL FIELD
INSTRUCTIONS
(ROR7-11, 16-19)
REGISTER/BUS CONTROL FIELDS
COUNTER/ REGISTER SELECT U82, U84
CLEAR
(ROR5)
(ROR0-4)
ALU CONTROL/DECODE U76, U77
TO ALL REGISTERS
(ROR8-19)
BRANCH ADDRESS FIELD
(ROR12-19)
IMMEDIATE OPERAND FIELD
PART OF ROR/RAR LOGIC
TO RAR
TO IMMEDIATE OPERAND GATES
COUNTER CONTROL FIELD
ALU CONTROL
DISPLAY
REGISTER GATE SELECT
PARALLEL INFORMATION
CONTROL AND SIGNALS
2180-10

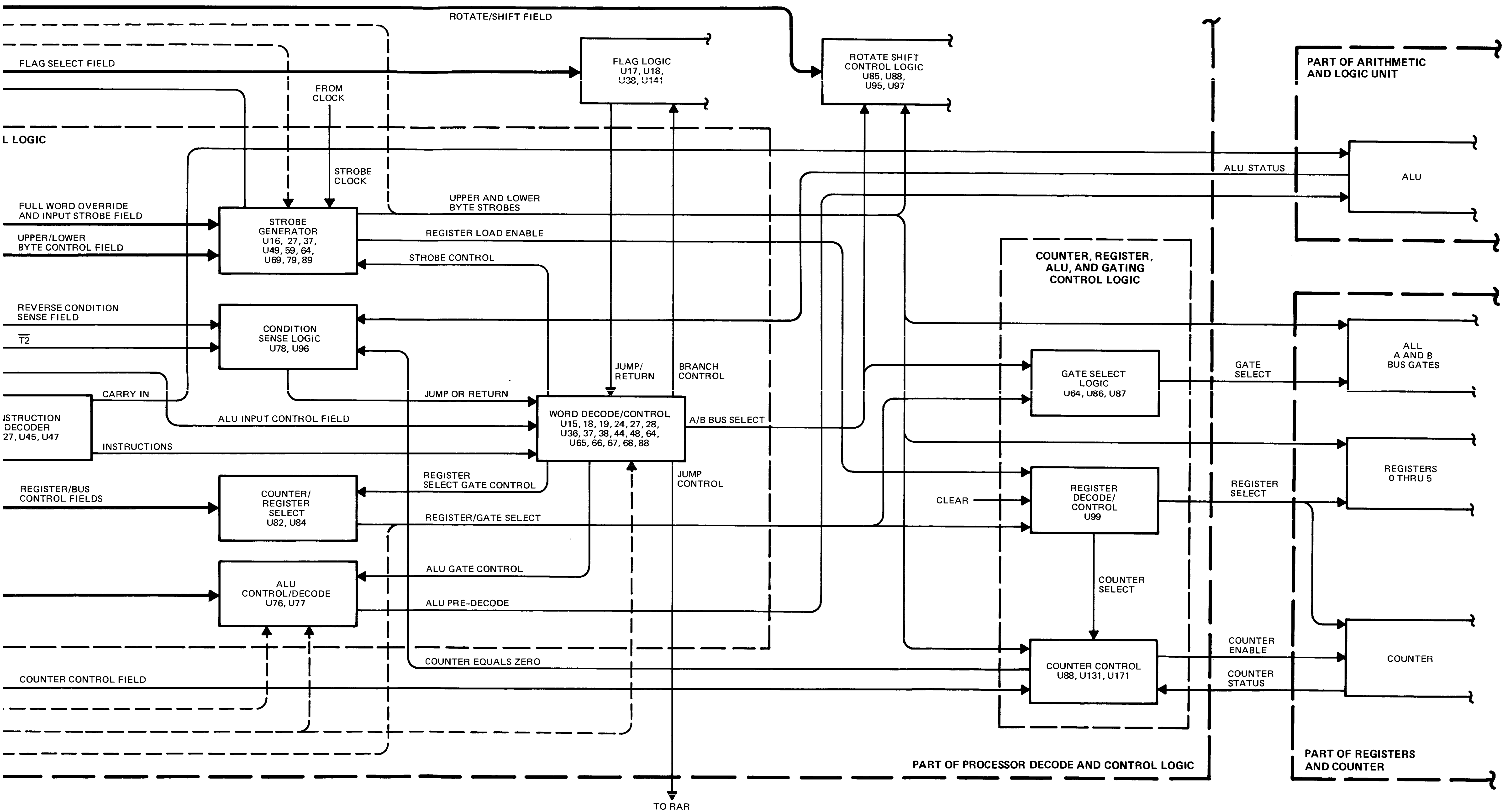


Figure 3-11. Controller Processor ROR, Decode, and Control Logic, Detailed Block Diagram

3-53. The ROR also has outputs fed to the flag logic and rotate/shift control logic in the processor decode and control logic section. The Counter Control field (ROR 5) is applied to the counter control logic in the counter, register, ALU, and gating control logic. The processor decode and control logic is explained in the next paragraph.

3-54. Processor Decode and Control Logic. See the processor decode and control logic in the overall block diagram, figure 3-8 and the detailed block diagram of control logic in figure 3-11. The blocks of logic listed below are expanded in the detailed figure.

a. The ROR, flag logic, and rotate/shift control logic block (representations may be more easily viewed in the overall block).

b. The decode and control logic.

c. Counter, register, ALU, and gating control logic.

3-55. The controller processor clock is shown in the detailed diagram in figure 3-12. The processor cycle time is selected to fit the need of the tape controller card. The timing is determined by the 9.216-MHz crystal. Crystals up to 10 MHz may be used in the controller processor. The cycle consists of four evenly divided phases, each phase being 100 nanoseconds when the controller processor is run at the maximum clock rate of 10 MHz. For the HP 30115A Magnetic Tape Subsystem, each phase time is 108.5 nanoseconds cycle time is 434 nanoseconds. Four clock lines leave the controller processor, but these are not used in this subsystem. Each of the lines represents one of the phases. The AT clock lines and CTL1, CTL2 lines are used to control timing in maintenance mode.

3-56. CONTROLLER PROCESSOR OPERATION. The controller processor operation discussion provides explanations of PCA logic operations, timing, and the microinstruction set. The discussion of the microinstruction set is the essential information to assimilate insofar as operation of the controller processor in the subsystem is concerned. Material concerning the microinstructions includes:

a. The microinstruction list.

b. Descriptions of the microinstructions.

c. Descriptions of the word format fields.

d. Field bit pattern information.

3-57. Although the controller processor may be thought of somewhat like a "black-box" when considering overall subsystem operation, it is necessary to understand the microinstructions, word formats, and internal operation of the controller processor if the specifics of the microprogram listing for the subsystem are to be understood.

3-58. Controller Processor Logic. Simplified logic diagrams that support the explanations of logic operation and data in the tables will be found in the *HP 3000 Computer System Simplified Diagrams Manual* under controller processor diagram set SD 163;

3-59. The general sequence of events in controller processor internal operation are that a general purpose register, and/or the counter, or immediate operand contents are placed on the A and B buses. The A and B buses are then fed into the ALU, the ALU output is stored in the T-register, which in turn feeds the rotate/shift

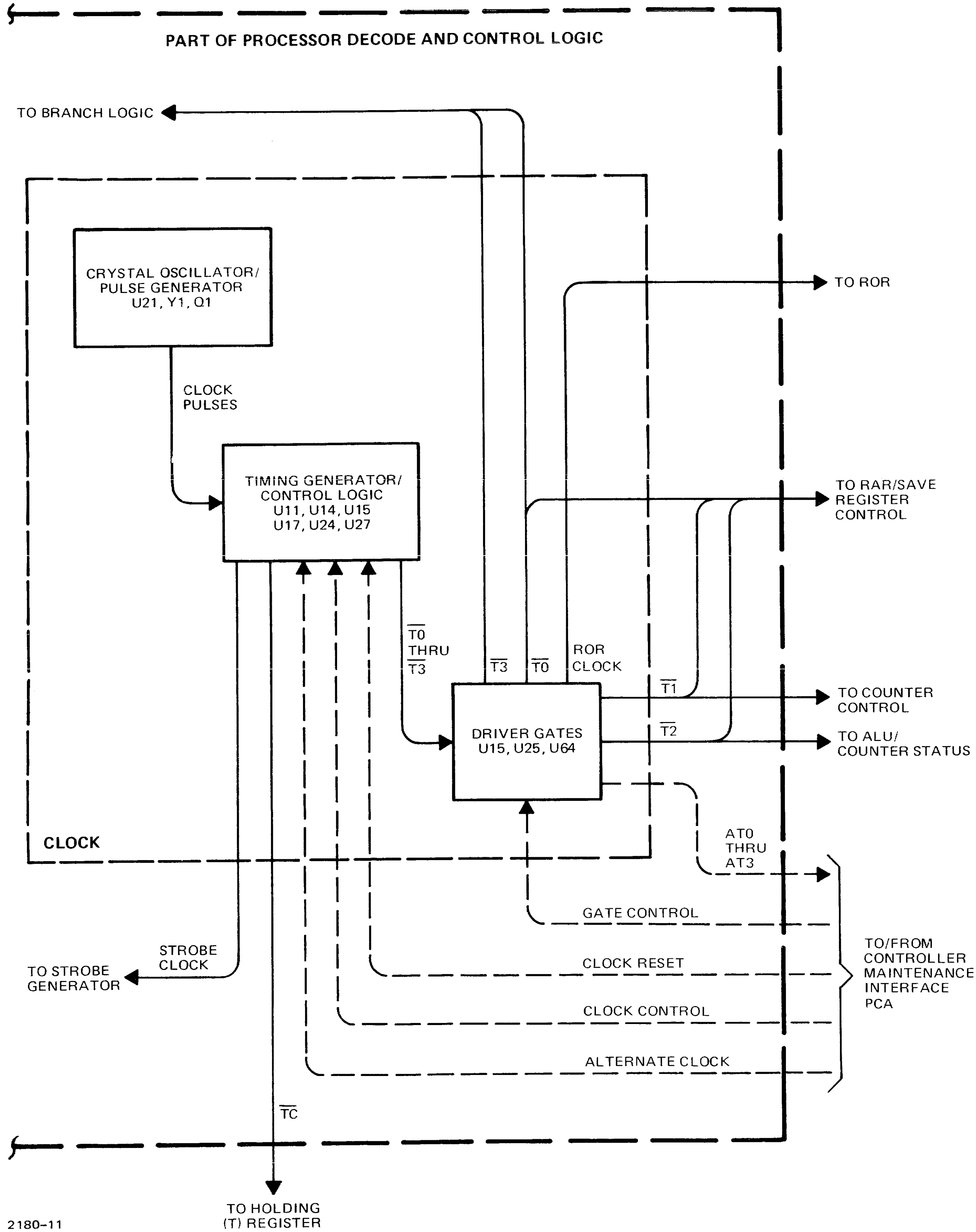


Figure 3-12. Controller Processor Clock, Detailed Block Diagram

logic, which finally drives the MIO bus with data to be written into the selected target register or to be transferred from the PCA. If the counter is to be counted, it is not used as a source for data or an address in the same instruction. If a preset and a decrement of the counter happen to be microprogrammed in the same instruction, the preset will prevail. The counter will never be microprogrammed to decrement when its contents are to be used as the next address. The internal general purpose registers, RG0 through RG5, are implemented with latching type flip-flops. After an I/O Reset or Power-up sequence, the state of general purpose registers RG0 through RG5 will be all bits set to logical 1.

3-60. Rotate instructions in the controller processor have no meaning when used in conjunction with the byte instruction, U/L. Rotate is applicable to full words only. The output of the rotate/shift logic is driven by three-state driver gates capable of sourcing or sinking 40 milliamperes. Of this 40 milliamperes, 24 are available for the tape controller logic. Data on the MIO bus goes to the high state when the drivers are in the third (high impedance) state. That is, the bus is forced to a logical 1 when idle. (Keep in mind that MIO bus data is complemented.) Data is valid only when an input or output strobe is present. See the discussion on controller processor timing, paragraph 3-61. Destination/source line data is indicated by a high signal, logical 1, on the line. These lines are also only valid when an input or output strobe is present. The master clear of the controller processor occurs when the Clear line is low.

3-61. Controller Processor Timing. Figure 4-14 in section IV illustrates basic controller processor timing. Four timing periods, $\overline{T0}$ through $\overline{T3}$, are output from the clock logic. The magnetic tape subsystem requires the clock have a 9.216-MHz crystal installed for 45 inch-per-second operation.. This provides four phases approximately 108.5 nanoseconds long. Maximum clock rate of the controller processor is achieved with a 10-MHz crystal installed. Phases are only 100 nanoseconds long under these conditions.

3-62. The controller processor timing cycle starts with the leading edge of $\overline{T0}$, proceeds through $\overline{T1}$ and $\overline{T2}$ and ends with the trailing edge of $\overline{T3}$. Input data to the controller processor on the MIO bus is accepted in registers RG0 through RG5, or the counter only during input strobe time. The Input Strobe, (IS) one quarter cycle long, appears during the last quarter of the controller processor timing cycle, during $\overline{T3}$. Data input for the general purpose registers RG0 through RG5 should be present at least 50 nanoseconds before the end of the controller processor input strobe and must remain present for at least 10 nanoseconds past the end of the input strobe. During normal controller processor operation these conditions will be met. The T-register is loaded in the middle of the timing cycle. Approximately sixty nanoseconds after the loading, output data is valid on the MIO bus. In general, the data will always be valid during the last quarter of the controller processor timing cycle. It is during this time that the output strobes appear. An upper byte, Upper Output Strobe (UOS), and lower byte, Lower Output Strobe (LOS), strobe are provided. This information may be useful during troubleshooting. The five destination/source bits are valid only when an input or output strobe is present. The external select signal (not used in this subsystem), is used in conjunction with $\overline{T3}$. As shown in figure 4-14, flags must be present during the last part of phase $\overline{T0}$ to be accepted when checked. ROM address and data timing is also shown in figure 4-14. Note the following in regard to the ROM address validation and ROM data received at the controller processor:

a. The ROM address is valid during $\overline{T3}$ and is always incremented at the beginning of $\overline{T0}$.

b. ROM data is read out and available from 60 to 100 nanoseconds (maximum) after the ROM is addressed and the data is latched into the ROR by the RORCK signal occurring during $\overline{T0}$.

c. The crossover in the ROM address timing line (in the controller processor timing diagram) immediately after $\overline{T3}$ indicates that the address (binary pattern) may or may not change state during this time depending upon previous instructions and internal states.

d. At the end of $\overline{T0}$ the address is latched into the save register if required (by the operation code).

e. From the beginning of $\overline{T1}$ through $\overline{T2}$ the address may or may not be changed.

3-63. Overall Controller Processor Microinstruction Set. Table 3-5 is a consolidated list of microinstructions available for use in the controller processor. The microinstruction set may be functionally described

Table 3-5. Controller Processor Microinstruction Operation Codes

MNEMONIC	DEFINITION
WORD TYPE ONE	
ADD	Addition operation code. The A bus is added to the B bus and the result is placed in the T-Register.
SUB	Subtraction operation code. The B bus in subtracted from the A bus and the results are placed in the T-Register. The subtraction is two's complement.
IOR	"Inclusive or" operation code. The A and B buses are "or"ed together and the results stored in the T-register.
XOR	"Exclusive or" operation code. The A and B buses are "exclusive or"ed together and the results are placed in the T-register.
AND	"And" operation code. The A and B buses are "and"ed and the results are placed in the T-register.
CMA	Complement A bus operation code. The complement of the A bus is placed in the T-register.
CMB	Complement B bus operation code. The complement of the B bus is placed in the T-register.
PSA	Pass A bus operation code. The A bus content is placed in the T-register.
PSB	Pass B bus operation code. The B bus content is placed in the T-register.
WORD TYPE TWO	
ADI	Addition to the immediate operand, operation code. The immediate operand is added to whichever byte is selected on the B bus and the results are placed in that byte of the T-register.
ANI	"And" with the immediate operand, operation code. The immediate operand is "and"ed with the selected B bus byte and the resulting byte is placed in the T-register.
XOI	"Exclusive or" with the immediate operand, operation code. The immediate operand is "Exclusive or"ed with the selected B bus byte and the resulting byte placed in the T-register.
IOI	"Inclusive or" with the immediate operand, operation code. The immediate operand is "or"ed with the selected B bus byte and the resulting byte is placed in the T-register.

Table 3-5. Controller Processor Microinstruction Operation Codes (Continued)

MNEMONIC	DEFINITION
	WORD TYPE TWO (Cont.)
PSI	Pass the immediate operand, operation code. The immediate operand is placed in the selected byte of the T-register.
	WORD TYPE THREE
OTI	Output immediate operand, operation code. The Immediate Operand field is placed on the selected byte of the MIO bus for output to the destination specified in the destination field.
	WORD TYPE FOUR
IOC	Input/output control operation code. The IOC instruction either sets up the path for data to be placed on the MIO bus from the selected register, or clocks data into the selected register from the MIO bus, depending on the I/O field bit. The data may also be rotated or shifted during the output phase in command execution.
	WORD TYPE FIVE
JMP	Jump operation code. This is an unconditional branch to the address specified in the branch address field. i.e. RAR ← BRANCH ADDRESS;
JMX	Jump, operation code. This is an unconditional branch to the address specified in the lower order 12 bits of the counter. The Branch Address field and the higher order four bits of the counter are ignored. The counter has to be made positive-true before it is used as an address. i.e. RAR (0:12) ← COUNTER (4:12);
JMZ	Jump on T = 0 operation code. This is a branch to the address specified in the Branch Address field if the condition T-register equals zero is met, if not, the next instruction in sequence is executed. In all internal conditional branch instructions, the condition under test is the one that existed mid-cycle of the previous instruction, that is, the value being loaded into the T-register. i.e. IF T = 0 THEN RAR ← BRANCH ADDRESS else RAR ← RAR + 1;
JXZ	Jump on counter = 0 operation code. The branch is taken if the condition, counter equals zero is met, otherwise, the next instruction in sequence is executed. Care should be used in interpreting this instruction as the test occurs *before* the counter is decremented. This instruction should not directly follow a preset of the counter since the counter will not have had

Table 3-5. Controller Processor Microinstruction Operation Codes (Continued)

MNEMONIC	DEFINITION
WORD TYPE FIVE (Cont.)	
JXZ (Cont.)	time to complete preset. An undesired jump may occur if the counter is still 0. i.e. IF COUNTER = 0 THEN RAR ← BRANCH ADDRESS else RAR ← RAR + 1;
JSZ	Jump on Sign = 0 operation code. The branch is taken if the condition, sign equals zero is met, otherwise, the next instruction is executed. i.e., IF SIGN = 0 THEN RAR ← BRANCH ADDRESS else RAR ← RAR + 1;
JOV	Jump on overflow operation code. The branch is taken if the condition, Overflow of the ALU is met, otherwise the next instruction is executed. i.e., IF OVERFLOW THEN RAR ← BRANCH ADDRESS else RAR ← RAR + 1;
CAL	Call subroutine operation code. This is a branch to a subroutine while retaining the return address in the save register. i.e., BEGIN RAR ← RAR + 1; SAVE ← RAR; RAR ← BRANCH ADDRESS END
CXZ	Call subroutine on Counter = 0 operation code. If the counter is zero, the call to subroutine is made, otherwise the next instruction in sequence is executed. i.e., IF COUNTER = 0 THEN BEGIN RAR ← RAR + 1; SAVE ← RAR; RAR ← BRANCH ADDRESS; END else RAR ← RAR + 1;

Table 3-5. Controller Processor Microinstruction Operation Codes (Continued)

MNEMONIC	DEFINITION
	WORD TYPE FIVE (Cont.)
RTN	Return from subroutine operation code. This instruction is an absolute return from a subroutine. The next instruction executed is the one whose address is stored in the save register. i.e., RAR ← SAVE;
RMN	Return on T≠ 0 operation code. This instruction is a conditional return from a subroutine. If the condition, T-register not equal zero, is met, the return will occur; however, if the condition fails, a branch to the address indicated in the Branch Address field will occur. The next instruction in sequence will not implicitly be executed. i.e., IF T≠0 THEN RAR ← SAVE else RAR ← BRANCH ADDRESS;
CAX	Call Subroutine operation code. This is a branch to a subroutine as explained in the CAL instruction except that the address of the subroutine is the lower order 12 bits of the counter. The counter contents must be positive true. i.e., BEGIN RAR ← RAR + 1; SAVE ← RAR; RAR (0:12) ← COUNTER (4:12); END
CMZ	Call subroutine on T = 0 operation code. This is a branch to a subroutine if the condition, T-register equals zero is met. If it is not, the next instruction in sequence is executed. i.e., IF T = 0 THEN BEGIN RAR ← RAR + 1; SAVE ← RAR; RAR ← BRANCH ADDRESS; END else RAR ← R + 1;

Table 3-5. Controller Processor Microinstruction Operation Codes (Continued)

MNEMONIC	DEFINITION
WORD TYPE FIVE (Cont.)	
RXN	Return on Counter ≠ 0 operation code. This instruction is a conditional return from a subroutine. If the condition, counter not equal to zero is met, the return will occur; if the condition fails, a branch to the address indicated in the Branch Address field will occur. i.e., IF COUNTER≠0 THEN RAR ← SAVE else RAR ← BRANCH ADDRESS;
WORD TYPE SIX	
JFS	Jump on Flag Set operation code. This is a branch to the address specified in the branch address field if the specified flag is present. If the flag is not present, the next instruction in sequence is executed. i.e., IF SELECTED FLAG = 1 THEN RAR ← BRANCH ADDRESS else RAR ← RAR + 1;
RFS	Return on Flag Set operation code. This instruction is similar to the conditional returns on internal conditions. If the specified flag is present, the return from subroutine is executed, if the flag is not present, the branch is taken. i.e., IF SELECTED FLAG = 1 RAR ← SAVE else RAR ← BRANCH ADDRESS;

by examining the operation codes. The ROM instruction word is 20 bits wide, with the highest order five bits containing the operation code. The codes fall into three broad categories; arithmetic/logic codes, input/output codes, and branch codes which are discussed further in later paragraphs. These categories may be further divided into six types of word formats. These six formats are shown in figure 3-13.

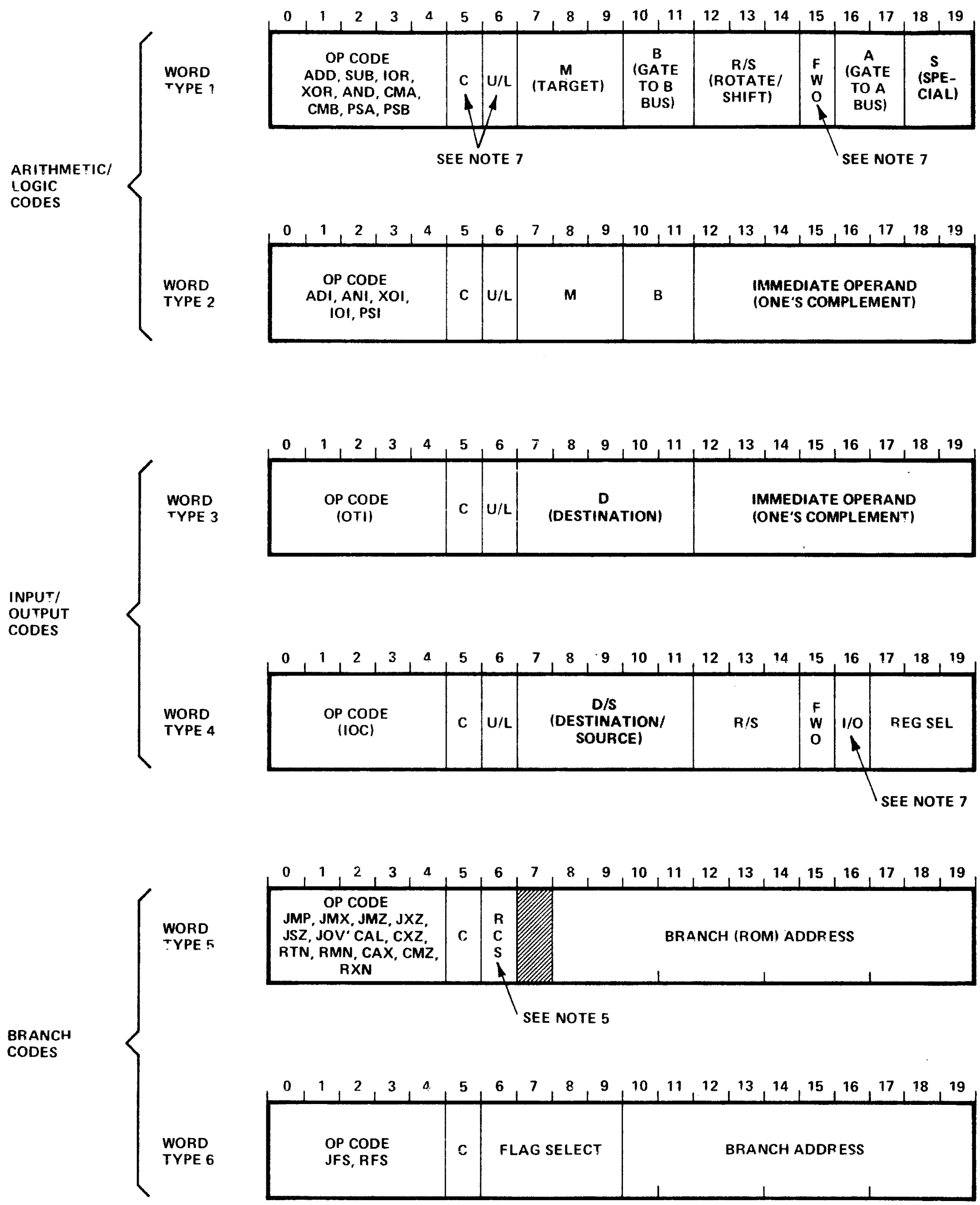
3-64. Word formats one and two are always decoded as arithmetic/logic instructions. Word formats three and four are decoded as input/output instructions and word formats five and six are decoded as branch instructions. A discussion of the word format fields follows. Some fields are common to two or more word types and explanations are not repeated in the following discussions. The consolidated coding sheet, figure 4-11, in section IV should be examined to determine bit patterns used for instructions in the various fields of each word type.

3-65. Arithmetic/Logic Instructions. The arithmetic/logic instructions utilize word type one or two, depending on whether or not an immediate operand is required. The fields of word type one are described in table 3-6. The Counter Control field (C) is common to all six word types.

3-66. Word type two is like word type one with the exception that the immediate operand replaces the Shift/Rotate field, A bus Register Select field, Special field, and the full-word override bit. Since the immediate operand is only 8-bits wide, it is necessary that it be specified in which byte the immediate operand is to be used by utilizing the U/L field. The immediate operand field is also described in table 3-6. The A bus Register Select field is not required in word type two because the immediate operand is placed on the A bus automatically (hard-wired). The B bus Select field is used in word type two to perform operations with the immediate operand. The target register field is available in word type two to specify a storage register.

3-67. Input/Output Instructions. There are only two types of input/output instructions. They are used *extensively* to control subsystem operation. The OTI instruction, word type three, has three fields; a C, U/L, and IMOP that were explained under word types one and two, and one new field, D, in lieu of the previously described fields for these bits. The new field is described in table 3-6. The IOC instruction, word type four, does not have the Immediate Operand field. The C and U/L fields are still used and the D (Destination) field becomes the D/S (Destination or Source) field. Two new fields, I/O and REG SEL, are also described in table 3-6.

3-68. Branch Instructions. The branch instructions utilize word types five and six. The two instructions JFS and RFS of word type six provide branching on external conditions. The remaining 13 operation codes of the total available, word type five, are used for branching unconditionally, or on internal conditions. Word type five has the Counter field and two new fields that replace previously described fields. These are the RCS and 12-bit Branch Address field described in table 3-6. Word type six uses the Counter field, a Flag Select field, described in table 3-6, and a 10-bit Branch Address field that allows a branch to anywhere in the present 1K (possible) memory of the microprogram. If the flag designated in the Flag Select field is set when this instruction is executed, a branch to the address indicated is made. Reiterating a few points made in the tables, the internal conditional branches or returns are always made on the results of the previous instruction.



NOTES:

1. SEE MICROCODING SHEET FOR CODES IN FIELDS.
2. SEE TEXT FOR FIELD FUNCTION EXPLANATIONS.
3. ▨ BIT NOT USED.
4. SHADED FIELDS SIGNIFY USE SUBJECT TO SPECIFIC CONTROLLER MICROPROGRAM.
5. (REVERSE CONDITION SENSE) RCS NOT VALID FOR JMP, JMX, CAL, CAX, OR RTN CODES.
6. $\overline{M0}$:$\overline{M7}$ = UPPER BYTE, $\overline{M8}$:$\overline{M15}$ = LOWER BYTE.
7. C = COUNTER, U/L = UPPER OR LOWER BYTE, FWO = FULL-WORD OVERRIDE, I/O = INPUT OR OUTPUT.

2180-13A

Figure 3-13. Controller Processor Microinstruction Word Formats

Table 3-6. Microinstruction Word Field Definitions

DESIGNATION	FIELD	DESCRIPTION
C	COUNTER	This is a one-bit field that determines whether the counter is to be decremented or not. A low, logical 0, in the field causes a decrement during the current instruction. The mnemonic is DEC. If no DEC is specified, a logical 1 is placed in the field. Bit 5, the C field, is used in all six word types.
U/L, FWO	UPPER BYTE/ LOWER BYTE, FULL-WORD OVERRIDE	This is a one-bit field for U/L, and a one-bit field for FWO. The options here are to select the upper byte, (MIO bits 0:7) the lower byte, (MIO bits 8:15) or the full word. If only one byte is selected, the other byte is left totally unaffected. The mnemonics are UPH and LWH. If no byte is specified, a full word is assumed. A logical 1 in the FWO field overrides the U/L field and allows a full word on the MIO bus.
M	TARGET	This is a three-bit field. The content of this field determines the place of storage for MIO bus data. The result of a calculation will be loaded into this target register. Any one of the six general purpose registers or the counter can be selected. The mnemonics are CTM, and ROM through R5M. An external register may be selected by this field also (all logical 1's in the field). The mnemonic is EXM for this selection. This last case is also the default selection.
B	B BUS REGISTER SELECT	This is a two-bit field used to select one of four possible general purpose registers to be gated onto the B bus for input to the ALU. The registers are RG0 through RG3. The mnemonics for the field are R0B, R1B, R2B, and R3B. If no specification is made R3B is selected (logical 1's in the field).
R/S	ROTATE/SHIFT	This is a three-bit field. As its name implies, this field invokes the rotate or shift option desired. The mnemonics are RL1, RR1, RL4, SL1, SR1, and SL4. If no rotate/ shift is specified, the code for no action is set.
A	A BUS REGISTER SELECT	This is a two-bit field used to select one of four sources to be gated onto the A bus for input to the ALU. The four sources are: the counter, RG3, RG4, and RG5. The mnemonics are CTA, R3A, R4A, and R5A. R3A (all logical 1's) is selected if not other specification is made.

Table 3-6. Microinstruction Word Field Definitions (Continued)

DESIGNATION	FIELD	DESCRIPTION
S	SPECIAL	A two-bit field available for special functions of a microprogram. The field is valid only when word type one operation codes are active. The field is not used in this subsystem.
IMOP	IMMEDIATE OPERAND	This is an eight-bit field that contains a constant for the particular microprogram running. The constant is called from the address of storage as programmed.
D or D/S	DESTINATION or DESTINATION/ SOURCE	This is a five-bit field used to specify an intended destination (for word type three) or destination or source (in word type four) for the data generated during this instruction. The output strobes (or the input strobe) indicate when the field is valid. The mnemonics are D00 through D37 (octal values).
I/O	INPUT/OUTPUT	This is a one-bit field used in word type four to determine whether an input or an output is being executed. The D/S field pattern specifies the destination or source. The mnemonics for this field are INP and OUT.
REG SEL	REGISTER SELECT	This is a three-bit field that determines which register (or the counter) internal to the controller processor is to be selected. Whether the register is the source of the data or the target depends on the state of the I/O field bit. The mnemonics are CTI, EXI, R0I, through R5I, for the counter, an external register, or registers RG0 through RG5 respectively.
RCS	REVERSE CONDITION SENSE	This one-bit field is to complement the sense of an internal condition when a conditional branch is being executed. The mnemonic is RCS. If no specification is made, the unaltered condition will prevail.
–––	BRANCH ADDRESS	For word type five, this is a 12-bit field to allow direct branching anywhere within a *possible* 4K page of ROM. Bit seven is not used in word type five. For word type six, this field is 10-bits long and allows branching anywhere within a current 1K (possible) segment of the possible 4K page of ROM.
–––	FLAG SELECT	This 4-bit field determines which of the 16 possible flags is under test. Only one of the 16 flags may be under test at any one time. Mnemonics for the flags are $F00_8$ through $F17_8$.

When the branch is indirectly made through the counter, only the lower order 12 bits of the counter are used on counter branch instructions. The counter is always incremented after the test. The branch is only within the current 4K (possible) page of ROM. Also, the instruction sequentially following a return is not always executed without question.

3-69. Other Microinstruction Set Mnemonics. Other mnemonics that may be used in the microprogram listing are: END, (End); NOP, (No Operation); EQU, (Equate); and SKP, (Skip). These are defined as follows:

a. The END mnemonic is the last entry in the microprogram.

b. The NOP operation code performs no operation. The wiring for the decoded command is not connected in the controller processor. Logical 1's are loaded in all fields except the operation code field.

c. The EQU mnemonic, if used in a listing, designates that the mnemonic shown with EQU represents the value of a particular constant. EQU is normally used only in the controller processor assembler.

d. The SKP mnemonic in a microprogram spaces the listing to the following print-out sheet.

4-1. INTRODUCTION.

4-2. This section includes general servicing information, preventive maintenance instructions, troubleshooting data, and corrective maintenance procedures for the HP 30115A Magnetic Tape subsystem. Procedures presented assume that the service engineer performing maintenance has a thorough knowledge of the hardware gained through the use of previous sections of this manual, and thorough classroom training on the HP 3000 Computer System.

4-3. GENERAL SERVICING INFORMATION.

4-4. Ensure that printed-circuit assemblies of the HP 30215A Magnetic Tape Unit Interface remain firmly installed in their PCA module slots, as described later in this paragraph, with the extractor handles locked in place. All cables should also be firmly attached to connectors per instructions included in the following paragraphs. Refer to the HP 7970B or HP 7970E Operating and Service Manual for general servicing information applicable to the tape units. Additional general servicing information is outlined in paragraphs 4-5 through 4-20.

4-5. SAFETY PRECAUTIONS.

4-6. The primary safety precautions to be observed involve electrical systems as follows.

WARNING

> Dangerous voltages are present in the HP 3000 Computer System Power Control Module and cabinet ac distribution system. Use caution when working on magnetic tape subsystem components and tape units installed in the cabinets. Observe all cautions and warnings stated in cabinet and tape unit maintenance documents.

4-7. Before pulling or installing printed-circuit assemblies (PCA) from a PCA cage, set the DC POWER switch for the computer system to STANDBY to remove power from the PCA connectors. Also follow this procedure for PCA extender assemblies and for the maintenance interface PCA. It is assumed that the maintenance personnel will perform proper system (software) shut down procedures before removing or installing any PCA in the HP 3000 Computer System.

4-8. When the interface cable is being connected to the tape controller PCA or to the tape unit, ensure that the tape unit ac power switch is off. Also turn off ac power switches on multiple tape units in the subsystem when removing or installing multiunit connector cables.

4-9. REQUIRED SERVICING EQUIPMENT.

4-10. Servicing equipment required for the HP 7970B or HP 7970E Digital Magnetic Tape Unit is listed in the operating and service manual for the applicable unit. Oscilloscopes, PCA extenders, voltmeters, logic probes, common hand tools, etc used for computer system servicing are also used for HP 30115A Magnetic Tape Subsystem and HP 30215A Magnetic Tape Unit Interface PCA servicing and maintenance. The equipment listed below is needed in addition to the items mentioned above. Refer to the *HP 3000 Computer System, Operator's Manual, 30350A Auxiliary Control Panel* and *30352A Hardware Maintenance Panel,* part no. 30352-90001, for the complete list of the equipment and instructions for the use of this equipment.

a. HP 30350A Auxiliary Control Panel.

b. HP 30351A Controller Processor Maintenance Panel Interface.

c. HP 30352A Hardware Maintenance Panel.

d. ROM Simulator ET 6710.

4-11. OPERATING CONTROLS AND INDICATORS.

4-12. Tape unit front panel controls are used when operating tape units in the off-line mode for maintenance. There are also maintenance switches within the tape unit. Refer to the operating and service manual on the applicable tape unit for a list of controls and their functions. Tape units used with the HP 30115A Magnetic Tape Subsystem have specific options included, as outlined in section I of this manual. Descriptions of controls (in the tape unit manual) that are not used with this subsystem should be ignored. There are no operating controls or indicators on the printed-circuit assemblies of the HP 30215A Magnetic Tape Unit Interface.

4-13. PRINCIPAL SERVICING POINTS.

4-14. Test points and terminals used for signal measurement and waveform analysis in the tape unit are identified in the applicable tape unit operating and service manual. The status register gates, U166, and U167, various registers, and connectors on the printed-circuit assemblies in the HP 30215A Magnetic Tape Unit Interface are used as measurement points when the printed-circuit assemblies are placed on a PCA extender. These measurement points are identified in the appropriate procedures. Additional points used for servicing are the PCA connectors and tape unit connectors. Normal connections for the basic subsystem and for additional tape units are described in the following paragraphs.

4-15. BASIC SUBSYSTEM CONNECTIONS. Overall basic subsystem interface cable and PCA connector cabling connections are shown in figure 4-1. When maintenance and troubleshooting is performed, ensure that cables are replaced as shown in the diagram for basic subsystems. If there are any changes that are applicable to the installed subsystem, refer to the connection instructions in the next paragraph.

4-16. ADDITIONAL TAPE UNIT CONNECTIONS. The multiple unit connection instructions in the *HP 7970B Digital Magnetic Tape Unit Operating and Service Manual* should be referenced if additional HP 7970B Digital Magnetic Tape Units are used. Also refer to the *HP 13194A Multiunit Cable Accessory Kit Installation Manual,* part no. 13194-90003. Refer to multiple unit connection instructions in section II of the *HP 7970E Digital Magnetic Tape Unit Operating and Service Manual,* if HP 7970E Digital Magnetic Tape Units are used. See figure 4-2 for additional tape unit connection points. Constraints for optional additions are as follows:

a. Interface cable part no. 30215-60003 must be connected between the tape controller PCA and the basic subsystem tape unit regardless of the number of additional tape units used.

b. In any parallel connections, the master or master/slave HP 7970E (if used) must be the last in the series if used in combination with the HP 7970B. Any HP 7970B tape units must be first in line from the tape controller PCA.

c. A slave HP 7970E can not be used alone; it must be connected to a master tape unit.

d. There can be no more than four tape units on one tape controller PCA.

e. The HP 13194A Multiunit Cable is used for all additional tape unit connections *except* where an HP 7970E slave tape unit follows HP 7970E master tape unit in the series. In this last instance, the HP 13194A-001 Multiunit Cable must be used between the master and slave and between slave units. The HP 13194A-001 cable must be installed on the connectors provided specifically for that cable. See the example cable connection diagrams for additional tape units in figure 4-2. The table in figure 4-2 lists all 24 possible connections for the subsystem.

4-17. TAPE UNIT CONNECTOR LOCATIONS. Basic subsystem cabling connection points in the tape unit are shown in figure 4-3. The physical locations for connecting an HP 13194A Multiunit Cable from an HP 7970B to an additional HP 7970B or HP 7970E read-after-write (RAW) master tape unit are shown in figure 4-4. Physical locations on the HP 7970E RAW master tape unit for connecting the HP 13194A and HP 13194A-001 Multiunit Cables are shown in figure 4-5. The connection points for the HP 7970E RAW slave tape units are shown in figure 4-6.

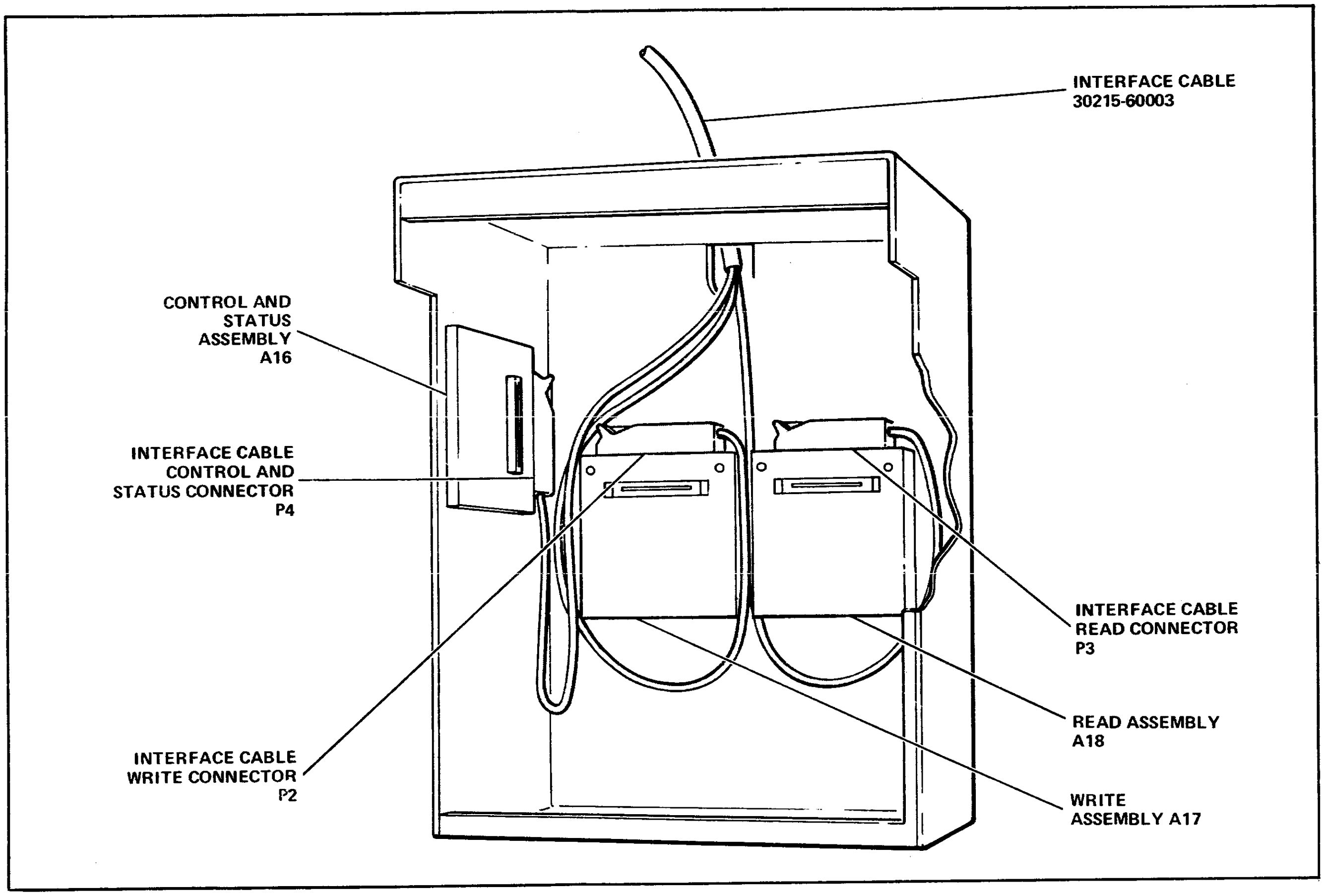


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Figure 4-3. Basic Subsystem, HP 7970B Digital Magnetic Tape Unit
Interface Cable Connection Points

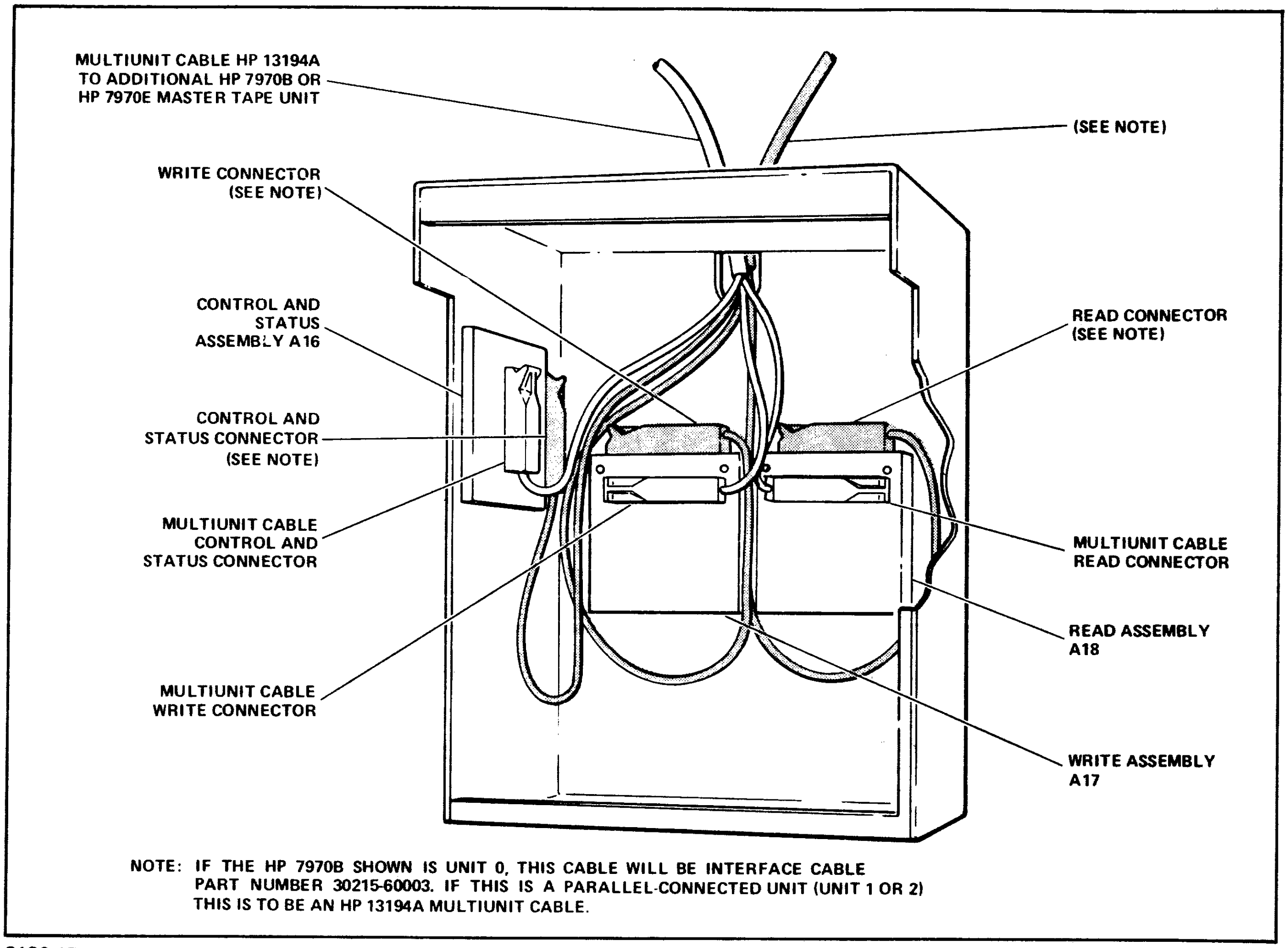

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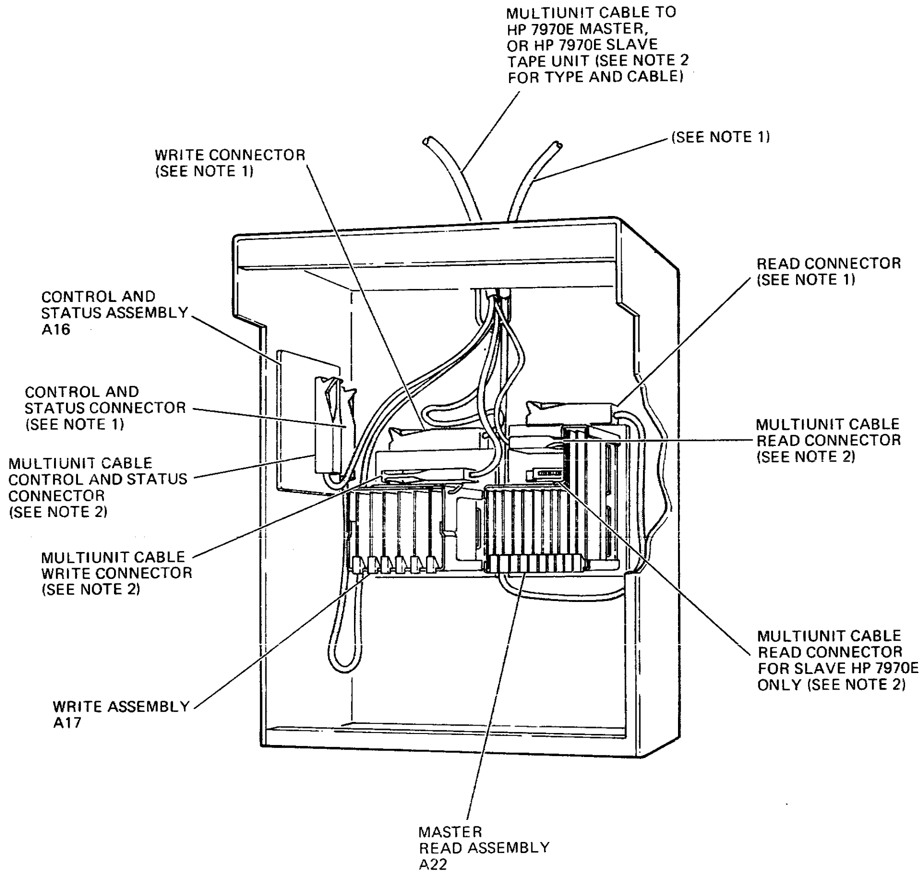
Figure 4-4. Additional HP 7970B Digital Magnetic Tape Unit Cable Connection Points



NOTES:
1. IF THE HP 7970E MASTER TAPE UNIT SHOWN IS UNIT 0, THIS WILL BE INTERFACE CABLE PART NO. 30215-60003. OTHERWISE IT WILL BE AN HP 13194A MULTIUNIT CABLE COMING FROM HP 7970B OR ANOTHER HP 7970E MASTER TAPE UNIT.
2. IF THE FOLLOWING UNIT IS ANOTHER HP 7970E MASTER TAPE UNIT, THIS CABLE WILL BE AN HP 13194A MULTIUNIT CABLE WITH READ CONNECTOR INSTALLED AS SHOWN. IF FOLLOWING UNIT IS AN HP 7970E SLAVE TAPE UNIT, THIS MUST BE AN HP 13194A-001 MULTIUNIT CABLE WITH READ CONNECTOR INSTALLED IN SLAVE READ POSITION AS DESIGNATED IN DRAWING.

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Figure 4-5. Master HP 7970E Digital Magnetic Tape Unit (PE) Cable Connection Points

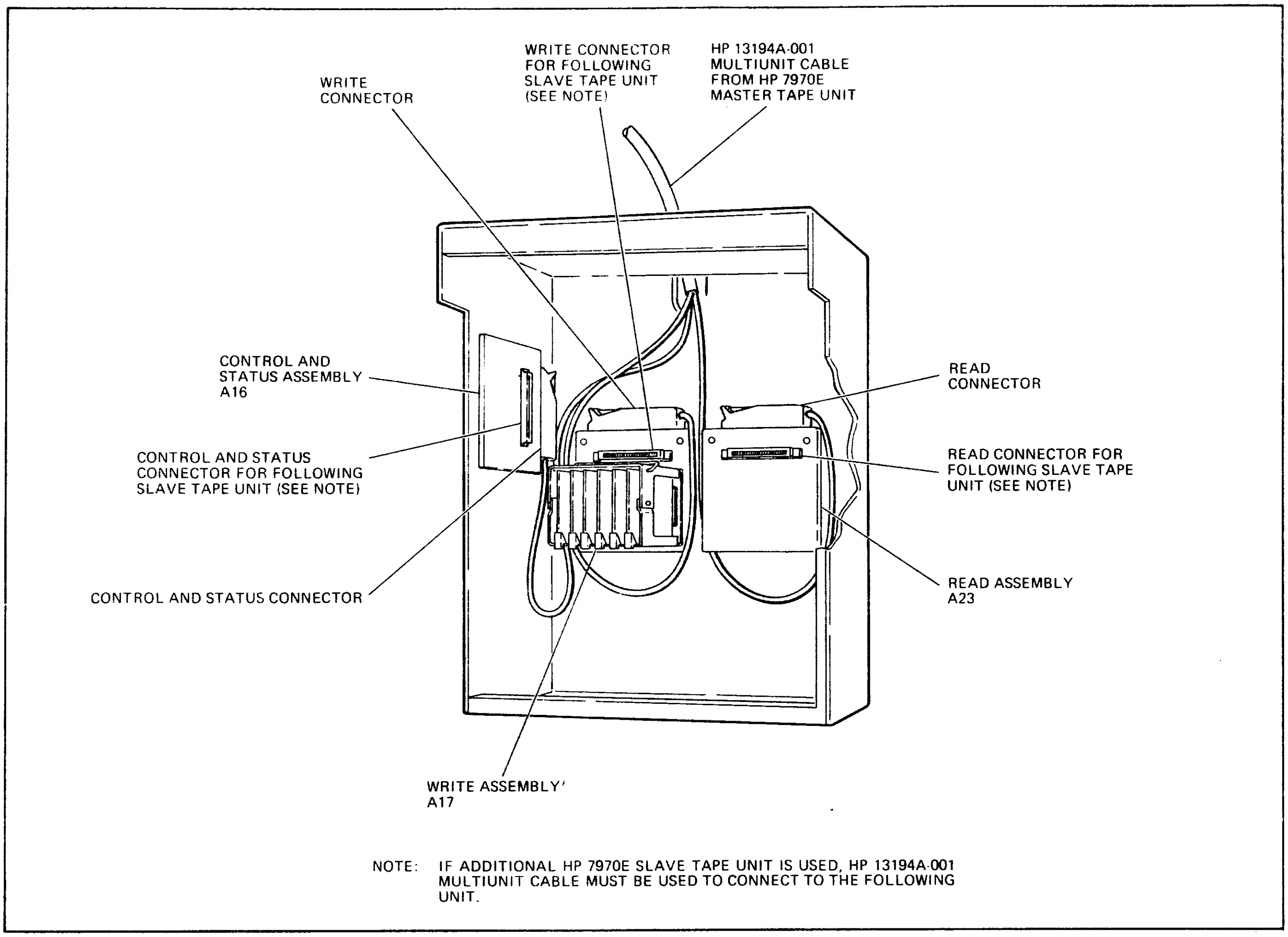

Figure 4-6. Slave HP 7970E Digital Magnetic Tape Unit (PE) Cable Connection Points

4-18. INTERFACE PCA POSITIONING AND CABLE CONNECTIONS. Figure 4-7 shows the normal position of the tape controller and controller processor printed-circuit assemblies in the system PCA cage. Ensure that these positions are maintained and cables connected as shown when performing preventive maintenance or troubleshooting procedures. The controller processor maintenance interface PCA may be installed in any vacant slot in the same PCA cage. The printed-circuit assemblies of the subsystem may be placed on extenders for maintenance and troubleshooting. When re-installing the subsystem printed-circuit assemblies, proceed as follows:

a. Pull the extractor handles on the printed-circuit assemblies to the straight-out position as shown in figure 4-7.

CAUTION

Ensure that the plastic extractor handles are moved to the straight-out position before sliding the printed-circuit assemblies into final position. Otherwise handles may be broken or the PCA may be cracked.

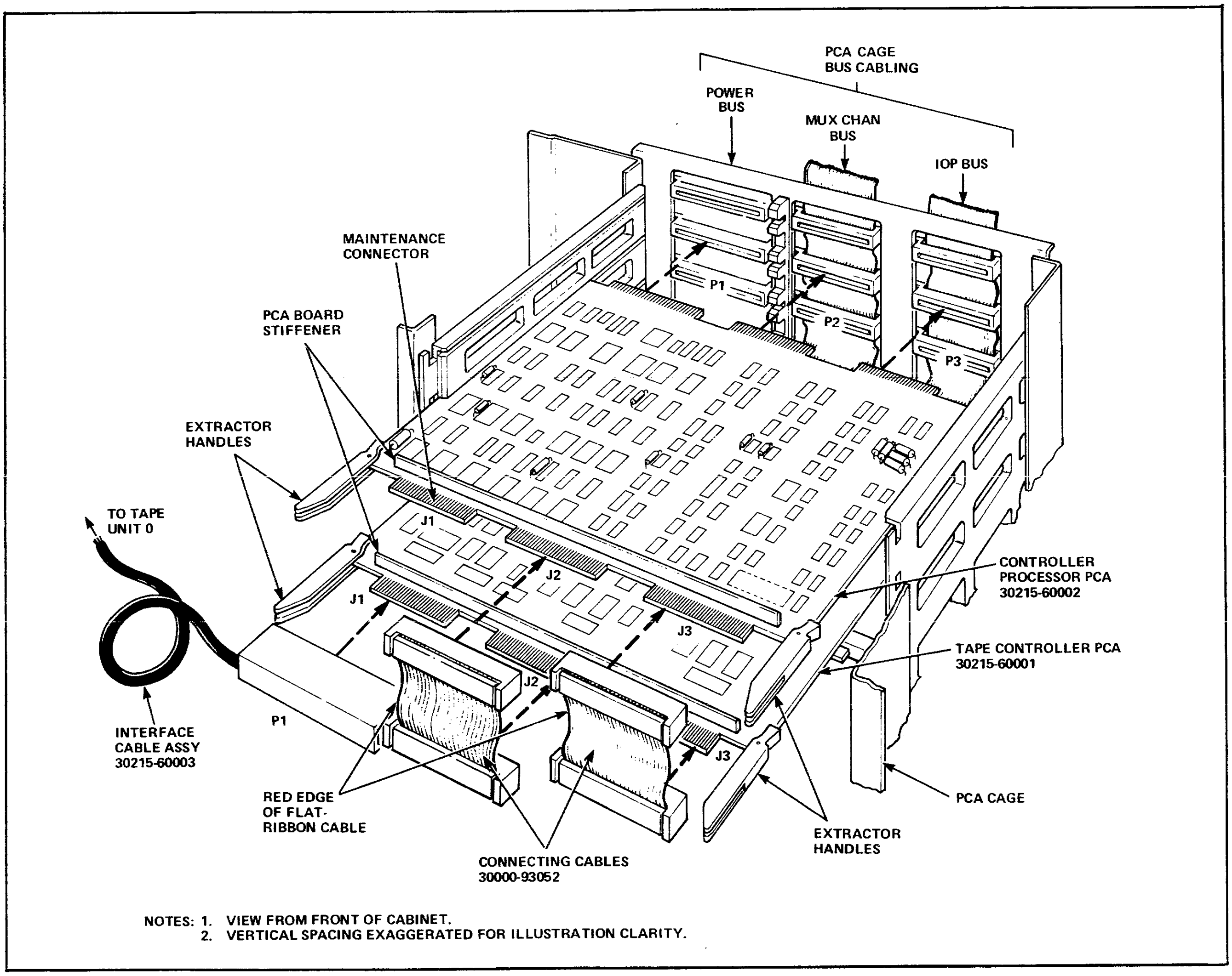

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Figure 4-7. HP 30215A Magnetic Tape Unit Interface PCA Position and Connect Details

b. Slide printed-circuit assemblies, component-side up, into two adjacent slots with the controller processor PCA in upper position.

CAUTION

Do not force or bend printed-circuit assemblies when re-installing. Slide straight in or damage to printed-circuit assemblies may result.

c. Lock extractor handles into slots on either side of PCA module.

4-19. TAPE CONTROLLER PCA JUMPERS. The four areas for jumper installation on the tape controller PCA are shown in figure 4-8. See table 4-1 for explanations of jumper use. Jumpers should be in place in required positions to be compatible with the existing HP 3000 Computer System addressing and interrupt structure. Refer to HP 3000 Computer System Configuration Package to ensure compatibility if it becomes necessary to move these jumpers for maintenance purposes. The multiplexer channel service request jumper should not be in the same position as that occupied by a multiplexer channel service request jumper of another subsystem served by the same multiplexer channel PCA. Device number jumpers should not be installed in the same positions occupied by device number jumpers of any other subsystem in this computer system.

Table 4-1. Tape Controller PCA Jumper Descriptions

JUMPER NAME	ASSIGNED DESIGNATION	DESCRIPTION
Multiplexer Channel Service Request	W1	Selects one of a possible 16 service request lines to the multiplexer channel PCA when installed.
Interrupt Mask Group	W2	Assigns the subsystem to an HP 3000 Computer System interrupt mask group when installed in positions 0 through 15, or enables subsystem response to all Set Mask commands when installed in the ENABLE position, or disables subsystem response to all Set Mask commands when installed in DISABLE position.
DRT Address Odd Parity	W3	Used with device number jumpers, explained below, to ensure odd parity of the bit pattern representing the DRT address that is transmitted on the IOP data bus to memory.

Table 4-1. Tape Controller PCA Jumper Descriptions (Continued)

JUMPER NAME	ASSIGNED DESIGNATION	DESCRIPTION
Device Number	W5 thru W11	Bit pattern generated by absence or presence of jumper connections corresponds to the subsystem device number or device interrupt number. Also used to generate the DRT address for this device. When all jumpers are removed the device is number 127 (177_8) in the device reference table. (Entry 123_{10} at address 774_8.) The device number jumpers and the odd parity jumper, explained previously, comprise a total of nine* jumper positions. There must be an *even* number of jumpers installed in these total available positions including W4 position to cause odd parity in memory. Each vacant jumper position causes logical 1 in the DRT address in memory. In the example shown in figure 4-8, note that jumpers W10(2^1) and W9(2^2) are removed. This identifies this subsystem as device number 6(6_8), fourth DRT entry, with the first of its four table entries located at address 30_8.

*W4 position is designated Direct Command Flag. Use W5 as most significant bit.

4-20. CONTROLLER PROCESSOR PCA CRYSTAL LOCATION. The 9.216-MHz crystal for nine track magnetic tape subsystem operation at 45 ips (114 cm/sec) is located as shown in figure 4-9. Installation of maintenance equipment makes it possible to override control established by the normal crystal oscillator. Ensure the proper crystal is installed if it is removed for any reason during maintenance.

4-21. PREVENTIVE MAINTENANCE.

4-22. Paragraph 4-23 provides scheduling information for preventive maintenance. Paragraph 4-25 outlines applicable routines.

4-23. SCHEDULED ITEMS.

4-24. Section III in part one of the tape unit operating and service manual contains schedules and procedures to be used for the tape unit(s). Insofar as possible preventive maintenance schedules for the subsystem should coincide with HP 3000 Computer System schedules. Preventive maintenance procedures for the HP 30215A Magnetic Tape Unit Interface printed-circuit assemblies should be performed at the same time that tape unit preventive maintenance is accomplished.

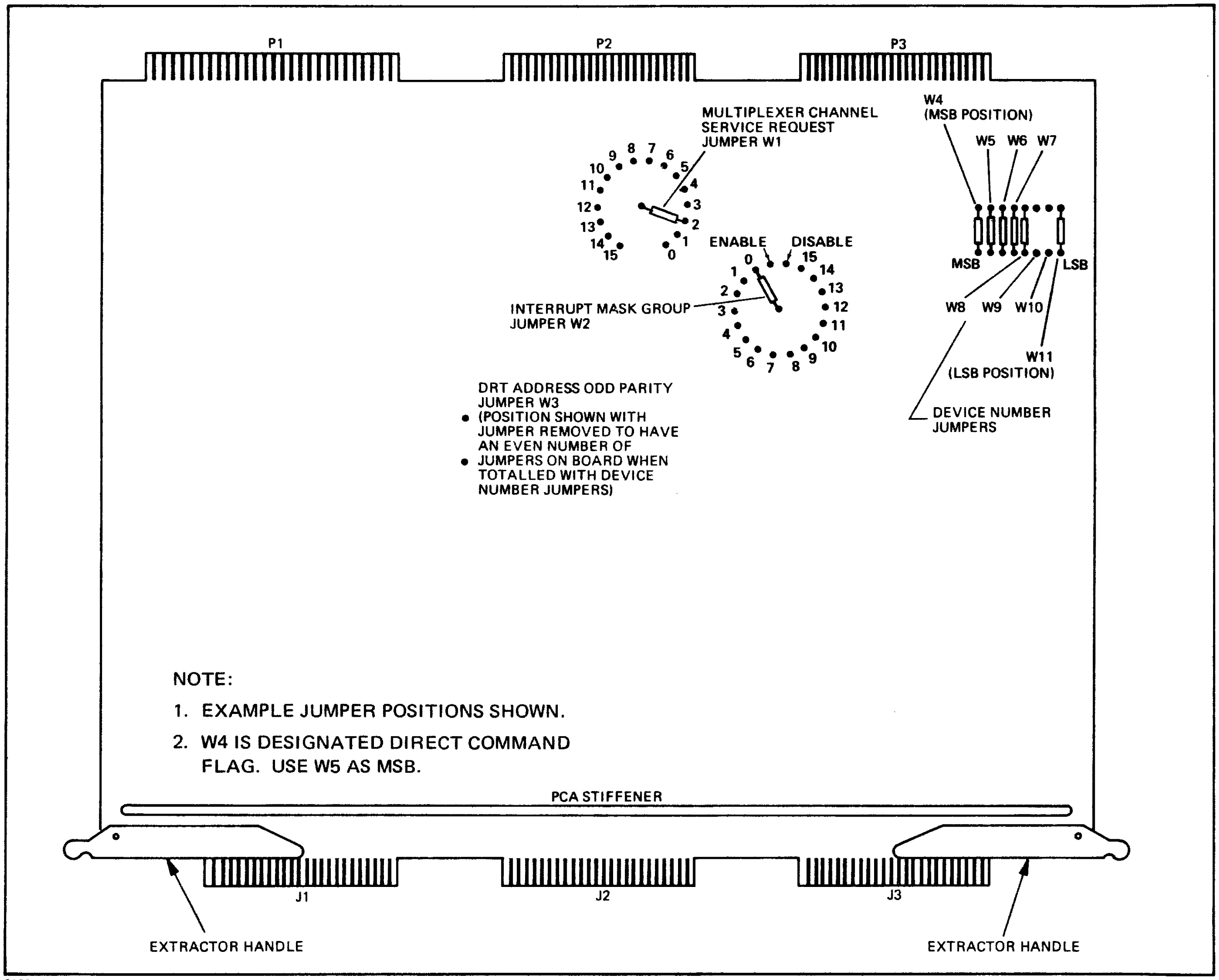

Figure 4-8. Tape Controller PCA, Jumper Locations

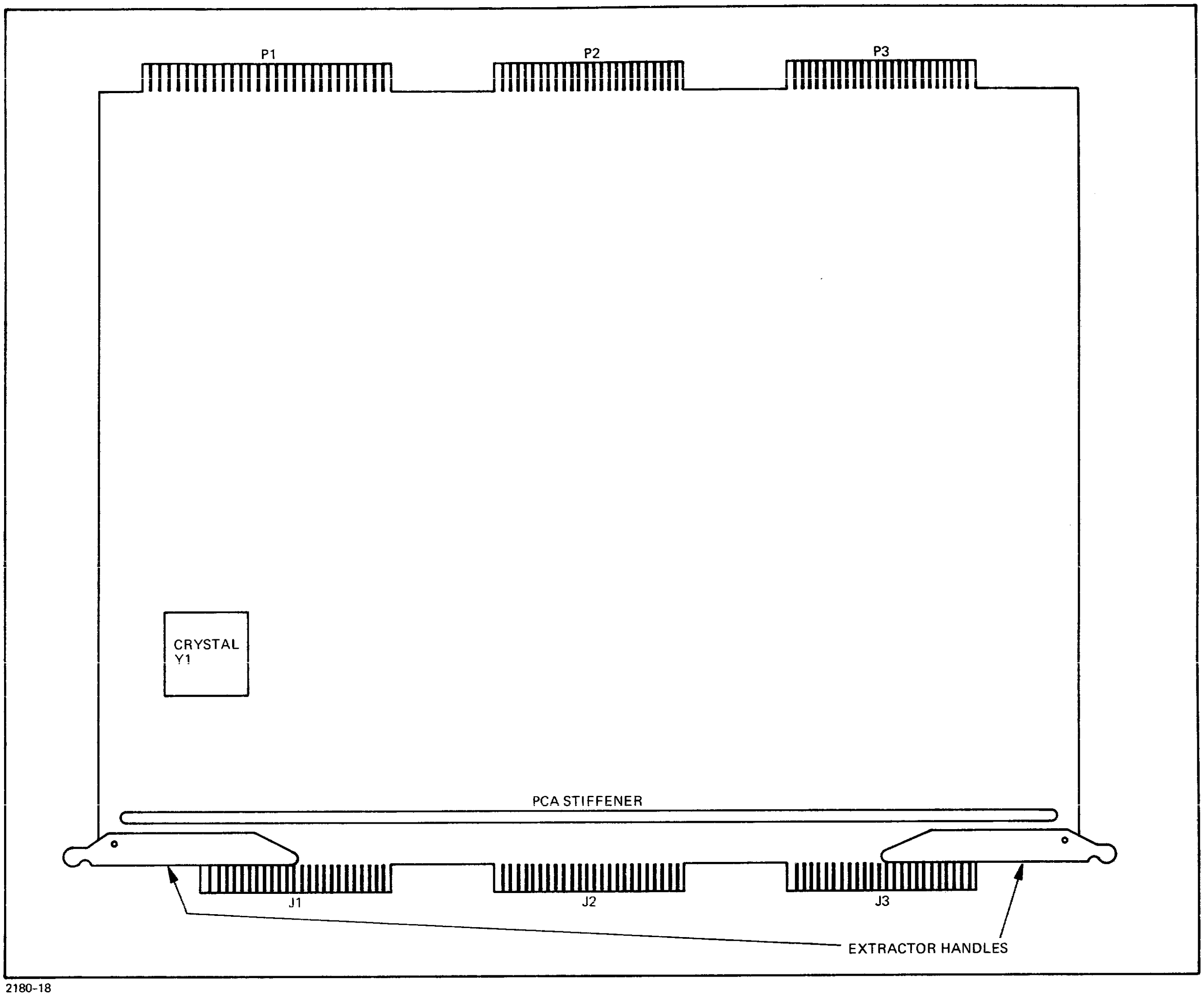

Figure 4-9. Controller Processor PCA, Crystal Location

4-25. SERVICING ROUTINES.

4-26. Preventive maintenance for the HP 30215A Magnetic Tape Unit Interface printed-circuit assemblies includes keeping them clean. Ensure that scraps of wire or other metal, accidently dropped when other maintenance has been performed in the PCA, do not remain on either PCA. Ensure that interface cables, and cables between the PCA's are not subjected to excessive bending or wear, particularly at the connectors.

4-27. Tapes remaining stationary at the load point for considerable lengths of time when the tape unit is running may slip in one spot due to accumulation of tape lubricant on the capstan. To prevent this, keep the tape unit capstan clean in accordance with procedures outlined in the tape unit operating and service manual. It may also help to periodically change the position of the BOT reflective marker.

4-28. TROUBLESHOOTING.

4-29. The troubleshooting philosophy for the HP 30115A Magnetic Tape Subsystem is as follows:

a. Ensure that the recording difficulties are not caused by a defective or worn magnetic tape.

b. If it is available, check the system log for any past history occurrance of similar difficulty and any pertinent operator's comments.

c. Analyze any results obtained from the on-line SDM test, part no. 30115-90003 in the HP 3000 Manual of On-Line Diagnostics.

d. Run the microdiagnostics, described in the microdiagnostic program listings for the magnetic tape subsystem, and analyze the results.

e. Use the information contained in this section to isolate the fault to a portion of the hardware, then to a replaceable component. Microdiagnostics should be used to at least isolate the fault to a PCA, cables, or to the tape unit. See the tape unit operating and service manual for further trouble-isolation procedures in that unit.

4-30. The remaining portion of this paragraph contains the reference information and test and analysis procedures needed to troubleshoot the overall HP 30115A Magnetic Tape Subsystem and the HP 30215A Magnetic Tape Unit Interface assemblies in particular.

4-31. REFERENCE INFORMATION.

4-32. The following reference information is needed to troubleshoot the subsystem in addition to on-line diagnostic and micro-diagnostic information.

a. Logic diagrams.

b. Connecting cable and PCA pin/signal information.

c. The microprogram listing and flowcharts.

d. Timing diagrams of subsystem operation.

e. Integrated circuit pack information.

4-33. Simplified Diagrams for the magnetic tape subsystem printed-circuit assemblies are contained in set number SD-163, part no. 30115-90002, of the *HP 3000 Computer System Simplified Diagrams Manual.* Detailed logic diagrams are contained in set numbers DD-607 and DD-608, part no.'s 30215-90001 and 30215-90003 of the *HP 3000 Computer System Detailed Diagrams Manual.* The detailed diagrams manual also contains diagrams for integrated-circuit packs and part location data. Parts information for servicing and replacement, after trouble isolation, is contained in the *HP 3000 Computer System Illustrated Parts Breakdown Manual (IPB).* As previously mentioned troubleshooting procedures for the HP 7970B Digital Magnetic Tape Unit will be found in operating and service manual part no. 07970-90383. Troubleshooting procedures for master and slave HP 7970E Digital Magnetic Tape Units will be found in operating and service manual part no. 07970-90765.

4-34. TEST PROCEDURES.

4-35. On-line diagnostics, run by the System Diagnostic Monitor (SDM), and microdiagnostics are the means employed for troubleshooting the magnetic tape subsystem. There are no stand-alone diagnostics for this subsystem. Procedures used for running the Controller Processor microdiagnostics are all included in the I/O microprocessor microdiagnostic program listings. Maintenance setup instructions for the equipment listed in paragraph 4-10 are included in *Operator's Manual, 30350A Auxiliary Control Panel and 30352A Hardware Maintenance Panel,* part no. 30352-90001. A cold dump of the HP 3000 Computer System must precede use of the microdiagnostics. Refer to software operating procedures and also see that cold dump summary in section II of this manual. After tests have been run, refer to trouble analysis information in paragraph 4-36.

4-36. TROUBLE ANALYSIS.

4-37. All mechanical and electrical functions of the subsystem should be checked under dynamic conditions were possible. Repair personnel must be able to recognize normal subsystem operation through the use of software routines and previous sections of this and the tape unit manual. With this background, malfunctions can be recognized and the trouble isolated to a function using the microdiagnostics in conjunction with the on-line diagnostics. The results of on-line and microdiagnostic tests should prove conclusively to repair personnel whether or not the subsystem is operating properly for data transfer modes and whether or not it is responding to all motion commands.

4-38. Analyze message printouts and the results of tests accomplished using the maintenance panels. If the subsystem will operate properly in diagnostic modes but will not perform correctly in normal operation, the ROM integrated-circuit packs holding the subsystem microprogram may have developed a fault. See the servicing data microprogram listing and flowcharts in the following paragraph. Status register integrated circuits U166 and U167 should be used in conjunction with appropriate sections of the microdiagnostic and status data in section II to isolate malfunctions. Do not overlook the interface cable and card connectors as a source of trouble. Troubleshooting usually requires that the PCA under test be placed on a PCA extender. Ensure that the extender is in good condition and supported from the PCA cage. Also ensure that a good maintenance interface PCA is being used. Refer to the servicing data included under paragraph 4-39 for pin and signal information.

4-39. SERVICING DATA.

4-40. The data listed below is included as an aid in isolating HP 30115A Magnetic Tape Subsystem faults. This data is also reference from other sections of the manual.

a. Flowchart conventions, figure 4-9A.

b. Table of flowchart conventions, table 4-1A.

c. Microprogram flowcharts, figure 4-10.

d. Consolidated microcoding sheet, figure 4-11.

e. Microprogram Address-to-Label Index, table 4-2.

f. Microprogram Label, Flowchart, Address, Subroutine Index, table 4-3.

g. Microprogram listing, table 4-4.

h. Timing diagrams, figures 4-12 through 4-14.

i. Connector pin/signal tables, tables 4-5 through 4-8.

j. Pin indexing information, figure 4-15.

4-41. Descriptive instructions for the microcoding information are included in section III. See paragraph 4-31 for additional data. Wiring information for cables is included in the repair paragraph.

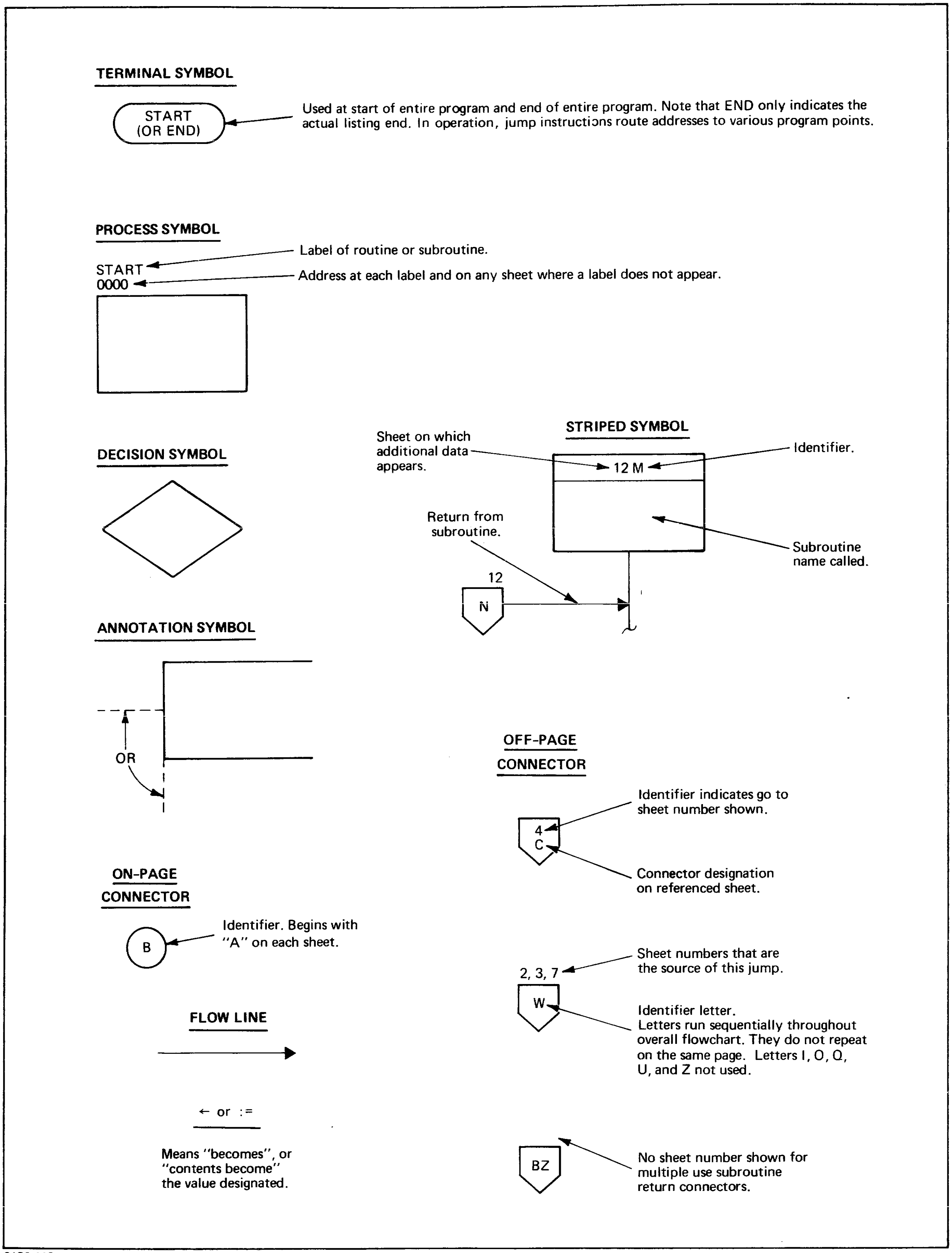

Figure 4-9A. Symbol Conventions Used in Flowcharts

Table 4-1A. Flow Chart Definitions and Conventions

ITEM	CHARACTERISTIC
	DEFINITIONS
AUX	Auxiliary.
CLK	Clock.
CMD	Command. See section II for a list of commands and definitions.
CNTR	Controller Processor counter.
Controller	The interface (PCAs).
CRCC	Cyclic Redundancy Check Character.
CRCR	Cyclic Redundancy Check Register.
DEC	Decrement the value stored in the counter by a count of one.
DSR	Device Service Request (FF).
ENB	Enable.
EOB	End of Block.
FF	Flip-Flop.
File Mark	Synonomous with tape mark. See section II for characteristics.
FLG (F0) thru F17)	Flags input to the Controller Processor. See listing for definitions.
FWD	Forward.
INT	Interrupt.
Lower Byte	MIO bus bits 8 through 15.
LRCC	Longitudinal Redundancy Check Character.
PAR	Parity.
RCS	Reverse Condition Sense (complement).
RD	Read.
RDBKD	Read reverse subgroup commands.
RDFWD	Read forward subgroup commands.
REV	Reverse.
REW	Rewind.

Table 4-1A. Flowchart Definitions and Conventions (Continued)

ITEM	CHARACTERISTIC
DEFINITIONS (Cont.)	
RG0 thru RG5	Controller Processor registers.
Tape Mark	Synonomous with File Mark. Tape Mark is generally used in this manual. See section II for characteristics.
Upper Byte	MIO bus bits 0 through 7.
WRFWD	Write forward subgroup commands.
WRT	Write.
XFER	Transfer.
x:y	x through y (i.e. bits 12:15 or bits 0:7 (upper byte).
000012_8	Octal values of constants entered in the counter or register (full word).
037_8	Octal value of constant entered in a register. In this case upper of lower byte must be specified.
CONVENTIONS	
Address	Octal addresses appear at all labels. Addresses are also shown at the top of flowchart columns to avoid confusion when no label appears on the sheet. Addresses are also shown on the flowchart where operations depicted occurs at any address that is not sequential to the last operation.
Annotations	Abbreviated decision information is generally amplified on one of the decision legs with the name of the flag, flip-flop, or use of F0, F1, or F2 for the particular decision. Off-page connectors are annotated with the label name of the jump location.
Clearing	An "XOR" of register 3 (RG3) on the A and B buses is used frequently to clear registers and/or the counter. When RG3 is "XOR'd" with itself the bits will be a pattern match thus, logical 0's will be loaded in the target register.
Connectors	Generally, off-page and on-page connectors are shown with the connectors to the right or bottom of the flow for exits. Entry points and returns to the flow are shown with connectors to the top or left.
Micro-instructions	Twenty one of the Controller Processor microinstructions are used for the nine-track magnetic tape microprogram. They are: ADD, ADI, AND, ANI, JFS, JMP, JMZ, JOV, OTI, PSA, PSB, PSI

Table 4-1A. Flowchart Definitions and Conventions (Continued)

<table>
<tr><th>ITEM</th><th>CHARACTERISTIC</th></tr>
<tr><td colspan="2">CONVENTIONS (Cont.)</td></tr>
<tr><td>Micro-instructions (Cont.)</td><td>
<table>
<tr><td>CAL</td><td>JSZ</td><td>RTN</td></tr>
<tr><td>IOC</td><td>JXZ</td><td>XOI</td></tr>
<tr><td>IOI*</td><td>NOP</td><td>XOR</td></tr>
</table>
*The IOI is not a true "inclusive OR" operation. The quantities called are actually "OR'ed" only.
e.g.
<table>
<tr><th></th><th></th><th>OR</th><th>IOR</th></tr>
<tr><td>A</td><td>B</td><td>X</td><td>X</td></tr>
<tr><td>0</td><td>0</td><td>0</td><td>1</td></tr>
<tr><td>0</td><td>1</td><td>1</td><td>0</td></tr>
<tr><td>1</td><td>0</td><td>1</td><td>0</td></tr>
<tr><td>1</td><td>1</td><td>1</td><td>1</td></tr>
</table>
</td></tr>
<tr><td>Operations</td><td>In general, the use of the word "get" in the flowcharts, means an external action to the Controller Processor. "Put" means an internal operation with the immediate operand or the registers.</td></tr>
<tr><td>Output</td><td>An OTI microinstruction with an immediate operand of 377_8 indicates that only the destination code is used to control magnetic tape controller PCA logic. The octal value of the immediate operand is the complement of the actual binary pattern (i.e. $\overline{377_8} = 000_8$).</td></tr>
<tr><td>Status</td><td>The internal status word (obtained from the AUX Status gates) appears on the MIO bus upper byte in the following format:
<table>
<tr><td>M0</td><td>$\overline{\text{IDB}}$ (1600 cpi)</td></tr>
<tr><td>M1</td><td>$\overline{\text{TM}}$ (1600 cpi)</td></tr>
<tr><td>M2</td><td>$\overline{\text{MTE}}$ or $\overline{\text{STE}}$ (1600 cpi)</td></tr>
<tr><td>M3</td><td>INT ACTIVE or Interrupt Request</td></tr>
<tr><td>M4</td><td>$\overline{\text{SIO OK}}$</td></tr>
<tr><td>M5</td><td>$\overline{\text{SFP}}$ (File Protect Status)</td></tr>
<tr><td>M6 and M7</td><td>(Tied low)</td></tr>
</table>
</td></tr>
<tr><td>Timing Functions</td><td>In the nine-track magnetic tape microprogram, the JXZ (Jump if the counter is zero) is always used with RCS. That is "Jump if the counter is not zero."

Timing for any constant loaded into the counter (CNTR) may be calculated from information in the flowcharts since the octal value of the entire counter entry is always stated. The upper or lower byte need not be considered. The procedure is as follows:</td></tr>
</table>

Table 4-1A. Flowchart Definitions and Conventions (Continued)

ITEM	CHARACTERISTIC
CONVENTIONS (Cont.)	
Timing Functions (Cont.)	a. Using the counter place value positions (shown below) calculate the number of cycles the counter must decrement. For example, if the value 000615_8 is shown to be loaded in the counter, total cycles to decrement equals 397.

BITS	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
COUNTER VALUES	32,768	16,384	8192	4096	2048	1024	512	256	128	64	32	16	8	4	2	1
VALUE LOADED (000615_8)	0	0	0	0	0	0	0	1	1	0	0	0	1	1	0	1

b. The product of total cycles and the cycle time for the Magnetic Tape Subsystem Controller Processor equals total time delay. For example, 397 cycles x 434 nanoseconds = 172.298 or 172 microseconds.

c. Note, in timing considerations, that 64 (100_8) controller processor instruction times equal one 800 cpi character time.

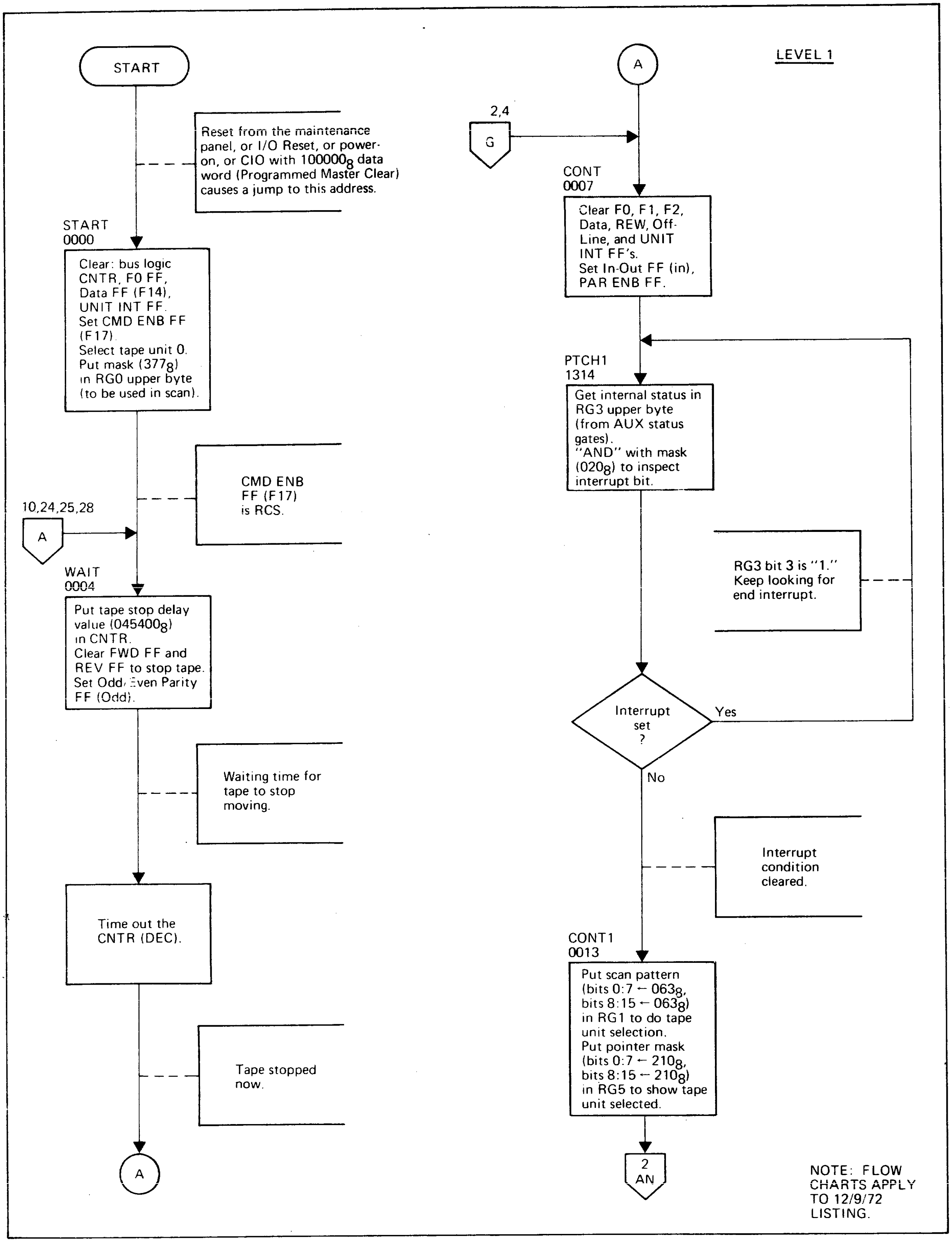

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Figure 4-10. Magnetic Tape Subsystem Microprogram Flowcharts (Sheet 1 of 58)

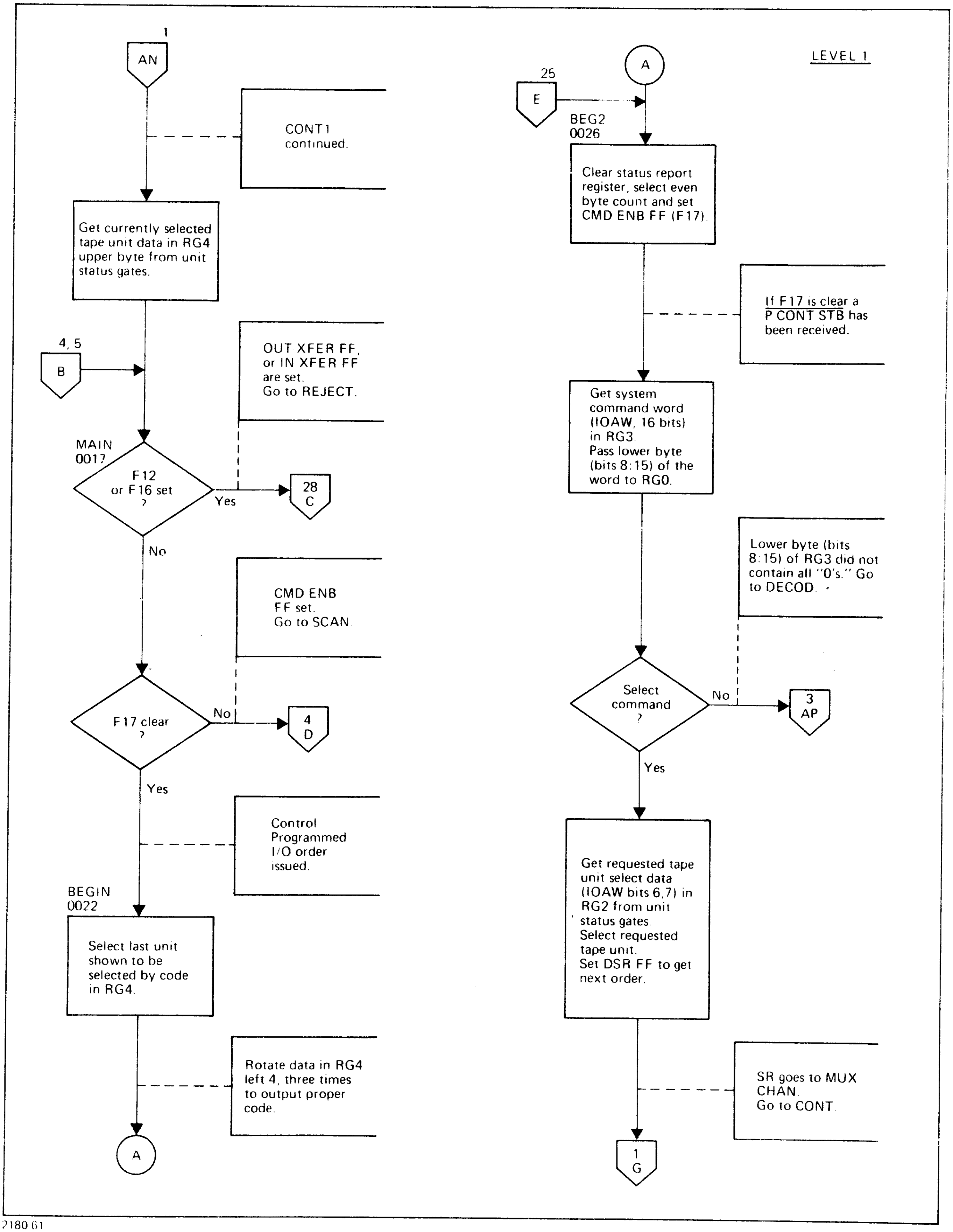

Figure 4-10. Magnetic Tape Subsystem Microprogram Flowcharts (Sheet 2 of 58)

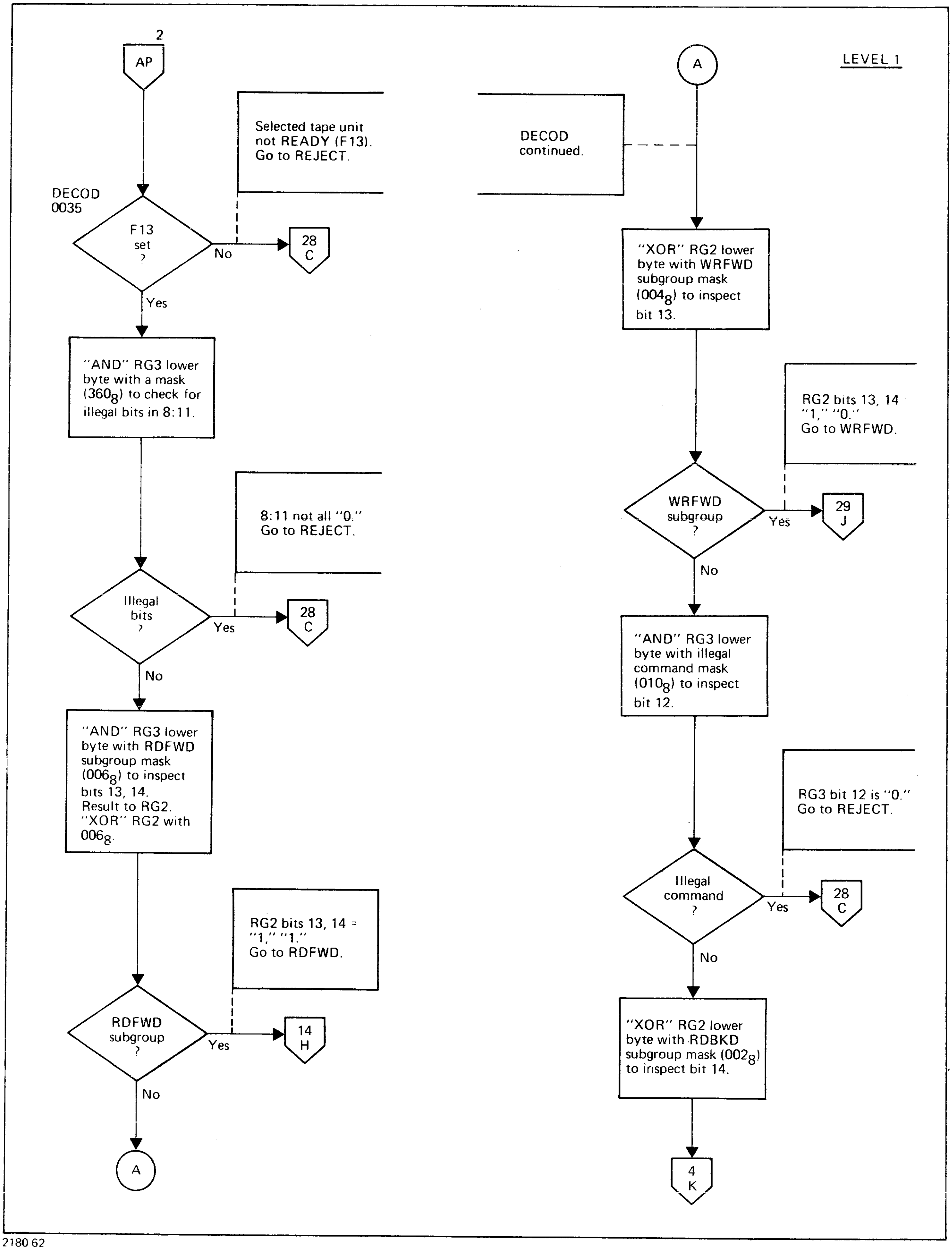

Figure 4-10. Magnetic Tape Subsystem Microprogram Flowcharts (Sheet 3 of 58)

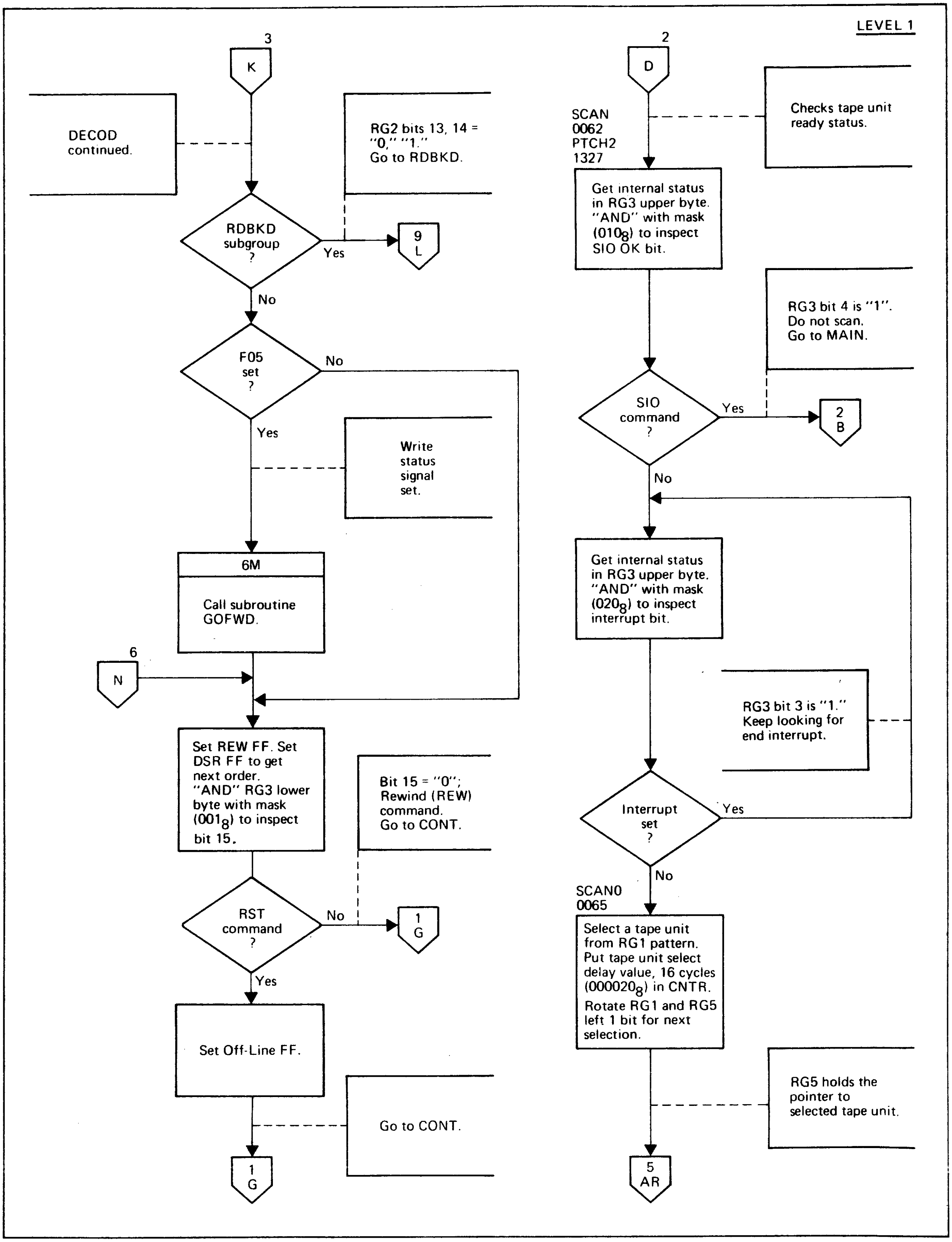

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Figure 4-10. Magnetic Tape Subsystem Microprogram Flowcharts (Sheet 4 of 58)

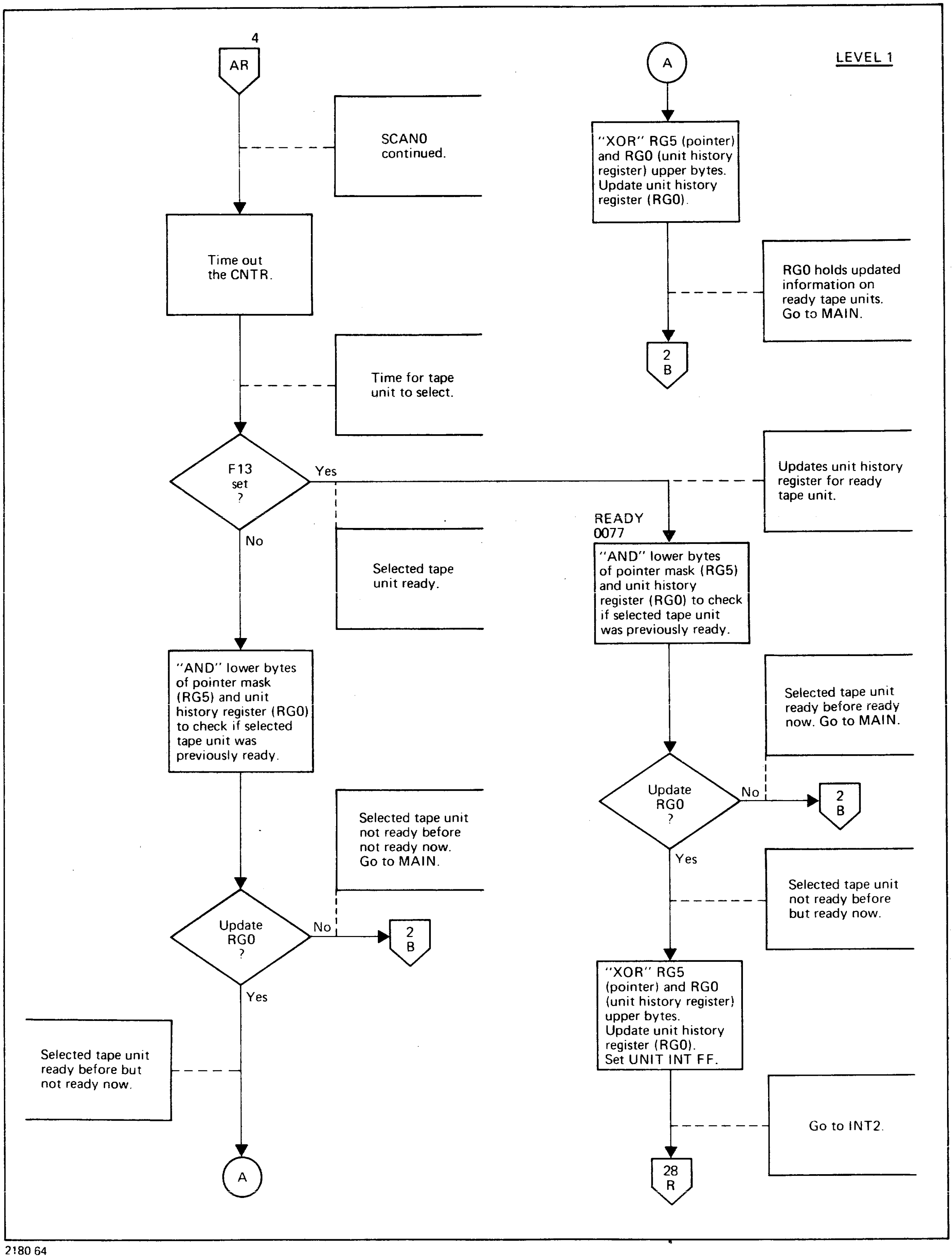

Figure 4-10. Magnetic Tape Subsystem Microprogram Flowcharts (Sheet 5 of 58)

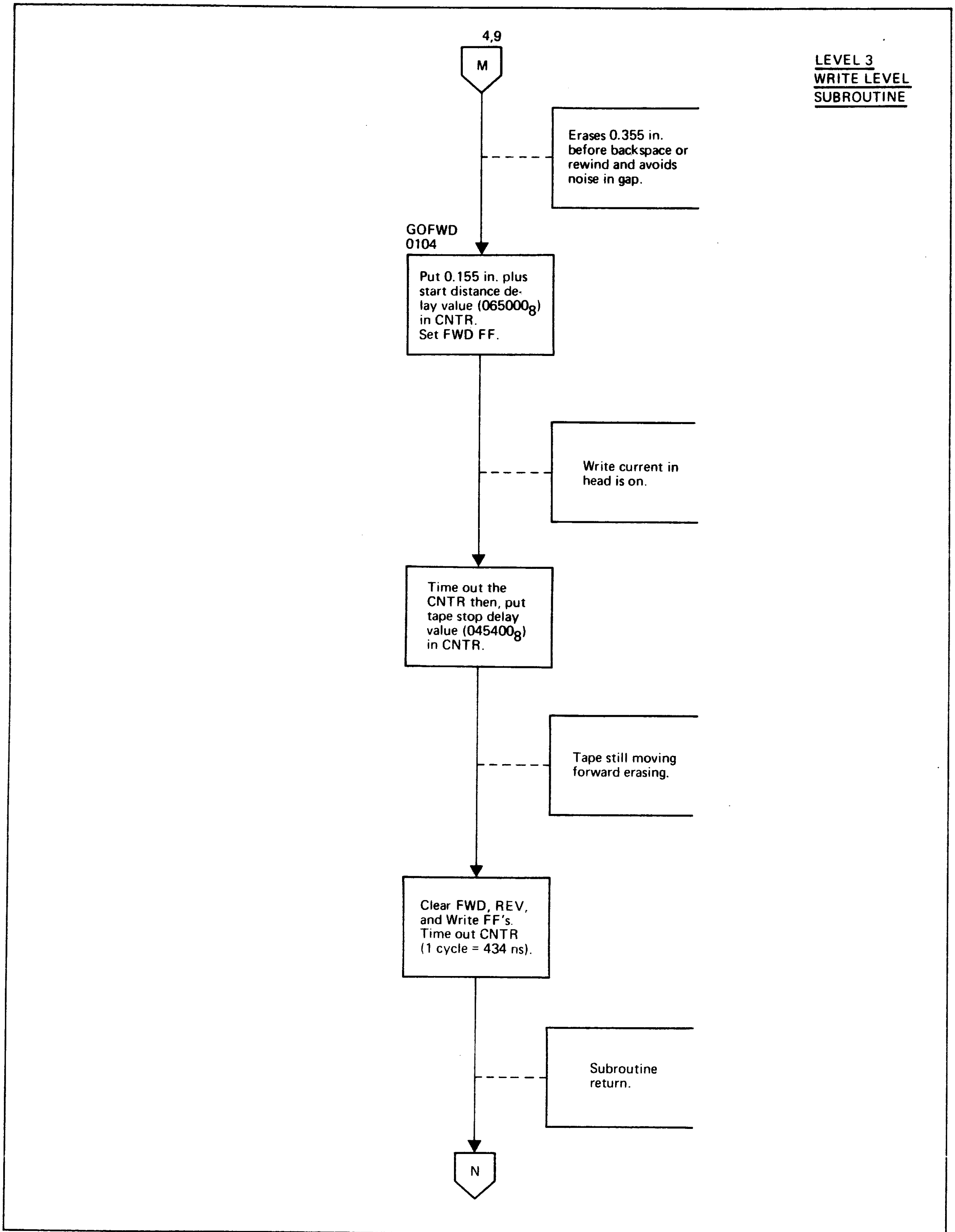

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Figure 4-10. Magnetic Tape Subsystem Microprogram Flowcharts (Sheet 6 of 58)

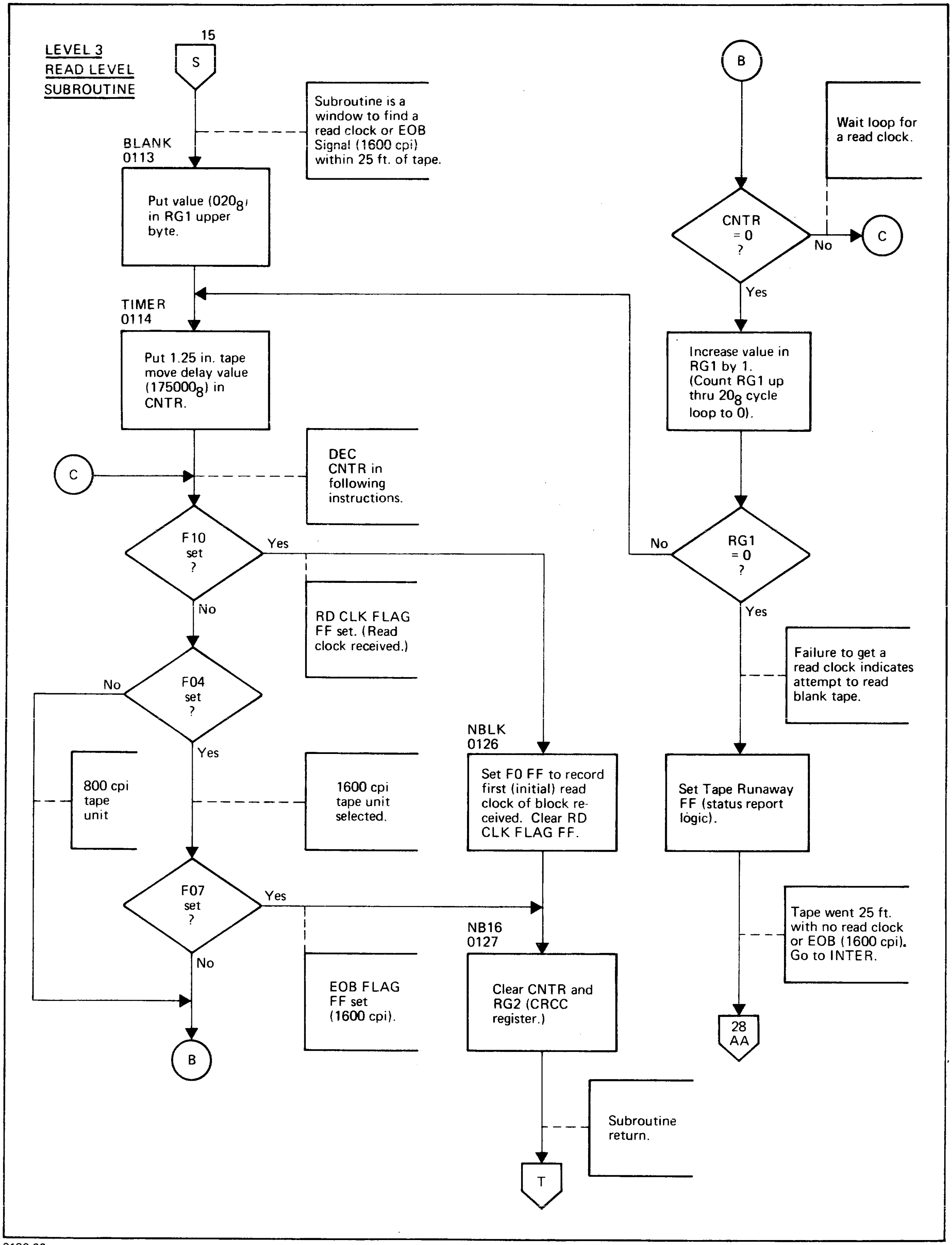

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Figure 4-10. Magnetic Tape Subsystem Microprogram Flowcharts (Sheet 7 of 58)

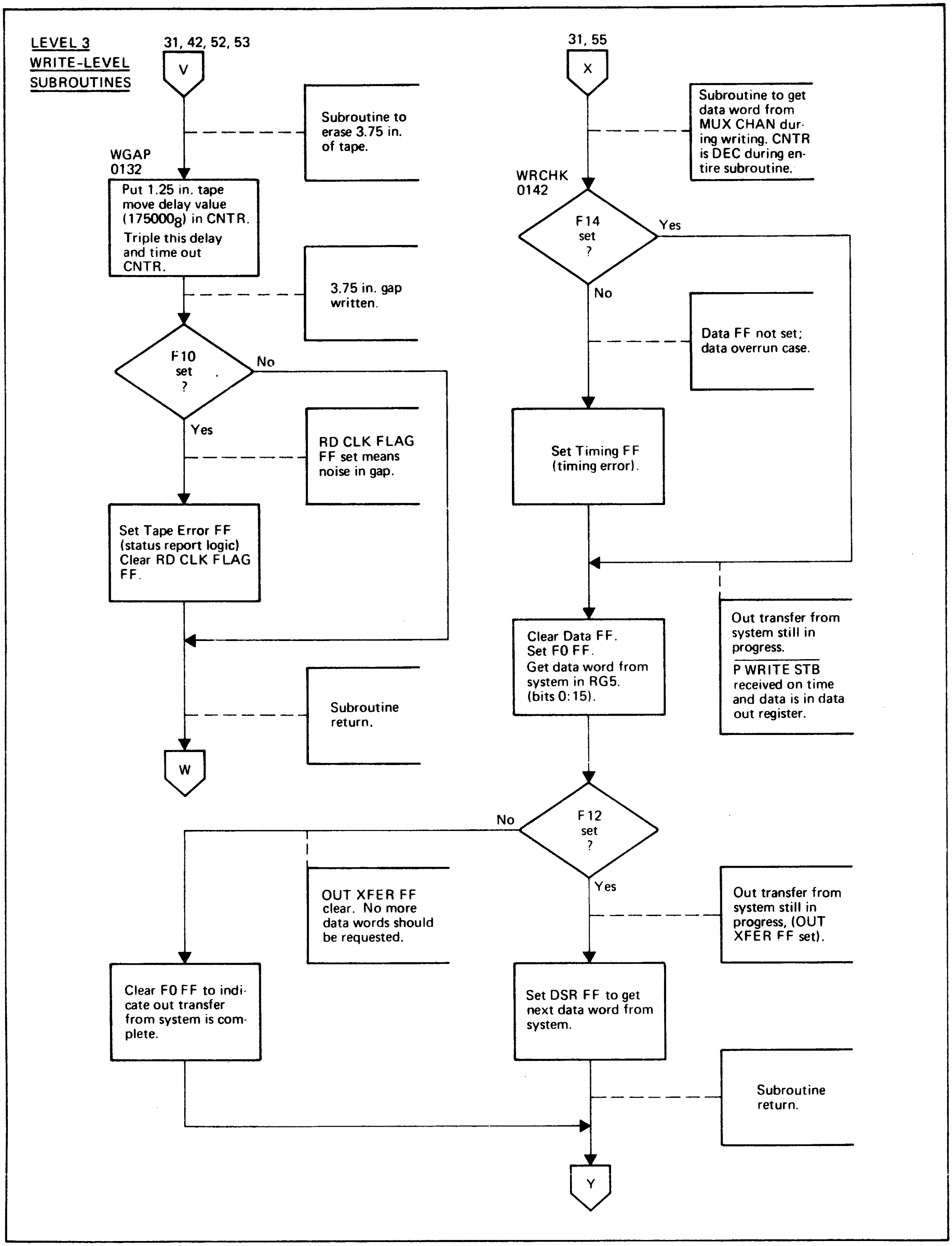

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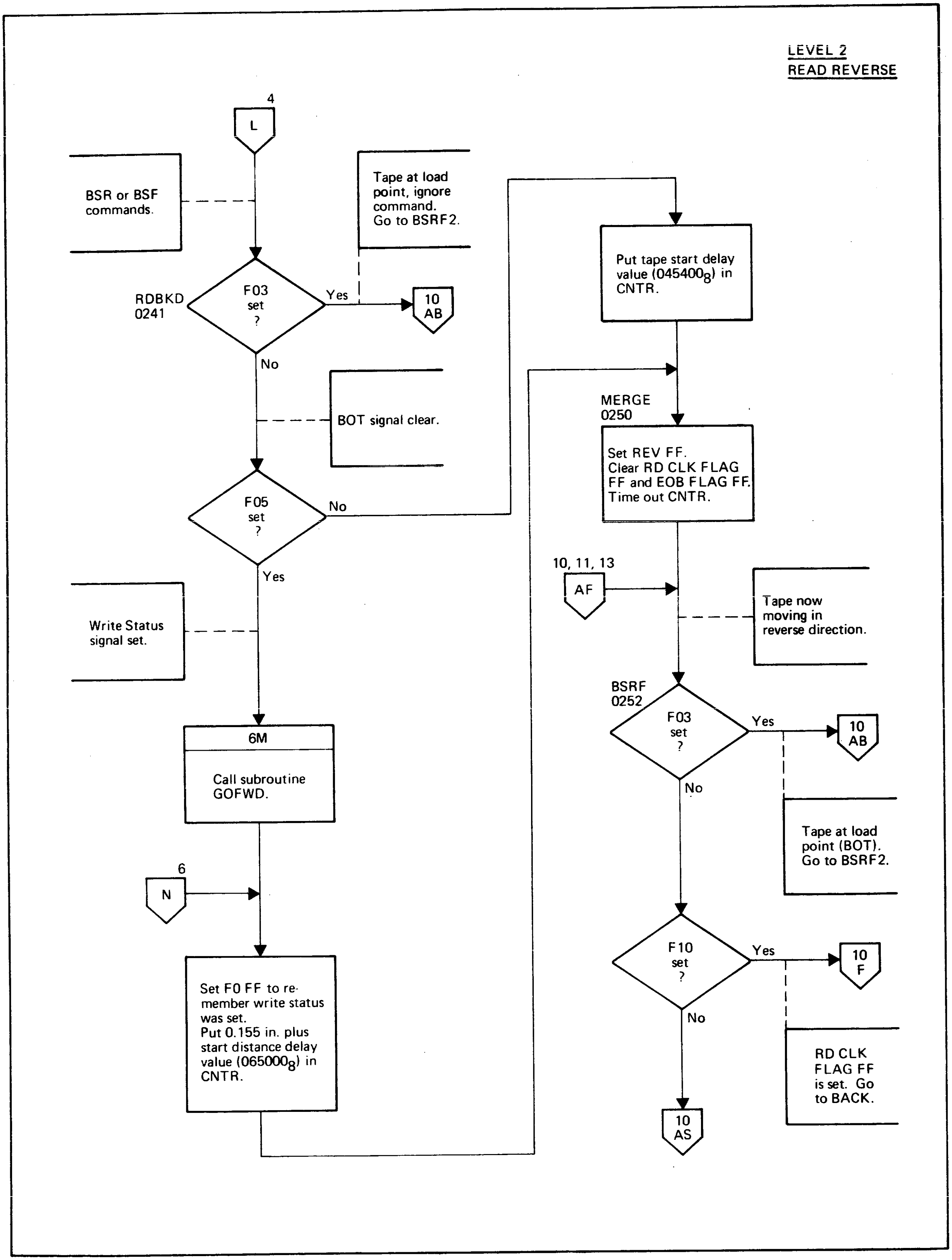
Figure 4-10. Magnetic Tape Subsystem Microprogram Flowcharts (Sheet 8 of 58)



2186-68

Figure 4-10. Magnetic Tape Subsystem Microprogram Flowcharts (Sheet 9 of 58)

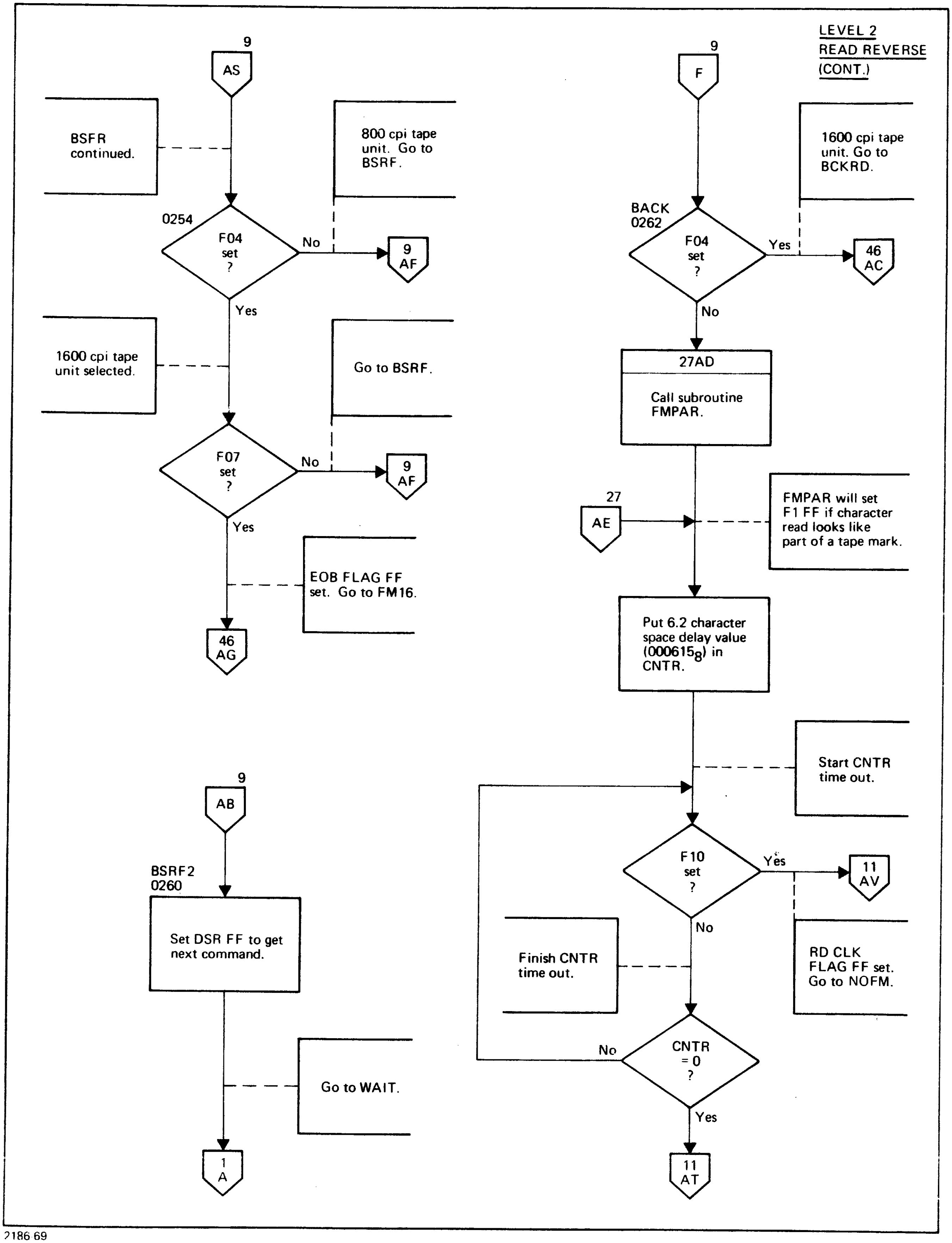


Figure 4-10. Magnetic Tape Subsystem Microprogram Flowcharts (Sheet 10 of 58)

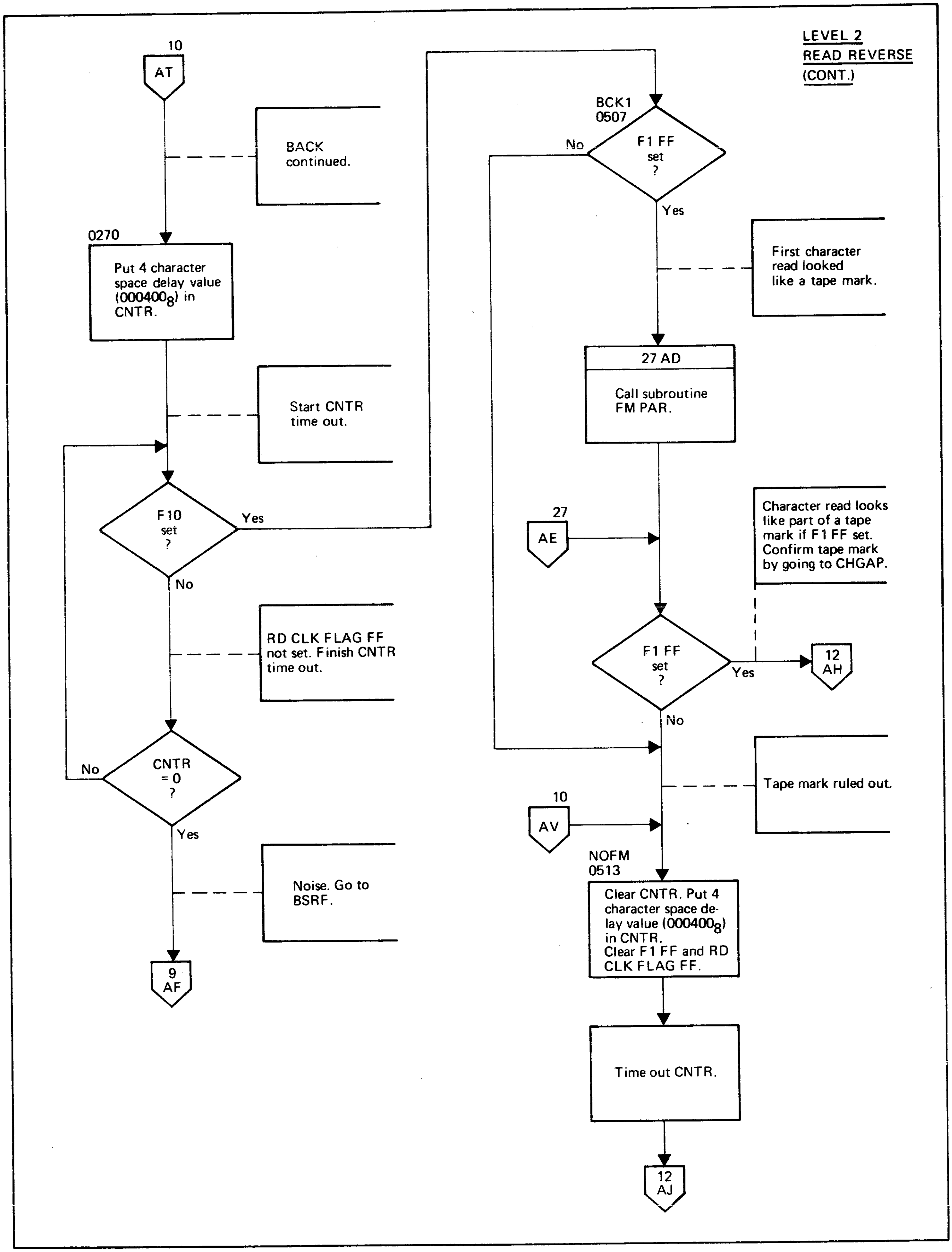


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Figure 4-10. Magnetic Tape Subsystem Microprogram Flowcharts (Sheet 11 of 58)

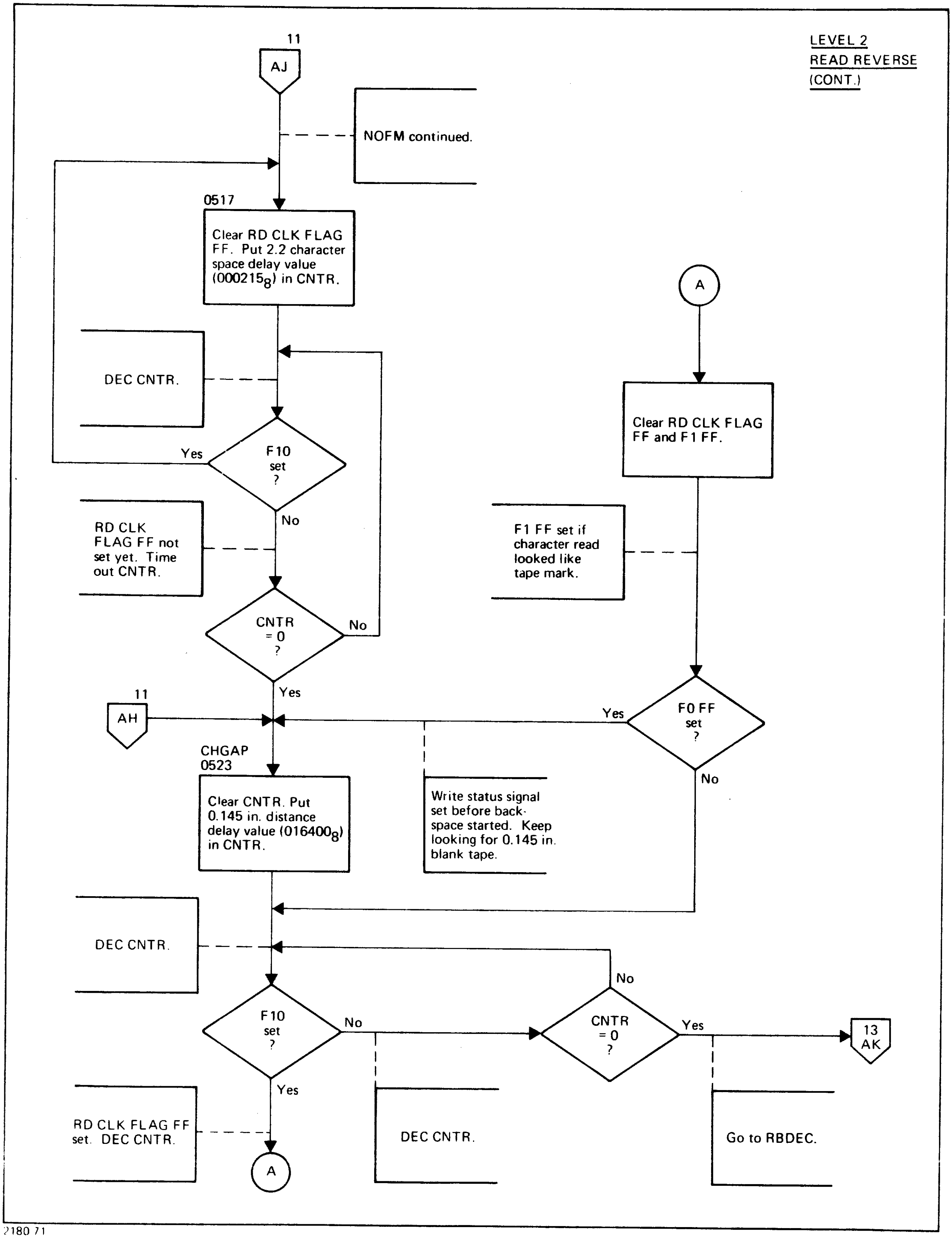
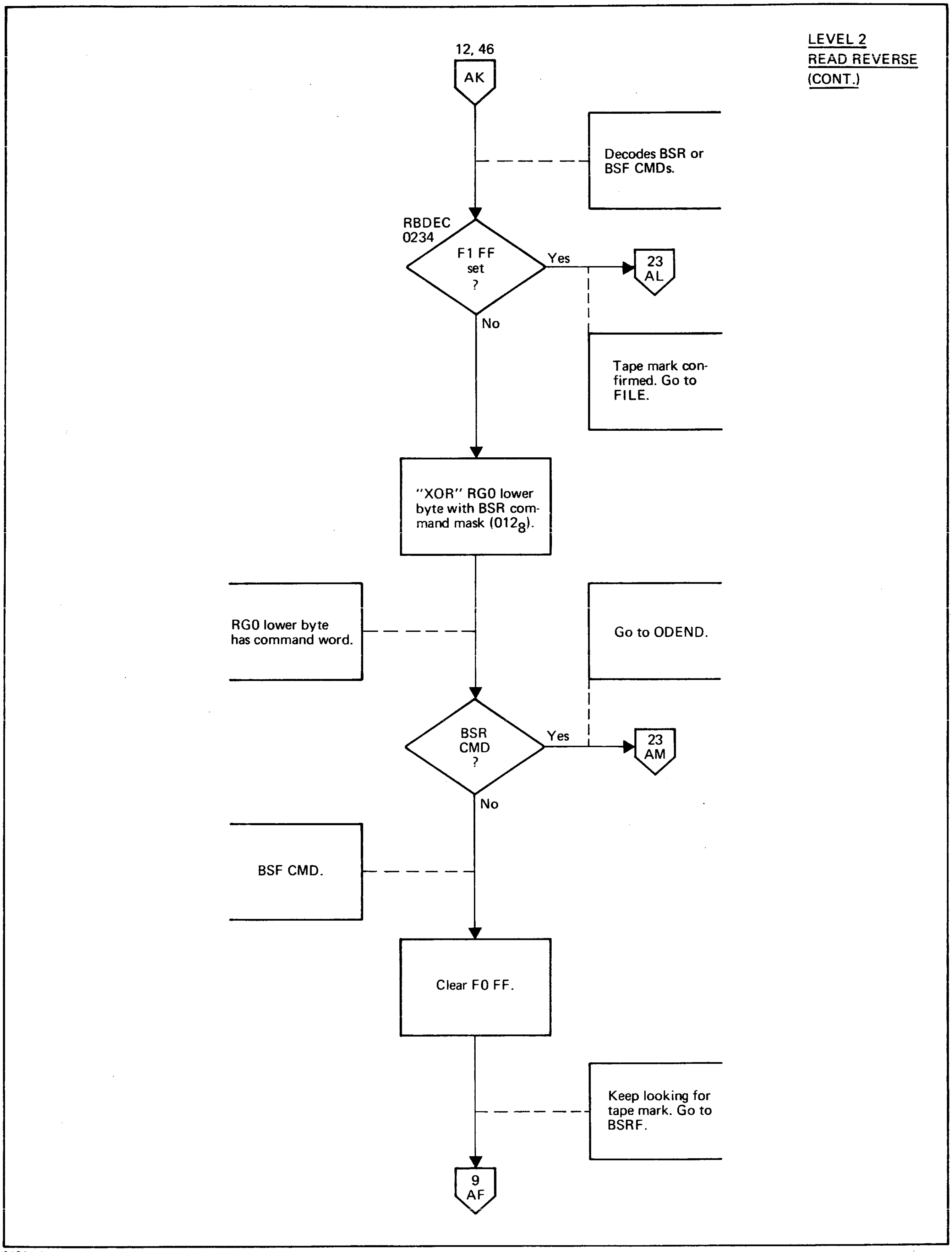


Figure 4-10. Magnetic Tape Subsystem Microprogram Flowcharts (Sheet 12 of 58)



2180-72

Figure 4-10. Magnetic Tape Subsystem Microprogram Flowcharts (Sheet 13 of 58)

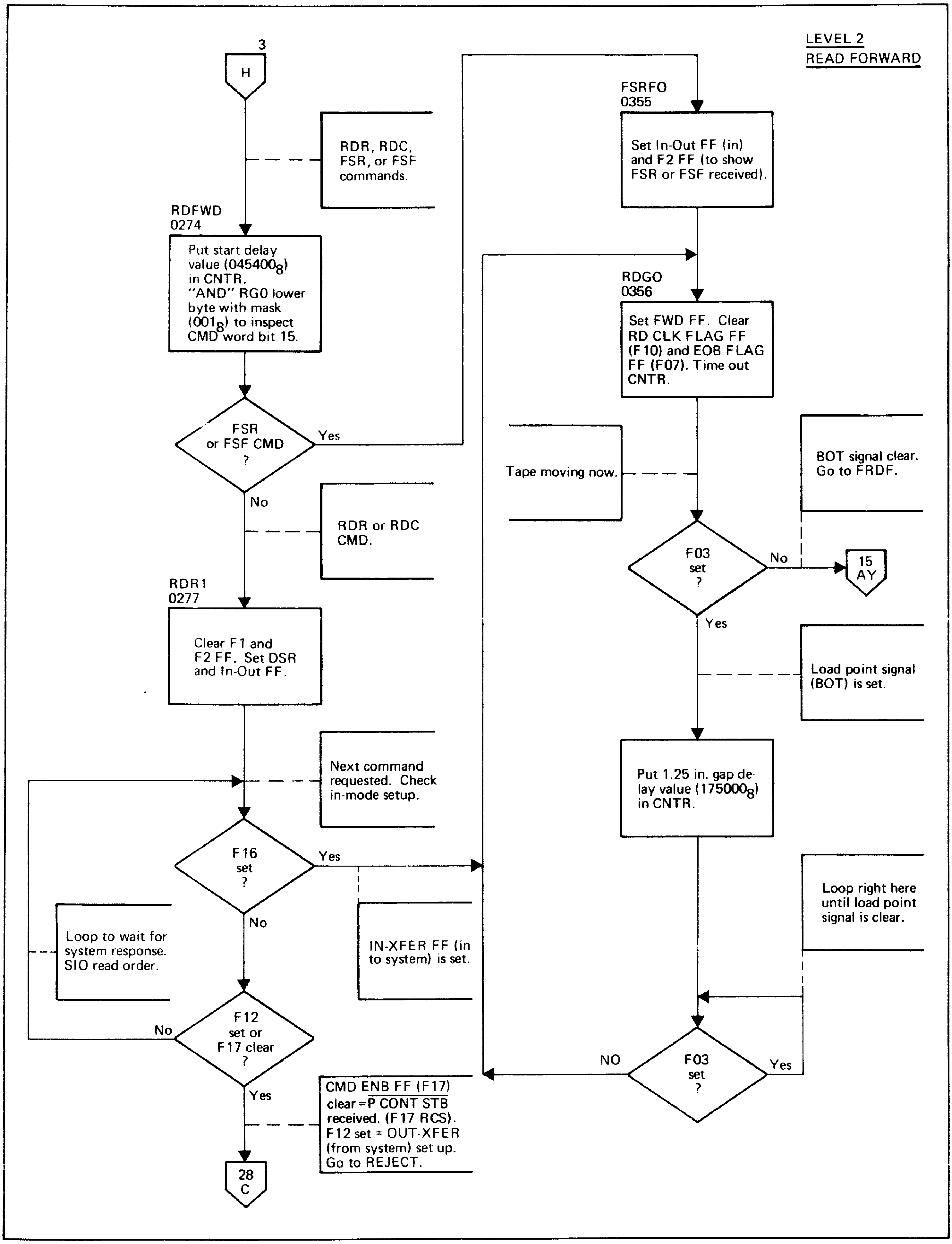


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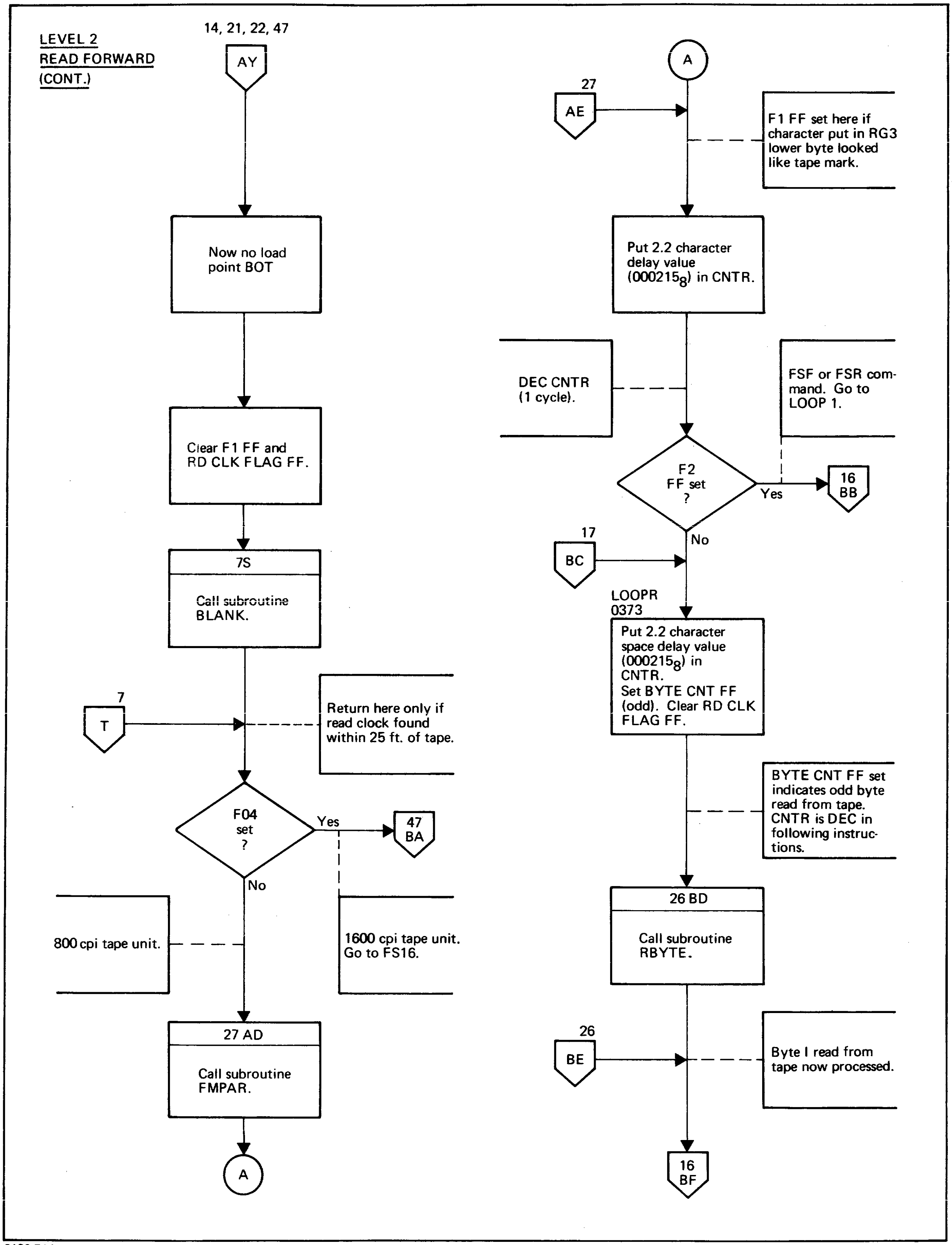
Figure 4-10. Magnetic Tape Subsystem Microprogram Flowcharts (Sheet 14 of 58)



2180-74A

Figure 4-10. Magnetic Tape Subsystem Microprogram Flowcharts (Sheet 15 of 58)

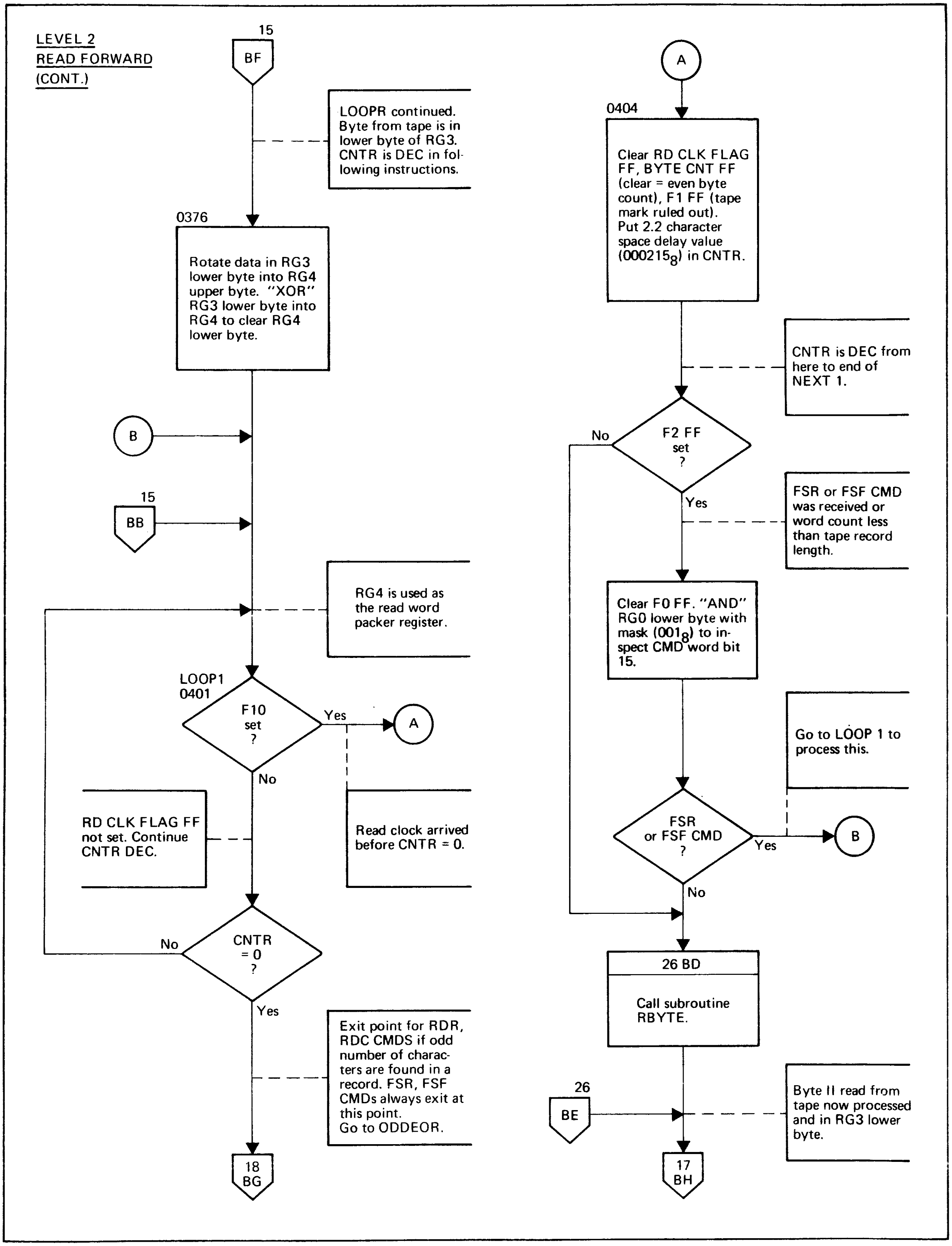


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Figure 4-10. Magnetic Tape Subsystem Microprogram Flowcharts (Sheet 16 of 58)

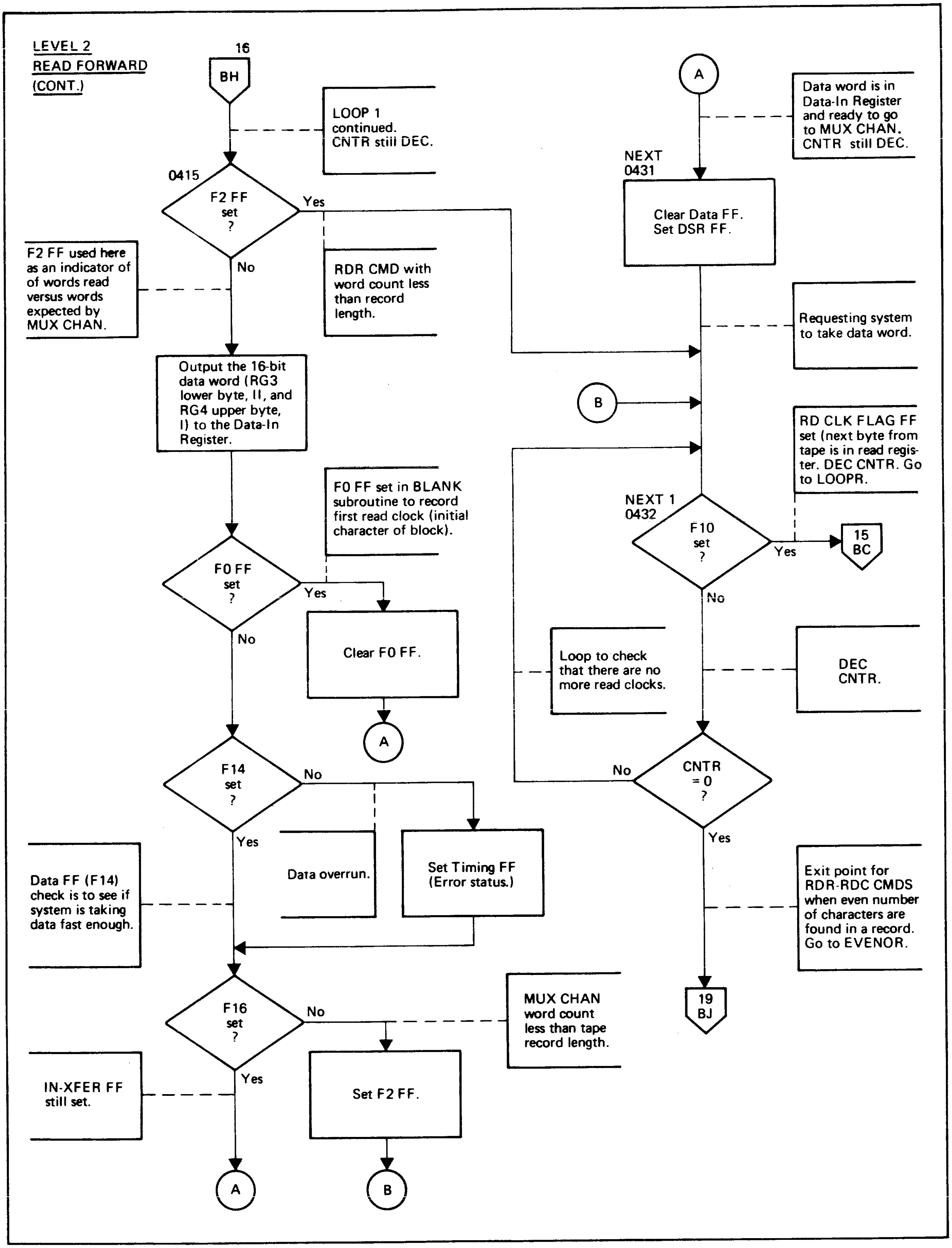

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Figure 4-10. Magnetic Tape Subsystem Microprogram Flowcharts (Sheet 17 of 58)

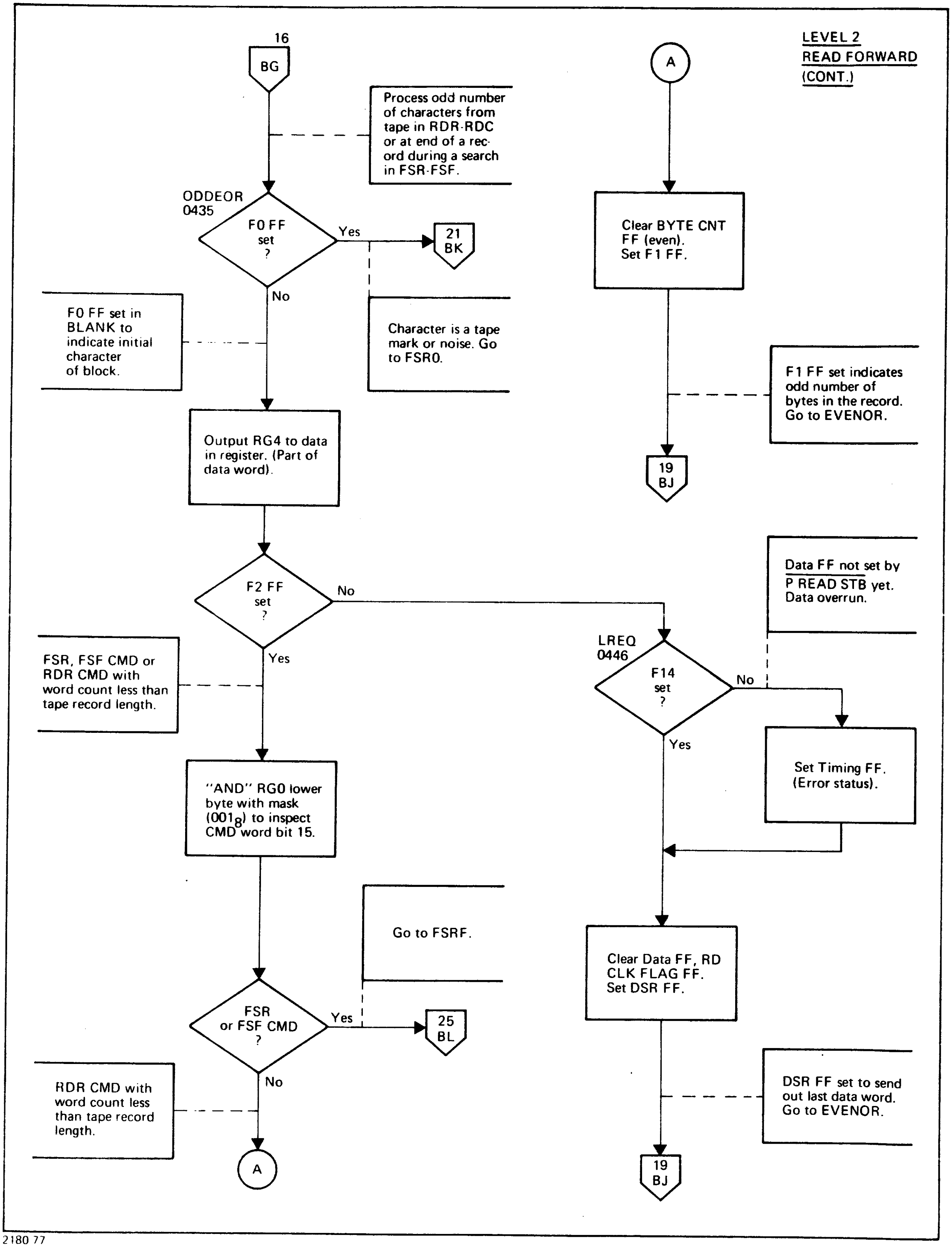

Figure 4-10. Magnetic Tape Subsystem Microprogram Flowcharts (Sheet 18 of 58)

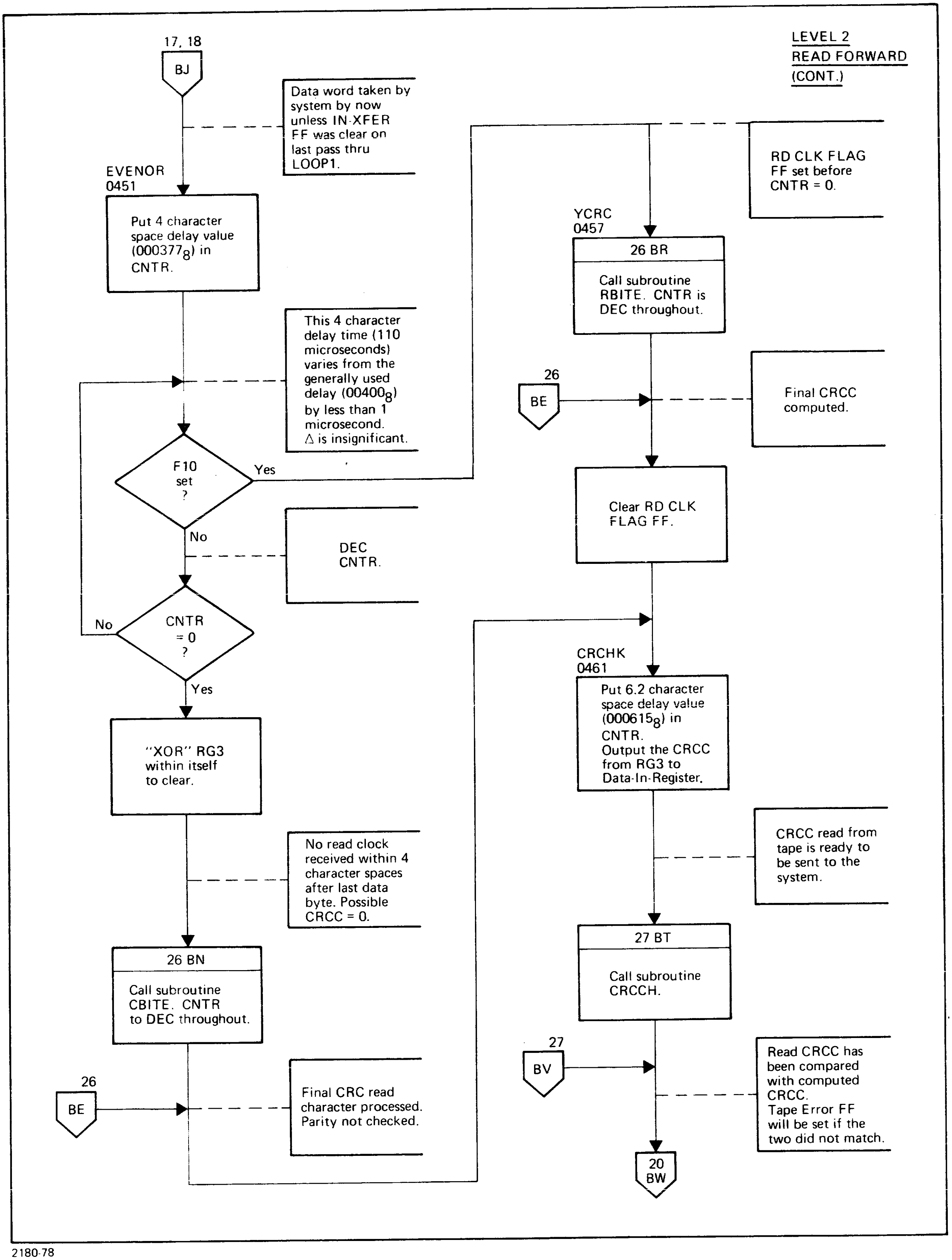

Figure 4-10. Magnetic Tape Subsystem Microprogram Flowcharts (Sheet 19 of 58)

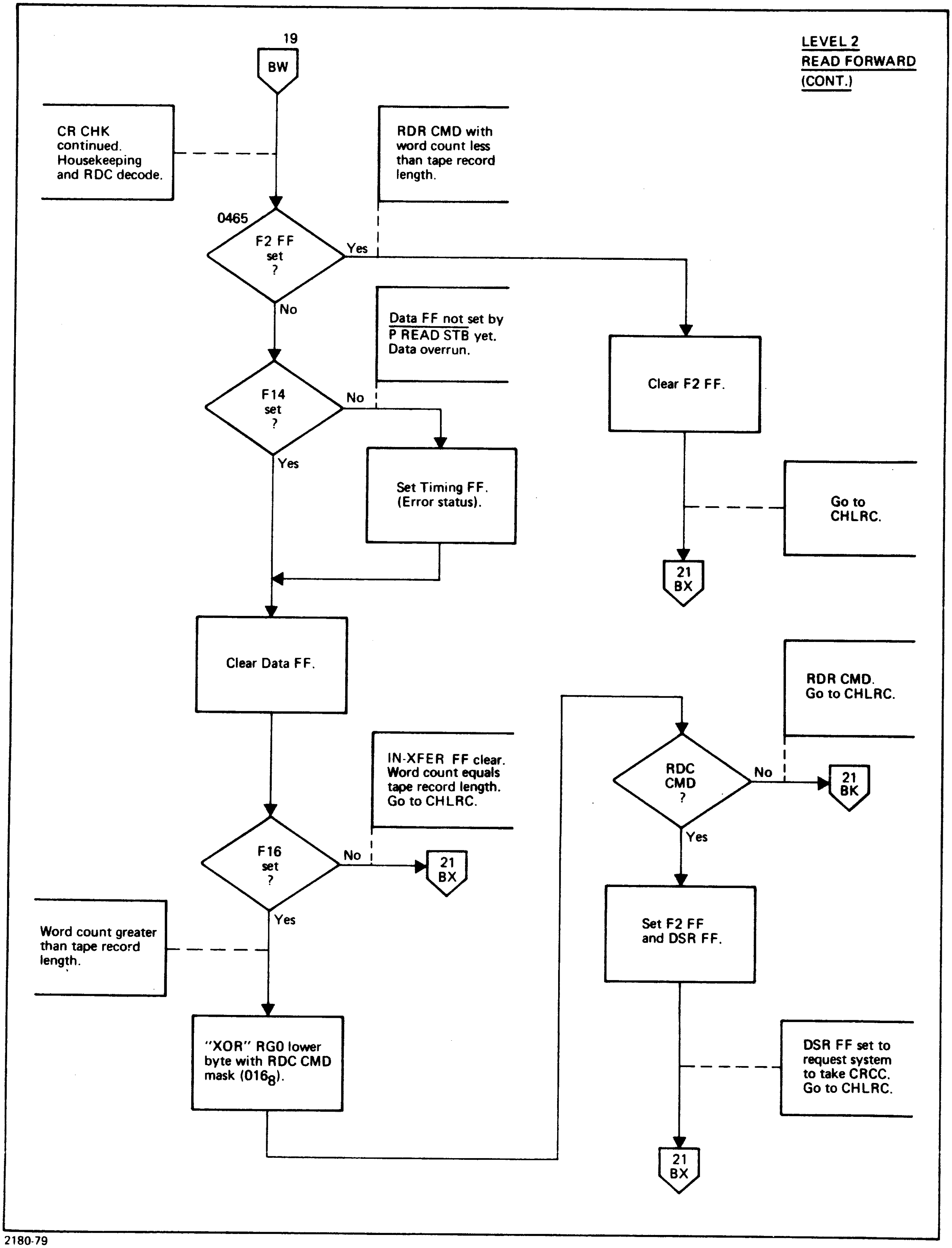

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Figure 4-10. Magnetic Tape Subsystem Microprogram Flowcharts (Sheet 20 of 58)

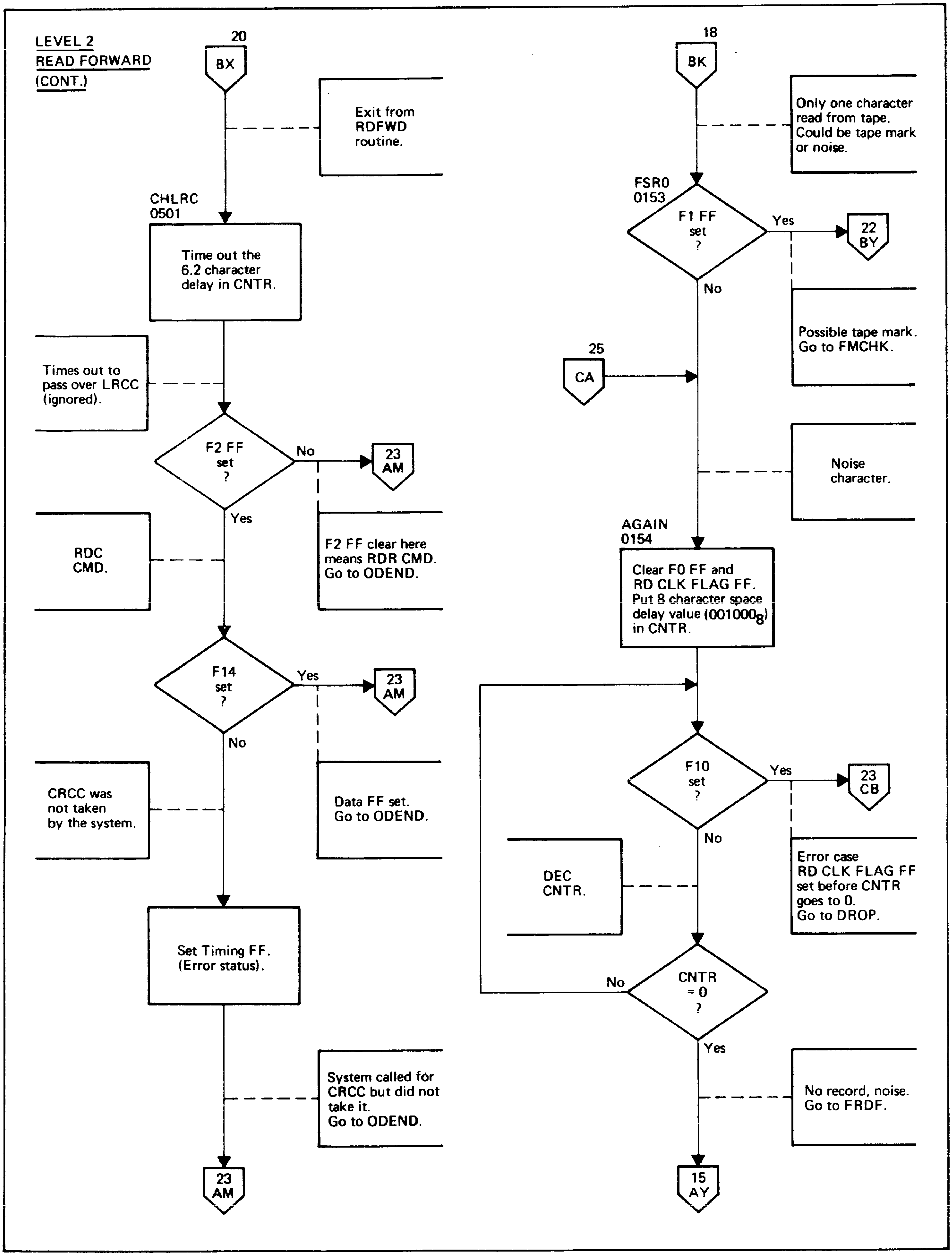

Figure 4-10. Magnetic Tape Subsystem Microprogram Flowcharts (Sheet 21 of 58)

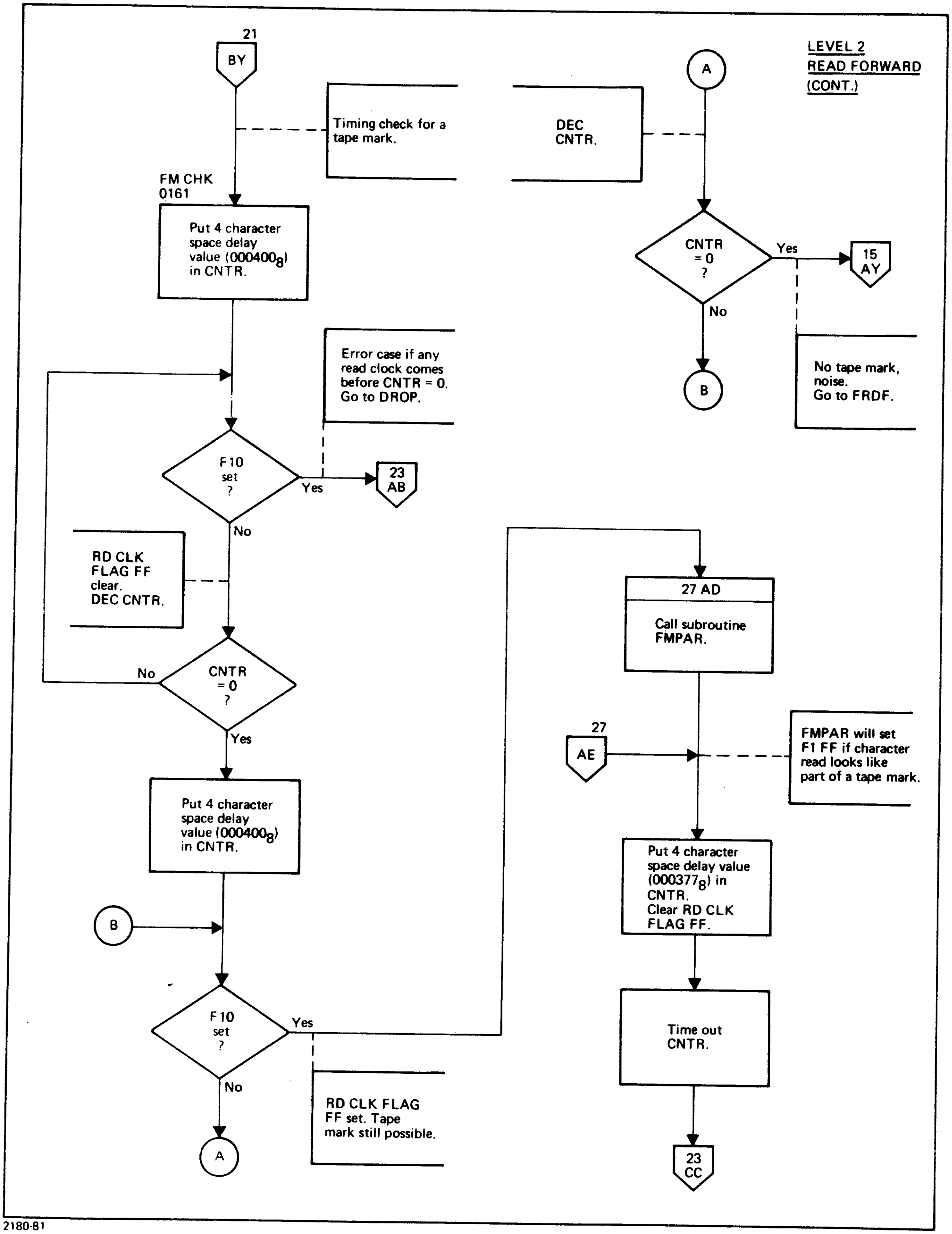

Figure 4-10. Magnetic Tape Subsystem Microprogram Flowcharts (Sheet 22 of 58)

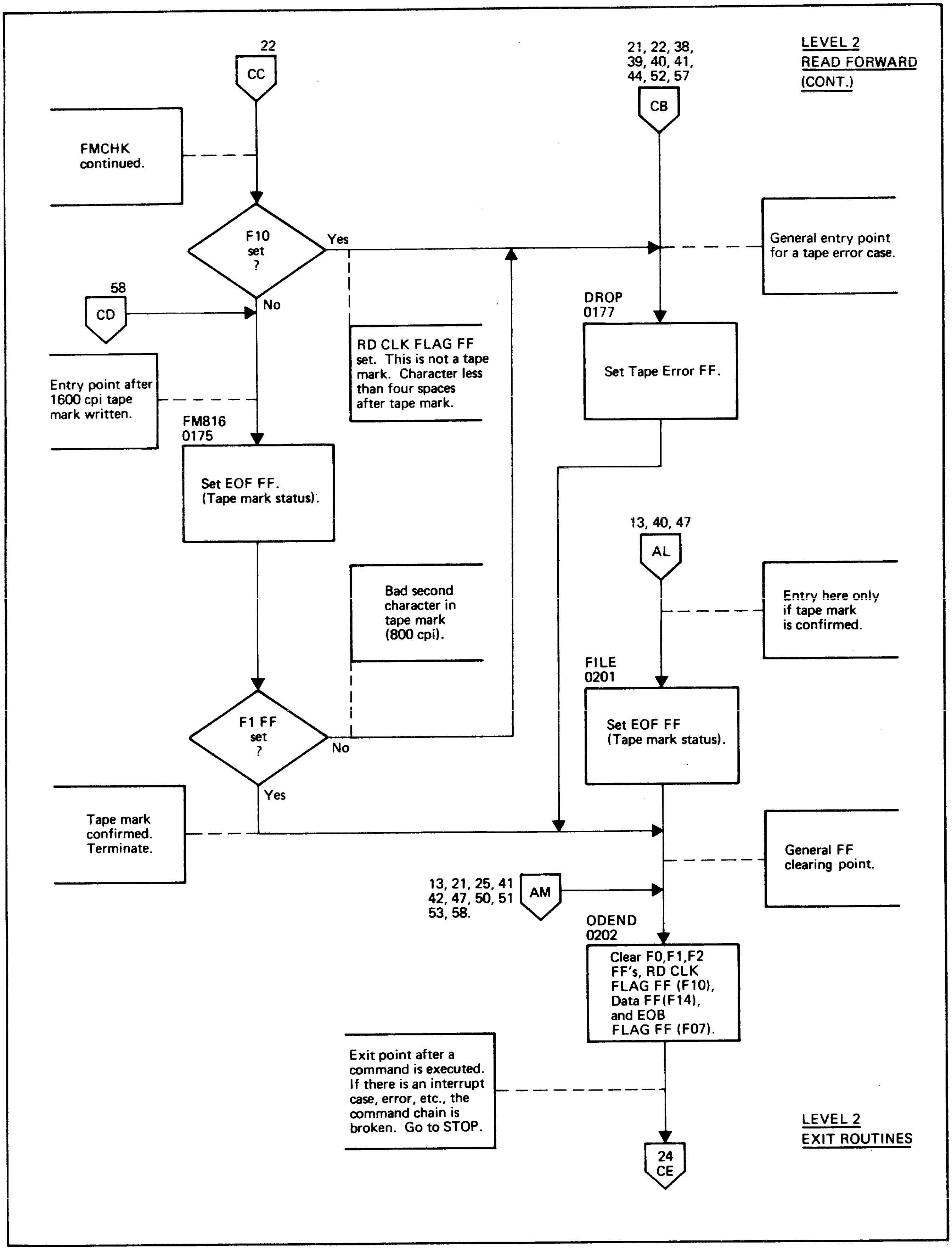

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Figure 4-10. Magnetic Tape Subsystem Microprogram Flowcharts (Sheet 23 of 58)

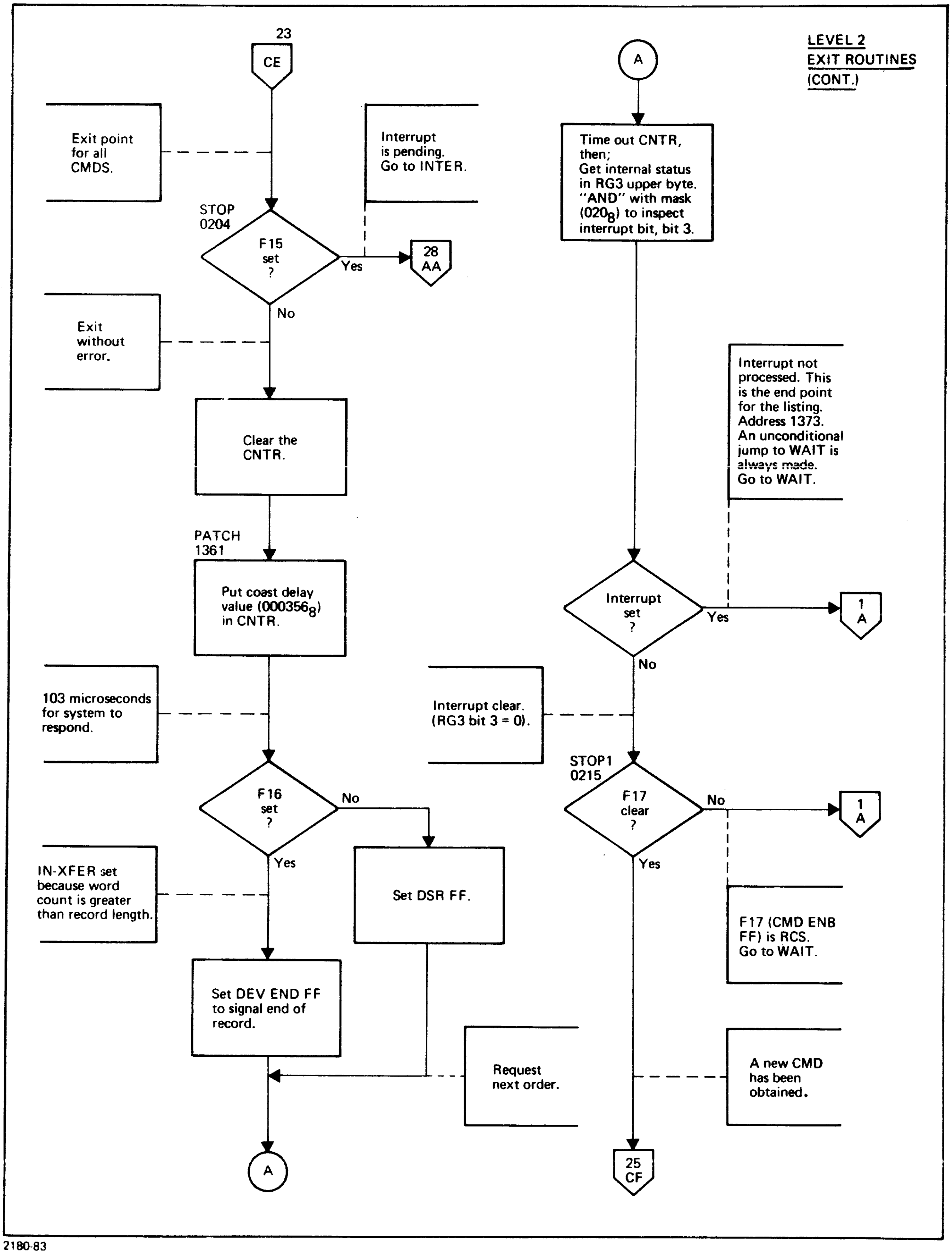


Figure 4-10. Magnetic Tape Subsystem Microprogram Flowcharts (Sheet 24 of 58)

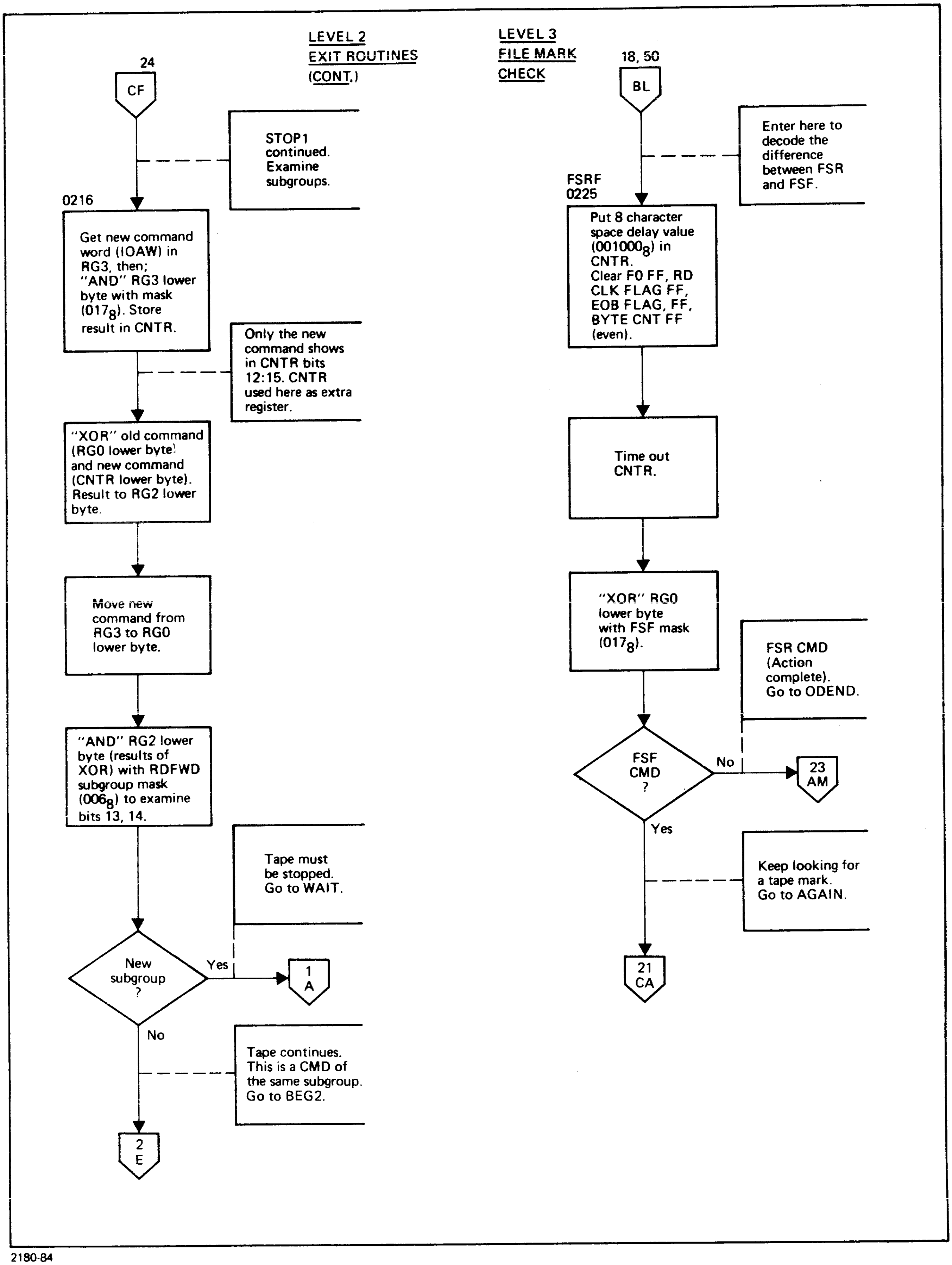


Figure 4-10. Magnetic Tape Subsystem Microprogram Flowcharts (Sheet 25 of 58)

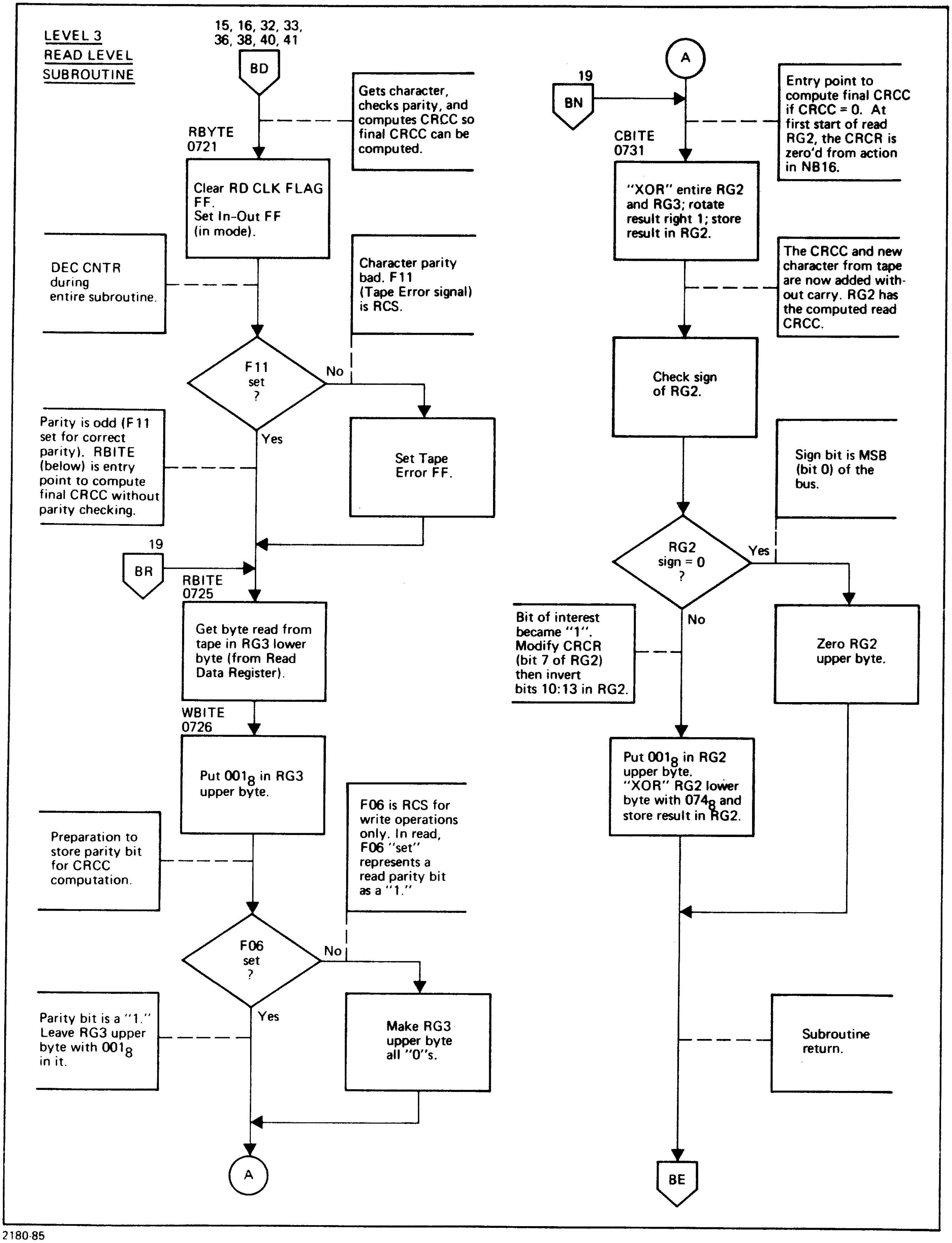


Figure 4-10. Magnetic Tape Subsystem Microprogram Flowcharts (Sheet 26 of 58)

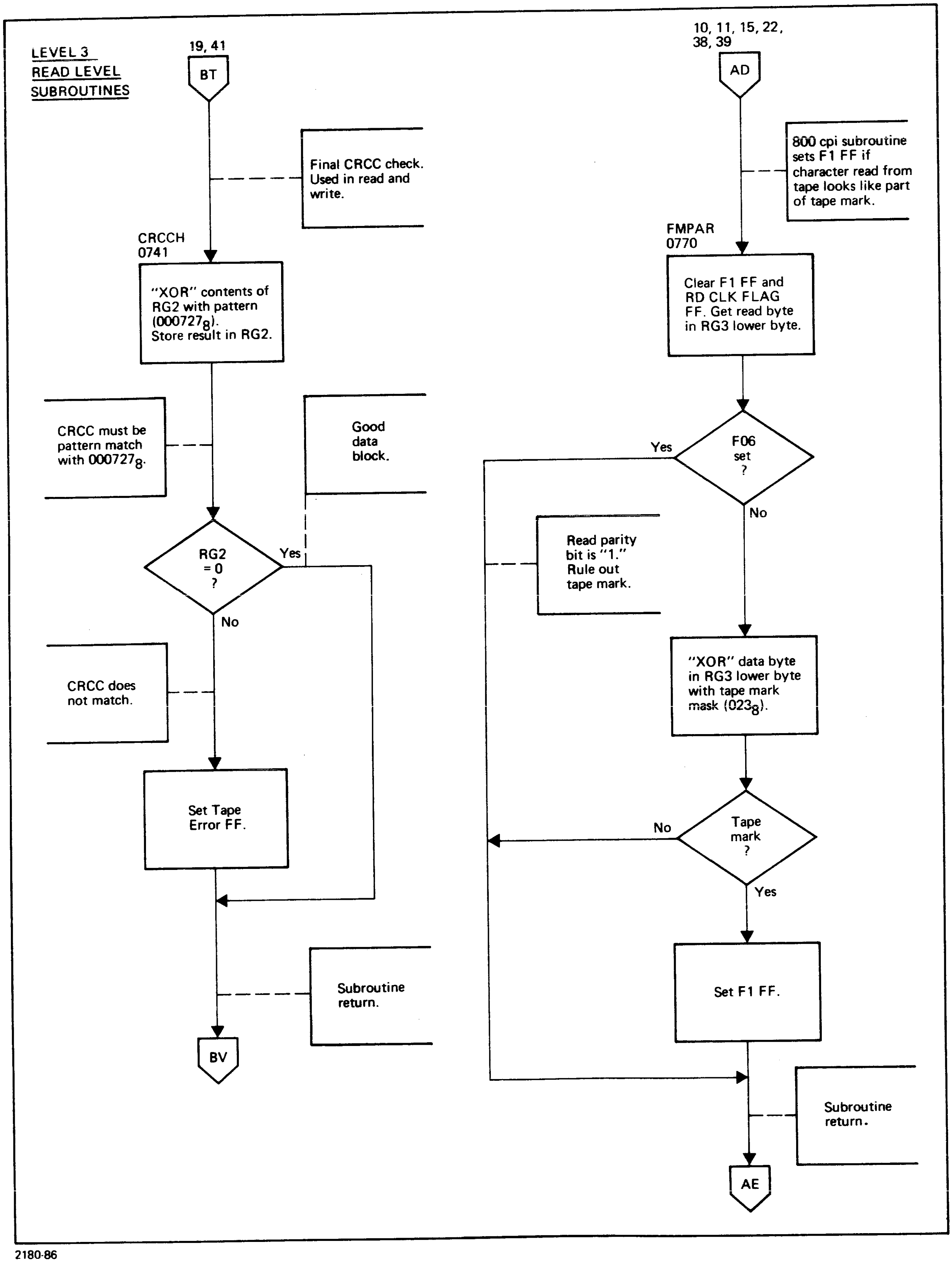


Figure 4-10. Magnetic Tape Subsystem Microprogram Flowcharts (Sheet 27 of 58)

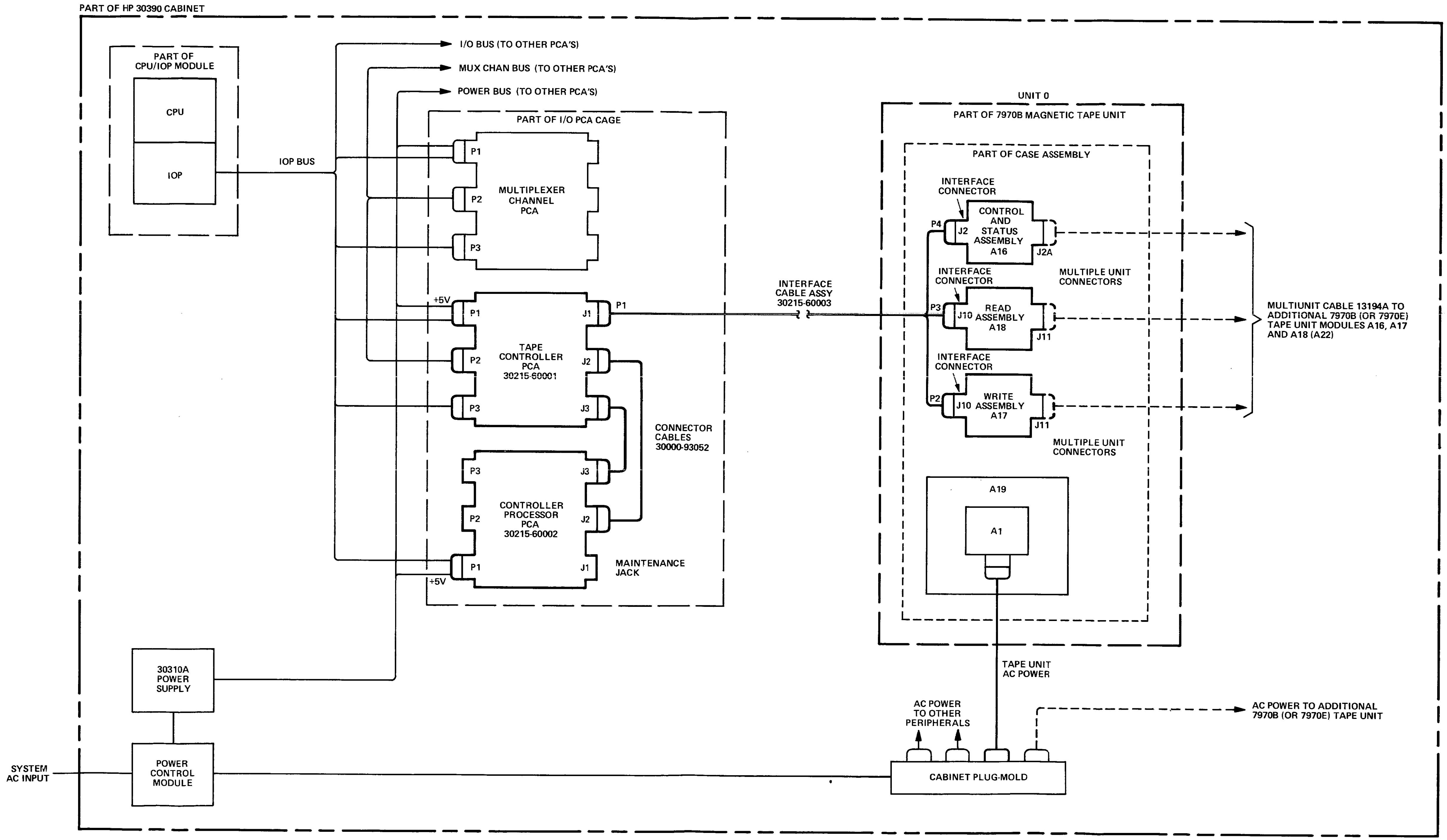


Figure 4-1. Magnetic Tape Subsystem Example
Single Tape Unit Cabling Diagram

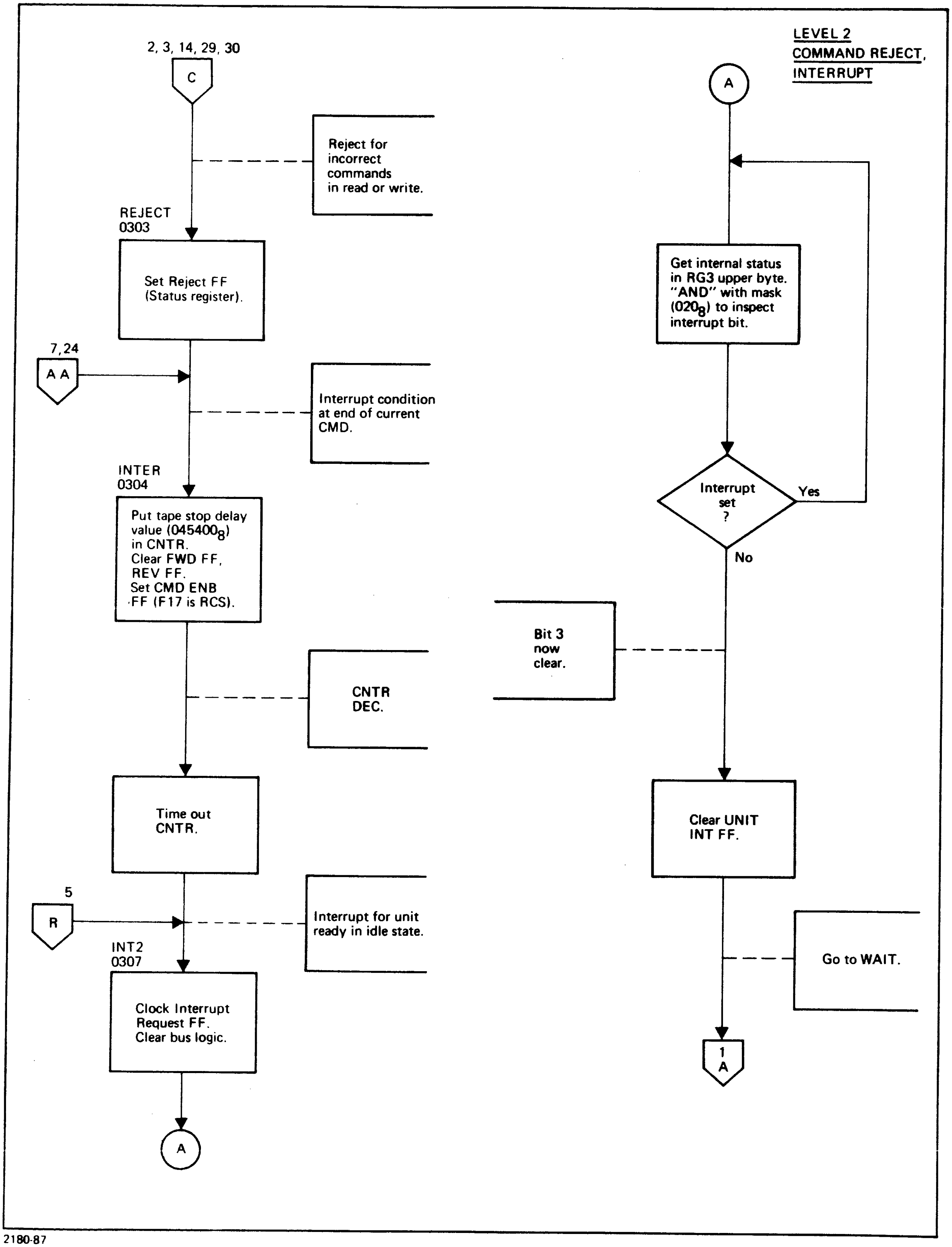
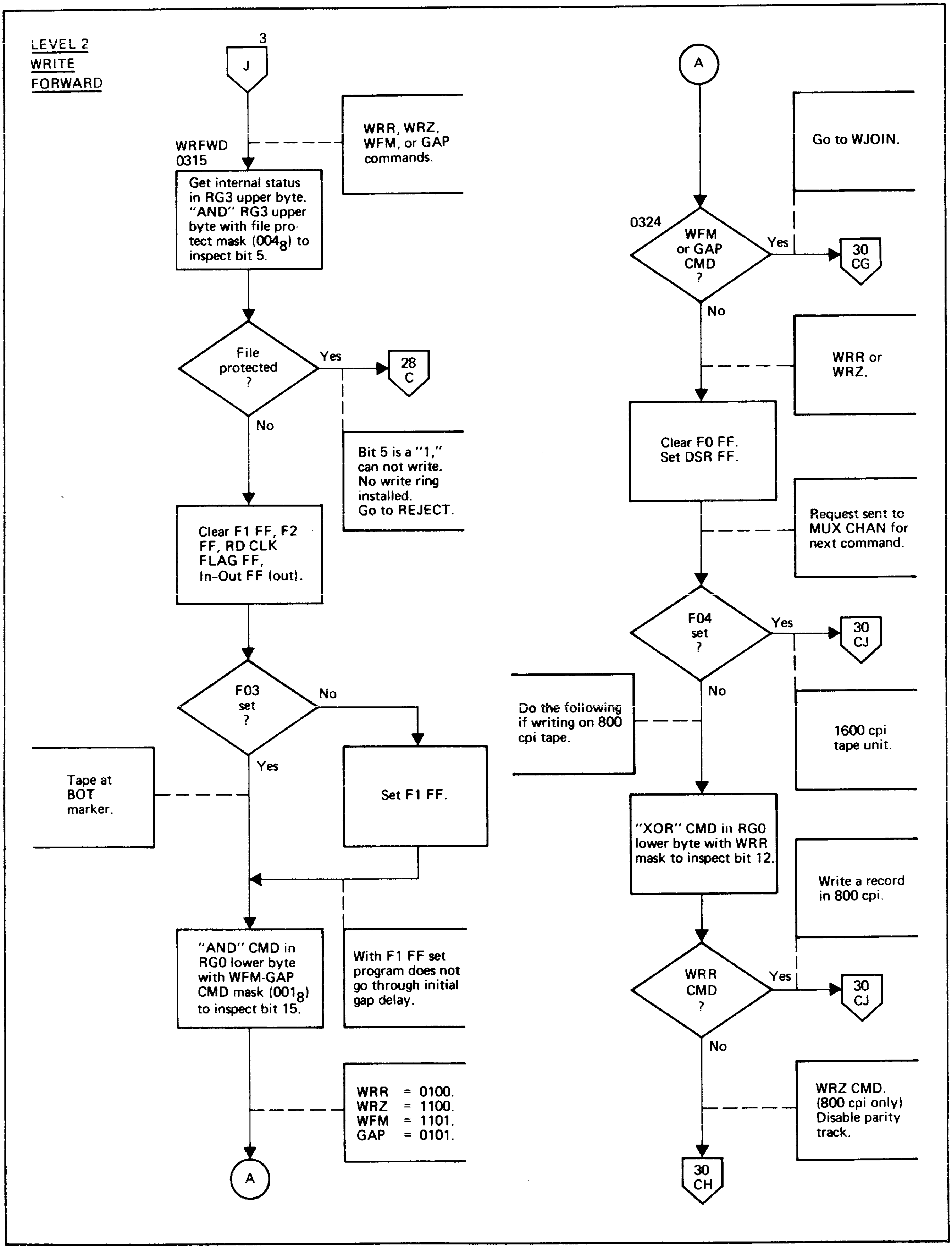


Figure 4-10. Magnetic Tape Subsystem Microprogram Flowcharts (Sheet 28 of 58)



2180-88

Figure 4-10. Magnetic Tape Subsystem Microprogram Flowcharts (Sheet 29 of 58)

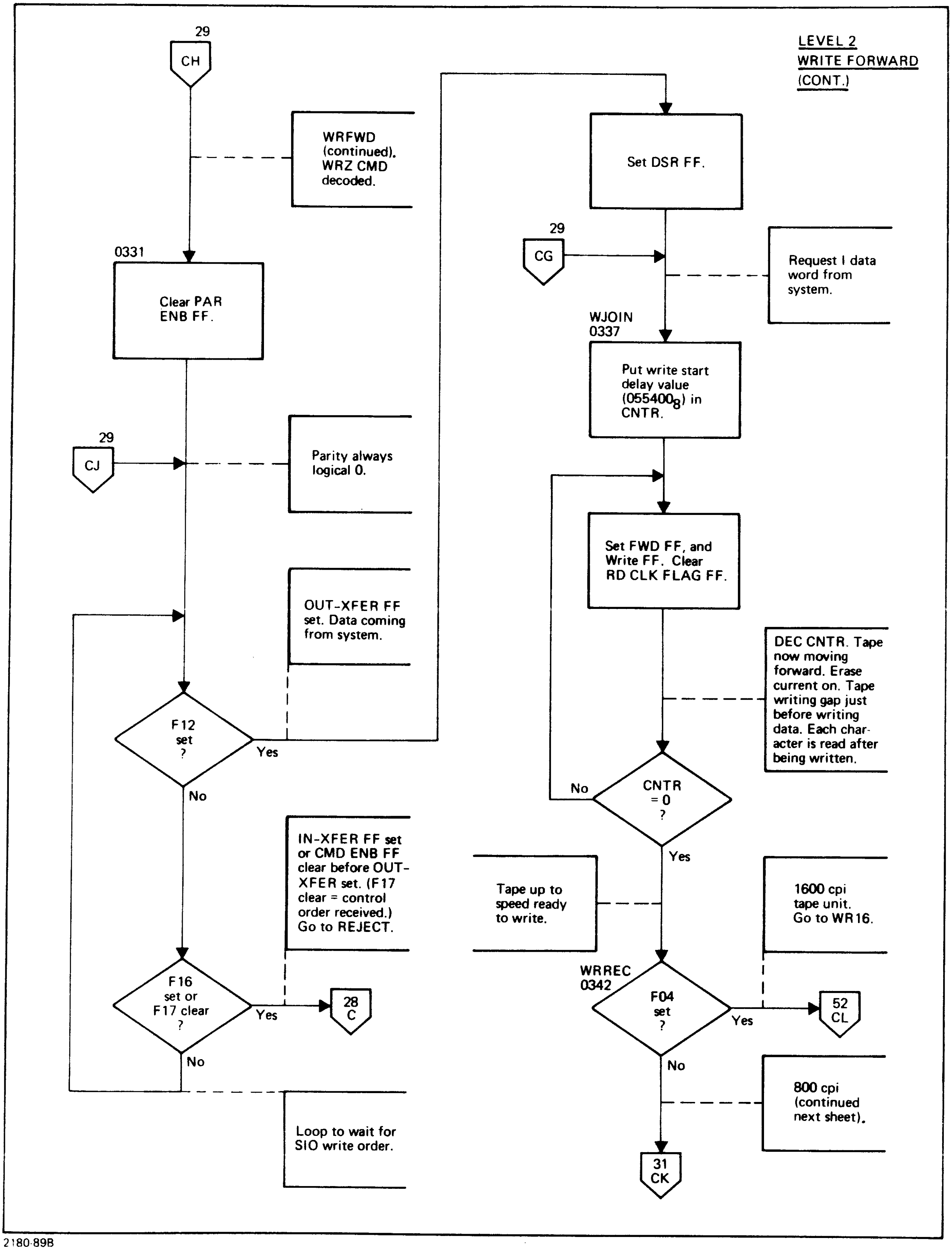
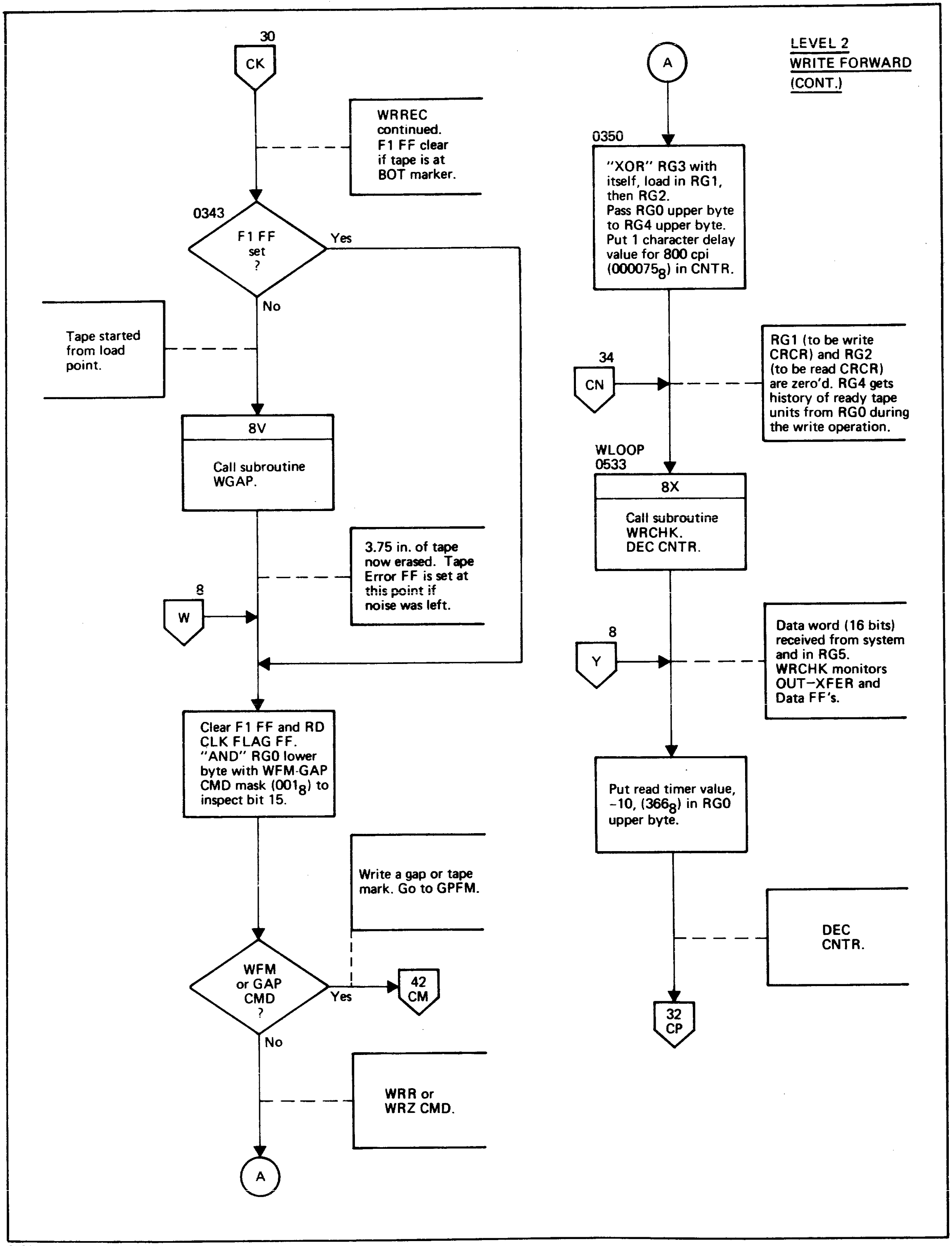


Figure 4-10. Magnetic Tape Subsystem Microprogram Flowcharts (Sheet 30 of 58)



2180-90

Figure 4-10. Magnetic Tape Subsystem Microprogram Flowcharts (Sheet 31 of 58)

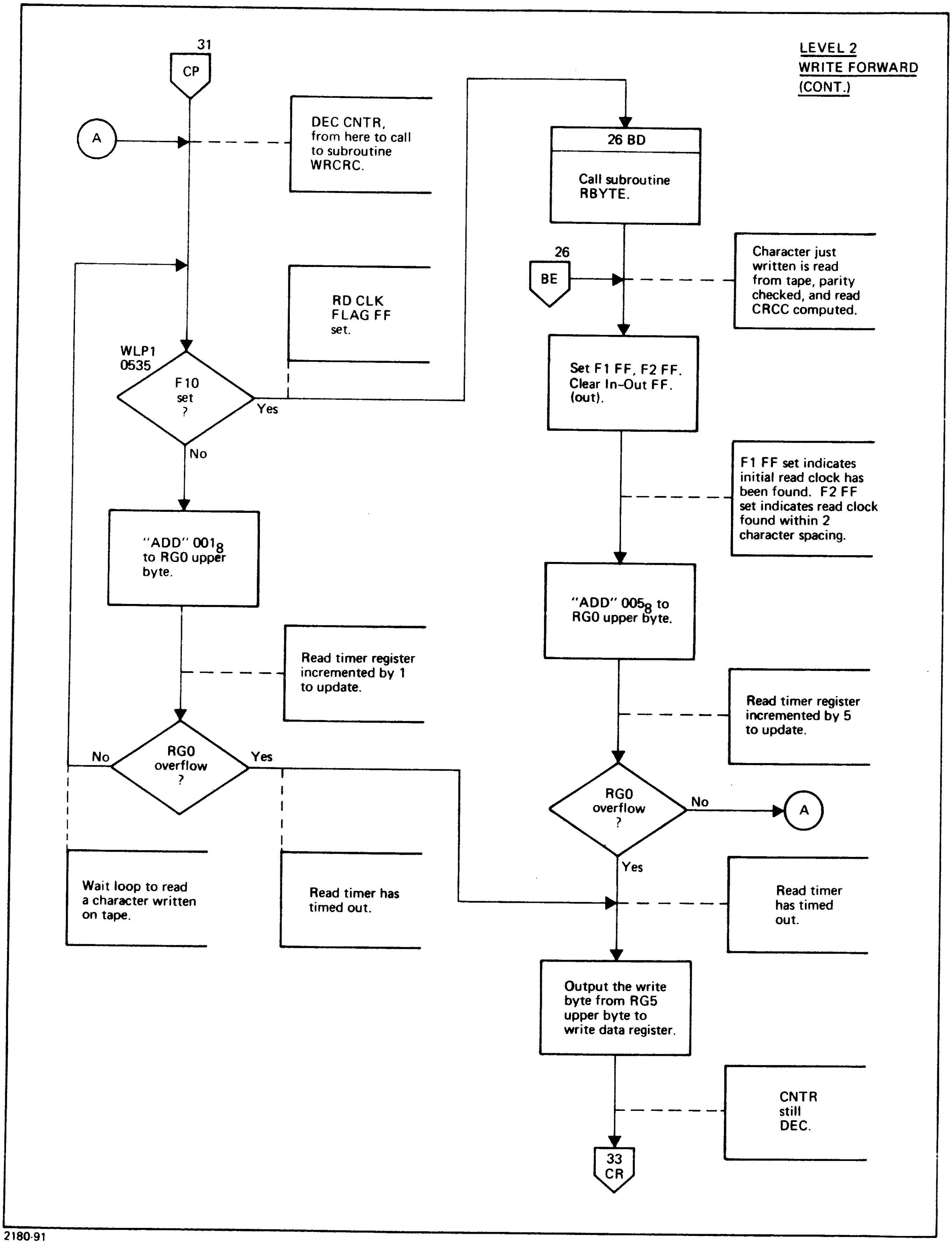
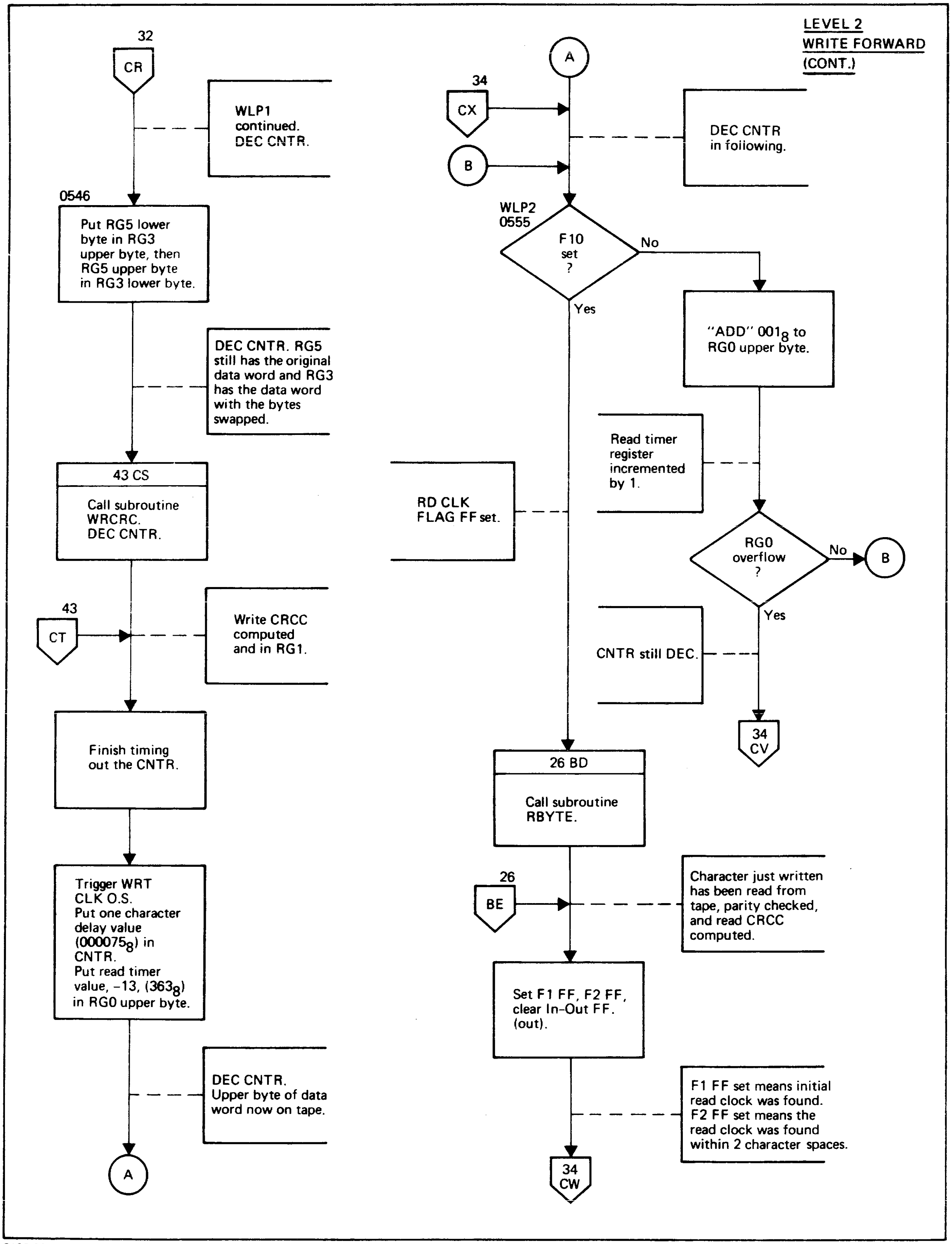
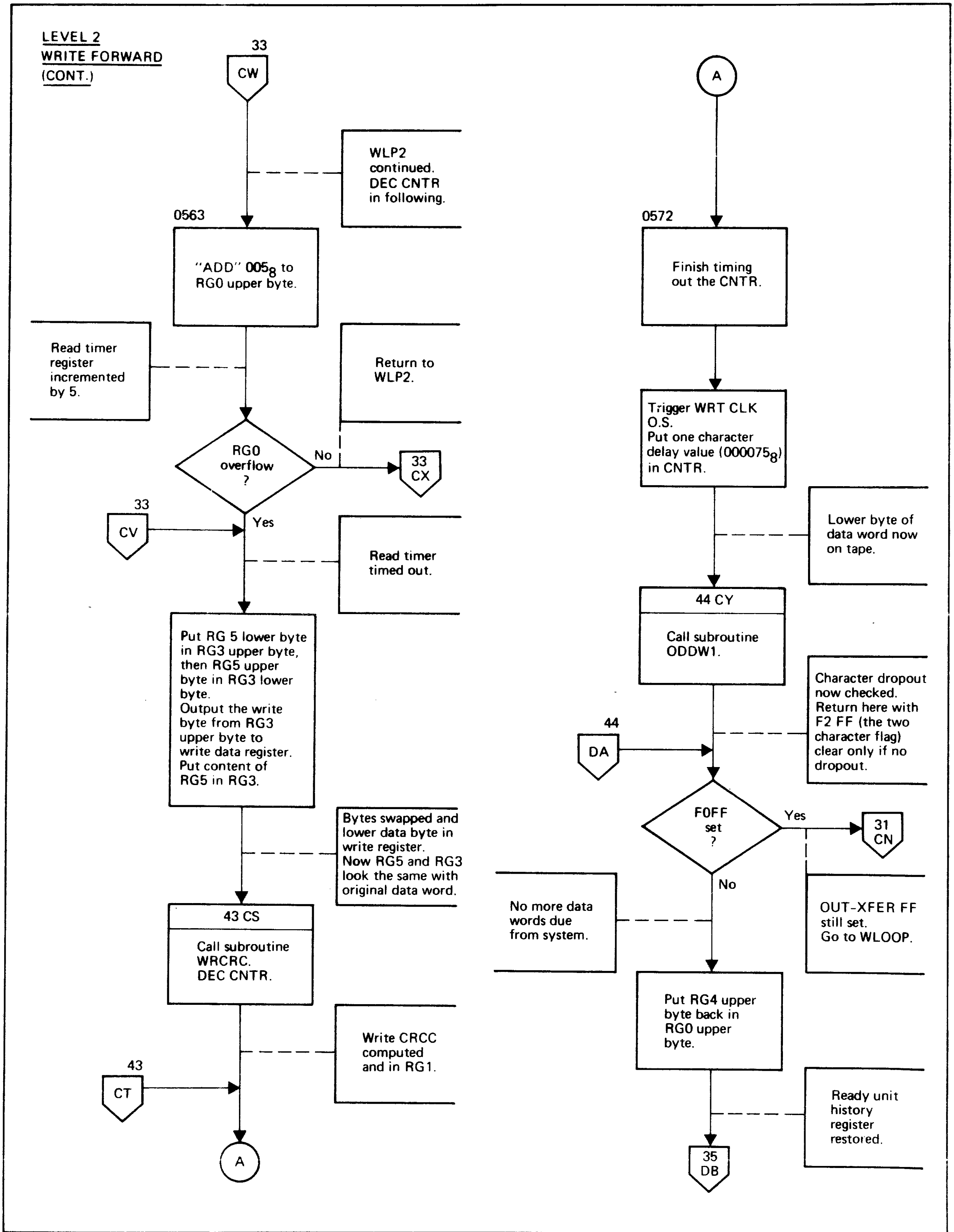


Figure 4-10. Magnetic Tape Subsystem Microprogram Flowcharts (Sheet 32 of 58)



2180-92

Figure 4-10. Magnetic Tape Subsystem Microprogram Flowcharts (Sheet 33 of 58)



2180-93

Figure 4-10. Magnetic Tape Subsystem Microprogram Flowcharts (Sheet 34 of 58)

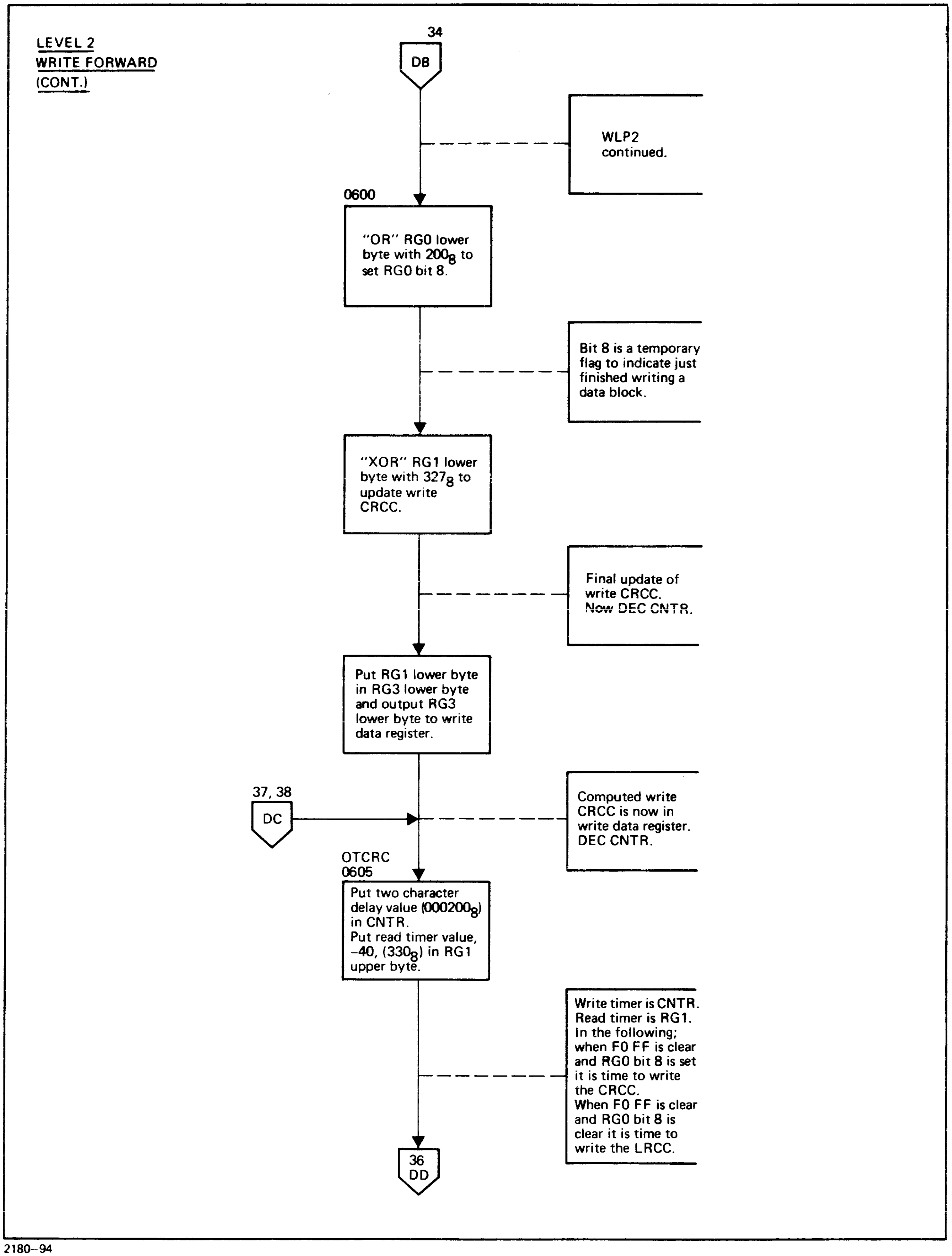
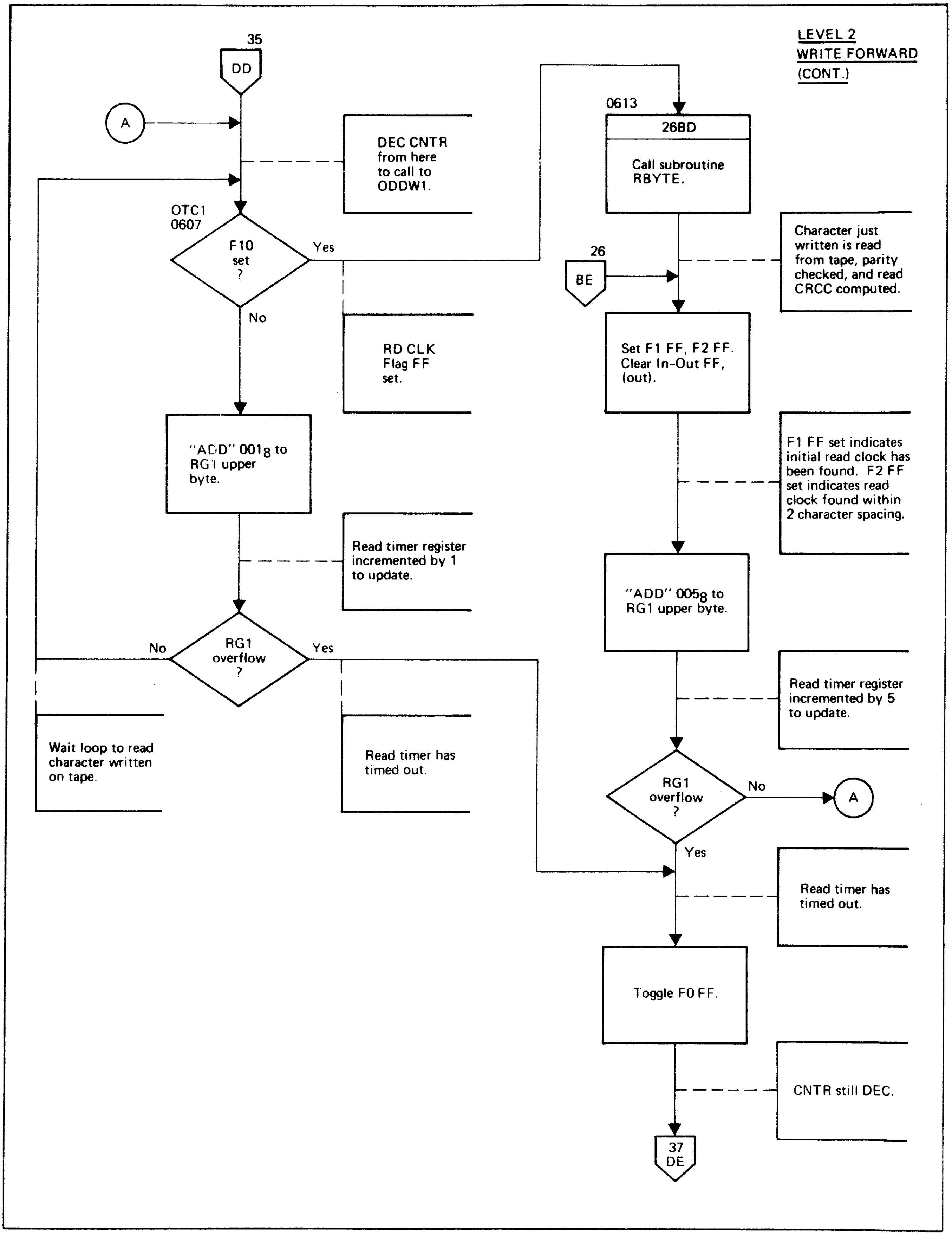
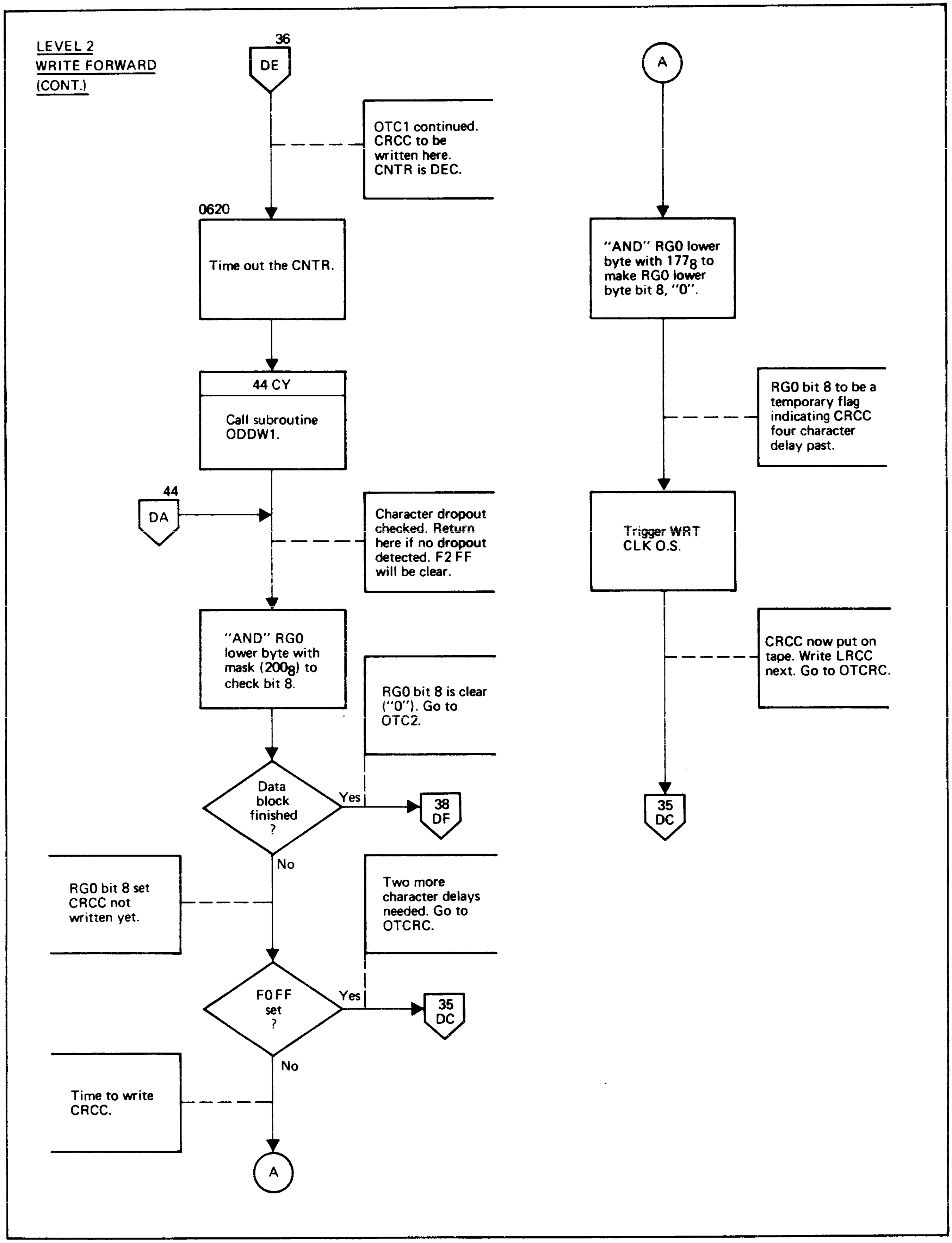


Figure 4-10. Magnetic Tape Subsystem Microprogram Flowcharts (Sheet 35 of 58)



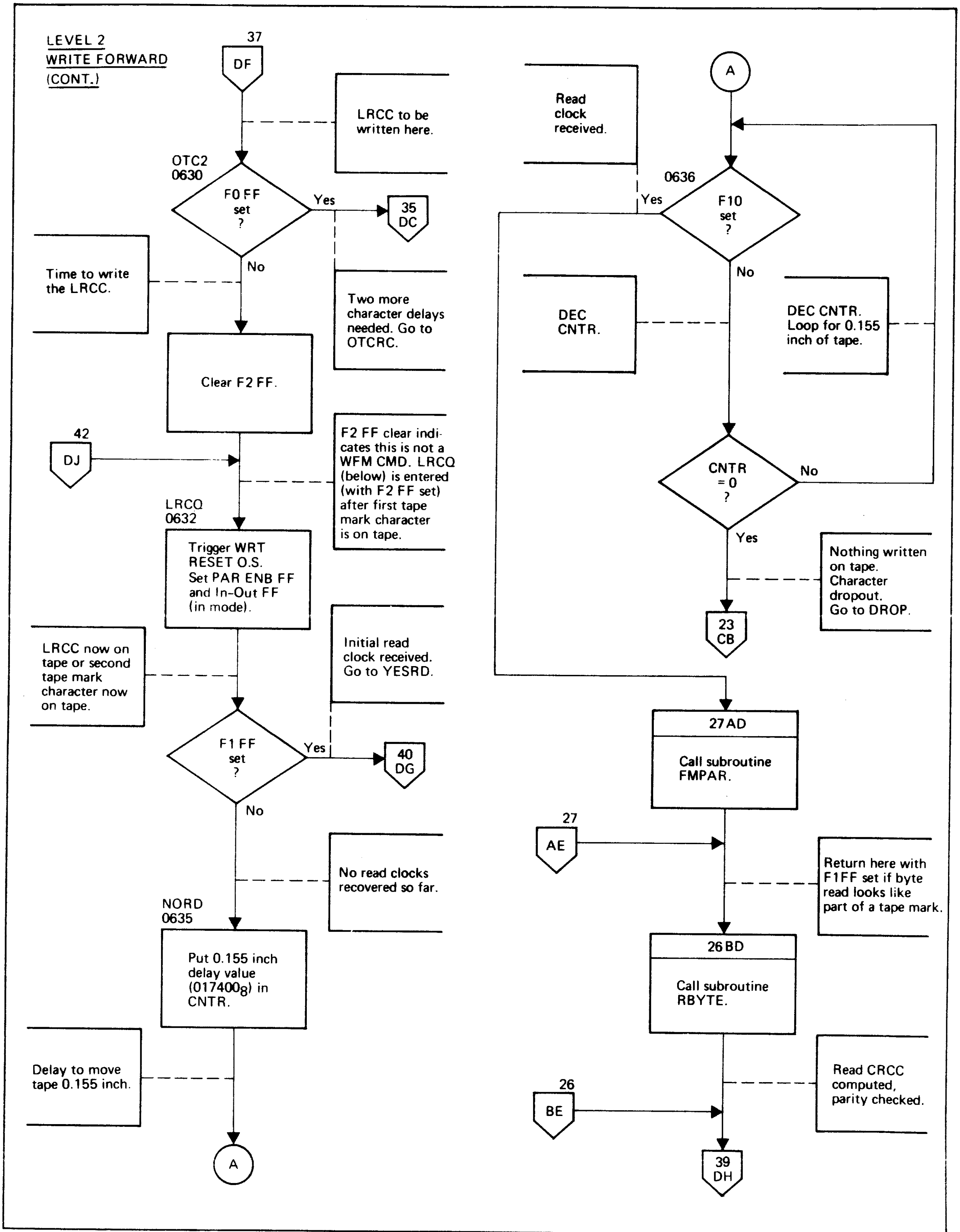
2180-95

Figure 4-10. Magnetic Tape Subsystem Microprogram Flowcharts (Sheet 36 of 58)



2180-96

Figure 4-10. Magnetic Tape Subsystem Microprogram Flowcharts (Sheet 37 of 58)



2180-97

Figure 4-10. Magnetic Tape Subsystem Microprogram Flowcharts (Sheet 38 of 58)

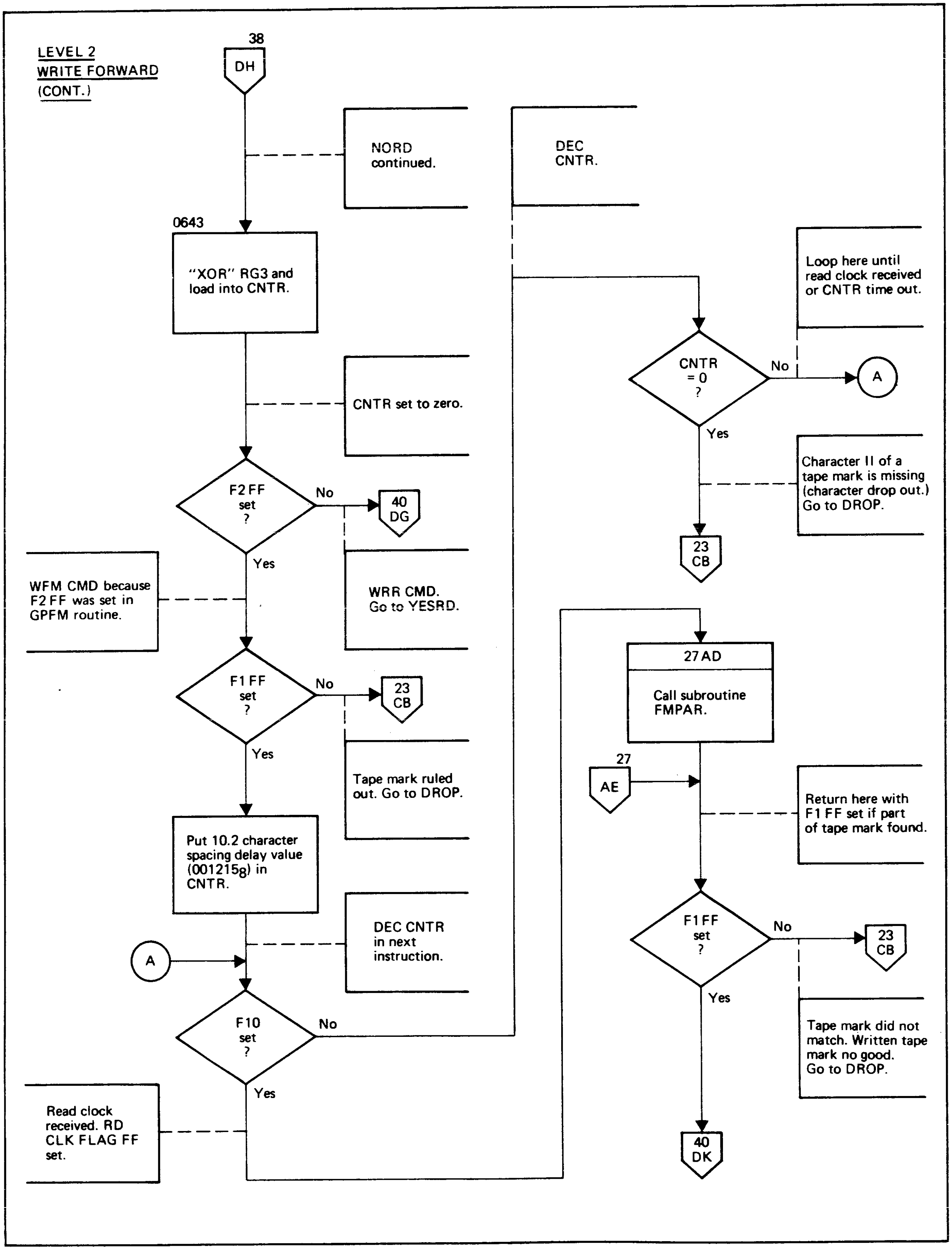


Figure 4-10. Magnetic Tape Subsystem Microprogram Flowcharts (Sheet 39 of 58)

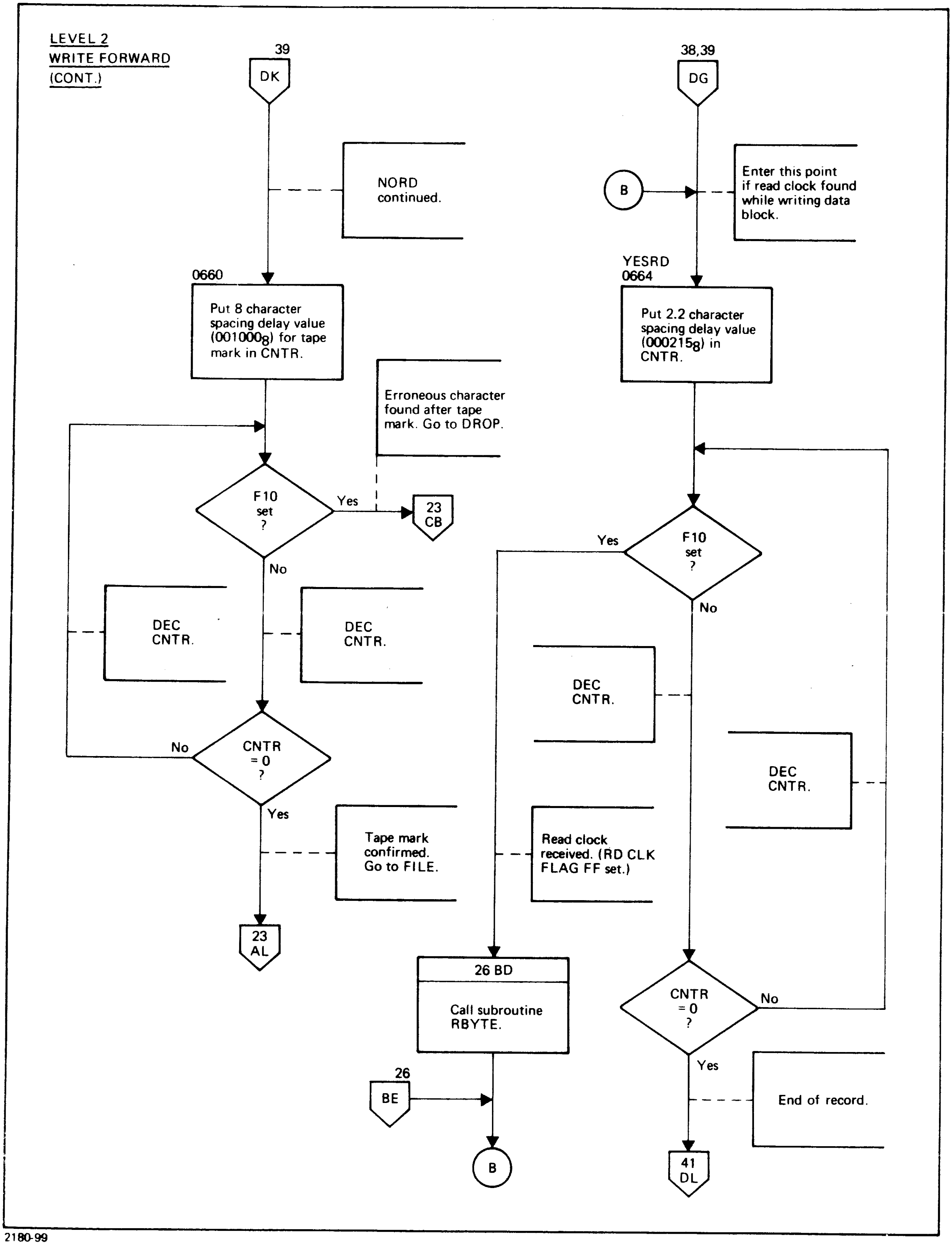


Figure 4-10. Magnetic Tape Subsystem Microprogram Flowcharts (Sheet 40 of 58)

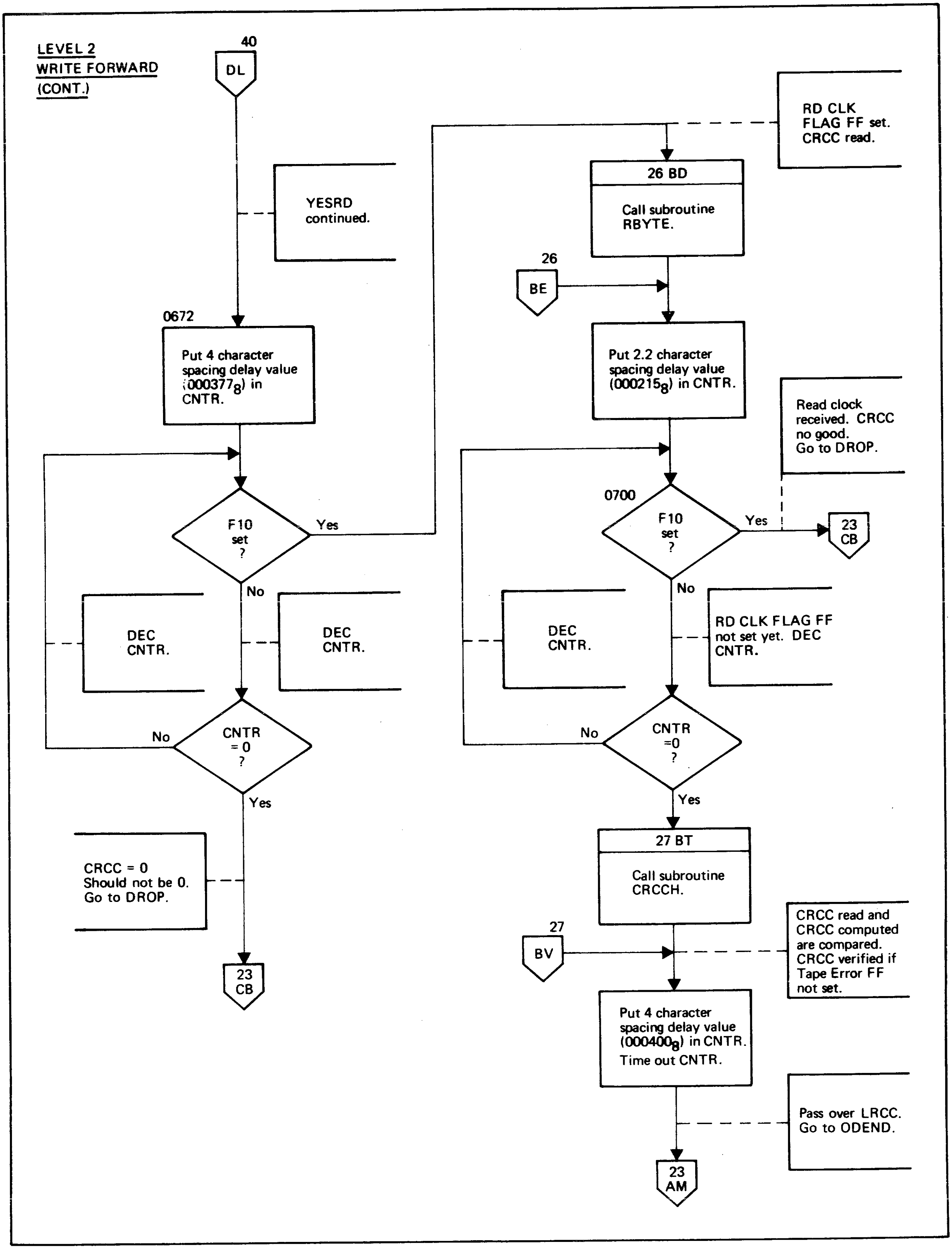
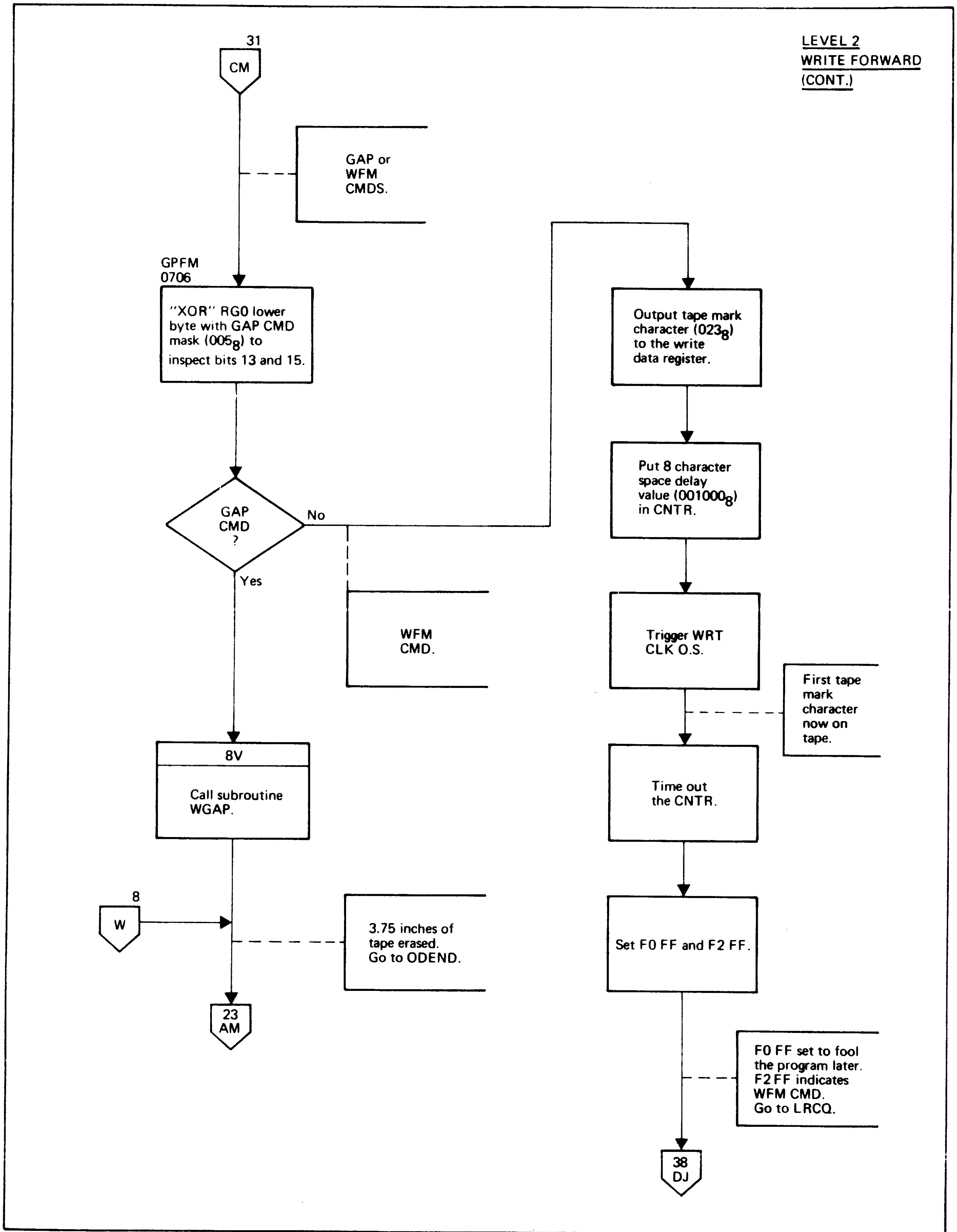
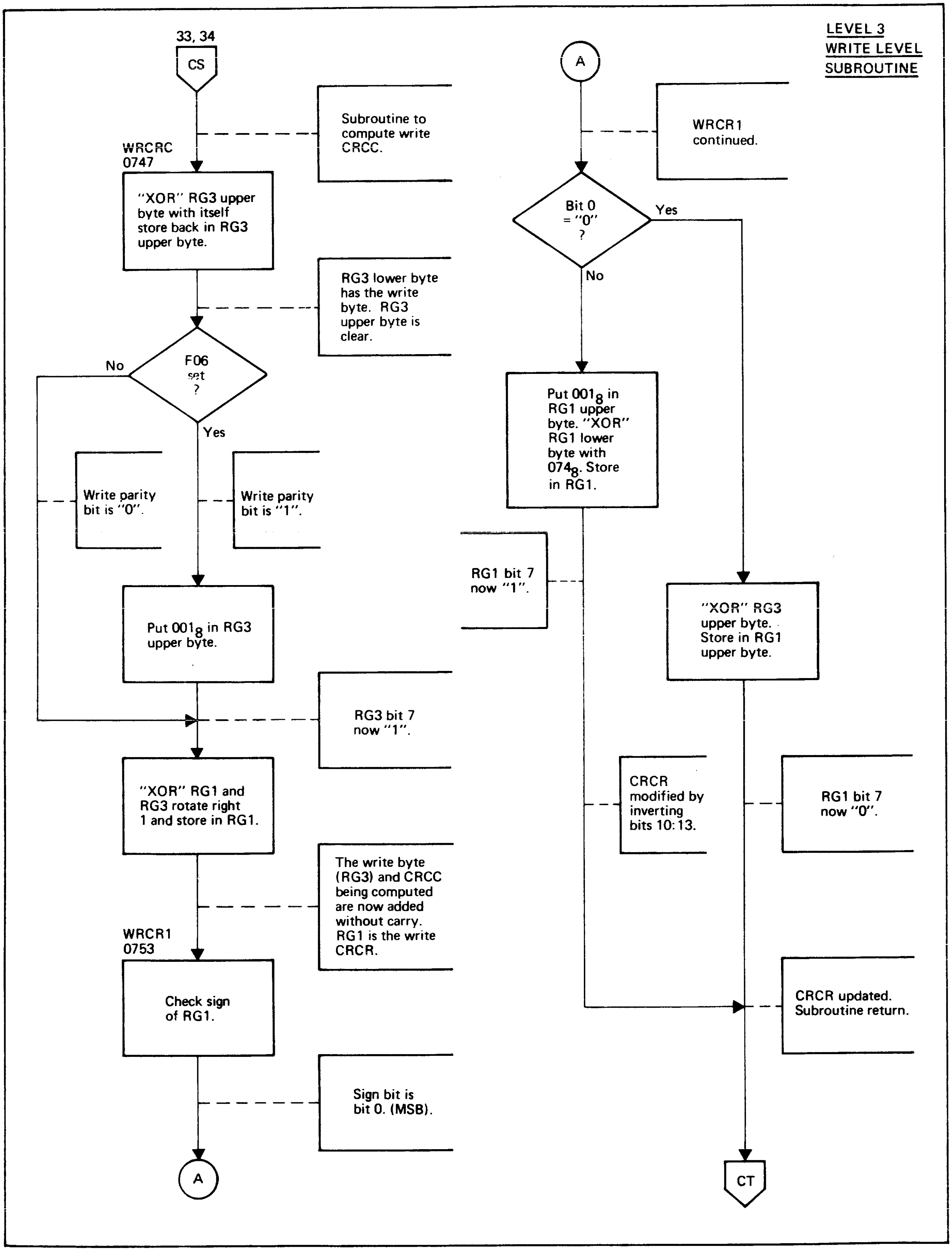


Figure 4-10. Magnetic Tape Subsystem Microprogram Flowcharts (Sheet 41 of 58)



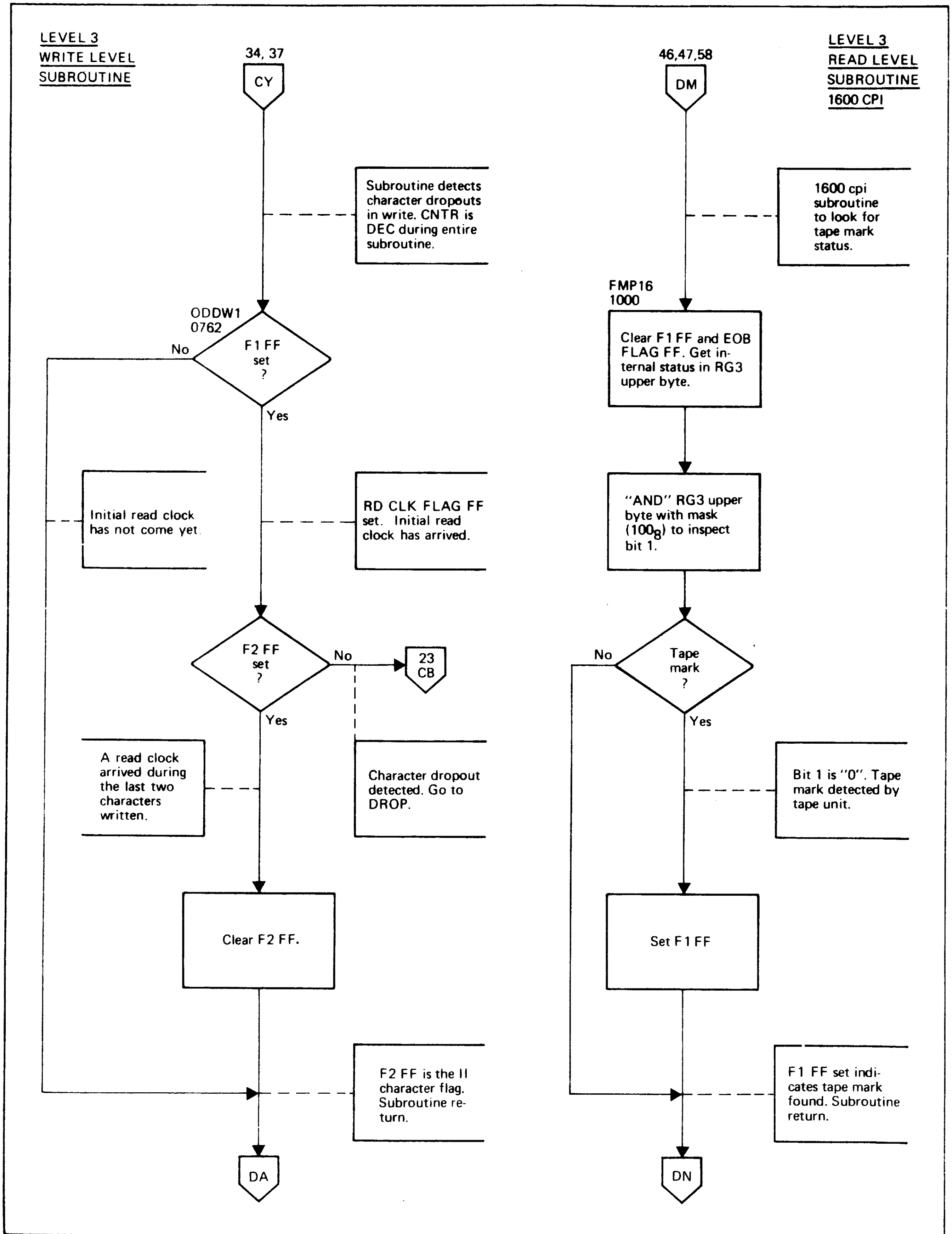
2180-101

Figure 4-10. Magnetic Tape Subsystem Microprogram Flowcharts (Sheet 42 of 58)



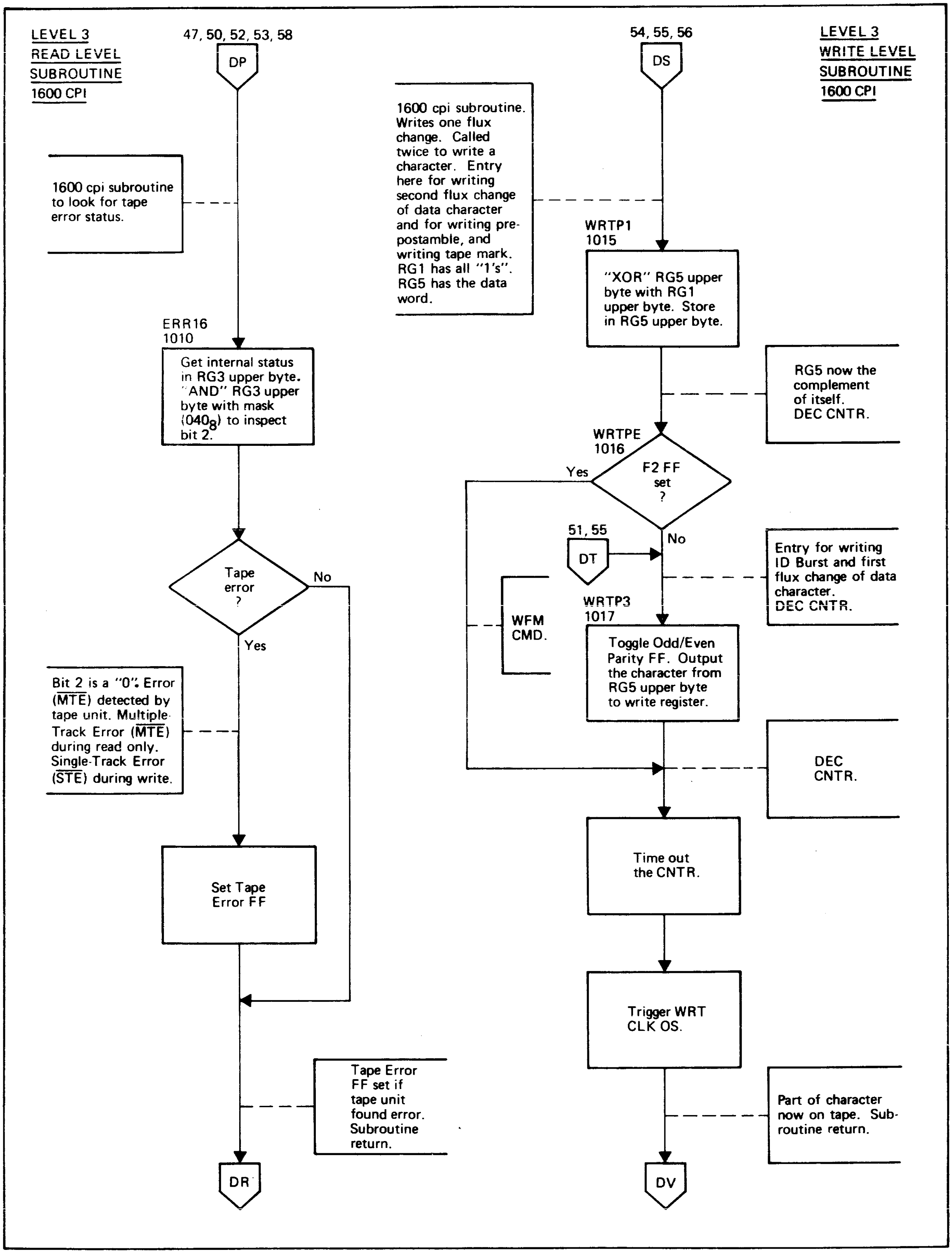
2180-102

Figure 4-10. Magnetic Tape Subsystem Microprogram Flowcharts (Sheet 43 of 58)



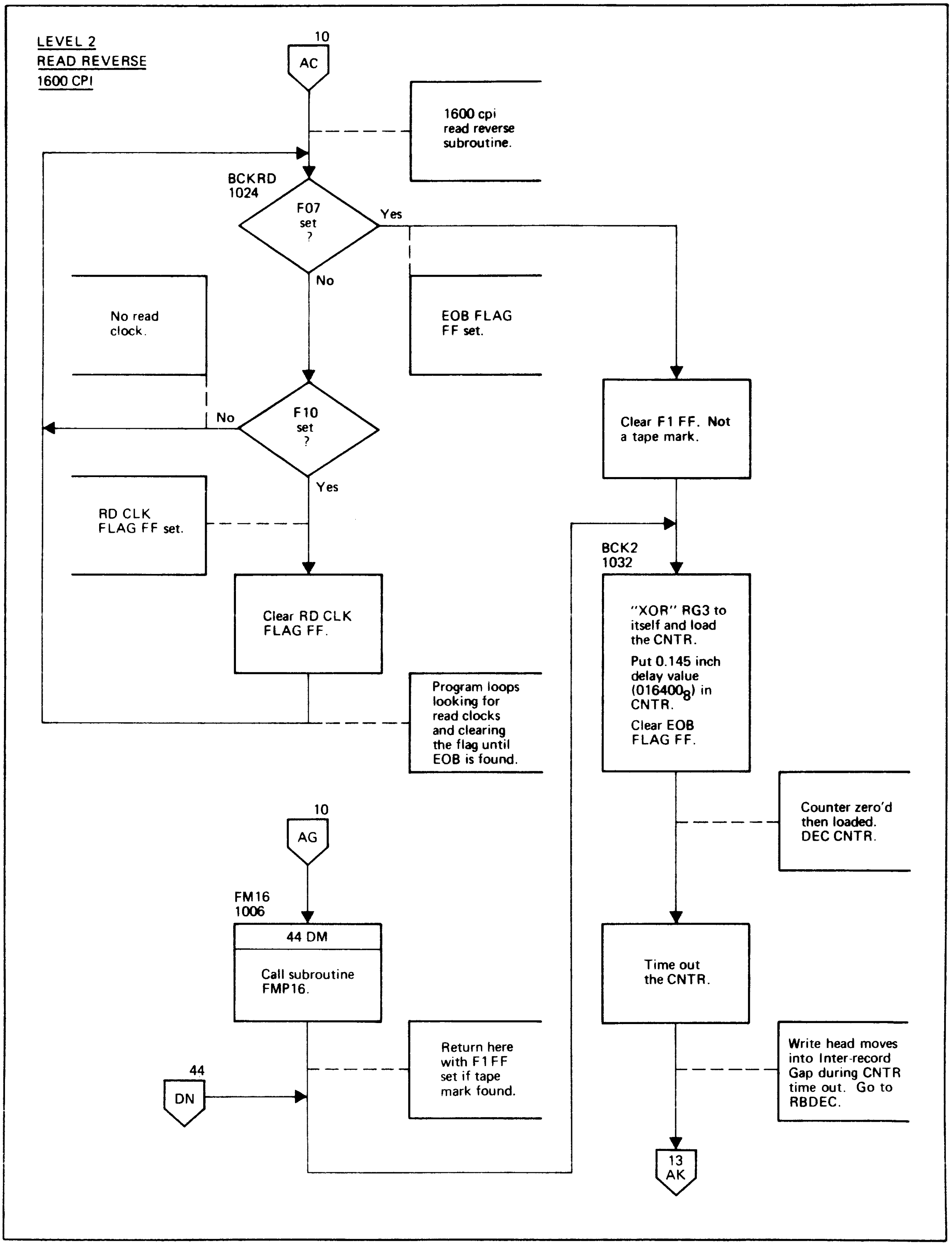
2180-103

Figure 4-10. Magnetic Tape Subsystem Microprogram Flowcharts (Sheet 44 of 58)



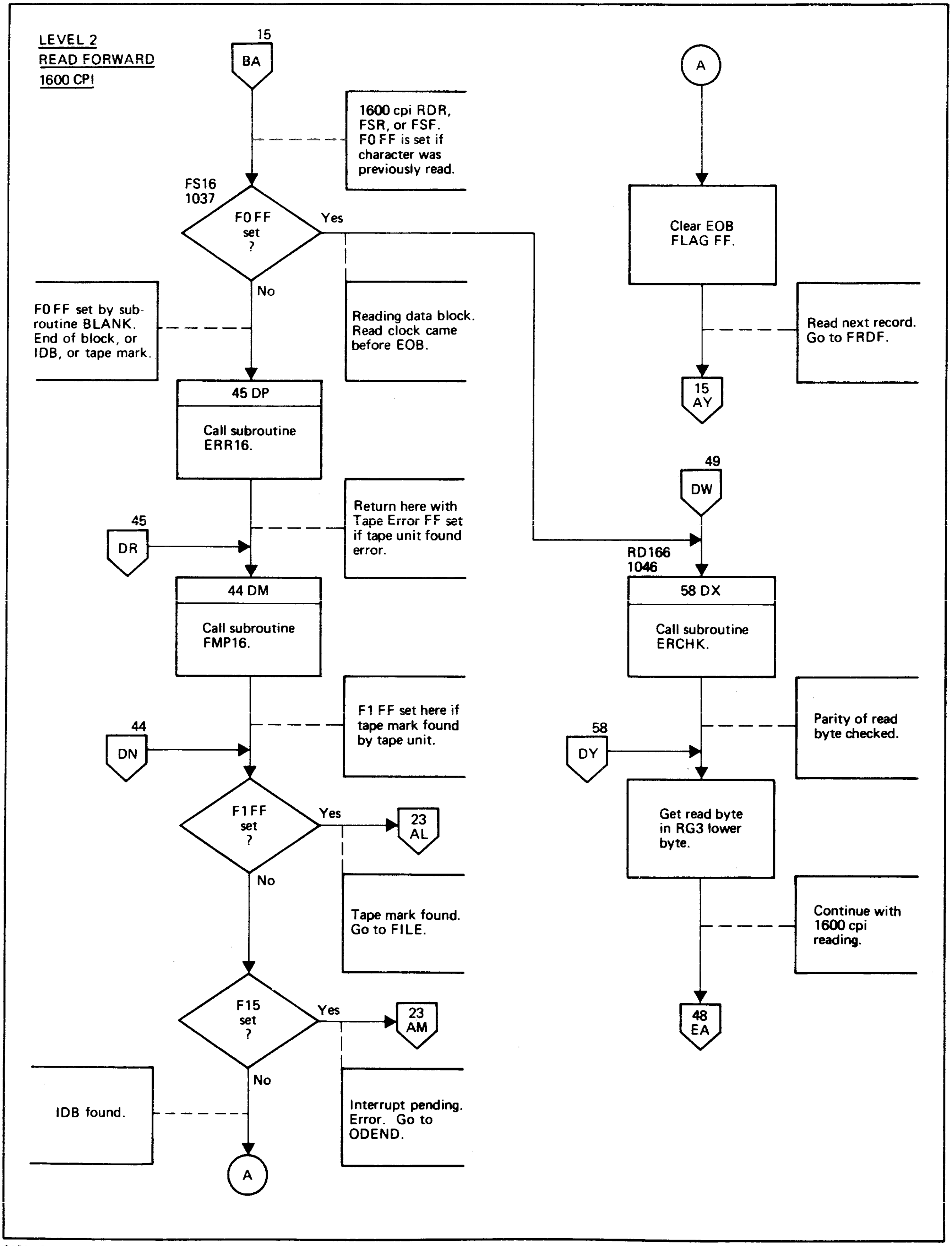
2180-104

Figure 4-10. Magnetic Tape Subsystem Microprogram Flowcharts (Sheet 45 of 58)



2180-105

Figure 4-10. Magnetic Tape Subsystem Microprogram Flowcharts (Sheet 46 of 58)



2180-106

Figure 4-10. Magnetic Tape Subsystem Microprogram Flowcharts (Sheet 47 of 58)

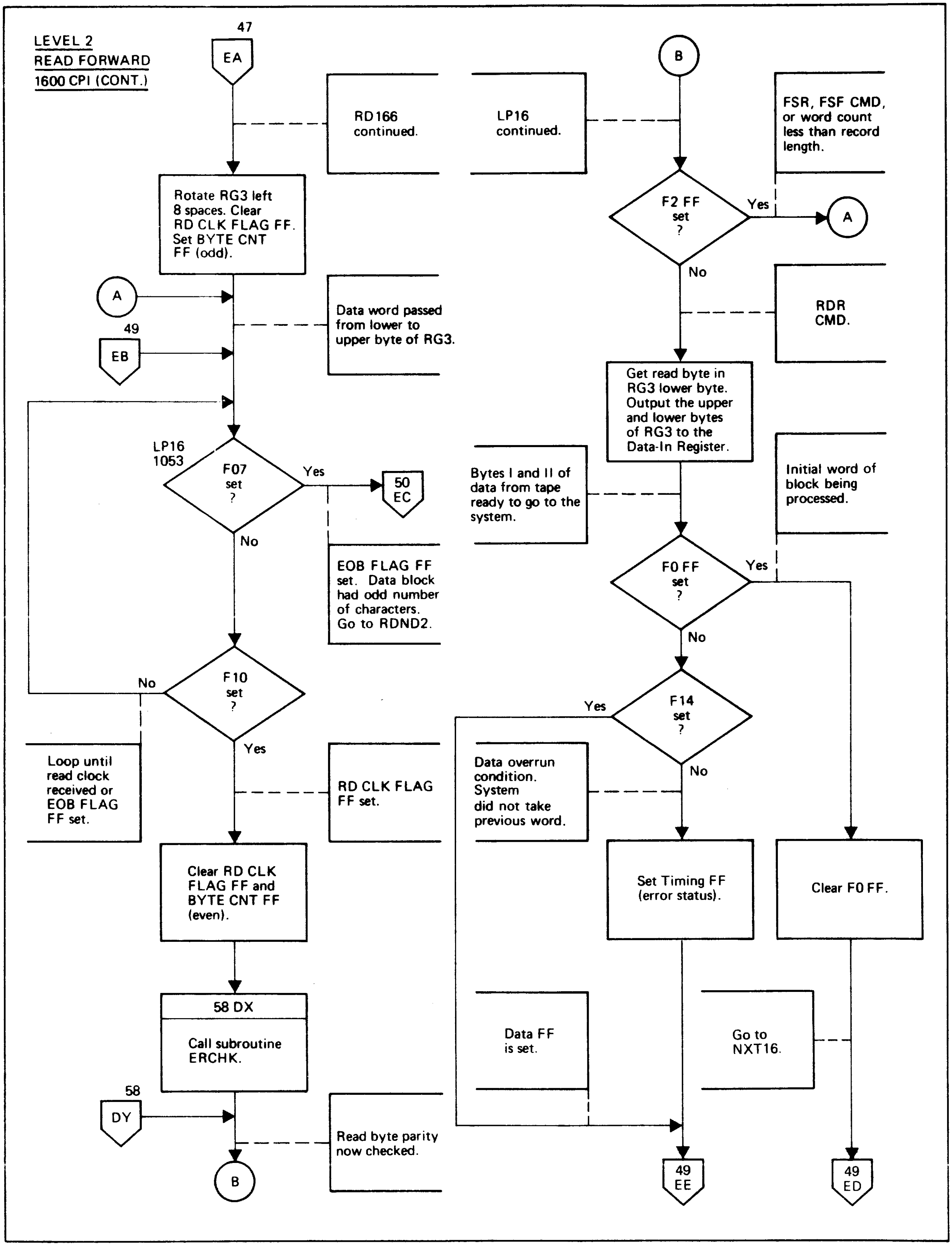


Figure 4-10. Magnetic Tape Subsystem Microprogram Flowcharts (Sheet 48 of 58)

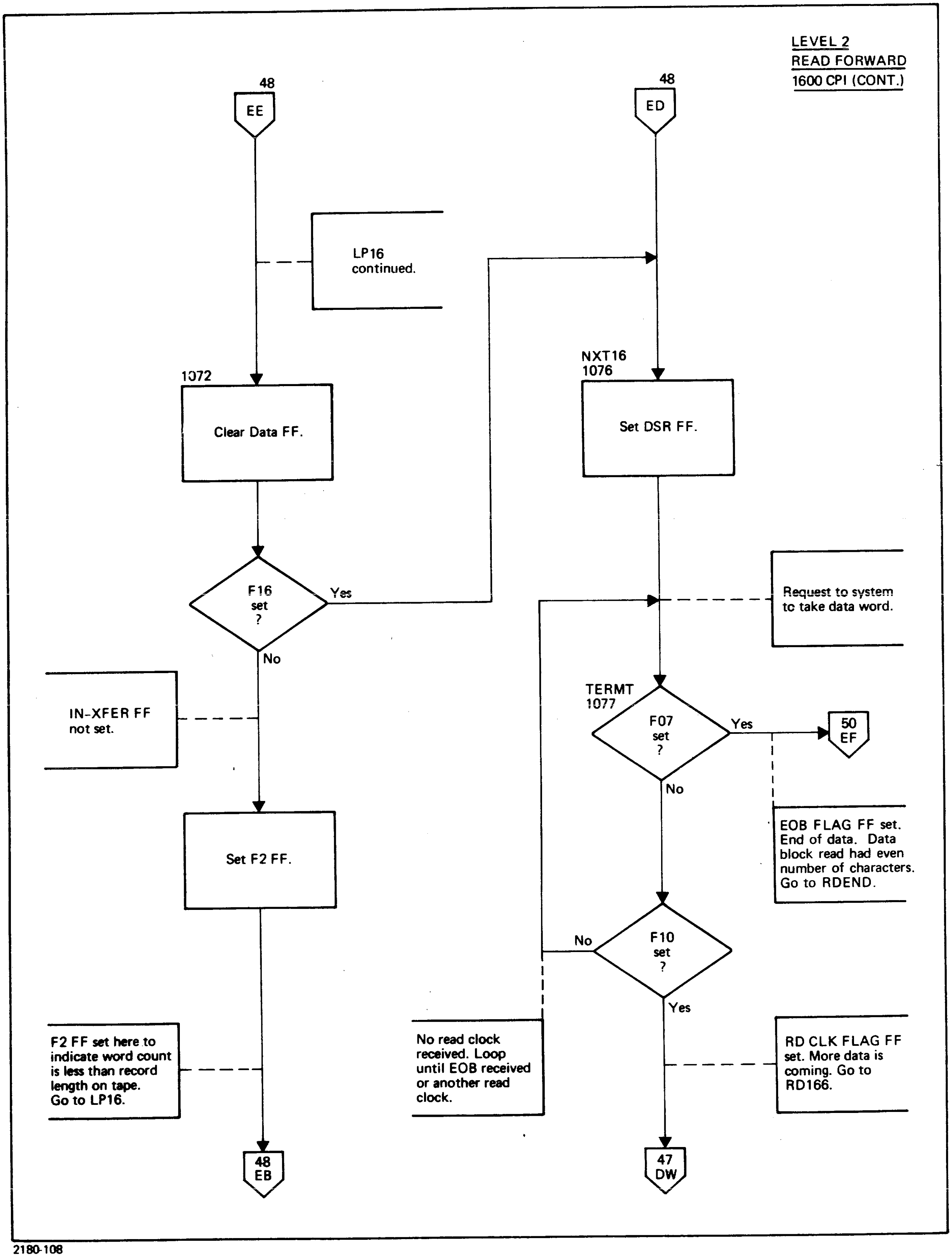


Figure 4-10. Magnetic Tape Subsystem Microprogram Flowcharts (Sheet 49 of 58)

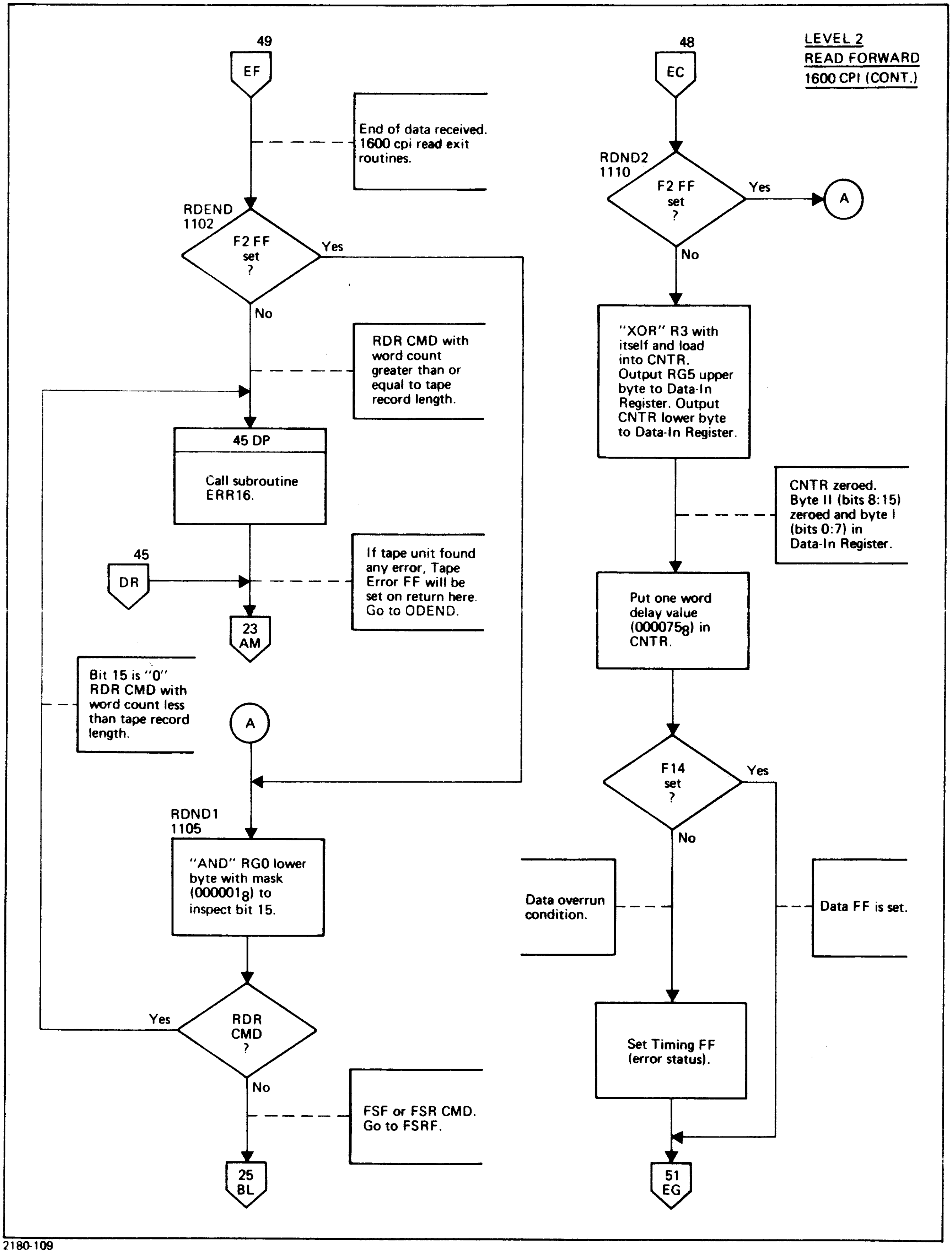
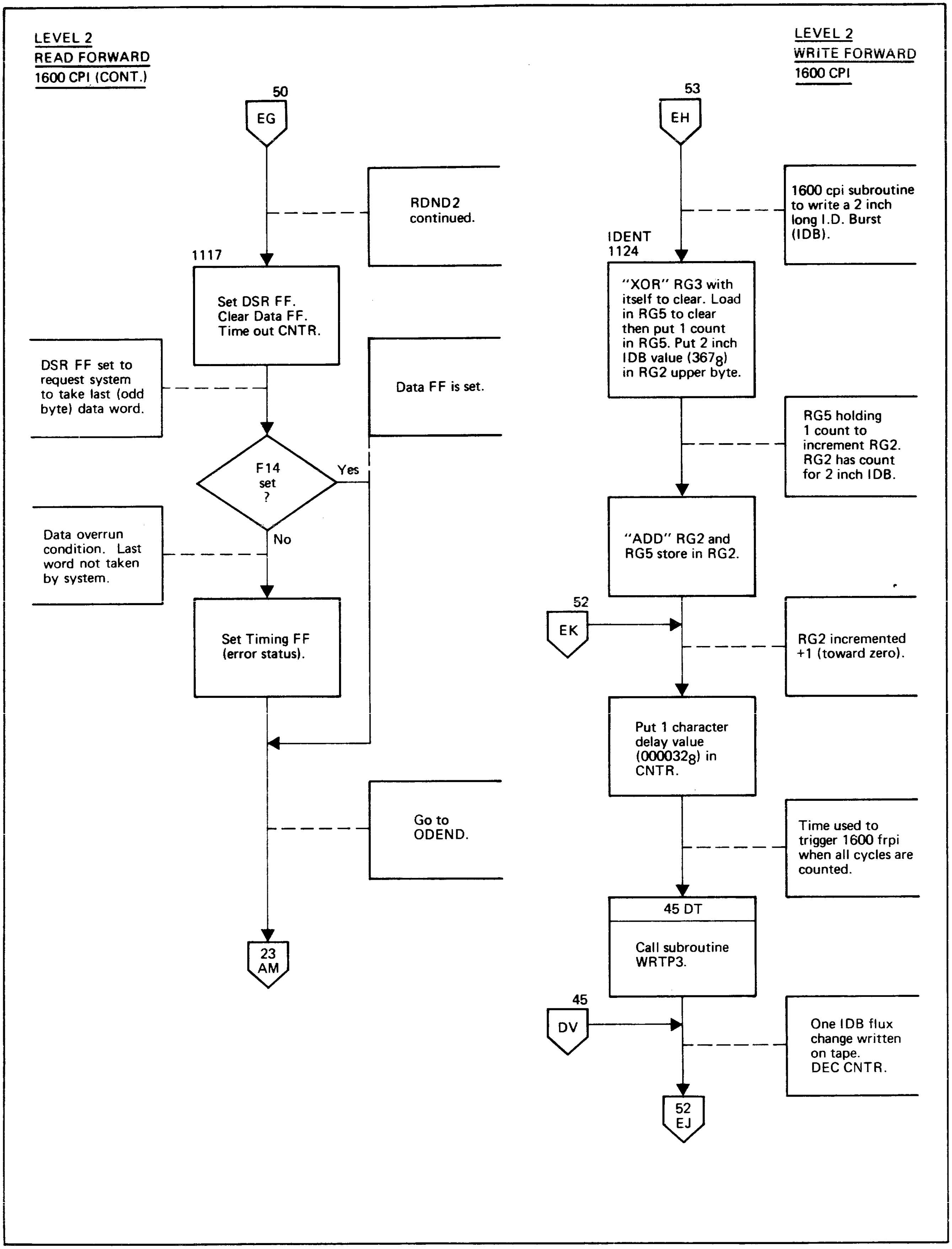
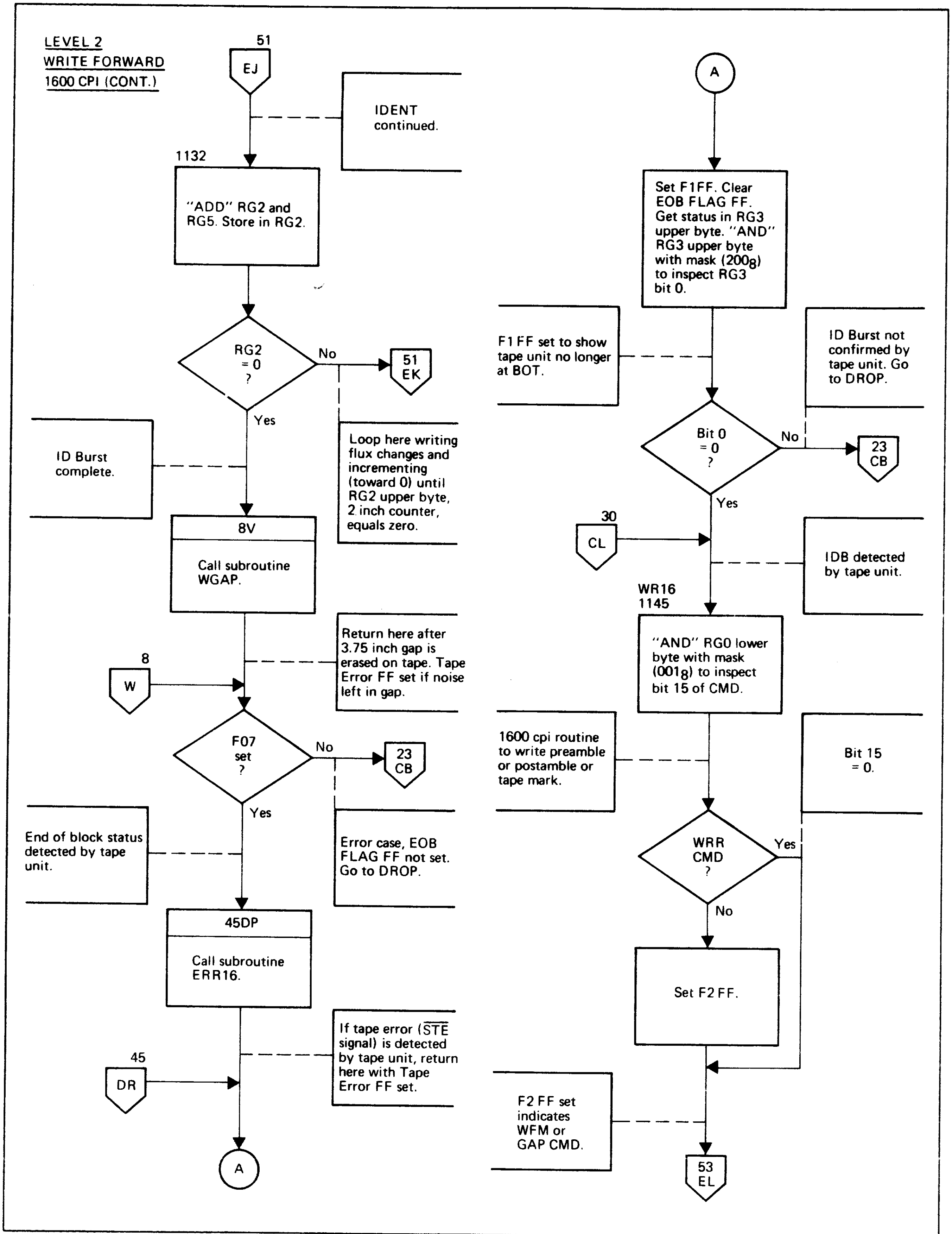


Figure 4-10. Magnetic Tape Subsystem Microprogram Flowcharts (Sheet 50 of 58)



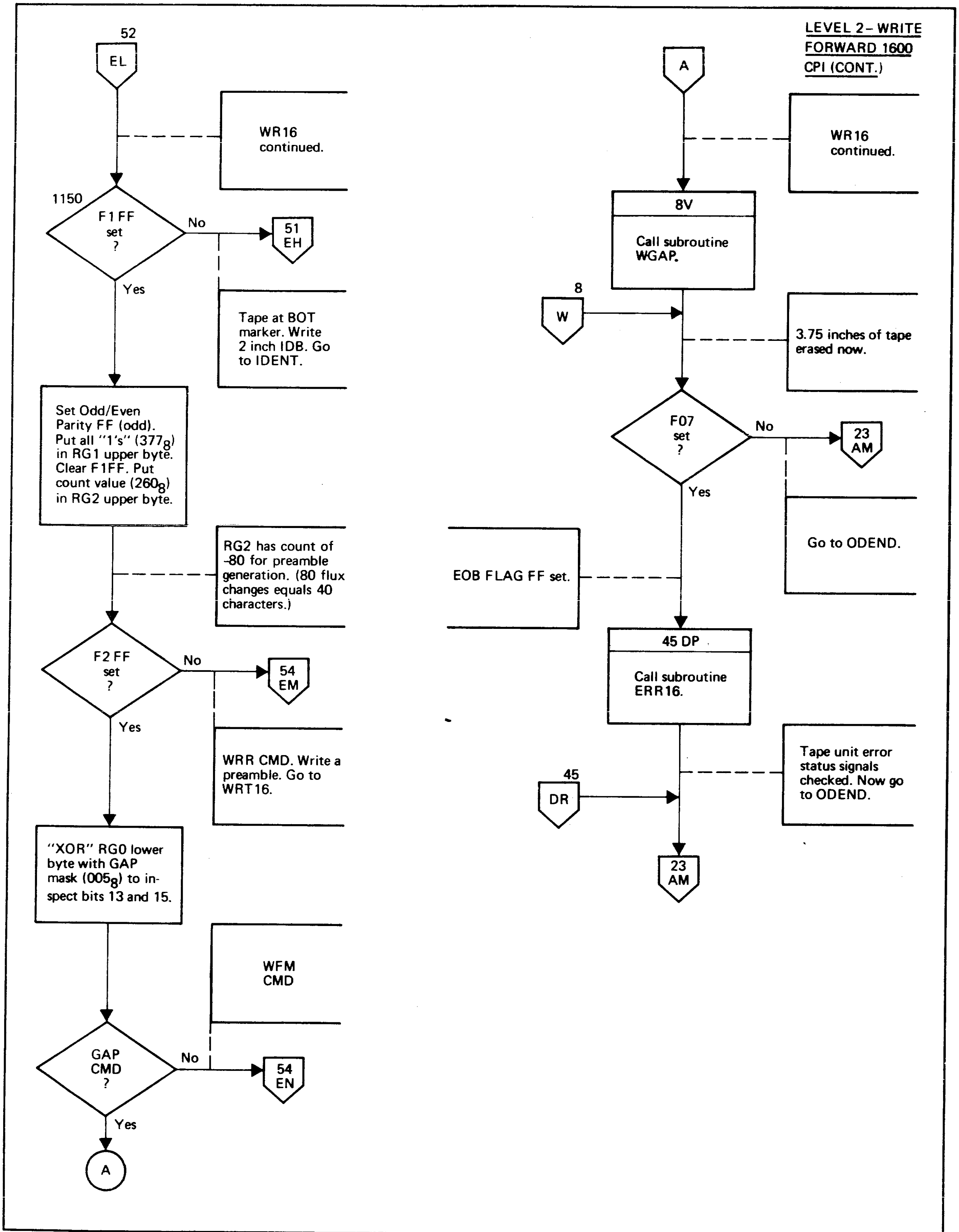
2180–110

Figure 4-10. Magnetic Tape Subsystem Microprogram Flowcharts (Sheet 51 of 58)



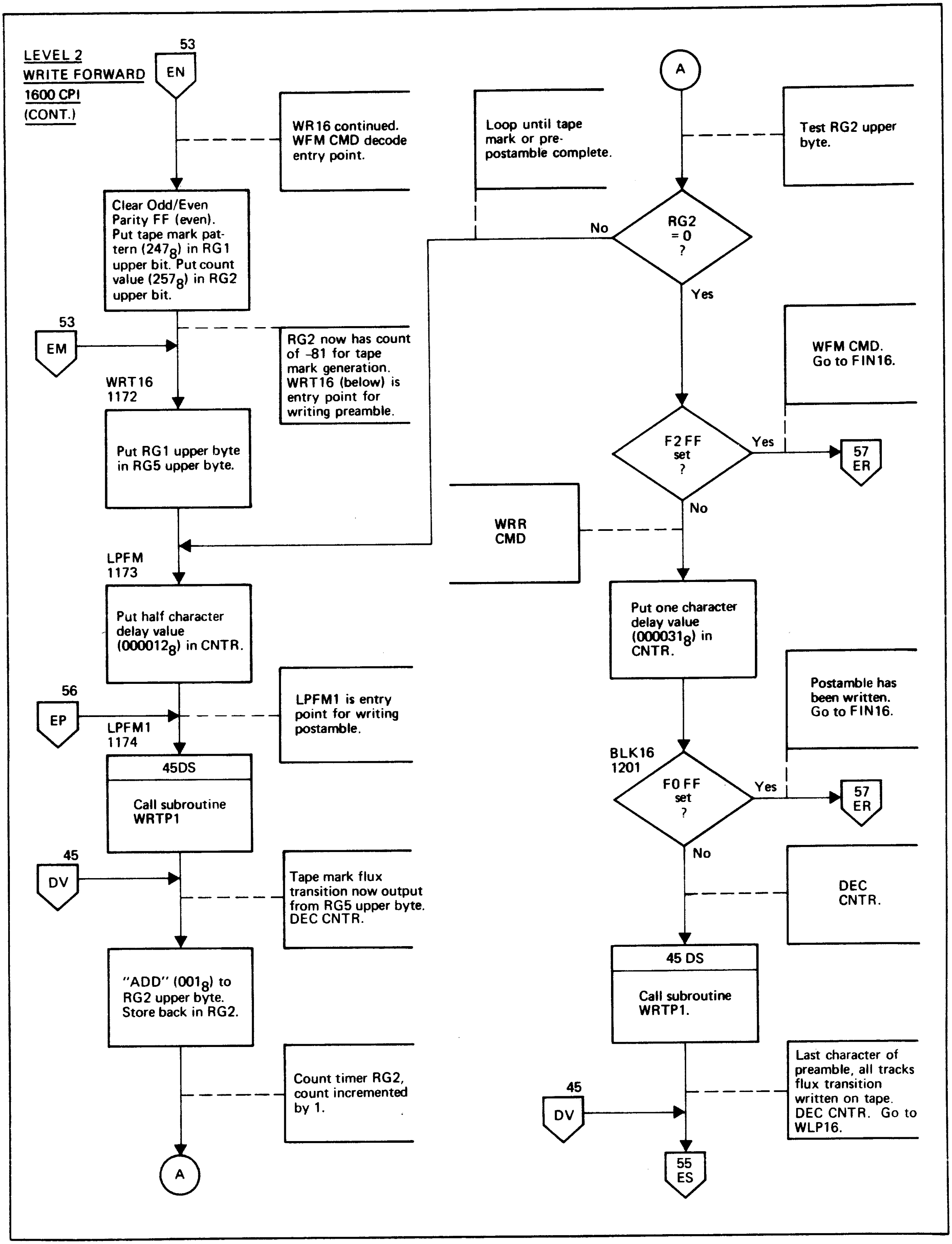
2180-111

Figure 4-10. Magnetic Tape Subsystem Microprogram Flowcharts (Sheet 52 of 58)



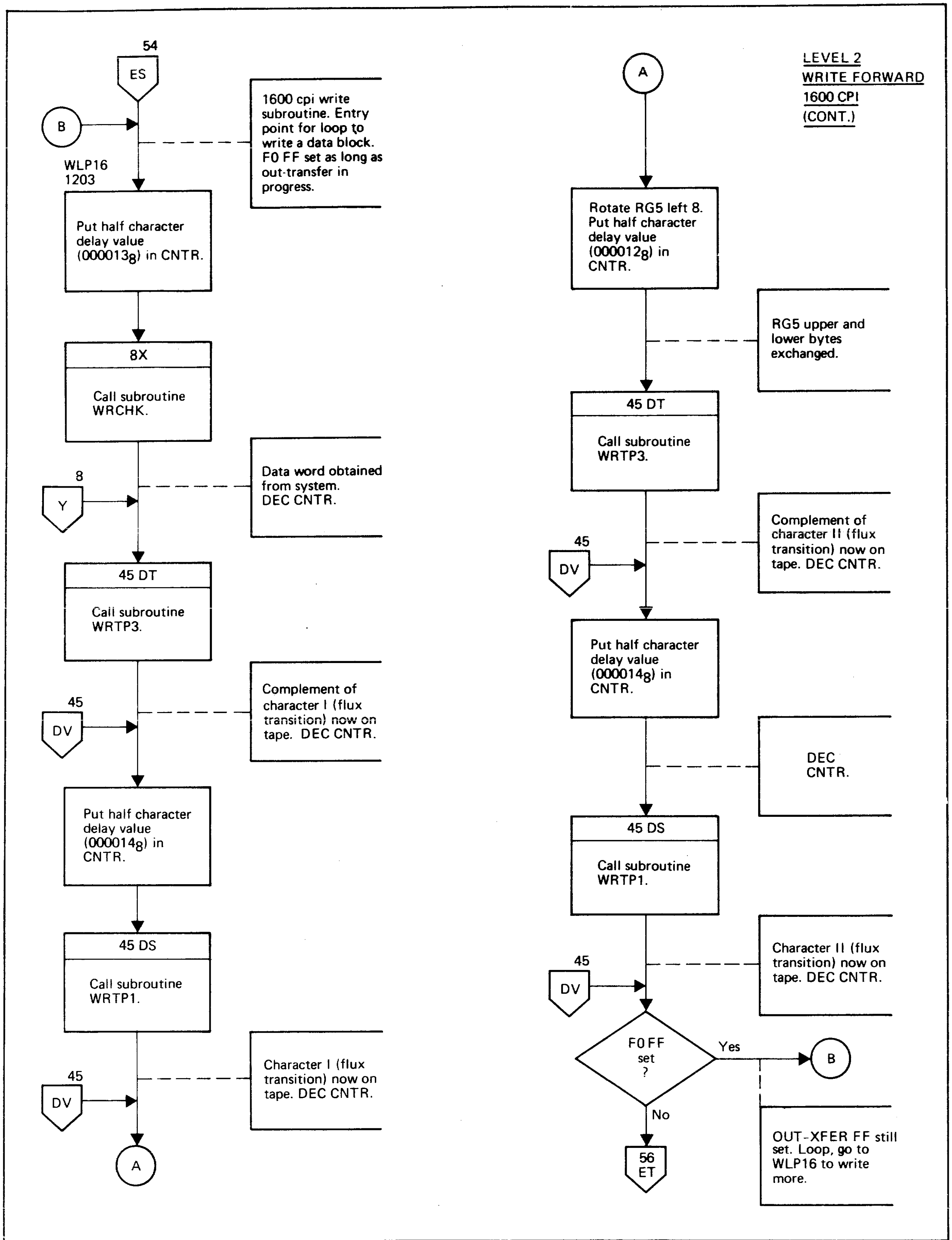
2180-112

Figure 4-10. Magnetic Tape Subsystem Microprogram Flowcharts (Sheet 53 of 58)



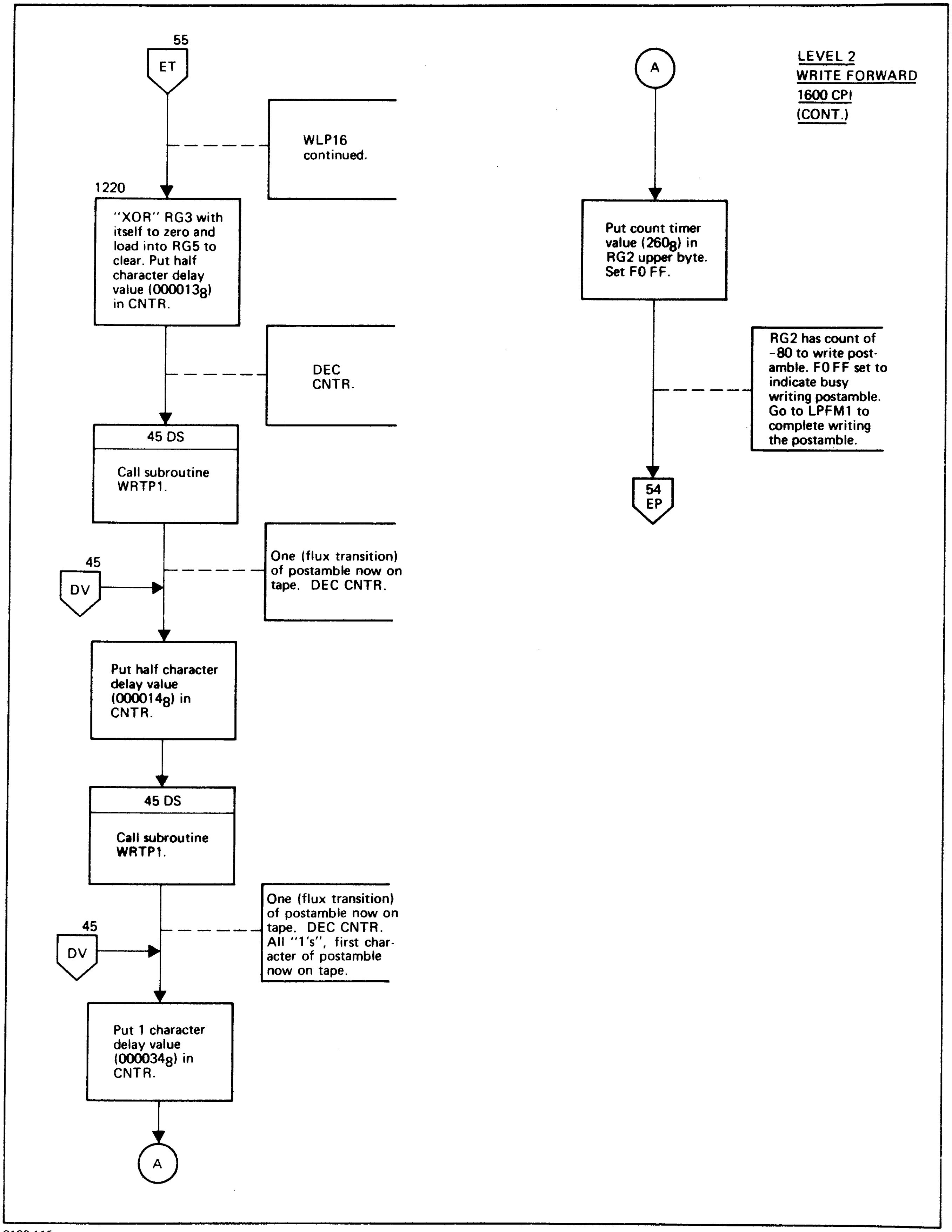
2180-113

Figure 4-10. Magnetic Tape Subsystem Microprogram Flowcharts (Sheet 54 of 58)



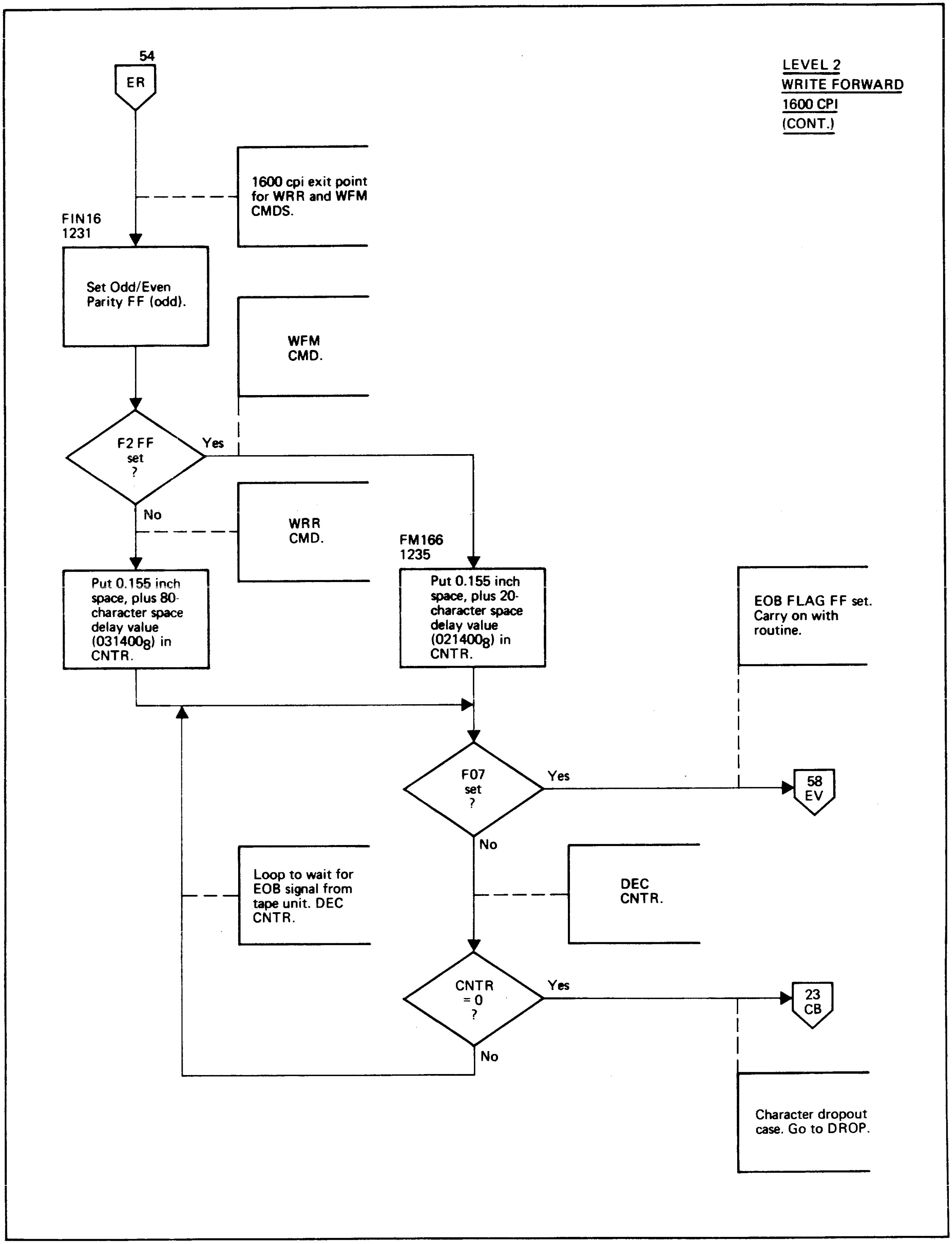
2180-114

Figure 4-10. Magnetic Tape Subsystem Microprogram Flowcharts (Sheet 55 of 58)



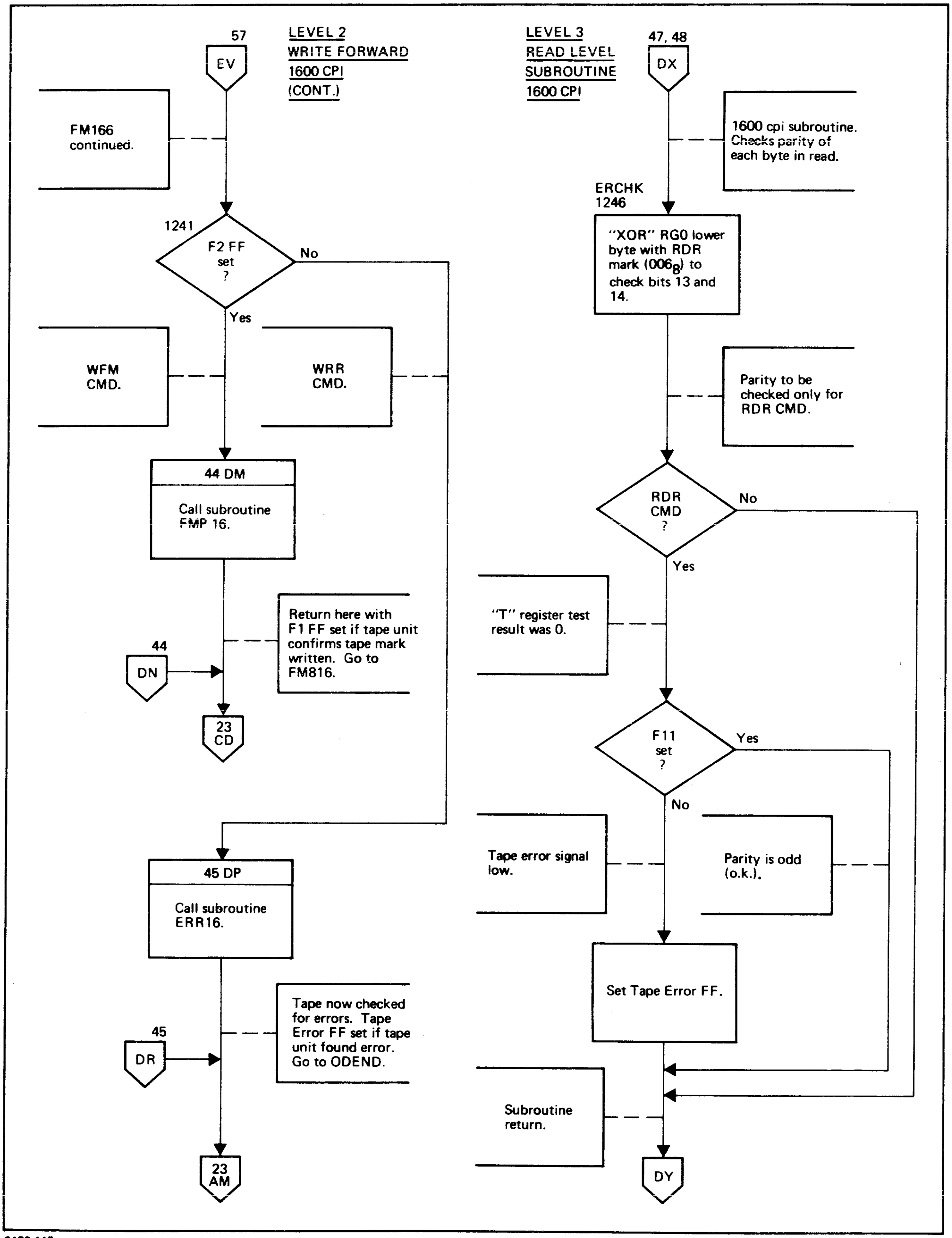
2180-115

Figure 4-10. Magnetic Tape Subsystem Microprogram Flowcharts (Sheet 56 of 58)



2180-116

Figure 4-10. Magnetic Tape Subsystem Microprogram Flowcharts (Sheet 57 of 58)



2180-117

Figure 4-10. Magnetic Tape Subsystem Microprogram Flowcharts (Sheet 58 of 58)

OP	0	1	2	3	4	5	6	7–10	11–14	15	16	17–19
IOC	0	0	0	1	0	DEC	U/L	DEST/SOURCE		FWO	I/O	REG SELECT
ADD	0	1	0	0	1	(C)		(M) (B)	(R/S)		(A)	SPECIAL
AND	1	1	1	1	0							
IOR	1	1	0	1	1							
XOR	1	1	0	0	1							
SUB	0	0	1	1	0							
CMA	1	0	0	0	0							
CMB	1	0	1	0	1							
PSA	1	1	1	1	1							
PSB	1	1	0	1	0							
ADI	0	0	0	0	1				IMMEDIATE OPERAND (ONES COMPLEMENT)			
ANI	1	0	1	1	0							
IOI	1	0	0	1	1							
XOI	1	0	0	0	1							
PSI	1	0	1	1	1							
OTI	0	0	1	1	1			DESTINATION				
JMP	0	0	0	0	0				BRANCH ADDRESS			
JMX	1	0	0	1	0							
JMZ	0	0	0	1	1		RCS					
JSZ	1	0	1	0	0							
CAL	0	1	1	1	0							
CAX	0	1	1	1	1							
CMZ	0	0	1	0	1		RCS					
CXZ	0	1	0	1	1							
JOV	1	1	0	0	0							
RMN	0	0	1	0	0							
RXN	0	1	1	0	0							
RTN	0	1	1	0	1							
JXZ	0	1	0	1	0		RCS					
RFS	1	1	1	0	1		FLAG SELECT		BRANCH ADDRESS			
JFS	1	1	1	0	0							
NOP	0	1	0	0	0							

(M) field:

CTM	000
R5M	001
R4M	010
R3M	011
R2M	100
R1M	101
ROM	110
EXM	111

(B) field:

R2B	00
R1B	01
R0B	10
R3B	11

(R/S) field:

RL1	001
RR1	010
RL4	011
PASS	100
SL1	101
SR1	110
SL4	111

(A) field:

CTA	00
R5A	01
R4A	10
R3A	11

REG SELECT:

CTI	000
R5I	001
R4I	010
R3I	011
R2I	100
R1I	101
R0I	110
EXI	111 (INPUT ONLY)

RCS = 0, reverse condition sense
I/O = 0, output
FWO = 0, byte op
DEC = 0, decrement counter, else 1
U/L = 0, lower half

2180-25

Figure 4-11. Controller Processor Consolidated Microcoding Sheet

Table 4-2. Microprogram Address-to-Label Index

ADDRESS	LABEL	ADDRESS	LABEL
0000	START	0304	INTER
0004	WAIT	0307	INT2
0007	CONT	0315	WRFWD
0013	CONT1	0337	WJOIN
0017	MAIN	0342	WRREC
0022	BEGIN	0355	FSRFO
0026	BEG2	0356	RDGO
0035	DECOD	0365	FRDF
0062	SCAN	0373	LOOPR
0065	SCAN0	0401	LOOP1
		0431	NEXT
0077	READY	0432	NEXT1
0104	GOFWD	0435	ODDEOR
0113	BLANK	0446	LREQ
0114	TIMER	0451	EVENOR
0126	NBLK	0457	YCRC
0127	NB16	0461	CRCHK
0132	WGAP	0501	CHLRC
0142	WRCHK	0507	BCK1
0153	FSRO	0513	NOFM
0154	AGAIN	0523	CHGAP
0161	FMCHK	0533	WLOOP
0175	FM816	0535	WLP1
0177	DROP	0555	WLP2
0201	FILE	0605	OTCRC
0202	ODEND	0607	OTC1
0204	STOP	0630	OTC2
0215	STOP1	0632	LRCQ
0225	FSRF	0635	NORD
0234	RBDEC	0664	YESRD
0241	RDBKD	0706	GPFM
0250	MERGE	0721	RBYTE
0252	BSRF	0725	RBITE
0260	BSRF2	0726	WBITE
0262	BACK	0731	CBITE
0274	RDFWD	0741	CRCCH
0277	RDR1	0747	WRCRC
0303	REJECT	0753	WRCR1

Table 4-2. Microprogram Address-to-Label Index (Continued)

ADDRESS	LABEL	ADDRESS	LABEL
0762	ODDWI	1105	RDND1
0770	FMPAR	1110	RDND2
1000	FMP16	1124	IDENT
1006	FM16	1145	WR16
1010	ERR16	1172	WRT16
1015	WRTPI	1173	LPFM
1016	WRTPE	1174	LPFM1
1017	WRTP3	1201	BLK16
1024	BCKRD	1203	WLP16
1032	BCK2	1231	FIN16
1037	FS16	1235	FM166
1046	RD166	1246	ERCHK
1053	LP16	1314	PTCH1
1076	NXT16	1327	PTCH2
1077	TERMT	1361	PATCH
1102	RDEND		

NOTE: Addresses and labels reflect listing dated 12/9/72.

Table 4-3. Microprogram Lable, Flowchart, Address, Subroutine Index

LABEL	FLOW-CHART SHEET	ADDRESS	LEVEL (NOTE 2)	LABEL	FLOW-CHART SHEET	ADDRESS	LEVEL (NOTE 2)
AGAIN	21	0154	–	IDENT	51	1124	–
BACK	10	0262	–	INTER	28	0304	2
BCKRD	46	1024	2	INT2	28	0307	–
BCK1	11	0507	–	LOOPR	15	0373	–
BCK2	46	1032	–	LOOP1	16	0401	–
BEGIN	2	0022	–	LPFM	54	1173	–
BEG2	2	0026	1	LPFM1	54	1174	–
BLANK	7	0113	3	LP16	48	1053	–
BLK16	54	1201	–	LRCQ	38	0632	–
BSRF	9	0252	2	LREQ	18	0446	–
BSRF2	10	0260	–	MAIN	2	0017	1
CBITE	26	0731	3	MERGE	9	0250	–
CHGAP	12	0523	–	NBLK	7	0126	–
CHLRC	21	0501	–	NB16	7	0127	–
CONT	1	0007	1	NEXT	17	0431	–
CONT1	1	0013	–	NEXT1	17	0432	–
CRCCH	27	0741	3	NOFM	11	0513	–
CRCHK	19	0461	–	NORD	38	0635	–
DECOD	3	0035	–	NXT16	49	1076	–
DROP	23	0177	2	ODDEOR	18	0435	–
ERCHK	58	1246	3	ODDW1	44	0762	3
ERR16	45	1010	3	ODEND	23	0202	2
EVENOR	19	0451	–	OTCRC	35	0605	2
FILE	23	0201	2	OTC1	36	0607	–
FIN16	57	1231	–	OTC2	38	0630	–
FMCHK	22	0161	–	PATCH	24	1361	–
FMPAR	27	0770	3	PTCH1	1	1314	–
FMP16	44	1000	3	PTCH2	4	1327	–
FM16	46	1006	–	RBDEC	13	0234	2
FM166	57	1235	–	RBITE	26	0725	3
FM816	23	0175	2	RBYTE	26	0721	3
FRDF	15	0365	2	RDBKD	9	0241	2
FSRF	25	0225	2	RDEND	50	1102	–
FSRFO	14	0355	–	RDFWD	14	0274	2
FSRO	21	0153	–	RDGO	14	0356	–
FS16	47	1037	2	RDND1	50	1105	–
GOFWD	6	0104	3	RDND2	50	1110	–
GPFM	42	0706	–	RDR1	14	0277	–

Table 4-3. Microprogram Label, Flowchart, Address, Subroutine Index (Continued)

LABEL	FLOW-CHART SHEET	ADDRESS	LEVEL (NOTE 2)	LABEL	FLOW-CHART SHEET	ADDRESS	LEVEL (NOTE 2)
RD166	47	1046	–	WLP1	32	0535	–
READY	5	0077	–	WLP2	33	0555	–
REJECT	28	0303	2	WLP16	55	1203	–
SCAN	4	0062	–	WRCHK	8	0142	3
SCAN0	4	0065	–	WRCRC	43	0747	3
START	1	0000	1	WRCR1	43	0753	–
STOP	24	0204	–	WRFWD	29	0315	2
STOP1	24	0215	–	WRREC	30	0342	–
TERMT	49	1077	–	WRTPE	45	1016	–
TIMER	7	0114	–	WRTP1	45	1015	3
WAIT	1	0004	1	WRTP3	45	1017	3
WBITE	26	0726	–	WRT16	54	1172	–
WGAP	8	0132	3	WR16	52	1145	2
WJOIN	30	0337	–	YCRC	19	0457	–
WLOOP	31	0533	–	YESRD	40	0664	2

NOTES: 1. Addresses and labels reflect listing dated 12/9/72.
2. Number indicates microprogram routine/subroutine level. Entry points only are numbered.

Table 4-4. Magnetic Tape Subsystem Microprogram Listing

```
*****************************************************************************
*                                                                           *
* XXXXX   XXXXX XXXXX X   X    X   X XXXXX XXXXX    XXXXX XXXXX XXXXX XXXXX *
* X   X     X   X   X X  X     XX XX X   X X          X   X   X X   X X     *
* X   X     X   X   X X X      X X X X   X X          X   X   X X   X X     *
* XXXXX     X   XXXXX XX       X   X XXXXX X          X   XXXXX XXXXX XXXX  *
*     X     X   X X   X X      X   X X   X X  XX      X   X   X X     X     *
*     X     X   X  X  X  X     X   X X   X X   X      X   X   X X     X     *
*     X     X   X   X X   X X  X   X X   X XXXXX X    X   X   X X     XXXXX *
*                    LISTING DATED 12/9/72                                  *
*****************************************************************************
*                                                                           *
*     CONSTANTS USED FOR TIMING CONTROL IN THE MAG. TAPE CONTROLLER         *
*                                                                           *
*****************************************************************************
*****          **DATA XFER TIMING DELAYS**
T1     EQU      #75                       1 CHARACTER TIME(L)
T22    EQU      #215                      2.2 CHARACTER GATE FOR READING(L)
T4     EQU      1                         4 CHARACTER SPACING FOR CRCC & LRCC(H)
T62    EQU      #306                      6.2 CHARACTER TIME(L)-SHOULD BE DOUBLED
T8     EQU      2                         8 CHARACTER SPACING FOR FILE MARK(4)
T12    EQU      3                         12 CHARACTER SPACING FOR BACKSPACING(H)
*****          **START/STOP DELAYS OF CAPSTAN**
TCOST  EQU      #356                      COAST DELAY FOR 103 USEC.
TSTRT  EQU      #113                      START DELAY FOR .2 INCH(H)
TWSTR  EQU      #133                      START DELAY FOR WRITE
TSTOP  EQU      #113                      STOP DELAY FOR .2 INCH(H)
TIRG   EQU      #113                      (START+STOP) COAST I/R DELAY FOR .4 INCH
*****          **DELAYS RELATING TO R/W HEADS**                                (H)
T145   EQU      #35                       MIN. & MAX. HEAD SPACING(H)
T155   EQU      #37                         DELAY AT FULL SPEED(H)
T15    EQU      #74                       NOM. HEAD SPACING DELAY AT HALF SPEED(H)
TS155  EQU      #152                      (MAX. HEAD + START) COAST DELAY(H)
TGAP   EQU      #372                      DELAY FOR 1.25 INCH-(1/3 OF GAP) (H)
*****
FM     EQU      #23                       FILE/MARK CODE FOR 800 BPI
*****************************************************************************
*                                                                           *
*                 COMMAND CODES FOR THE CONTROLLER                          *
*                                                                           *
*****************************************************************************
SEL    EQU 0                              SELECT THE UNIT
RDR    EQU #6                             READ RECORD
RDC    EQU #16                            READ RECORD WITH CRCC(800 BPI ONLY)
FSR    EQU #7                             FORWARD SPACE RECORD
FSF    EQU #17                            FORWARD SPACE FILE
WRR    EQU #4                             WRITE RECORD
WRZ    EQU #14                            WRITE RECORD WITH 0 PARITY(800 BPI ONLY)
WFM    EQU #15                            WRITE FILE-MARK
GAP    EQU #5                             WRITE A GAP
BSR    EQU #12                            BACK-SPACE RECORD
BSF    EQU #13                            BACK SPACE FILE
REW    EQU #10                            REWIND THE TAPE UNIT
RST    EQU #11                            REWIND & RESET
RDREV  EQU #2                             READ-REV. SUB GROUP
*****************************************************************************
       SKP
```

NOTES:

1. FILE-MARK AND TAPE MARK ARE SYNONYMOUS.
2. CLEAR AND RESET ARE SYNONYMOUS.
3. R0:R5 REFER TO CONTROLLER PROCESSOR REGISTERS RG0:RG5.
4. SEE TEXT FOR COMPLETE COPY OF CODING SHEET.

Table 4-4. Magnetic Tape Subsystem Microprogram Listing (Continued)

```
**********************************************************************************
*                                                                                *
*          REFERENCE CODING SHEET FOR THE CONTROLLER PROCESSOR                   *
*                                                                                *
**********************************************************************************
* OP * 0   1 * 2   3   4 *  5   6   7 * 8    9   10 * 11 12 13 * 14   15 16 * 17   18 19*
**********************************************************************************
*IOC * 0   0 * 0   1   0 *DEC*U/L*   DEST/SOURCE   *             *FWO*I/O*RFG SELECT*
*ADD * 0   1 * 0   0   1 *DEC*U/I* CTM  000 * R2B 00* RL1  001 *FWO* CTA 00 *       *
*AND * 1   1 * 1   1   0 *     *    * R5M  001 * R1B 01* RR1  010 *   * P5A 01 *       *
*IOR * 1   1 * 0   1   1 *     *    * R4M  010 * R0B 10* RL4  011 *   * R4A 10 *       *
*XOR * 1   1 * 0   0   1 *     *    * R3M  011 * R3B 11* PASS 100 *   * R3A 11 * SPEC*
*SUB * 0   0 * 1   1   0 *     *    * R2M  100 *        * SL1  101 *   *        *       *
*CMA * 1   0 * 0   0   0 *     *    * R1M  101 *        * SR1  110 *   *        *       *
*CMP * 1   0 * 1   0   1 *     *    * ROM  110 *        * SL4  111 *   *        *       *
*PSA * 1   1 * 1   1   1 *     *    * EXM  111 *        *          *   *        *       *
*PSB * 1   1 * 0   1   0 *     *    *              *        *          *   *        *       *
*****************************               *        ****************************
*ADI * 0   0 * 0   0   1 *DEC*U/L*              *        *                            *
*ANI * 1   0 * 1   1   0 *     *    *              *        *      IMMEDIATE             *
*IOI * 1   0 * 0   1   1 *     *    *              *        *        OPERAND             *
*XOI * 1   0 * 0   0   1 *     *    *              *        *   (ONES COMPLEMENT)        *
*PSI * 1   0 * 1   1   1 *     *    *              *        *                            *
**********************************************************************************
*OTI * 0   0 * 1   1   1 *DEC*U/L*    DESTINATION    *       IMMEDIATE OPERAND      *
**********************************************************************************
*JMP * 0   0 * 0   0   0 *DEC* * *  *                   BRANCH ADDRESS                *
*JMX * 1   0 * 0   1   0 *   * * *  *                                                 *
*JMZ * 0   0 * 0   1   1 *   *RCS*  *                                                 *
*JSZ * 1   0 * 1   0   0 *   *   *  *                                                 *
*CAL * 0   1 * 1   1   0 *   * * *  *                                                 *
*CAX * 0   1 * 1   1   1 *   * * *  *                                                 *
*CMZ * 0   0 * 1   0   1 *   *RCS*  *                                                 *
*CXZ * 0   1 * 0   1   1 *   *   *  *                                                 *
*JOV * 1   1 * 0   0   0 *   *   *  *                                                 *
*RMN * 0   0 * 1   0   0 *   *   *  *                                                 *
*RXN * 0   1 * 1   0   0 *   *   *  *                                                 *
*RTN * 0   1 * 1   0   1 *   * * *  *                                                 *
*JXZ * 0   1 * 0   1   0 *   *RCS*  *                                                 *
**********************************************************************************
*RFS * 1   1 * 1   0   1 *DEC*    FLAG       *           BRANCH                      *
*JFS * 1   1 * 1   0   0 *   *       SELECT  *             ADDRESS                   *
**********************************************************************************
* RCS = 0,REVERSE CONDITION SENSE                                                *
* I/O = 0,OUTPUT                                                                 *
* FWO = 0,BYTE OPERATION                                                         *
* DEC = 0,DECREMENT COUNTER                                                      *
* U/L = 0,LOWER HALF                                                             *
**********************************************************************************
      SKP
```

Table 4-4. Magnetic Tape Subsystem Microprogram Listing (Continued)

```
*********************************************************************************
*                                                                               *
*       CONTROLLER PROCESSOR SIGNALS(CONNECTOR J2)                              *
*                                                                               *
*********************************************************************************
*                                                                               *
* 1     GND         GROUND                                                      *
* 2     GND         GROUND                                                      *
* 48    RAR11       ROM ADDRESS BIT 11(LSB)                                     *
* 47    RAR10       ROM ADDRESS BIT 10                                          *
* 46    RAR9        ROM ADDRESS BIT  9                                          *
* 45    RAR8        ROM ADDRESS BIT  8                                          *
* 44    RAR7        ROM ADDRESS BIT  7                                          *
* 43    RAR6        ROM ADDRESS BIT  6                                          *
* 42    RAR5        ROM ADDRESS BIT  5                                          *
* 41    RAR4        ROM ADDRESS BIT  4                                          *
* 40    RAR3        ROM ADDRESS BIT  3                                          *
* 39    RAR2        ROM ADDRESS BIT  2                                          *
* 38    RAR1        ROM ADDRESS BIT  1                                          *
* 37    RAR0        ROM ADDRESS BIT  0(MSB)                                     *
* 33    ROM19       ROM OUTPUT BIT 19(LSB)                                      *
* 31    ROM18       ROM OUTPUT BIT 18                                           *
* 29    ROM17       ROM OUTPUT BIT 17                                           *
* 27    ROM16       ROM OUTPUT BIT 16                                           *
* 25    ROM15       ROM OUTPUT BIT 15                                           *
* 23    ROM14       ROM OUTPUT BIT 14                                           *
* 21    ROM13       ROM OUTPUT BIT 13                                           *
* 19    ROM12       ROM OUTPUT BIT 12                                           *
* 17    ROM11       ROM OUTPUT BIT 11                                           *
* 15    ROM10       ROM OUTPUT BIT 10                                           *
* 13    ROM9        ROM OUTPUT BIT  9                                           *
* 11    ROM8        ROM OUTPUT BIT  8                                           *
* 9     ROM7        ROM OUTPUT BIT  7                                           *
* 7     ROM6        ROM OUTPUT BIT  6                                           *
* 5     ROM5        ROM OUTPUT BIT  5                                           *
* 3     ROM4        ROM OUTPUT BIT  4                                           *
* 34    ROM3        ROM OUTPUT BIT  3                                           *
* 32    ROM2        ROM OUTPUT BIT  2                                           *
* 30    ROM1        ROM OUTPUT BIT  1                                           *
* 28    ROM0        ROM OUTPUT BIT  0(MSB)                                      *
* 36    ENB         ROM ENABLE                                                  *
* 49    GND         GROUND                                                      *
* 50    GND         GROUND                                                      *
*                                                                               *
*********************************************************************************
        SKP
```

Table 4-4. Magnetic Tape Subsystem Microprogram Listing (Continued)

```
*****************************************************************************
*                                                                           *
*     CONTROLLER PROCCESSOR SIGNALS (CONNECTOR J3)                          *
*                                                                           *
*****************************************************************************
*                                                                           *
* 47  M0       MIO BUS BIT 0(MSB)                                           *
* 45  M1       MIO BUS BIT 1                                                *
* 43  M2       MIO BUS BIT 2                                                *
* 41  M3       MIO BUS BIT 3                                                *
* 42  M4       MIO BUS BIT 4                                                *
* 44  M5       MIO BUS BIT 5                                                *
* 46  M#       MIO BUS BIT 6                                                *
* 48  M7       MIO BUS BIT 7                                                *
* 40  M8       MIO BUS BIT 8                                                *
* 38  M9       MIO BUS BIT 9                                                *
* 36  M10      MIO BUS BIT 10                                               *
* 34  M11      MIO BUS BIT 11                                               *
* 31  M12      MIO BUS BIT 12                                               *
* 33  M13      MIO BUS BIT 13                                               *
* 35  M14      MIO BUS BIT 14                                               *
* 37  M15      MIO BUS BIT 15(LSB)                                          *
* 8   IS       INPUT STROBE                                                 *
* 10  LOS      LOWER OUTPUT STROBE                                          *
* 7   UOS      UPPER OUTPUT STROBE                                          *
* 18  ROR7     DESTINATION BIT 7(MSB)                                       *
* 6   ROR9     DESTINATION BIT 9                                            *
* 20  ROR10    DESTINATION BIT 10                                           *
* 15  ROR8     DESTINATION BIT 8                                            *
* 17  ROR11    DESTINATION BIT 11(LSB)                                      *
* 1   GND      GROUND                                                       *
* 2   CLR      CLEAR RAR TO 0                                               *
* 3   T0       CLOCK PHASE 0                                                *
* 4   T3       CLOCK PHASE 3                                                *
* 5   T2       CLOCK PHASE 2                                                *
* 39  T1       CLOCK PHASE 1                                                *
* 32  EXT SEL  EXTERNAL SELECT                                              *
* 49  RUN      FROM MAINTENANCE PANEL                                       *
* 50  GND      GROUND                                                       *
*                                                                           *
*****************************************************************************
      SKP
```

Table 4-4. Magnetic Tape Subsystem Microprogram Listing (Continued)

```
*************************************************************************
*                                                                       *
*     DEVICE CABLE CONNECTIONS (CONNECTOR J1)                           *
*                                                                       *
*************************************************************************
*************************************************************************
*   J1      WRT. RD.  C/S       NAME OF SIGNAL                          *
*           (SIG/GND)                                                   *
*                                                                       *
*************************************************************************
*                                                                       *
*  33/27  L/10                  WRITE DATA 0-WD0(MSB)                   *
*  34/27  M/11                  WRITE DATA 1-WD1                        *
*  39/27  N/12                  WRITE DATA 2-WD2                        *
*  40/27  P/13                  WRITE DATA 3-WD3                        *
*  37/28  R/14                  WRITE DATA 4-WD4                        *
*  38/28  S/15                  WRITE DATA 5-WD5                        *
*  35/28  T/16                  WRITE DATA 6-WD6                        *
*  36/28  U/17                  WRITE DATA 7-WD7(LSB)                   *
*  10/28  K/9                   WRITE DATA PARITY-WDP                   *
*  11/28  F/6                   WRITE STATUS-SW                         *
*  30/27  J/8                   WRITE CLOCK-WC                          *
*  22/27  H/7                   WRITE RESET-WRS                         *
*  47/50       L/10             READ DATA 0-RD0(MSB)                    *
*  48/50       M/11             READ DATA 1-RD1                         *
*  45/50       N/12             READ DATA 2-RD2                         *
*  46/50       P/13             READ DATA 3-RD3                         *
*  43/49       R/14             READ DATA 4-RD4                         *
*  44/49       S/15             READ DATA 5-RD5                         *
*  41/49       T/16             READ DATA 6-RD6                         *
*  42/49       U/17             READ DATA 7-RD7(LSB)                    *
*   9/25       K/9              READ DATA PARITY-RDP                    *
*   8/23       J/8              READ CLOCK-RC                           *
*   7/23       BB/24            END OF BLOCK-EOB                        *
*  12/26       V/18             800/1600 BPI STATUS-SD16                *
*  31/26       X/20             MULTIPLE TRACK IN ERROR-MTE             *
*  32/26       Y/21             TAPE MARK-TM                            *
*   2/26       Z/22             SINGLE TRACK IN ERROR-STE               *
*  29/26       AA/23            IDENTIFICATION BURST-IDB                *
*   3/23             P/13       SELECT UNIT 0-CS0                       *
*   4/23             N/12       SELECT UNIT 1-CS1                       *
*   5/24             M/11       SELECT UNIT 2-CS2                       *
*   6/24             L/10       SELECT UNIT 3-CS3                       *
*  13/23             B/2        LOAD POINT(BOT)-SLP                     *
*  16/23             D/4        END OF TAPE(EOT)-SET                    *
*  14/24             E/5        READY-SR                                *
*  15/24             F/6        FILE PROTECT-SFP                        *
*  17/24             T/16       FORWARD-CF                              *
*  21/24             R/14       REWIND-CRW                              *
*  18/25             U/17       REVERSE-CR                              *
*  20/25             S/15       OFF LINE-CL                             *
*  19/25             W/19       SET WRITE-WSW                           *
*                                                                       *
*************************************************************************
      SKP
```

Table 4-4. Magnetic Tape Subsystem Microprogram Listing (Continued)


```
*****************************************************************************
*                                                                           *
*                 DESTINATION CODES FOR OUTPUT FUNCTIONS                    *
*                                                                           *
*****************************************************************************
*                                                                           *
*     D00      7970                                  RD. CLK. F/F           *
*     D01      STATUS                                 IS NOT CHANGED        *
*     D02      XFACE                                   IN D00,D01 & D02     *
*     D03      WRITE REGISTER                                               *
*     D04      7970 + RESET RD. CLK.F/F                                     *
*     D05      STATUS + RESET RD. CLK. F/F                                  *
*     D06      XFACE + RESET RD. CLK. F/F                                   *
*     D07      DATA-IN REGISTER                                             *
*     D1X      RESET CMD. ENB. F/F                   X IS ANY OCTAL DIGIT-  *
*     D2X      SET SERV. REQ. F/F                     THESE 3 PERFORM ANY OF *
*     D3X      SET SERV. REQ. & RST. CMD. ENB. F/F  ABOVE + D1X,D2X & D3X  *
*                                                                           *
*****************************************************************************
*                                                                           *
*                    SOURCE CODES FOR INPUT FUNCTIONS                       *
*                                                                           *
*****************************************************************************
*                                                                           *
*     D20,24   UNIT NO.                                                     *
*     D11,15   LOW BYTE OF DATA-OUT                                         *
*     D21,25   HIGH BYTE OF DATA-OUT                                        *
*     D31,35   FULL WORD OF DATA-OUT                                        *
*     D12,16   8-BITS OF READ DATA (RD0 THRU RD7)                           *
*     D22,D26  8-BITS OF STATUS                                             *
*     D32,36   RD. DATA & STATUS                                            *
*                                                                           *
*****************************************************************************
*                                                                           *
*     NAMES OF THE EXTERNAL FLAGS ARE AS FOLLOWS                            *
*                                                                           *
*****************************************************************************
*                                                                           *
* 29  F00      FLAG0                                                        *
* 30  F01      FLAG1                                                        *
* 27  F02      FLAG2                                                        *
* 28  F03      LOAD POINT(BOT)                                              *
* 25  F04      800/1600 BPI(800=0)                                          *
* 26  F05      WRITE STATUS                                                 *
* 23  F06      RD/WRT PARITY(REV. SENSE FOR WRITE PARITY)                   *
* 24  F07      END OF BLOCK F/F(USED IN 1600 BPI ONLY)                      *
* 9   F10      READ CLOCK                                                   *
* 22  F11      TAPE ERROR(REV. SENSE)                                       *
* 12  F12      OUT-XFER                                                     *
* 21  F13      READY STATUS                                                 *
* 11  F14      DATA F/F                                                     *
* 14  F15      INTERRUPT CONDITION                                          *
* 13  F16      IN-XFER                                                      *
* 16  F17      CMD. ENB.(REV. SENSE)                                        *
*                                                                           *
*****************************************************************************
      SKP
```

Table 4-4. Magnetic Tape Subsystem Microprogram Listing (Continued)

```
********************************************************************************
*                                                                              *
*            THE FOLLOWING ARE IMMEDIATE OPERAND/REGISTER BIT                  *
*             DEFINITIONS USED WITH OTI/IOC OP-CODES. CHECK                    *
*              DESTINATION/SOURCE CODE FIELD(PREVIOUS PAGE)                    *
*               & DETERMINE WHAT BIT CONFIGURATION IS USED.                    *
*                                                                              *
********************************************************************************
*                              MIO BUS BITS                                    *
********************************************************************************
*  0 * 1 *  2 *  3 *  4 *  5 *  6 *  7 *  8 *  9 * 10 * 11 * 12 * 13 * 14 * 15 *
********************************************************************************
*   -7970- (OUTPUT)       (UPH)         *             (LWH)                    *
********************************************************************************
*RST *    * SET*SET *    * SET*SET *RST *    *RST * SET* SET* RST* SET* SET* SET*
*DATA* * * WRT*WRT *   * * REW*OFF *REW *  * *FWD * FWD* REV* WRT* WRT*FVEN* ODD*
* F/F*    * STB*RST *    *     *LINE*&O.L*    *REV *    *    *    *    *    *    *
********************************************************************************
*   -STATUS- (OUTPUT)     (UPH)         *             (LWH)                    *
********************************************************************************
*RST *    *    *    *SET *SET *SET *SET *EVEN* ODD* SET*TAPE*TIM-*TAPE* SET* CLR*
*DATA* * *  * *  * *UNIT*UNIT*UNIT*UNIT*BYTE*BYTE* EOF*ERR-* ING*RUN-*REJ *STA *
* F/F*    *    *    *0,2 *0,1 *1,3 *2.3 * CNT* CNT*    *  OR*FRR *AWAY* ECT* TUS*
********************************************************************************
*   -XFACE- (OUTPUT)      (UPH)         *             (LWH)                    *
********************************************************************************
* RST*SET* SET* RST* SET* RST* CLR* CLK* RST* SET* RST* SET* SUP* ENB* SET* SET*
*DATA*UNT* F0 * F0 * DEV*UNIT* BUS* INT* F2 * F2 * F1 * F1 * PAR* PAR* OUT* IN *
* F/F*INT*    *    * END* INT*LOGC* F/F*    *    *    *    * BIT* BIT*MODE*MODE*
********************************************************************************
*   -STATUS/RD DATA- (INPUT)  (UPH)  *                (LWH)                    *
********************************************************************************
* ID * TP*TAPE* INT* SIO*FILE*    *    * R  * R  * R  * R  * R  * R  * R  * R  *
* BUR*MRK* FRR*PEND* OK *PROT* * *  * *  D *  D *  D *  D *  D *  D *  D *  D *
*-ST *   * -OR*-ING*    *    *    *    *  0*   1*   2*   3*   4*   5*   6*   7*
********************************************************************************
*  -UNIT NO.- (INPUT, HIGH BYTE ONLY)
*****************************************
*UNIT*UNIT*UNIT*UNIT* SEL* SEL* SEL* SEL*
*--- *---*    *    *UNIT*UNIT*UNIT*UNIT*
*MSB *LSB* MSB* LSB* 0,2* 0,1* 1,3* 2,3*
*****************************************
      SKP
```

Table 4-4. Magnetic Tape Subsystem Microprogram Listing (Continued)

```
                                   ******************************************************************************
                                   *                                                                            *
                                   *     POWER ON, I/O RESET OR RESET FROM THE MAINTENANCE                      *
                                   *        PANEL FORCES THE CONTROLLER AT THE ADDRESS 0(START).                *
                                   *                                                                            *
                                   ******************************************************************************
0000  00 111 110 100 110 001 100   START OTI UPH  D11  #163          RST DATA & CMD ENB F/F-SELECT UNIT #0
0001  11 001 110 001 110 011 111         XOR CTM  R3B  R3A           REGISTER & THE COUNTER
0002  00 111 110 001 000 010 110         OTI UPH  D02  #351          RST. F0.BUS-LOGIC & UNIT INT F/F
0003  10 111 111 101 100 000 000         PSI UPH  R0M  #377          R0(0:7'):=ALL ONES
0004  10 111 110 001 110 110 100   WAIT  PSI UPH  CTM  TSTOP         CNTR := STOP DELAY
0005  00 111 000 000 001 000 001         OTI LWH  D00  #276 DEC      RESET FWD. REV. & SET ODD PARITY MODE
0006  01 010 001 000 000 000 110         JXZ RCS  *    DEC           TIME OUT THE COUNTER
0007  00 111 100 011 010 100 101   CONT  OTI LWH  D06  #132          RST. F1.F2;ENABLE PARITY & IN-MODE
0010  00 111 110 000 010 000 001         OTI UPH  D00  #176          RST DATA F/F, REWIND & OFF-LINE
0011  00 111 110 001 000 010 100         OTI UPH  D02  #353          RESET F0 & UNIT INT. F/F
0012  00 000 111 001 011 001 100         JMP PTCH1                   GOTO PTCH1 TO LOOK FOR END INTERRUPT
0013  10 111 101 011 111 001 100   CONT1 PSI LWH  R1M  #63           0011001100110011
0014  10 111 110 011 101 110 111         PSI UPH  R5M  #210          R5:=(SELECT THIS UNIT NOW)
0015  10 111 100 011 101 110 111         PSI LWH  R5M  #210          1000100010001000
0016  00 010 111 000 010 011 010         IOC INP  R4I  D20           GET PRESENT UNIT NO. IN R4
                                   ******************************************************************************
                                   *                                                                            *
                                   * HERE THE CONTROLLER WAITS FOR A 'CONTROL-ORDER' FROM THE MULTIPLEXOR.      *
                                   *   IF NO CONTROL COMES, IT GOES TO 'SCAN' TO LOOK FOR THE LATEST            *
                                   *     DRIVE-READY STATUS. THE CURRENT SELECTED UNIT INFORMATION              *
                                   *                    IS STORED IN THE REGISTER R4.                           *
                                   *                                                                            *
                                   ******************************************************************************
0017  11 100 111 100 011 000 011   MAIN  JFS F16  REJECT             REJECT IF IN-XFER
0020  11 100 110 100 011 000 011         JFS F12  REJECT               OR OUT-XFER = 1
0021  11 100 111 110 000 110 010         JFS F17  SCAN               GOTO SCAN IF NO CONTROL ORDER
                                   ******************************************************************************
                                   *                                                                            *
                                   *          ENTRY AT 'BEGIN' ONLY IF A CONTROL ORDER IS ISSUED FIRST          *
                                   *                                                                            *
                                   ******************************************************************************
0022  11 111 110 101 101 111 011   BEGIN PSA R4M  R4A  RL4           ROTATE R4 LEFT BY 4
0023  11 111 110 101 101 111 011         PSA R4M  R4A  RL4           ADJUST PROPER CODE FOR
0024  11 111 110 101 101 111 011         PSA R4M  R4A  RL4            LAST UNIT SELECTED AND
0025  00 010 110 000 110 000 010         IOC OUT  UPH  R4I  D01        OUTPUT TO SELECT IT
0026  00 111 100 100 110 000 001   BEG2  OTI LWH  D11  #176          RST. STATUS, CMD. ENB. & BYTE CNT.
0027  00 010 111 100 110 011 011         IOC INP  R3I  D31           GET COMMAND WORD IN R3
0030  11 010 101 101 110 001 111         PSB LWH  R0M  R3B           PASS LOW HALF OF R3 IN R0
0031  00 011 101 000 000 011 101         JMZ RCS  DECOD              GOTO DECOD IF NOT A SELECT COMMAND
0032  00 010 111 000 010 001 100         IOC INP  UPH  R2I  D20      SELECT THE PROPER
0033  00 010 111 000 110 000 100         IOC OUT  UPH  R2I  D21       UNIT & SET SERV. REQ.
0034  00 000 111 000 000 000 111         JMP CONT                    GOTO CONT
                                   ******************************************************************************
                                         SKP
```

Table 4-4. Magnetic Tape Subsystem Microprogram Listing (Continued)

```
                                   ***************************************************************************
                                   *                                                                         *
                                   * THE GIVEN COMMAND IS DECODED HERE TO LOOK FOR WHICH SUBGROUP IT BELONGS TO.  *
                                   *                                                                         *
                                   ***************************************************************************
0035  11 100 110 110 000 011 111   DECOD JFS F13  *+2                        REJECT THE COMMAND IF
0036  00 000 111 000 011 000 011         JMP REJECT                           TAPE UNIT IS NOT READY
0037  10 110 101 111 100 001 111         ANI LWH  R3B  #360                  LOOK FOR ILLEGAL BITS IN R3
0040  00 011 101 000 011 000 011         JMZ RCS  REJECT                     REJECT THE COMMAND IF ILLEGAL BITS IN R3
0041  10 110 101 001 111 111 001         ANI LWH  R2M  R3B  RDR              MASK OFF SUB-GROUP CMD. CODE IN R2
0042  10 001 101 110 011 111 001         XOI LWH  R2B  RDR                   GOTO RDFWD IF READ
0043  00 011 111 000 010 111 100         JMZ RDFWD                            FORWARD COMMAND
0044  10 001 101 110 011 111 011         XOI LWH  R2B  WRR                   GOTO WRFWD IF
0045  00 011 111 000 011 001 101         JMZ WRFWD                            WRITE COMMAND
0046  10 110 101 111 111 110 111         ANI LWH  R3B  #10                   GOTO REJECT IF COMMAND IS
0047  00 011 111 000 011 000 011         JMZ REJECT                           ANY OF THREE REMAINING ILLEGAL CODES
0050  10 001 101 110 011 111 101         XOI LWH  R2B  RDREV                 GOTO RDBKD IF READ
0051  00 011 111 000 010 100 001         JMZ RDBKD                            REVERSE TYPE COMMAND
0052  11 100 101 010 000 101 100         JFS F05  *+2                        SKIP NEXT IF WRT. STATUS=1
0053  00 000 111 000 000 101 101         JMP *+2                             SKIP NEXT INSTRUCTION
0054  01 110 111 000 001 000 100         CAL GOFWD                           SUB. CALL TO AVOID NOISE IN GAP
0055  00 111 111 000 000 000 100         OTI UPH  D20  #373                  SET REWIND & SERV. REQ
0056  10 110 101 111 111 111 110         ANI LWH  R3B  #1                    LOOK FOR REW OR RST
0057  00 011 111 000 000 000 111         JMZ CONT                            GOTO CONT IF'REW' COMMAND
0060  00 111 110 000 000 000 010         OTI UPH  D00  #375                  SET OFF-LINE F/F & GOTO
0061  00 000 111 000 000 000 111         JMP CONT                             CONT IF 'RST' COMMAND
                                   ***************************************************************************
                                   *                                                                         *
                                   * 'SCAN' CONTINUOUSLY SELECTS A UNIT & LOOKS FOR ITS READY STATUS. THIS IS  *
                                   *    DONE ONLY IF CONTROLLER IS IN IDLE STATE(NO SIO GOING ON). UNIT INT-   *
                                   *      -ERRUPT F/F IS SET WHEN A UNIT , PREVIOUSLY 'NOT-READY' BECOMES       *
                                   *        READY. AN INTERRUPT IS GENERATED TO TELL THE CPU ABOUT IT.         *
                                   *                                                                         *
                                   ***************************************************************************
0062  00 010 111 001 010 001 011   SCAN  IOC INP  R3I  D22  UPH              GET STATUS BYTE IN R3
0063  00 000 111 001 011 010 111         JMP PTCH2                           GOTO PATCH THE PROGRAM
0064  00 011 101 000 000 001 111         JMZ RCS  MAIN                       GOTO MAIN IF ALREADY IN SIO ROUTINE
0065  00 010 110 000 110 000 101   SCAN0 IOC OUT  UPH  R1I  D01              SELECT UNIT FROM R1
0066  10 111 100 001 111 101 111         PSI LWH  CTM  #20                   PRESET CNTR TO 16 CYCLE DELAY
0067  11 010 111 010 100 111 111         PSB R1M  R1B  RL1                   R1 & R5 ARE ROTATED
0070  11 111 110 011 100 110 111         PSA R5M  R5A  RL1                    LEFT BY ONE BIT
0071  01 010 001 000 000 111 001         JXZ RCS  DEC  *                     TIME OUT THE COUNTER
0072  11 100 110 110 000 111 111         JFS F13 READY                       GOTO READY IF F13=1
0073  11 110 111 111 010 000 111         AND UPH  R0B  R5A                   WAS THIS UNIT READY BEFORE ?
0074  00 011 111 000 000 001 111         JMZ MAIN                            NOT RDY BEFORE; NOT RDY NOW-GOTO MAIN
0075  11 001 111 101 010 000 111         XOR UPH  R0M  R0B  R5A              RDY BEFORE: NOT RDY NOW-MODIFY R0
0076  00 000 111 000 000 001 111         JMP MAIN                            GOTO MAIN
0077  11 110 111 111 010 000 111   READY AND UPH  R0B  R5A                   WAS THIS UNIT READY BEFORE ?
0100  00 011 101 000 000 001 111         JMZ RCS  MAIN                       RDY BEFORE: RDY NOW-GOTO MAIN
0101  11 001 111 101 010 000 111         XOR UPH  R0M  R0B  R5A              NOT RDY BEFORE; RDY NOW-INT. CASE
0102  00 111 110 001 001 000 000         OTI UPH  D02  #277                  SET UNIT INTERRUPT F/F
0103  00 000 111 000 011 000 111         JMP INT2                            GOTO INT2
                                   ***************************************************************************
                                         SKP
```

OPTION CONFIGURATION
TABLE (SEE NOTES 1 AND 2)

UNIT 0	UNIT 1	UNIT 2	UNIT 3
B	B	B	B
E	E	E	E
B	E	E	E
E	S[3]	S[3]	S[3]
B	B	E	E
E	E	S[3]	S[3]
B	E	S[3]	S[3]
B	B	B	E
B	B	E	S[3]
E	E	E	S[3]
B	E	E	S[3]

NOTES:

1. SUPERSCRIPT 3 IN THE TABLE SIGNIFIES NOTE 3 BELOW.
2. LETTERS IN THE TABLE REPRESENT TAPE UNITS AS FOLLOWS: "B" MEANS 7970B, "E" MEANS MASTER 7970E, "S" MEANS SLAVE 7970E. UNIT 0 CAN BE A "B" OR "E" AS SHOWN IN SMALL OUTLINED BOX. ALL POSSIBLE COMBINATIONS USING TWO TAPE UNITS ARE SHOWN BY LETTER COMBINATIONS IN THE SECOND LARGEST OUTLINED BOX, ETC. ALL COMBINATIONS USING FOUR (MAXIMUM) UNITS IS SHOWN USING ENTIRE TABLE.
3. MULTIUNIT CABLE HP 13194A-001 MUST BE USED AND FROM 7970E MASTER TO SLAVE TAPE UNIT AND FROM SLAVE TO SLAVE. SEE EXAMPLE CONNECTION DIAGRAM NUMBER 2.

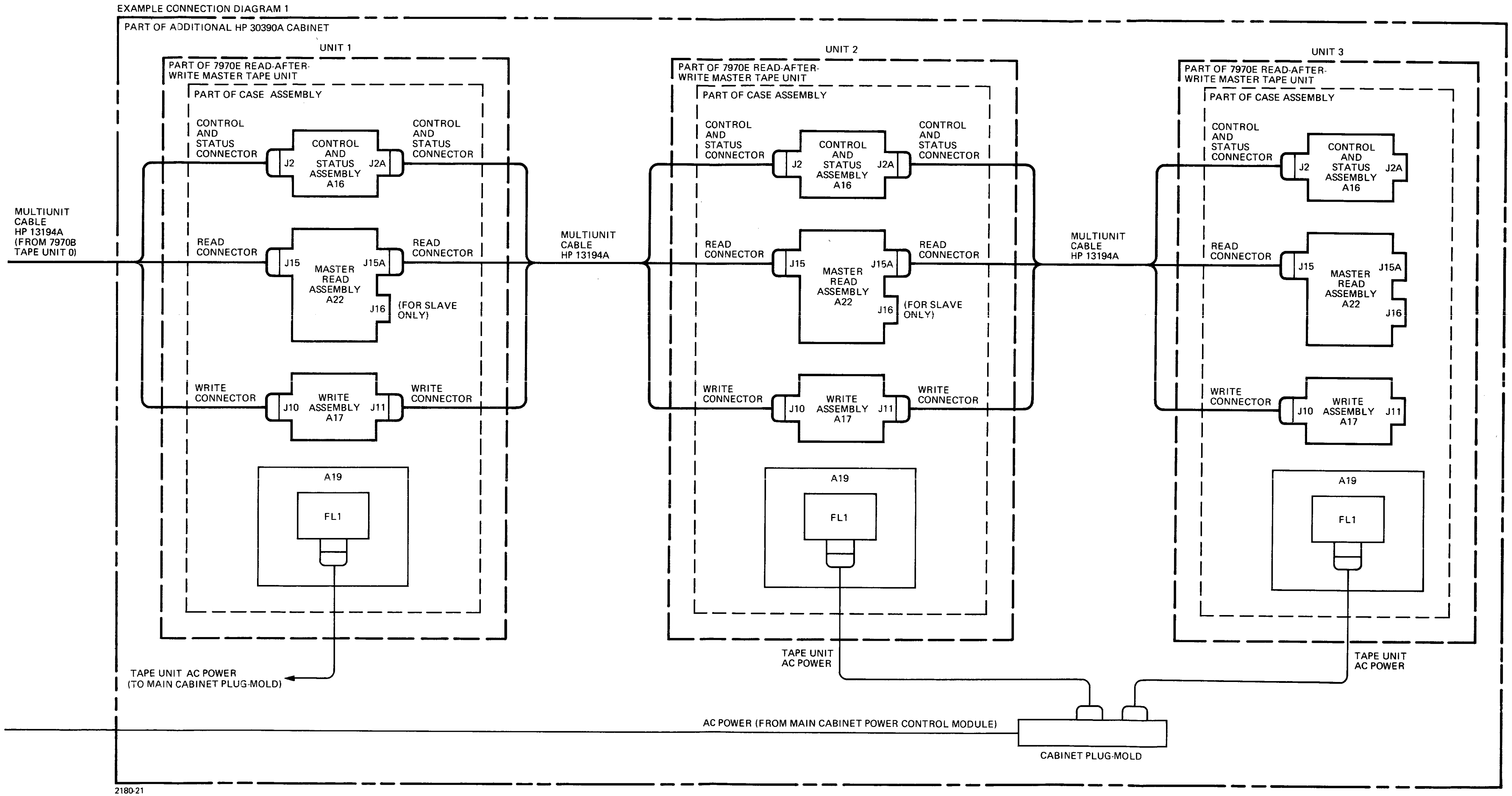


Figure 4-2. Magnetic Tape Subsystem, Example Multiple Tape Unit Cabling Diagram (Sheet 1 of 2)

Table 4-4. Magnetic Tape Subsystem Microprogram Listing (Continued)

```
                                         ************************************************************************
                                         *                                                                      *
                                         * THIS SUBROUTINE MAKES THE TAPE GO FORWARD & ERASE SOME PART OF THE TAPE  *
                                         *   BEFORE EXECUTING A BACKSPACE OR REWIND TYPE COMMAND WHEN THE CURRENT   *
                                         *     IN WRITE HEADS WAS ON. THIS ENSURES THAT NOISE CHARACTER IS NOT      *
                                         *       WRITTEN IN THE GAP WHEN WRITE CURRENT IN HEADS IS SWITCHED.        *
                                         *                                                                      *
                                         ************************************************************************
0104  10 111 110 001 110 010 101  GOFWD PSI UPH  CTM  TS155          CNTR:=.155 INCH + START DELAY
0105  00 111 100 000 000 100 000        OTI LWH  D00  #337           SET FWD F/F
0106  01 010 001 000 001 000 110        JXZ RCS  DEC *               TIME OUT THE COUNTER
0107  10 111 110 001 110 110 100        PSI UPH  CTM  TSTOP          CNTR:=STOP DELAY
0110  00 111 000 000 001 001 000        OTI LWH  D00  DEC  #267      RST. FWD.-REV. F/F &WRITE F/F
0111  01 010 001 000 001 001 001        JXZ RCS  DEC  *              TIME OUT THE COUNTER
0112  01 101 111 111 111 111 111        RTN                          SUBROUTINE RETURN
                                         ************************************************************************
                                         *                                                                      *
                                         *     SUBROUTINE BLANK ATTEMPTS TO GET A READ CLOCK OR END-OF-BLOCK     *
                                         *       (IN 1600 BPI) WITHIN 25 FEET OF TAPE WHEN CONTROLLER HAS        *
                                         *         INITIATED A READ OPERATION. F0 IS SET IF RD. CLK. IS          *
                                         *           FOUND. IF RD. CLK. OR EOB IS NOT FOUND, TAPE-               *
                                         *             RUNAWAY F/F IS SET INDICATING AN ATTEMPT                  *
                                         *               IS MADE TO READ BLANK TAPE.                             *
                                         *                                                                      *
                                         ************************************************************************
0113  10 111 111 011 111 101 111  BLANK PSI UPH  R1M  #20            R1:=-240(IN UPPER HALF)
0114  10 111 110 001 100 000 101  TIMER PSI UPH  CTM  TGAP           CNTR:=TIMER FOR 1.25" OF TAPE
0115  11 100 010 000 001 010 110        JFS F10  DEC  NBLK           GOTO NBLK IF RD. CLK.=1
0116  11 100 001 000 001 010 000        JFS F04  DEC  *+2            NO SKIP IF 800 BPI
0117  00 000 011 000 001 010 001        JMP *+2  DEC                 SKIP NEXT INSTRUCTION
0120  11 100 001 110 001 010 111        JFS F07  DEC  NB16           GOTO NB16 IF EOB=1
0121  01 010 001 000 001 001 101        JXZ RCS  DEC  *-4            WAIT FOR CNTR TO TIME OUT
0122  00 001 111 010 111 111 110        ADI UPH  R1M  R1B  1         R1:=R1+1
0123  00 011 101 000 001 001 100        JMZ RCS  TIMER               STAY IN LOOP TILL TIMER NON-ZERO
0124  00 111 100 000 100 000 100        OTI LWH  D01  #373           SET TAPE RUNAWAY BIT
0125  00 000 111 000 011 000 100        JMP INTER                    GOTO INTER
0126  00 111 110 011 000 100 000  NBLK  OTI UPH  D06  #337           SET F0 TO INDICATE I RD. CLK.
0127  11 001 110 001 110 011 111  NB16  XOR CTM  R3B  R3A            ZERO OUT THE COUNTER
0130  11 001 111 001 110 011 111        XOR R2M  R3B  R3A            ZERO OUT R2 (CRC REGISTER)
0131  01 101 111 111 111 111 111        RTN                          SUBROUTINE RETURN
                                         ************************************************************************
                                         *                                                                      *
                                         *             SUBROUTINE WGAP ERASES 3.75 INCHES OF TAPE AND            *
                                         *               THEN CHECKS FOR ANY NOISE LEFT IN THE GAP               *
                                         *                                                                      *
                                         ************************************************************************
0132  10 111 110 001 100 000 101  WGAP  PSI UPH  CTM  TGAP           PRESET CNTR. WITH 1.25 IN. TIMER
0133  01 000 111 111 111 111 111        NOP                          TIME OUT THREE
0134  01 000 111 111 111 111 111        NOP                           TIMES THE VALUE
0135  01 010 001 000 001 011 011        JXZ RCS  DEC  *-2              OF THE COUNTER
0136  11 100 110 000 001 100 000        JFS F10  *+2                 SKIP NEXT IF RD CLK = 1
0137  00 000 111 000 001 100 001        JMP *+2                      DONE-RETURN
0140  00 111 100 010 100 010 000        OTI LWH  D05  #357           SET TAPE-ERROR & RST RD CLK-NOISE IN GAP
0141  01 101 111 111 111 111 111        RTN                          RETURN
                                         ************************************************************************
                                        SKP
```

Table 4-4. Magnetic Tape Subsystem Microprogram Listing (Continued)

```
                                             ***********************************************************************
                                             *                                                                     *
                                             * 'WRCHK'-THIS SUBROUTINE GETS THE DATA-WORD(WHILE WRITING ON TAPE) FROM *
                                             *    THE MULTIPLEXOR, CHECKS FOR DATA OVERRUN CONDITION & MONITORS    *
                                             *     'OUT-XFER' TO DECIDE WHEN TO TERMINATE DATA TRANSFERS.          *
                                             *                                                                     *
                                             ***********************************************************************
0142  11 100 011 000 001 100 100  WRCHK JFS F14  DEC  *+2               SKIP NEXT IF DATA F/F=1
0143  00 111 000 000 100 001 000        OTI LWH  DEC  D01  #367         SET TIMING ERROR IF DATA F/F = 0
0144  00 111 010 001 010 100 000        OTI UPH  DEC  D02  #137         RST DATA F/F & SET F0
0145  00 010 011 100 110 011 001        IOC INP  DEC  D31  R5I          GET DATA OUT WORD IN R5
0146  11 100 010 100 001 101 001        JFS F12  DEC  *+3               SKIP 2 IF OUT-XFER=1
0147  00 111 010 001 000 010 000        OTI UPH  DEC  D02  #357         RST F0 INDICATING OUT-XFER = 0
0150  01 101 011 111 111 111 111        RTN      DEC                    SUBROUTINE RETURN
0151  00 111 001 000 000 000 000        OTI LWH  DEC  D20  #377         SET SERV. REQ. TO GET NEXT WORD
0152  01 101 011 111 111 111 111        RTN      DEC                    SUBROUTINE RETURN
                                  ***********************************************************************
                                  *                                                                     *
                                  * 'FSR0' - ENTRY HERE IS ONLY IF EXACTLY 1 CHARACTER READ FROM TAPE.  *
                                  *                                                                     *
                                  ***********************************************************************
0153  11 100 100 010 001 110 001  FSR0  JFS F01  FMCHK                  GOTO FMCHK IF F1=1(POSSIBLE FILE-MARK
0154  00 111 110 011 000 010 000  AGAIN OTI UPH  D06  #357              RESET F0 & RD. CLK.
0155  10 111 110 001 111 111 101        PSI UPH  CTM  T8                CNTR:=8 CHAR. DELAY
0156  11 100 010 000 001 111 111        JFS F10  DEC  DROP              ERROR CASE IF RD. CLK. COMES
0157  01 010 001 000 001 101 110        JXZ RCS  DEC  *-1                IN BEFORE COUNTER GOES TO 0
0160  00 000 111 000 011 110 101        JMP FRDF                        GOTO FRDF TO CONTINUE NEXT RECORD
0161  10 111 110 001 111 111 110  FMCHK PSI UPH  CTM  T4                CNTR:=4 CHARA. DELAY
0162  11 100 010 000 001 111 111        JFS F10  DEC  DROP              ERROR CASE IF ANY RD. CLK. COMES
0163  01 010 001 000 001 110 010        JXZ RCS  DEC  *-1                IN BEFORE COUNTER GOES TO ZERO
0164  10 111 110 001 111 111 110        PSI UPH  CTM  T4                CNTR:=T4.0
0165  11 100 010 000 001 111 000        JFS F10  DEC  *+3               LOOK FOR A RD. CLK.
0166  01 010 001 000 001 110 101        JXZ RCS  DEC  *-1                BEFORE COUNTER=0
0167  00 000 111 000 011 110 101        JMP FRDF                        NOISE: GOTO FRDF TO READ NEXT RECORD
0170  01 110 111 000 111 111 000        CAL FMPAR                       SUB. CALL TO LOOK FOR FILE-MARK
0171  10 111 100 001 100 000 000        PSI LWH  CTM  #377              CNTR:=4 CHAR. DELAY
0172  00 111 100 010 000 000 000        OTI LWH  D04  #377              RESET RD. CLK. F/F
0173  01 010 001 000 001 111 011        JXZ RCS  DEC *                  TIME OUT THE COUNTER
0174  11 100 110 000 001 111 111        JFS F10  DROP                   GOTO DROP IF RD. CLK.=1
0175  00 111 100 000 110 100 000  FM816 OTI LWH  D01  #137              SET EOF STATUS
0176  11 100 100 010 010 000 010        JFS F01  ODEND                  TERMINATE IF F1=1 (FILE-MARK CONFIRMED)
0177  00 111 100 000 100 010 000  DROP  OTI LWH  D01  #357              SET TAPE ERROR STATUS
0200  00 000 111 000 010 000 010        JMP ODEND                       GOTO ODEND
0201  00 111 100 000 110 100 000  FILE  OTI LWH  D01  #137              SET EOF STATUS
                                  ***********************************************************************
                                  *                                                                     *
                                  * 'ODEND' - IT IS A GENERAL EXIT POINT & RESET VARIOUS F/F'S.         *
                                  *                                                                     *
                                  ***********************************************************************
0202  00 111 100 011 010 100 000  ODEND OTI LWH  D06  #137              RST. F1,F2 & RD. CLK.
0203  00 111 110 101 010 010 000        OTI UPH  D12  #157              RESET F0, DATA F/F & EOB FLAG
                                  ***********************************************************************
                                        SKP
```

Table 4-4. Magnetic Tape Subsystem Microprogram Listing (Continued)

```
                                    **************************************************************************
                                    *                                                                        *
                                    *          STOP ROUTINE IS THE EXIT POINT FOR ALL COMMANDS               *
                                    *                                                                        *
                                    **************************************************************************
0204  11 100 111 010 011 000 100   STOP  JFS F15  INTER                    GOTO INTER IF INTERRUPT FLAG=1
0205  11 001 110 001 110 011 111         XOR CTM  R3B  R3A                 ZERO OUT THE COUNTER
0206  00 000 111 001 011 110 001         JMP PATCH                         GOTO PATCH TO LOOK FOR END INTERRUPT
0207  11 100 111 100 010 001 001         JFS F16  *+2                      SKIP NEXT IF IN-XFER=1
0210  00 000 111 000 010 001 011         JMP *+3                           SKIP 2 INSTRUCTIONS
0211  00 111 110 001 000 001 000         OTI UPH  D02  #367                SET DEVICE-END
0212  00 000 111 000 010 001 100         JMP *+2                            & SKIP NEXT INSTR.
0213  00 111 111 000 000 000 000         OTI UPH  D20  #377                SET SERV. REQ.
0214  01 010 001 000 010 001 100         JXZ RCS  *    DEC                 TIME OUT THE CNTR.
0215  11 100 111 110 000 000 100   STOP1 JFS F17  WAIT                     GOTO WAIT IF NO CONTROL ORDER
0216  00 010 111 100 110 011 011         IOC INP  R3I  D31                 GET COMMAND WORD IN R3
0217  10 110 100 001 111 110 000         ANI LWH  CTM  R3B  #17            MASK OFF COMMAND CODES IN CNTR
0220  11 001 101 001 010 000 011         XOR LWH  R2M  R0B  CTA            R2 := R0 'XOR' R3
0221  11 111 101 101 110 001 111         PSA LWH  R0M  R3A                 R0(LOWER):=R3(NEW COMMAND)
0222  10 110 101 110 011 111 001         ANI LWH  R2B  #6                  GO TO WAIT IF NEW CMD. IS
0223  00 011 101 000 000 000 100         JMZ RCS  WAIT                      OF DIFFERENT SUB-GROUP
0224  00 000 111 000 000 010 110         JMP BEG2                          GOTO BEG2
                                    **************************************************************************
                                    *                                                                        *
                                    *      'FSRF'   -   FSR & FSF COMMANDS ARE DECODED HERE.                 *
                                    *                                                                        *
                                    **************************************************************************
0225  10 111 110 001 111 111 101   FSRF  PSI UPH  CTM  T8                  CNTR:=T8.0
0226  00 111 010 011 000 010 000         OTI UPH  DEC  D06  #357           RESET F0 & RD. CLK.
0227  00 111 000 100 110 000 000         OTI LWH  DEC  D11  #177           RST. EOB & SET EVEN BYTE CNT.
0230  01 010 001 000 010 011 000         JXZ RCS  DEC  *                   TIME OUT THE COUNTER
0231  10 001 101 111 011 110 000         XOI LWH  R0B  FSF                 GOTO AGAIN IF CMD.
0232  00 011 111 000 001 101 100         JMZ AGAIN                          IS FSF - ELSE
0233  00 000 111 000 010 000 010         JMP ODEND                           GOTO ODEND
                                    **************************************************************************
                                    *                                                                        *
                                    *      'RBDEC'   -   BSR & BSF COMMANDS ARE DECODED HERE.                *
                                    *       (IF F1=1 THEN A FILE-MARK HAS BEEN FOUND)                        *
                                    *                                                                        *
                                    **************************************************************************
0234  11 100 100 010 010 000 001   RBDEC JFS F01  FILE                     GOTO FILE IF F1=1
0235  10 001 101 111 011 110 101         XOI LWH  R0B  BSR                 GOTO ODEND
0236  00 011 111 000 010 000 010         JMZ ODEND                          IF CMD IS BSR
0237  00 111 110 001 000 010 000         OTI UPH  D02  #357                RESET F0
0240  00 000 111 000 010 101 010         JMP BSRF                          GOTO BSRF TO CONTINUE BSF COMMAND
                                    **************************************************************************
                                         SKP
```

Table 4-4. Magnetic Tape Subsystem Microprogram Listing (Continued)

```
                                          ***********************************************************************
                                          *                                                                     *
                                          *        READ REVERSE GROUP(BSR OR BSF) COMMAND IS INITIATED BELOW.  *
                                          *         IF LAST OPERATION WAS A WRITE, THEN .15 INCH OF TAPE IS     *
                                          *          ERASED BEFORE THE BACKSPACE OPERATION IS PERFORMED.        *
                                          *           F0=1 IF WRITE STATUS=1 BEFORE BACKSPACING                 *
                                          *                                                                     *
                                          ***********************************************************************
0241  11 100 100 110 010 110 000  RDBKD JFS F03  BSRF2               GOTO BSRF2 IF TAPE AT LOAD POINT
0242  11 100 101 010 010 100 101        JFS F05  *+3                 SKIP 2 IF WRITE STATUS=1
0243  10 111 110 001 110 110 100        PSI UPH  CTM   TSTRT         PRESET COUNTER WITH TAPE
0244  00 000 111 000 010 101 000        JMP MERGE                     START DELAY & GOTO MERGE
0245  01 110 111 000 001 000 100        CAL GOFWD                    SUB. CALL TO AVOID NOISE IN GAP
0246  00 111 110 001 000 100 000        OTI UPH  D02   #337          SET F0 TO REMEMBER WRT. STATUS WAS 1
0247  10 111 110 001 110 010 101        PSI UPH  CTM   TS155         CNTR:=.155" + START DELAY
0250  00 111 000 110 000 010 000  MERGE OTI LWH  DEC   D14   #357    SET REV.,RST. RD. CLK. &EOB F/F
0251  01 010 001 000 010 101 000        JXZ RCS  DEC   *-1           TIME OUT THE COUNTER
                                  ***********************************************************************
                                  *                                                                     *
                                  * 'BSRF' - ENTRY TO LOOK FOR BOT, READ CLOCK OR END-OF-BLOCK(1600 BPI ONLY)  *
                                  *              WHEN THE TAPE IS GOING IN REVERSE DIRECTION.           *
                                  *                                                                     *
                                  ***********************************************************************
0252  11 100 100 110 010 110 000  BSRF  JFS F03  BSRF2               GOTO BSRF2 IF BOT=1
0253  11 100 110 000 010 110 010        JFS F10  BACK                GOTO BACK IF RD. CLK.=1
0254  11 100 101 000 010 101 110        JFS F04  *+2                 SKIP NEXT IF 1600 BPI
0255  00 000 111 000 010 101 010        JMP BSRF                     GO BACK TO BSRF
0256  11 100 101 111 000 000 110        JFS F07  FM16                GOTO FM16 IF EOB FLAG=1
0257  00 000 111 000 010 101 010        JMP BSRF                     GO BACK IN LOOP
0260  00 111 101 000 000 000 000  BSRF2 OTI LWH  D20   #377          SET SERV.REQ. & GOTO
0261  00 000 111 000 000 000 100        JMP WAIT                      WAIT FOR NEW COMMAND
                                  ***********************************************************************
                                  *                                                                     *
                                  *     AT 'BACK' ALL THE READ CLOCKS IN A DATA BLOCK ARE ENCOUNTERED   *
                                  *                                                                     *
                                  ***********************************************************************
0262  11 100 101 001 000 010 100  BACK  JFS F04  BCKRD               GOTO BCKRD IF 1600 BPI
0263  01 110 111 000 111 111 000        CAL FMPAR                    SUB. CALL TO LOOK FOR FM CHARACTER
0264  10 111 100 001 101 110 010        PSI LWH  CTM   T22           PRESET THE CNTR
0265  10 111 110 001 111 111 110        PSI UPH  CTM   T4             WITH T6.2 DELAY
0266  11 100 010 000 101 001 011        JFS F10  DEC   NOFM          GOTO NOFM IF RD. CLK.
0267  01 010 001 000 010 110 110        JXZ RCS  DEC   *-1            CAME BEFORE CNTR = 0
0270  10 111 110 001 111 111 110        PSI UPH  CTM   T4            PRESET CNTR WITH T4
0271  11 100 010 000 101 000 111        JFS F10  DEC   BCK1          GOTO BCK1 IF RD. CLK.
0272  01 010 001 000 010 111 001        JXZ RCS  DEC   *-1            CAME BEFORE CNTR = 0
0273  00 000 111 000 010 101 010        JMP BSRF                     NOISE CHARACTER-GOTO BSRF
                                  ***********************************************************************
                                        SKP
```

Table 4-4. Magnetic Tape Subsystem Microprogram Listing (Continued)


```
                                        ************************************************************************
                                        *                                                                      *
                                        *     'RDFWD' IS THE ENTRY FOR READ FWD. CMDS. - RDR, RDC, FSR OR FSF. *
                                        *                                                                      *
                                        ************************************************************************
0274  10 111 110 001 110 110 100  RDFWD PSI UPH  CTM  TSTRT                CNTR:=START DELAY
0275  10 110 101 111 011 111 110        ANI LWH  R0B  1                    LOOK FOR SUBGROUP OF READ
0276  00 011 101 000 011 101 101        JMZ RCS  FSRF0                     FSR-FSF GROUP-GOTO FSRS0
0277  00 111 101 001 010 100 001  RDR1  OTI LWH  D22  #136                 RST. F1,F2 & SET SERV. REQ.& IN MODE
0300  11 100 111 100 011 101 110        JFS F16  RDGO                      GOTO RDGO IF IN-XFER=1
0301  11 100 110 100 011 000 011        JFS F12  REJECT                    REJECT IF OUT-XFER OR
0302  11 100 111 110 011 000 000        JFS F17  *-2                        CMD=1-OTHERWISE STAY IN LOOP
                                        ************************************************************************
                                        *                                                                      *
                                        * 'REJECT' - ENTRY ONLY WHEN A 'COMMAND-REJECT' CONDITION HAS OCCURRED. *
                                        *                                                                      *
                                        ************************************************************************
0303  00 111 100 000 100 000 010  REJECT    OTI  LWH  D01  #375            SET REJECT BIT OF STATUS
                                        ************************************************************************
                                        *                                                                      *
                                        * 'INTER' - ENTRY ONLY IF AN INTERRUPT CONDITION IS DETECTED AT THE    *
                                        *           END OF CURRENT COMMAND OR IN IDLE STATE OF THE             *
                                        *             CONTROLLER. THE POSSIBLE INTERRUPT CONDITIONS            *
                                        *               ARE:1. UNIT READY INTERRUPT 2. TRANSFER ERROR          *
                                        *                 3. CMD. REJECT 4. BLANK TAPE 5. TIMING               *
                                        *                   ERROR & 6. TAPE ERROR.                             *
                                        *                                                                      *
                                        *                                                                      *
                                        ************************************************************************
0304  10 111 110 001 110 110 100  INTER PSI UPH  CTM  TSTOP                PRESET CNTR. WITH TAPE STOP DELAY
0305  00 111 000 100 001 000 000        OTI LWH  D10  #277 DEC             RESET FWD,REV. & CMD. ENB.
0306  01 010 001 000 011 000 110        JXZ RCS  *    DEC                  TIME OUT THE CNTR.
0307  00 111 110 001 000 000 011  INT2  OTI UPH  D02  #374                 CLOCK INTERRUPT & CLR. BUS LOGIC
0310  00 010 111 001 010 001 011        IOC INP  R3I  D22  UPH             GET STATUS BYTE IN UPPER R3
0311  10 110 111 111 111 101 111        ANI UPH  R3B  #20                  IS INT. FLAG=1?
0312  00 011 101 000 011 001 000        JMZ RCS  *-2                       YES. KEEP LOOKING AT THIS BIT
0313  00 111 110 001 000 000 100        OTI UPH  D02  #373                 RESET UNIT INT. F/F
0314  00 000 111 000 000 000 100        JMP WAIT                           NO, GO TO WAIT
                                        ************************************************************************
                                               SKP
```

Table 4-4. Magnetic Tape Subsystem Microprogram Listing (Continued)

```
                                   ****************************************************************************
                                   *                                                                          *
                                   *    ENTRY FOR WRITE COMMAND - ANY ONE OF WRR, WRZ, WFM OR GAP             *
                                   *                                                                          *
                                   ****************************************************************************
0315  00 010 111 001 010 001 011   WRFWD IOC INP  R3I  D22  UPH        GET 7970 STATUS IN R3
0316  10 110 111 111 111 111 011         ANI UPH  R3B  #4              REJECT THE COMMAND IF
0317  00 011 101 000 011 000 011         JMZ RCS  REJECT                TAPE REEL IS PROTECTED
0320  00 111 100 011 010 100 010         OTI LWH  D06  #135            RESET F1,F2,RD. CLK. & SET OUT MODE
0321  11 100 100 110 011 010 011         JFS F03  *+2                  SKIP NEXT IF TAPE AT LOAD POINT
0322  00 111 100 001 000 010 000         OTI LWH  D02  #357            SET F1 (BOT = 0)
0323  10 110 101 111 011 111 110         ANI LWH  R0B  1               GOTO WJOIN IF
0324  00 011 101 000 011 011 111         JMZ RCS  WJOIN                 CMD IS WFM-GAP
0325  00 111 111 001 000 010 000         OTI UPH  D22  #357            SET SERV. REQ. & RST. F0
0326  11 100 101 000 011 011 010         JFS F04  *+4                  SKIP 3 IF 1600 BPI
0327  10 001 101 111 011 111 011         XOI LWH  R0B  WRR             LOOK FOR WRZ COMMAND
0330  00 011 111 000 011 011 010         JMZ *+2                       SKIP NEXT IF WRR COMMAND
0331  00 111 100 001 000 001 000         OTI LWH  D02  #367            WRZ CMD: DISABLE PARITY TRACK
0332  11 100 110 100 011 011 110         JFS F12  *+4                  SKIP 3 IF OUT-XFER=1
0333  11 100 111 100 011 000 011         JFS F16  REJECT               REJECT THE COMMAND IF
0334  11 100 111 110 011 011 010         JFS F17  *-2                   CONTROL ORDER OR IN-XFER
0335  00 000 111 000 011 000 011         JMP      REJECT                 COMES BEFORE OUT-XFER
0336  00 111 101 000 000 000 000         OTI LWH  D20  #377            SET SERV. REQ.
0337  10 111 110 001 110 100 100   WJOIN PSI UPH  CTM  TWSTR           PRESET COUNTER WITH START DELAY
0340  00 111 000 010 000 100 100         OTI LWH  DEC  D04  #333       SET FWD., WRITE & RST. PD. CLK.
0341  01 010 001 000 011 100 000         JXZ RCS  DEC  *-1             TIME OUT THE COUNTER
                                   ****************************************************************************
                                   *                                                                          *
                                   *    AT THIS POINT TAPE IS UP TO SPEED & READY TO DO WRITE OPERATIONS.     *
                                   *     IF F0=1 THEN TAPE STARTED AT BOT. WRITE A 3.75" GAP FIRST.           *
                                   *      IF F2=1 THEN COMMAND IS WFM OR GAP, OTHERWISE WRR OR WRZ.           *
                                   *                                                                          *
                                   ****************************************************************************
0342  11 100 101 001 001 100 101   WRREC JFS F04  WR16                 GOTO WR16 IF 1600 BPI
0343  11 100 100 010 011 100 101         JFS F01  *+2                  WRITE A GAP IF
0344  01 110 111 000 001 011 010         CAL WGAP                       TAPE WAS AT BOT
0345  00 111 100 011 000 100 000         OTI LWH  D06  #337            RESET RD CLK & F1
0346  10 110 101 111 011 111 110         ANI LWH  R0B  1               GOTO GPFM IF
0347  00 011 101 000 111 000 110         JMZ RCS  GPFM                  CMD IS WFM-GAP
0350  11 001 111 011 110 011 111         XOR R1M  R3B  R3A             ZERO OUT R1(WRITE CRC CHARACTER)
0351  11 001 111 001 110 011 111         XOR R2M  R3B  R3A             ZERO OUT R2(READ CRC CHARACTER)
0352  11 010 110 101 010 001 111         PSB UPH  R4M  R0B             STORE HISTORY OF UNITS IN R4
0353  10 111 100 001 111 000 010         PSI LWH  CTM  T1              CNTR:=1 CHAR. DELAY
0354  00 000 011 000 101 011 011         JMP      DEC  WLOOP           GOTO WLOOP
                                   ****************************************************************************
                                         SKP
```

Table 4-4. Magnetic Tape Subsystem Microprogram Listing (Continued)

```
                                         ************************************************************************
                                         *              IF COMMAND IS FSR OR FSF THEN F2 = 1 ELSE F2 = 0.       *
                                         ************************************************************************
0355  00 111 100 001 001 000 001  FSRF0  OTI LWH  D02  #276           SET F2 & IN-MODE
0356  00 111 100 110 000 101 000  RDGO   OTI LWH  D14  #327           RST. EOB.RD. CLK. & SET FWD
0357  01 010 001 000 011 101 111         JXZ RCS  *    DEC            TIME OUT THE COUNTER
0360  11 100 100 110 011 110 010         JFS F03  *+2                 SKIP NEXT IF BOT STATUS=1
0361  00 000 111 000 011 110 101         JMP *+4                      SKIP 3 INSTRUCTIONS
0362  10 111 110 001 100 000 101         PSI UPH  CTM  TGAP           CNTR:=1.25" DELAY
0363  11 100 100 110 011 110 011         JFS F03  *                   STAY HERE UNTIL BOT STATUS=0
0364  00 000 111 000 011 101 110         JMP RDGO                       BOT IS NO MORE - GOTO RDGO AGAIN
0365  00 111 100 011 000 100 000  FROF   OTI LWH  D06  #337           RST. RD. CLK. & F1
0366  01 110 111 000 001 001 011         CAL BLANK                    SUBROUTINE CALL TO BLANK
0367  11 100 101 001 000 011 111         JFS F04  FS16                GOTO FS16 IF 1600 BPI
0370  01 110 111 000 111 111 000         CAL FMPAR                    SUB. CALL TO SET F1 IF FM BYTE
0371  10 111 100 001 101 110 010         PSI LWH  CTM  T22            CNTR:=2.2 CHAR. DELAY
0372  11 100 000 100 100 000 001         JFS F02  DEC  LOOP1          GOTO LOOP1 IF F2 = 1
0373  10 111 100 001 101 110 010  LOOPR  PSI LWH  CTM  T22            PRESET COUNTER WITH T2.2
0374  00 111 000 010 101 000 000         OTI LWH  DEC  D05  #277      SET ODD BYTE COUNT & RST. RD. CLK.
0375  01 110 011 000 111 010 001         CAL      DEC  RBYTE          SUB. CALL TO PROCESS 1 BYTE
0376  11 111 010 101 101 111 111         PSA R4M  DEC  R3A  RL4       MOVE THE LOWER BYTE
0377  11 111 010 101 101 111 011         PSA R4M  DEC  R4A  RL4        IN R3 INTO UPPER R4
0400  11 001 000 101 110 001 111         XOR LWH  DEC  R4M  R3B  R3A  ZERO OUT LOW HALF OF R4
0401  11 100 010 000 100 000 100  LOOP1  JFS F10  DEC *+3             GOTO ODDEOR IF
0402  01 010 001 000 100 000 001         JXZ RCS  DEC  *-1             CNTR = 0 BEFORE
0403  00 000 111 000 100 011 101         JMP ODDEOR                     A READ CLOCK COMES
0404  00 111 100 010 110 000 000         OTI LWH  D05  #177           RST. RD. CLK.& SET EVEN BYTE CNT.
0405  00 111 100 001 000 100 000         OTI LWH  D02  #337           RESET F1
0406  10 111 100 001 101 110 010         PSI CTM  LWH  T22            PRESET COUNTER WITH T2.2
0407  11 100 000 100 100 001 001         JFS *+2  DEC  F02            SKIP NEXT IF F2=1
0410  00 000 011 000 100 001 100         JMP *+4  DEC                 SKIP NEXT 3 INSTRUCTIONS
0411  00 111 010 001 000 010 000         OTI UPH  DEC  D02  #357      RESET F0
0412  10 110 001 111 011 111 110         ANI LWH  DEC  R0B  1         GOTO LOOP1 IF
0413  00 011 001 000 100 000 001         JMZ RCS  DEC  LOOP1           CMD IS FSR+FSF
0414  01 110 011 000 111 010 001         CAL      DEC  RBYTE          PROCESS THE BYTE
0415  11 100 000 100 100 011 010         JFS F02  DEC  NEXT1          GOTO NEXT1 IF F2=1
0416  00 010 010 011 110 000 010         IOC OUT  DEC  UPH  R4I  D07  OUTPUT THE I-BYTE TO DATA-IN REG.
0417  00 010 000 011 110 000 011         IOC OUT  DEC  LWH  R3I  D07  OUTPUT THE BYTE IN DATA-IN REG.
0420  11 100 000 000 100 010 010         JFS *+2  DEC  F00            SKIP NEXT IF F0=1
0421  00 000 011 000 100 010 100         JMP *+3  DEC                 SKIP 2 INSTRUCTIONS
0422  00 111 010 001 000 010 000         OTI UPH  DEC  D02  #357      RESET F0 (1 WORD)
0423  00 000 011 000 100 011 001         JMP NEXT  DEC                GOTO NEXT
0424  11 100 011 000 100 010 110         JFS *+2  DEC  F14            SKIP NEXT IF DATA F/F=1
0425  00 111 000 000 100 001 000         OTI LWH  DEC  D01  #367      SET TIMING ERROR STATUS
0426  11 100 011 100 100 011 001         JFS F16  DEC  NEXT           GOTO NEXT IF IN-XFER=1
0427  00 111 000 001 001 000 000         OTI LWH  DEC  D02  #277      SET F2 TO INDICATE WC<REC. LENGTH
0430  00 000 011 000 100 011 010         JMP      DEC  NEXT1          GOTO NEXT1
0431  00 111 011 001 010 000 000  NEXT   OTI UPH  DEC  D22  #177      RST. DATA F/F & SET SERV. REQ.
0432  11 100 010 000 011 111 011  NEXT1  JFS F10  DEC  LOOPR          STAY IN LOOP TILL
0433  01 010 001 000 100 011 010         JXZ RCS  DEC  *-1             ALL RD CLKS ARE DONE
0434  00 000 111 000 100 101 001         JMP EVENOR                   GOTO EVENOR
                                  ************************************************************************
                                  *        F0=1 IF EXACTLY ONE CHARACTER READ FROM TAPE                  *
                                  *        F1=1 IF THE CHARACTER READ LOOKS PART OF FILE-MARK (OCTAL 23) *
                                  *        F2=1 IF THE COMMAND IS FSR OR FSF - OR IN RDR, RDC            *
                                  *             COMMAND, THE WORD COUNT < RECORD LENGTH                  *
                                  ************************************************************************
                                         SKP
```

Table 4-4. Magnetic Tape Subsystem Microprogram Listing (Continued)

```
                                        ************************************************************************
                                        *                                                                      *
                                        *      IF CMD. IS FSR OR FSF THEN ODDEOR IS                            *
                                        *       ENTERED AFTER THE END OF RECORD.                               *
                                        *      IF CMD. IS RDR, RDC THEN ODDEOR IS                              *
                                        *       ENTERED ONLY IF ODD NUMBER OF                                  *
                                        *        CHARACTERS ARE FOUND IN THE                                   *
                                        *         RECORD BLOCK.                                                *
                                        *                                                                      *
                                        ************************************************************************
0435  11 100 100 000 001 101 011  ODDEOR JFS F00 FSR0              GOTO FSR0 IF F0=1
0436  00 010 110 011 110 010 010         IOC OUT  R4I  D07         OUTPUT THE FULL WORD TO DATA-IN REG.
0437  11 100 100 100 100 100 001         JFS F02  *+2              SKIP NEXT IF F2=1
0440  00 000 111 000 100 100 110         JMP LREQ                  GOTO LREQ
0441  10 110 101 111 011 111 110         ANI LWH  R0B  1           GOTO FSRF IF
0442  00 011 101 000 010 010 101         JMZ RCS  FSRF              FSR-FSF CMD.
0443  00 111 100 000 110 000 000         OTI LWH  D01  #177        SET EVEN BYTE CNT.
0444  00 111 100 001 000 010 000         OTI LWH  D02  #357        SET F1 TO INDICATE ODD# OF BYTES
0445  00 000 111 000 100 101 001         JMP EVENOR                GOTO EVENOR
0446  11 100 111 000 100 101 000  LREQ   JFS F14  *+2              SKIP NEXT IF DATA F/F=1
0447  00 111 100 000 100 001 000         OTI LWH  D01  #367        SET TIMING ERROR STATUS
0450  00 111 111 011 010 000 000         OTI UPH  D26  #177        RST RD.CLK.& DATA F/F;SET SERV.REQ.
0451  10 111 100 001 100 000 000  EVENOR PSI LWH  CTM  #377        CNTR:=4 CHAR. DELAY
0452  11 100 010 000 100 101 111         JFS F10  DEC  YCRC        GOTO YCRC IF RD. CLK.=1
0453  01 010 001 000 100 101 010         JXZ RCS  DEC  *-1          BEFORE COUNTER = 0
0454  11 001 110 111 110 011 111         XOR R3M  R3B  R3A         R3:=0(NULL CRC CHARACTER)
0455  01 110 111 000 111 011 001         CAL CRITE                 SUB. CALL TO PROCESS RD. CRCC
0456  00 000 111 000 100 110 001         JMP CRCHK                 GOTO CRCHK
0457  01 110 111 000 111 010 101  YCRC   CAL RRITE                 SUB. CALL TO PROCESS CRCC
0460  00 111 100 010 000 000 000         OTI LWH  D04  #377        RESET RD. CLK. F/F
0461  10 111 100 001 101 110 010  CRCHK  PSI LWH  CTM  T22         PRESET CNTR. WITH
0462  10 111 110 001 111 111 110         PSI UPH  CTM  T4           6.2 CHAR. DELAY
0463  00 010 110 011 110 010 011         IOC OUT  R3I  D07         OUTPUT THE CRCC IN DATA-IN REG.
0464  01 110 111 000 111 100 001         CAL CRCCH                 SUB. CALL TO VERIFY CRCC
0465  11 100 100 100 100 110 111         JFS F02  *+2              SKIP NEXT IF F2=1
0466  00 000 111 000 100 111 001         JMP *+3                   SKIP 2 INSTRUCTIONS
0467  00 111 100 001 010 000 000         OTI LWH  D02  #177        RESET F2
0470  00 000 111 000 101 000 001         JMP CHLRC                 GOTO CHLRC
0471  11 100 111 000 100 111 011         JFS F14  *+2              SKIP NEXT IF DATA-F/F=1
0472  00 111 100 000 100 001 000         OTI LWH  D01  #367        SET TIMING ERROR STATUS
0473  00 111 110 001 010 000 000         OTI UPH  D02  #177        RESET DATA F/F
0474  11 100 111 100 100 111 110         JFS *+2  F16              SKIP NEXT IF IN-XFER=1
0475  00 000 111 000 101 000 001         JMP CHLRC                 GOTO CHLRC
0476  10 001 101 111 011 110 001         XOI LWH  R0B  RDC         IF CMD. IS NOT RDC
0477  00 011 101 000 101 000 001         JMZ RCS  CHLRC             THEN GOTO CHLRC
0500  00 111 101 001 001 000 000         OTI LWH  D22  #277        SET SERV. REQ. TO SEND CRCC & SET F2
0501  01 010 001 000 101 000 001  CHLRC  JXZ RCS  DEC  *           TIME OUT THE COUNTER
0502  11 100 100 100 101 000 100         JFS F02  *+2              SKIP NEXT IF F2=1
0503  00 000 111 000 010 000 010         JMP ODEND                 GOTO ODEND
0504  11 100 111 000 010 000 010         JFS F14  ODEND            GOTO ODEND IF DATA F/F=1
0505  00 111 100 000 100 001 000         OTI LWH  D01  #367        SET TIMING ERROR STATUS
0506  00 000 111 000 010 000 010         JMP ODEND                 GOTO ODEND
                                  ************************************************************************
                                         SKP
```

Table 4-4. Magnetic Tape Subsystem Microprogram Listing (Continued)

```
                                       ************************************************************************
                                       *                                                                      *
                                       *  AT THE ENTRY OF BCK1 IT IS LIKELY THAT FILE-MARK IS FOUND           *
                                       *                                                                      *
                                       ************************************************************************
0507  11 100 100 010 101 001 001      BCK1  JFS F01  *+2                 SKIP NEXT IF F1=1
0510  00 000 111 000 101 001 011            JMP NOFM                     GOTO NOFM
0511  01 110 111 000 111 111 000            CAL FMPAR                    SUB. CALL TO LOOK FOR FM CHARACTER
0512  11 100 100 010 101 010 011            JFS F01  CHGAP               GOTO CHGAP IF F1=1
                                       ************************************************************************
                                       *                                                                      *
                                       *  AT THE ENTRY OF NOFM FILE-MARK IS RULED OUT                         *
                                       *                                                                      *
                                       ************************************************************************
0513  11 001 110 001 110 011 111      NOFM  XOR CTM  R3B  R3A            ZERO OUT THE COUNTER
0514  10 111 110 001 111 111 110            PSI UPH  CTM  T4             CNTR:=4 CHARACTER DELAY
0515  00 111 000 011 000 100 000            OTI LWH  DEC  D06  #337      RST. RD. CLK. & F1
0516  01 010 001 000 101 001 110            JXZ RCS  DEC  *              TIME OUT THE COUNTER
0517  00 111 100 011 000 000 000            OTI LWH  D06  #377           RESET RD. CLK.
0520  10 111 100 001 101 110 010            PSI LWH  CTM  T22            CNTER:=2.2 CHARACTER DELAY
0521  11 100 010 000 101 001 111            JFS F10  DEC  *-2            GO BACK 2 IF RD. CLK.
0522  01 010 001 000 101 010 001            JXZ RCS  DEC  *-1             CAME BEFORE COUNTER = 0
0523  11 001 110 001 110 011 111      CHGAP XOR CTM  R3B  R3A            ZERO OUT THE COUNTER
0524  10 111 110 001 111 100 010            PSI UPH  CTM  T145           CNTR:=.145" DELAY
0525  11 100 010 000 101 011 000            JFS F10  DEC  *+3            SKIP 2 IF RD. CLK.
0526  01 010 001 000 101 010 101            JXZ RCS  DEC  *-1             CAME BEFORE CNTR = 0
0527  00 000 111 000 010 011 100            JMP RBDEC                    GOTO RBDEC TO SEPARATE BSR-BSF CMD.
0530  00 111 100 011 000 100 000            OTI LWH  D06  #337           RESET RD. CLK. & F1
0531  11 100 100 000 101 010 011            JFS F00  CHGAP               GOTO CHGAP IF F0=1(WPT. STATUS WAS 1)
0532  00 000 111 000 101 010 101            JMP *-5                      GO BACK 5 INSTRUCTIONS
                                       ************************************************************************
                                       *                                                                      *
                                       *        F0=1 IF THE WRITE STATUS WAS 1 BEFORE BACKSPACE STARTED       *
                                       *        F1=1 IF THE CHARACTER READ LOOKS PART OF FILE-MARK(OCTAL 23)  *
                                       *        F2 IS NOT USED IN THE BSR OR BSF COMMAND                      *
                                       *                                                                      *
                                       ************************************************************************
                                            SKP
```

Table 4-4. Magnetic Tape Subsystem Microprogram Listing (Continued)

```
                                        ************************************************************************
                                        *                                                                      *
                                        *          F0=1 AS LONG AS OUT-XFER=1 (DATA WORDS STILL COMMING)       *
                                        *          F1=1 IF ATLEAST ONE READ CLOCK HAS COME                     *
                                        *          F2=1 IF ATLEAST ONE READ CLOCK IS FOUND                     *
                                        *                 WITHIN TWO CHARACTER SPACING                         *
                                        *                                                                      *
                                        ************************************************************************
0533  01 110 011 000 001 100 010  WLOOP CAL      DEC  WRCHK             SUB. CALL TO ASK FOR DATA WORD
0534  10 111 011 101 100 001 001        PSI UPH  DEC  ROM   #366        R0(0:7):=-10
0535  11 100 010 000 101 100 001  WLP1  JFS F10  DEC  *+4               SKIP 3 IF RD. CLK.=1
0536  00 001 011 101 011 111 110        ADI UPH  DEC  ROM   R0B  1      INCREMENT R0
0537  11 000 001 000 101 011 101        JOV RCS  DEC  WLP1    -         GOTO WLP1 IF NO-OVERFLOW
0540  00 000 011 000 101 100 101        JMP *+5  DEC                    SKIP 4 INSTRUCTIONS
0541  01 110 011 000 111 010 001        CAL      DEC  RBYTE             SUB. CALL TO COMPUTE RD. CRCC & LRCC
0542  00 111 000 001 001 010 010        OTI LWH  DEC  D02   #255        SET F1,F2 & OUT MODE
0543  00 001 011 101 011 111 010        ADI UPH  DEC  ROM   R0B  #5     UPDATE R0 BY 5
0544  11 000 001 000 101 011 101        JOV RCS  DEC  WLP1              GOTO WLP1 IF NO-OVERFLOW
0545  00 010 010 001 110 000 001        IOC OUT  DEC  UPH   R5I  D03    OUTPUT THE WRITE BYTE
0546  11 111 010 111 101 110 111        PSA R3M  DEC  R5A   RL4         SWOP UPPER & LOWER
0547  11 111 010 111 101 111 111        PSA R3M  DEC  R3A   RL4          HALVES OF R5 IN R3
0550  01 110 011 000 111 100 111        CAL      DEC  WRCRC             SUB. CALL TO COMPUTE WRITE CRCC
0551  01 010 001 000 101 101 001        JXZ RCS  DEC  *                 TIME OUT THE COUNTER
0552  00 111 110 000 000 100 000        OTI UPH  D00  #337              SET WRITE STROBE
0553  10 111 100 001 111 000 010        PSI LWH  CTM  T1                CNTR:=1 CHAR. DELAY
0554  10 111 011 101 100 001 100        PSI UPH  DEC  ROM   #363        R0(0:7):=-13
0555  11 100 010 000 101 110 001  WLP2  JFS F10  DEC  *+4               SKIP 3 IF RD. CLK.=1
0556  00 001 011 101 011 111 110        ADI UPH  DEC  ROM   R0B  1      INCREMENT R0 BY 1
0557  11 000 001 000 101 101 101        JOV RCS  DEC  WLP2              GOTO WLP2 IF NO-OVERFLOW
0560  00 000 011 000 101 110 101        JMP *+5  DEC                    SKIP 4 INSTRUCTIONS
0561  01 110 011 000 111 010 001        CAL      DEC  RBYTE             SUB. CALL TO COMPUTE RD. CRCC & LRCC
0562  00 111 000 001 001 010 010        OTI LWH  DEC  D02   #255        SET F1,F2 & OUT MODE
0563  00 001 011 101 011 111 010        ADI UPH  DEC  ROM   R0B  #5     UPDATE R0 BY 5
0564  11 000 001 000 101 101 101        JOV RCS  DEC  WLP2              GOTO WLP2 IF NO-OVERFLOW
0565  11 111 010 111 101 110 111        PSA R3M  DEC  R5A   RL4         SWOP UPPER & LOWER
0566  11 111 010 111 101 111 111        PSA R3M  DEC  R3A   RL4          BYTES OF R5 IN R3
0567  00 010 010 001 110 000 011        IOC OUT  DEC  UPH   R3I  D03    OUTPUT WRT. BYTE
0570  11 111 010 111 110 010 111        PSA R3M  DEC  R5A               PASS R5 IN R3
0571  01 110 011 000 111 100 111        CAL      DEC  WRCRC             SUB. CALL TO COMPUTE WRT. CRCC
0572  01 010 001 000 101 111 010        JXZ RCS  DEC  *                 TIME OUT THE COUNTER
0573  00 111 110 000 000 100 000        OTI UPH  D00  #337              SET WRITE STROBE
0574  10 111 100 001 111 000 010        PSI LWH  CTM  T1                CNTR:=1 CHAR. DELAY
0575  01 110 011 000 111 110 010        CAL      DEC  ODDW1             SUB. CALL TO FIND OUT CHAR. DROPOUT
0576  11 100 000 000 101 011 011        JFS F00  DEC  WLOOP             GOTO WLOOP IF F0=1
0577  11 111 111 101 110 001 011        PSA UPH  ROM  R4A               MAKE R0 BACK TO WHAT IT WAS
0600  10 011 101 101 001 111 111        IOI LWH  ROM  R0B   #200        SET BIT 8 IN R0 TO INDICATE CRCC BYTE
0601  10 001 001 010 100 101 000        XOI LWH  DEC  R1M   R1B  #327   UPDATE CRC CHARACTER
0602  11 010 010 110 101 111 111        PSB R3M  DEC  R1B   RL4         OUTPUT
0603  11 111 010 111 101 111 111        PSA R3M  DEC  R3A   RL4          CRC
0604  00 010 010 001 110 000 011        IOC OUT  DEC  UPH   R3I  D03      CHARACTER
                                        ************************************************************************
                                                SKP
```

Table 4-4. Magnetic Tape Subsystem Microprogram Listing (Continued)

```
                                           ******************************************************************************
                                           *                                                                            *
                                           *        IF F0=0 & R0(8:1)=1 THEN IT IS TIME TO WRITE CRCC                   *
                                           *        IF F0=0 & R0(8:1)=0 THEN IT IS TIME TO WRITE LRCC                   *
                                           *                                                                            *
                                           ******************************************************************************
0605  10 111 100 001 101 111 111  OTCRC PSI LWH  CTM  #200            CNTR:=2.0 CHAR. DELAY
0606  10 111 011 011 100 100 111        PSI UPH  DEC  R1M  #330       R1(0:7):=-40
0607  11 100 010 000 110 001 011  OTC1  JFS F10  DEC  *+4             SKIP 3 IF RD. CLK.=1
0610  00 001 011 010 111 111 110        ADI UPH  DEC  R1M  R1B  1     INCREMENT R1
0611  11 000 001 000 110 000 111        JOV RCS  DEC  OTC1            GOTO OTC1 IF NO-OVERFLOW
0612  00 000 011 000 110 001 111        JMP *+5  DEC                  SKIP 4 INSTRUCTIONS
0613  01 110 011 000 111 010 001        CAL      DEC  RBYTE           SUB. CALL TO COMPUTE RD. CRCC & LRCC
0614  00 111 000 001 001 010 010        OTI LWH  DEC  D02  #255       SET F1,F2 & OUT MODE
0615  00 001 011 010 111 111 010        ADI UPH  DEC  R1M  R1B  #5    UPDATE R1 BY 5
0616  11 000 001 000 110 000 111        JOV RCS  DEC  OTC1            GOTO OTC1 IF NO-OVERFLOW
0617  00 111 010 001 000 110 000        OTI UPH  DEC  D02  #317       TOGGLE F0
0620  01 010 001 000 110 010 000        JXZ RCS  DEC  *               TIME OUT THE COUNTER
0621  01 110 111 000 111 110 010        CAL ODDW1                     SUB. CALL TO DETECT CHARACTER DROPOUT
0622  10 110 101 111 001 111 111        ANI LWH  R0B  #200            LOOK FOR BIT 8 OF R0
0623  00 011 111 000 110 011 000        JMZ OTC2                      GOTO OTC2 IF R0(8)=0
0624  11 100 100 000 110 000 101        JFS F00  OTCRC                GOTO OTCRC IF F0=1
0625  10 110 101 101 010 000 000        ANI LWH  R0M  R0B  #177       MAKE BIT 8 OF R0 = 0
0626  00 111 110 000 000 100 000        OTI UPH  D00  #337            SET WRITE STROBE (TO WRITE CRCC)
0627  00 000 111 000 110 000 101        JMP OTCRC                     GOTO OTCRC
0630  11 100 100 000 110 000 101  OTC2  JFS F00  OTCRC                GOTO OTCRC IF F0=1
0631  00 111 100 001 010 000 000        OTI LWH  D02  #177            RESET F2
0632  00 111 110 000 000 010 000  LRCQ  OTI UPH  D00  #357            SET WRITE RESET PULSE
0633  00 111 100 001 000 000 101        OTI LWH  D02  #372            ENABLE PARITY & SET IN-MODE
0634  11 100 100 010 110 110 100        JFS F01  YESRD                GOTO YESRD IF F1=1
0635  10 111 110 001 111 100 000  NORD  PSI UPH  CTM  T155            CNTR:=.155" DELAY
0636  11 100 010 000 110 100 001        JFS F10  DEC  *+3             SKIP 2 IF RD. CLK.=1
0637  01 010 001 000 110 011 110        JXZ RCS  DEC  *-1              BEFORE CNTR=0
0640  00 000 111 000 001 111 111        JMP DROP                      CHAR. DROPOUT-GO TO DROP
0641  01 110 111 000 111 111 000        CAL FMPAR                     SUB. CALL TO LOOK FOR FM BYTE
0642  01 110 111 000 111 010 001        CAL RBYTE                     SUB. CALL TO COMPUTE RD. CRCC
0643  11 001 110 001 110 011 111        XOR CTM  R3B  R3A             ZERO OUT THE COUNTER
0644  11 100 100 100 110 100 110        JFS F02  *+2                  SKIP NEXT IF F2=1(WFM CMD.)
0645  00 000 111 000 110 110 100        JMP YESRD                     GOTO YESRD
0646  11 100 100 010 110 101 000        JFS F01  *+2                  SKIP NEXT IF F1=1
0647  00 000 111 000 001 111 111        JMP DROP                      GOTO DROP
0650  10 111 110 001 111 111 101        PSI UPH  CTM  T8              CNTR:=
0651  10 111 100 001 101 110 010        PSI LWH  CTM  T22              10.2 CHAR. DELAY
0652  11 100 010 000 110 101 101        JFS F10  DEC  *+3             SKIP 2 IF RD. CLK. = 1
0653  01 010 001 000 110 101 010        JXZ RCS  DEC  *-1              BEFORE CNTR 0
0654  00 000 111 000 001 111 111        JMP DROP                      CHAR. DROPOUT CASE-GOTO DROP
0655  01 110 111 000 111 111 000        CAL FMPAR                     SUB. CALL TO LOOK FOR FM BYTE
0656  11 100 100 010 110 110 000        JFS F01  *+2                  SKIP NEXT IF F1=1
0657  00 000 111 000 001 111 111        JMP DROP                      FM DOES NOT MATCH-GOTO DROP
0660  10 111 110 001 111 111 101        PSI UPH  CTM  T8              CNTR:=8.0 CHAR. DELAY
0661  11 100 010 000 001 111 111        JFS F10  DEC  DROP            GOTO DROP IF RD. CLK.=1
0662  01 010 001 000 110 110 001        JXZ RCS  DEC  *-1              BEFORE CNTR=0
0663  00 000 111 000 010 000 001        JMP FILE                      GOTO FILE(FM CONFIRMED)
                                  ******************************************************************************
                                        SKP
```

Table 4-4. Magnetic Tape Subsystem Microprogram Listing (Continued)

```
                                         ************************************************************************
                                         *                                                                      *
                                         *    ENTRY AT YESRD ONLY IF A READ CLOCK IS ENCOUNTERED                *
                                         *           DURING THE WRITING OF A DATA BLOCK                         *
                                         *                                                                      *
                                         ************************************************************************
0664  10 111 100 001 101 110 010   YESRD PSI LWH  CTM  T22          CNTR:=2.2 CHAR. DELAY
0665  11 100 010 000 110 111 000         JFS F10  DEC  *+3          SKIP 2 IF RD. CLK.=1
0666  01 010 001 000 110 110 101         JXZ RCS  DEC  *-1           BEFORE CNTR = 0
0667  00 000 111 000 110 111 010         JMP *+3                    SKIP 2 INSTRUCTIONS
0670  01 110 111 000 111 010 001         CAL RBYTE                  SUB. CALL TO COMPUTE RD. CRCC
0671  00 000 111 000 110 110 100         JMP YESRD                  GO BACK TO YESRD
0672  10 111 100 001 100 000 000         PSI LWH  CTM  #377         CNTR:=4.0 CHAR. DELAY
0673  11 100 010 000 110 111 110         JFS F10  DEC  *+3          SKIP 2 IF RD. CLK.=1
0674  01 010 001 000 110 111 011         JXZ RCS  DEC  *-1           BEFORE CNTR=0
0675  00 000 111 000 001 111 111         JMP DROP                   CRCC=0; GOTO DROP(CHAR. DROPOUT)
0676  01 110 111 000 111 010 001         CAL RBYTE                  SUB. CALL TO COMPUTE CRCC
0677  10 111 100 001 101 110 010         PSI LWH  CTM  T22          CNTR:=2.2 CHAR. DELAY
0700  11 100 010 000 001 111 111         JFS F10  DEC  DROP         GOTO DROP IF RD. CLK.=1
0701  01 010 001 000 111 000 000         JXZ RCS  DEC  *-1           BEFORE CNTR. = 0
0702  01 110 111 000 111 100 001         CAL CRCCH                  SUB. CALL TO VERIFY READ CRCC
0703  10 111 110 001 111 111 110         PSI UPH  CTM  T4           CNTR:=4 CHAR. DELAY
0704  01 010 001 000 111 000 100         JXZ RCS  DEC  *            TIME OUT THE COUNTER
0705  00 000 111 000 010 000 010         JMP ODEND                  GOTO ODEND
                                         ************************************************************************
                                         *                                                                      *
                                         *    ENTRY AT GPFM ONLY IF WFM OR GAP COMMAND                          *
                                         *                                                                      *
                                         ************************************************************************
0706  10 001 101 111 011 111 010   GPFM  XOI LWH  R0B  GAP          LOOK FOR GAP COMMAND
0707  00 011 101 000 111 001 010         JMZ RCS  *+3               SKIP 2 IF WFM COMMAND
0710  01 110 111 000 001 011 010         CAL WGAP                   WRITE A GAP OF 3.75 INCH
0711  00 000 111 000 010 000 010         JMP ODEND                  FO TO ODEND
0712  00 111 110 001 111 101 100         OTI UPH  D03  FM           OUTPUT THE FILE-MARK CHARACTER
0713  10 111 110 001 111 111 101         PSI UPH  CTM  T8           PRESET THE CNTR WITH T8.0 DELAY
0714  00 111 110 000 000 100 000         OTI UPH  D00  #337         SET WRITE STROBE
0715  01 010 001 000 111 001 101         JXZ RCS  DEC  *            TIME OUT THE COUNTER
0716  00 111 110 001 000 100 000         OTI UPH  D02  #337         SET F0
0717  00 111 100 001 001 000 000         OTI LWH  D02  #277         SET F2 TO INDICATE WFM CMD.
0720  00 000 111 000 110 011 010         JMP LRCQ                   GOTO LRCQ
                                         ************************************************************************
                                               SKP
```

Table 4-4. Magnetic Tape Subsystem Microprogram Listing (Continued)

```
                                            ********************************************************************************
                                            *                                                                              *
                                            *     SUBROUTINE RBYTE TAKES THE READ CHARACTER IN LOW HALF                    *
                                            *       OF R3. CHECKS PARITY & COMPUTES READ-CRCC IN R2                        *
                                            *                                                                              *
                                            ********************************************************************************
0721  00 111 000 001 000 000 001   RBYTE OTI LWH  DEC  D02  #376          SET IN-MODE F/F
0722  00 111 000 010 000 000 000         OTI LWH  DEC  D04  #377          RESET RD. CLK. F/F
0723  11 100 010 010 111 010 101         JFS F11  DEC  *+2                SKIP NEXT IF PARITY OKAY
0724  00 111 000 000 100 010 000         OTI LWH  DEC  D01  #357          SET TAPE ERROR BIT
0725  00 010 000 101 010 001 011   RBITE IOC INP  DEC  LWH  R3I  D12      GET READ BYTE IN R3
0726  10 111 010 111 111 111 110   WBITE PSI UPH  DEC  R3M  1             R3(8):=1
0727  11 100 001 100 111 011 001         JFS F06  DEC  *+2                SKIP NEXT IF READ PARITY = 1
0730  11 001 010 111 110 001 111         XOR UPH  DEC  R3M  R3B  R3A      ZERO OUT UPPER HALF OF R3
0731  11 001 011 000 001 011 111   CBITE XOR R2M  DEC  R2B  R3A  RR1      CRCR:=(CRCR 'XOR' R3) ROTATED RT. 1
0732  11 010 011 000 010 011 111         PSB R2M  DEC  R2B                LOOK FOR SIGN OF R2
0733  10 100 011 000 111 011 111         JSZ *+4  DEC                     SKIP 3 IF SIGN = 0
0734  10 111 011 001 111 111 110         PSI UPH  DEC  R2M  1             MODIFY CRCR-BIT SIGN IN BIT 7 OF R2
0735  10 001 001 000 011 000 011         XOI LWH  DEC  R2M  R2B  #74      INVERT BITS 10-13 OF R2
0736  01 101 011 111 111 111 111         RTN      DEC                     SUBROUTINE RETURN
0737  11 001 011 001 110 001 111         XOR UPH  DEC  R2M  R3B  R3A      ZERO OUT UPPER HALF OF R2
0740  00 000 011 000 111 011 110         JMP *-2  DEC                     GO BACK 2 INSTRUCTIONS
                                   ********************************************************************************
                                   *                                                                              *
                                   *          SUBROUTINE CRCCH CHECKS THE READ CRC CHARACTER                      *
                                   *           AGAINST THE COMPUTED CRCC(IN R2). IF THE                           *
                                   *            TWO DO NOT MATCH. THEN TAPE ERROR F/F                             *
                                   *             IS SET. THIS IS CALLED BOTH IN                                   *
                                   *              THE WRITE & READ MODES.                                         *
                                   *                                                                              *
                                   ********************************************************************************
0741  10 001 101 000 000 101 000   CRCCH XOI LWH  R2M  R2B  #327          UPDATE FINAL
0742  10 001 111 000 011 111 110         XOI UPH  R2M  R2B  #1             CRC CHARACTER
0743  11 010 111 000 010 011 111         PSB R2M  R2B                     R2 SHOULD BE 0 FOR GOOD DATA BLOCK
0744  00 011 111 000 111 100 110         JMZ *+2                          SKIP NEXT IF CRCC CHECKS OUT
0745  00 111 100 000 100 010 000         OTI LWH  D01  #357               SET TAPE ERROR BIT
0746  01 101 111 111 111 111 111         RTN                              SUBROUTINE RETURN
                                   ********************************************************************************
                                         SKP
```

Table 4-4. Magnetic Tape Subsystem Microprogram Listing (Continued)

```
                                         ***************************************************************************
                                         *                                                                         *
                                         *             SUBROUTINE WRCRC COMPUTES THE CRC                           *
                                         *              CHARACTER FOR THE WRITE DATA                               *
                                         *               BLOCK & STORE IT IN R1.                                   *
                                         *                                                                         *
                                         ***************************************************************************
0747  11 001 010 111 110 001 111   WRCRC XOR UPH  DEC  R3M  R3B  R3A    ZERO OUT UPPER HALF OF R3
0750  11 100 001 100 111 101 010         JFS F06  DEC  *+2              SKIP NEXT IF WRITE PARITY = 0
0751  10 111 010 111 111 111 110         PSI UPH  DEC  R3M  1           APPEND PARITY IN BIT 7 OF R3
0752  11 001 011 010 101 011 111         XOR R1M  DEC  R1B  R3A  RR1    CRCR:=(CRCR 'XOR' R3) ROTATED RT. 1
0753  11 010 011 010 110 011 111   WRCR1 PSR R1M  DEC  R1B              LOOK FOR SIGN OF R1
0754  10 100 011 000 111 110 000         JSZ *+4  DEC                   SKIP 3 IF SIGN=0
0755  10 111 011 011 111 111 110         PSI UPH  DEC  R1M  1           MODIFY CRCR-PUT SIGN IN BIT 7 OF R1
0756  10 001 001 010 111 000 011         XOI LWH  DEC  R1M  R1B  #74    INVERT BITS 10-13 OF R1
0757  01 101 011 111 111 111 111         RTN      DEC                   SUBROUTINE RETURN
0760  11 001 011 011 110 001 111         XOR UPH  DEC  R1M  R3B  R3A    ZERO OUT UPPER HALF OF R1
0761  00 000 011 000 111 101 111         JMP *-2  DEC                   GO BACK 2 INSTRUCTIONS
                                         ***************************************************************************
                                         *                                                                         *
                                         *             SUBROUTINE ODDW1 CHECKS FOR TWO OR                          *
                                         *              MORE CHARACTER DROPOUTS ON TAPE                            *
                                         *               DURING WRITE MODE. IT LOOKS                               *
                                         *                FOR F2=1 IF F1 WAS 1.                                    *
                                         *                                                                         *
                                         ***************************************************************************
0762  11 100 000 010 111 110 100   ODDW1 JFS F01  DEC  *+2              SKIP NEXT IF I-CHAR. FLAG=1
0763  00 000 011 000 111 110 111         JMP *+4  DEC                   NO CHARACTER YET-GO BACK
0764  11 100 000 100 111 110 110         JFS F02  DEC  *+2              SKIP NEXT IF II-CHAR. FLAG=1
0765  00 000 011 000 001 111 111         JMP      DEC  DROP             CHAR. DROPOUT CASE-GOTO DROP
0766  00 111 000 001 010 000 000         OTI LWH  DEC  D02  #177        RESET F2 (II-CHAR. FLAG)
0767  01 101 011 111 111 111 111         RTN      DEC                   SUBROUTINE RETURN
                                         ***************************************************************************
                                         *                                                                         *
                                         *             SUBROUTINE FMPAR SETS F1 IF THE                             *
                                         *              CHARACTER READ(IN LOW HALF OF                              *
                                         *               R3) LOOKS LIKE PART OF FILE-                              *
                                         *                MARK (OCTAL 23) IN 800 BPI.                              *
                                         *                                                                         *
                                         ***************************************************************************
0770  00 111 100 011 000 100 000   FMPAR OTI LWH  D06  #337             RESET F1 & RD. CLK. F/F
0771  00 010 100 101 010 001 011         IOC INP  LWH  R3I  D12         GET READ BYTE IN R3
0772  11 100 101 100 111 111 110         JFS *+4  F06                   RETURN IF PARITY = 1
0773  10 001 101 111 111 101 100         XOI LWH  R3B  FM               SET F1 IF
0774  00 011 101 000 111 111 110         JMZ RCS  *+2                    THE READ BYTE
0775  00 111 100 001 000 010 000         OTI LWH  D02  #357               IS A FILE MARK
0776  01 101 111 111 111 111 111         RTN                            SUBROUTINE RETURN
                                         ***************************************************************************
0777  01 000 111 111 111 111 111         NOP
                                         SKP
```

Table 4-4. Magnetic Tape Subsystem Microprogram Listing (Continued)


```
                                     ***********************************************************************
                                     *                                                                     *
                                     *           FMP16 SETS F1 IF FILE-MARK IS FOUND(1600 BPI).            *
                                     *                                                                     *
                                     ***********************************************************************
1000  00 111 100 101 000 100 000    FMP16 OTI LWH  D12  #337             RESET F1 & EOB FLAG
1001  00 010 111 001 010 001 011          IOC INP  R3I  D22  UPH         GET STATUS BYTE IN R3
1002  10 110 111 111 110 111 111          ANI UPH  R3B  #100             LOOK FOR TAPE MARK BIT
1003  00 011 101 001 000 000 101          JMZ RCS  *+2                   SKIP NEXT IF TAPE MARK BIT = 0
1004  00 111 100 001 000 010 000          OTI LWH  D02  #357             SET F1 TO INDICATE TAPE MARK
1005  01 101 111 111 111 111 111          RTN                            SUBROUTINE RETURN
                                     ***********************************************************************
1006  01 110 111 001 000 000 000    FM16  CAL FMP16                      SUB. CALL TO LOOK FOR TAPE MARK
1007  00 000 111 001 000 011 010          JMP BCK2                       GOTO BCK2
                                     ***********************************************************************
                                     *                                                                     *
                                     *           SUBROUTINE ERR16 SETS TAPE ERROR F/F IF AN ERROR          *
                                     *            IS DISCOVERED BY THE TAPE DRIVE(1600 BPI ONLY).          *
                                     *                                                                     *
                                     ***********************************************************************
1010  00 010 111 001 010 001 011    ERR16 IOC INP  UPH  R3I  D22         GET STATUS BYTE IN R3
1011  10 110 111 111 111 011 111          ANI UPH  R3B  #40              LOOK FOR TAPE ERROR
1012  00 011 101 001 000 001 100          JMZ RCS  *+2                   SKIP NEXT IF TAPE ERROR=0
1013  00 111 100 000 100 010 000          OTI LWH  D01  #357             SET TAPE ERROR BIT OF STATUS
1014  01 101 111 111 111 111 111          RTN                            SUBROUTINE RETURN
                                     ***********************************************************************
                                     *                                                                     *
                                     *           SUBROUTINES WRTP1 & WRTP3 ARE CALLED TO OUTPUT            *
                                     *            THE WRITE BYTE & SET WRITE STROBE(1600 BPI)              *
                                     *                                                                     *
                                     ***********************************************************************
1015  11 001 010 010 110 000 111    WRTP1 XOR UPH  DEC  R5M  R5A  R1B    R5(UPPER):=R5 'XOR' R1
1016  11 100 000 101 000 010 000    WRTPE JFS *+2  DEC  F02              SKIP NEXT IF F2=1(WFM)
1017  00 111 000 000 000 000 011    WRTP3 OTI LWH  DEC  D00  #374        TOGGLE ODD/EVEN F/F
1020  00 010 010 001 110 000 001          IOC OUT  DEC  UPH  R5I  D03    OUTPUT THE BYTE FROM R5
1021  01 010 001 001 000 010 001          JXZ RCS DEC  *                 TIME OUT THE COUNTER
1022  00 111 110 000 000 100 000          OTI UPH  D00  #337             SET WRITE STROBE
1023  01 101 111 111 111 111 111          RTN                            SUBROUTINE RETURN
                                     ***********************************************************************
                                     *                                                                     *
                                     *  BCKRD IS THE READ REV. 1600 BPI ROUTINE(F0=1 IF WRT. STATUS WAS 1) *
                                     *                                                                     *
                                     ***********************************************************************
1024  11 100 101 111 000 011 001    BCKRD JFS F07  *+5                   SKIP 4 IF EOB=1
1025  11 100 110 001 000 010 111          JFS F10  *+2                   SKIP NEXT IF RD. CLK.=1
1026  00 000 111 001 000 010 100          JMP BCKRD                      GOTO BCKRD
1027  00 111 100 011 000 000 000          OTI LWH  D06  #377             RESET RD. CLK. F/F
1030  00 000 111 001 000 010 100          JMP BCKRD                      GO BACK TO BCKRD
1031  00 111 100 001 000 100 000          OTI LWH  D02  #337             RESET F1
1032  11 001 110 001 110 011 111    BCK2  XOR CTM  R3B  R3A              ZERO OUT THE COUNTER
1033  10 111 110 001 111 100 010          PSI UPH  CTM  T145             CNTR:=.145 IN. DELAY
1034  00 111 000 100 000 000 000          OTI LWH  DEC  D10  #377        RESET EOB FLAG
1035  01 010 001 001 000 011 101          JXZ RCS  DEC  *                TIME OUT THE COUNTER
1036  00 000 111 000 010 011 100          JMP RBDEC                      GOTO RBDEC
                                     ***********************************************************************
                                          SKP
```

Table 4-4. Magnetic Tape Subsystem Microprogram Listing (Continued)

```
                                                 ***********************************************************************************
                                                 *  FS16 IS THE 1600 BPI READ FWD. ENTRY(F0=1 FOR 1 CHARACTER READ)               *
                                                 ***********************************************************************************
1037  11 100 100 001 000 100 110    FS16  JFS F00  RD166                     GOTO RD166 IF F0=1
1040  01 110 111 001 000 001 000          CAL ERR16                          SUB. CALL TO LOOK FOR TAPE ERROR
1041  01 110 111 001 000 000 000          CAL FMP16                          SUB. CALL TO LOOK FOR TAPE MARK
1042  11 100 100 010 010 000 001          JFS F01  FILE                      GOTO FILE IF F1=1(FM CONFIRMED)
1043  11 100 111 010 010 000 010          JFS F15  ODEND                     TERMINATE READ IF INTERRUPT CONDITION=1
1044  00 111 100 100 000 000 000          OTI LWH  D10   #377                RESET EOB F/F
1045  00 000 111 000 011 110 101          JMP FRDF                           GOTO FRDF TO READ NEXT RECORD
1046  01 110 111 001 010 100 110    RD166 CAL ERCHK                          CHECK PARITY OF THE READ BYTE
1047  00 010 100 101 010 001 011          IOC INP  LWH   R3I   D12           GET READ BYTE IN R3
1050  11 010 110 111 101 111 111          PSB R3M  R3B   RL4                 MOVE THE DATA BYTE FROM LOW
1051  11 010 110 111 101 111 111          PSB R3M  R3B   RL4                  HALF OF R3 TO UPPER HALF
1052  00 111 100 010 101 000 000          OTI LWH  D05   #277                SET ODD BYTE CNT & RST. RD. CLK.
1053  11 100 101 111 001 001 000    LP16  JFS F07  RDND2                     GOTO RDND2 IF EOB=1
1054  11 100 110 001 000 101 110          JFS F10  *+2                       SKIP NEXT IF RD. CLK.=1
1055  00 000 111 001 000 101 011          JMP LP16                           GO BACK IN LOOP
1056  00 111 100 010 110 000 000          OTI LWH  D05   #177                SET EVEN BYTE CNT & RST. RD. CLK.
1057  01 110 111 001 010 100 110          CAL ERCHK                          CHECK PARITY OF READ BYTE
1060  11 100 100 101 000 101 011          JFS F02  LP16                      GO BACK IN LOOP IF F2=1
1061  00 010 100 101 010 001 011          IOC INP  LWH   R3I   D12           GET READ BYTE IN R3
1062  00 010 110 011 110 000 011          IOC OUT  UPH   R3I   D07           OUTPUT THE I-BYTE TO DATA-IN REG.
1063  00 010 100 011 110 000 011          IOC OUT  LWH   R3I   D07           OUTPUT THE II DATA BYTE
1064  11 100 100 001 000 110 110          JFS F00  *+2                       SKIP NEXT IF F0=1
1065  00 000 111 001 000 111 000          JMP *+3                            SKIP 2 INSTRUCTIONS
1066  00 111 110 001 000 010 000          OTI UPH  D02   #357                RESET F0
1067  00 000 111 001 000 111 110          JMP NXT16                          GOTO NXT16
1070  11 100 111 001 000 111 010          JFS F14  *+2                       SKIP NEXT IF DATA-F/F=1
1071  00 111 100 000 100 001 000          OTI LWH  D01   #367                SET TIMING ERROR STATUS
1072  00 111 110 001 010 000 000          OTI UPH  D02   #177                RESET DATA F/F
1073  11 100 111 101 000 111 110          JFS F16  *+3                       SKIP 2 IF IN-XFER = 1
1074  00 111 100 001 001 000 000          OTI LWH  D02   #277                SET F2 TO INDICATE WC<REC. LENGTH
1075  00 000 111 001 000 101 011          JMP LP16                           GOTO LP16
1076  00 111 101 000 000 000 000    NXT16 OTI LWH  D20   #377                SET SERV. REQ.
1077  11 100 101 111 001 000 010    TERMT JFS F07  RDEND                     GOTO RDEND IF EOB FLAG=1
1100  11 100 110 001 000 100 110          JFS F10  RD166                     GOTO RD166 IF RD. CLK.=1
1101  00 000 111 001 000 111 111          JMP TERMT                          OTHERWISE STAY IN LOOP
1102  11 100 100 101 001 000 101    RDEND JFS F02  *+3                       SKIP 2 IF F2=1
1103  01 110 111 001 000 001 000          CAL ERR16                          SUB. CALL TO LOOK FOR TAPE ERROR
1104  00 000 111 000 010 000 010          JMP ODEND                          GOTO ODEND
1105  10 110 101 111 011 111 110    RDND1 ANI LWH  R0B   1                   GOTO FSRF IF
1106  00 011 101 000 010 010 101          JMZ RCS  FSRF                       FSR-FSF CMD.
1107  00 000 111 001 001 000 011          JMP *-4                               ELSE GO BACK 4
1110  11 100 100 101 001 000 101    RDND2 JFS F02  RDND1                     GOTO RDND1 IF F2=1
1111  11 001 110 001 110 011 111          XOR CTM  R3B   R3A                 ZERO OUT THE COUNTER
1112  00 010 110 011 110 000 011          IOC OUT  UPH   R3I   D07           OUTPUT THE I-BYTE TO DATA-IN REG.
1113  00 010 100 011 110 000 000          IOC OUT  LWH   CTI   D07           ZERO OUT THE LOWER DATA BYTE
1114  10 111 100 001 111 000 010          PSI LWH  CTM   T1                  CNTR:=1 WORD DELAY
1115  11 100 111 001 001 001 111          JFS F14  *+2                       SKIP NEXT IF DATA-F/F=1
1116  00 111 100 000 100 001 000          OTI LWH  D01   #367                SET TIMING ERROR
1117  00 111 111 001 010 000 000          OTI UPH  D22   #177                SET SERV. REQ. & RST. DATA F/F
1120  01 010 001 001 001 010 000          JXZ RCS  DEC   *                   TIME OUT THE COUNTER
1121  11 100 111 001 001 010 011          JFS F14  *+2                       SKIP NEXT IF DATA F/F=1
1122  00 111 100 000 100 001 000          OTI LWH  D01   #367                SET TIMING ERROR
1123  00 000 111 000 010 000 010          JMP ODEND                          GOTO ODEND
                                    ***********************************************************************************
                                          SKP
```

Table 4-4. Magnetic Tape Subsystem Microprogram Listing (Continued)

```
                                          ***************************************************************************
                                          *                                                                         *
                                          *       AT IDENT 2" OF ID BURST IS WRITTEN AT LOAD POINT                  *
                                          *                                                                         *
                                          ***************************************************************************
1124  11 001 110 011 110 011 111   IDENT XOR R5M  R3B  R3A                ZERO OUT R5
1125  10 111 111 001 100 001 000         PSI R2M  UPH  #367               SET R2 WITH 2" ID-BURST COUNT
1126  10 111 100 011 111 111 110         PSI R5M  LWH  #1                 R5:=1
1127  01 001 111 000 010 010 111         ADD R2M  R2B  R5A                INCREMENT R2
1130  10 111 100 001 111 100 101         PSI CTM  LWH  #32                PRESET THE COUNTER
1131  01 110 011 001 000 001 111         CAL DEC  WRTP3                   SUBROUTINE CALL
1132  01 001 111 000 010 010 111         ADD R2M  R2B  R5A                R2:=R2+1
1133  00 011 101 001 001 011 000         JMZ RCS  *-3                     GO BACK IN LOOP IF R2 IS NON-ZERO
1134  01 110 111 000 001 011 010         CAL WGAP                         CALL TO WGAP TO WRITE A GAP
1135  11 100 101 111 001 011 111         JFS F07  *+2                     SKIP NEXT IF EOB DETECTED BY DRIVE
1136  00 000 111 000 001 111 111         JMP DROP                         NO EOB - ERROR CASE
1137  01 110 111 001 000 001 000         CAL ERR16                        SUB. CALL TO LOOK FOR TAPE ERROR
1140  00 111 100 101 000 010 000         OTI LWH  D12  #357               SET F1 & RESET EOB
1141  00 010 111 001 010 001 011         IOC INP  UPH  R3I  D22           GET 1600 STATUS IN R3
1142  10 110 111 111 101 111 111         ANI UPH  R3B  #200               LOOK FOR ID-BURST STATUS
1143  00 011 111 001 001 100 101         JMZ *+2                          ID-BURST CONFIRMED-SKIP NEXT INSTRUCTION
1144  00 000 111 000 001 111 111         JMP DROP                         NO ID-BURST STATUS-ERROR CASE
                                          ***************************************************************************
                                          *          WR16 IS THE LOOP-ENTRY POINT FOR WRITING PREAMBLE,             *
                                          *           POSTAMBLE OR FILE-MARK BLOCK.(1600 BPI ONLY)                  *
                                          ***************************************************************************
1145  10 110 101 111 011 111 110   WR16  ANI LWH  R0B  1                  LOOK FOR SUBGROUP OF WRITE
1146  00 011 111 001 001 101 000         JMZ *+2                          SKIP NEXT IF WRR CMD.
1147  00 111 100 001 001 000 000         OTI LWH  D02  #277               SET F2 TO INDICATE WFM OR GAP CMD.
1150  11 100 100 011 001 101 010         JFS F01  *+2                     SKIP NEXT IF F1=1(NOT BOT)
1151  00 000 111 001 001 010 100         JMP IDENT                        GOTO IDENT TO WRITE ID-BURST
1152  00 111 100 000 000 000 001         OTI LWH  D00  #376               SET ODD F/F
1153  10 111 111 011 100 000 000         PSI R1M  UPH  #377               FILL UPPER BYTE OF R1 WITH ALL 1'S
1154  00 111 100 001 000 100 000         OTI LWH  D02  #337               RESET F1
1155  10 111 111 001 101 001 111         PSI R2M  UPH  #260               R2:=-80
1156  11 100 100 101 001 110 000         JFS F02  *+2                     SKIP NEXT INSTRUCTION IF F2=1
1157  00 000 111 001 001 111 010         JMP WRT16                        WRR CMD.-GOTO WR16 TO WRITE PREAMBLE
1160  10 001 101 111 011 111 010         XOI LWH  R0B  GAP                LOOK FOR GAP COMMAND
1161  00 011 101 001 001 110 111         JMZ RCS  *+6                     SKIP 5 IF WFM COMMAND
1162  01 110 111 000 001 011 010         CAL WGAP                         SUBROUTINE CALL TO WRITE 3.75" GAP
1163  11 100 101 111 001 110 101         JFS F07  *+2                     SKIP NEXT IF EOB FLAG=1
1164  00 000 111 000 010 000 010         JMP ODEND                        GOTO ODEND
1165  01 110 111 001 000 001 000         CAL ERR16                        SUB. CALL TO LOOK FOR TAPE ERROR
1166  00 000 111 000 010 000 010         JMP ODEND                        GOTO ODEND
1167  00 111 100 000 000 000 010         OTI LWH  D00  #375               SET EVEN F/F
1170  10 111 111 011 101 011 000         PSI R1M  UPH  #247               R1(UPPER):=FM CHARACTER
1171  10 111 111 001 101 010 000         PSI R2M  UPH  #257               R2:=-81
1172  11 010 110 010 110 001 111   WRT16 PSB R5M  UPH  R1B                PASS UPPER BYTE OF R1 IN R5
1173  10 111 100 001 111 110 101   LPFM  PSI CTM  LWH  #12                PRESET THE COUNTER
1174  01 110 011 001 000 001 101   LPFM1 CAL      DEC  WRTP1              SUBROUTINE CALL
1175  00 001 111 000 011 111 110         ADI R2M  UPH  R2B  #1            R2(UPPER):=R2+1
1176  00 011 101 001 001 111 011         JMZ RCS  LPFM                    GO IN LOOP IF R2 IS NON-ZERO
1177  11 100 100 101 010 011 001         JFS F02  FIN16                   GOTO FIN16 IF F2=1
1200  10 111 100 001 111 100 110         PSI CTM  LWH  #31                PRESET THE COUNTER
1201  11 100 000 001 010 011 001   BLK16 JFS F00  DEC  FIN16              GOTO FIN16 IF F0=1(POSTAMBLE WRITTEN)
1202  01 110 011 001 000 001 101         CAL      DEC  WRTP1              SUBROUTINE CALL
                                          ***************************************************************************
                                         SKP
```

Table 4-4. Magnetic Tape Subsystem Microprogram Listing (Continued)

```
                                        ******************************************************************************
                                        *        WLP16 IS THE LOOP-ENTRY POINT FOR WRITING THE                        *
                                        *          DATA-BLOCK. F0=1 AS LONG AS OUT-XFER=1.                            *
                                        *                        (1600 BPI ONLY)                                      *
                                        ******************************************************************************
1203  10 111 100 001 111 110 100        WLP16 PSI CTM  LWH  #13               PRESET THE COUNTER
1204  01 110 011 000 001 100 010              CAL      DEC  WRCHK             SUBROUTINE CALL TO WRCHK
1205  01 110 011 001 000 001 111              CAL      DEC  WRTP3             SUBROUTINE CALL
1206  10 111 100 001 111 110 011              PSI CTM  LWH  #14               PRESET THE COUNTER
1207  01 110 011 001 000 001 101              CAL      DEC  WRTP1             SUBROUTINE CALL
1210  11 111 110 011 101 110 111              PSA R5M  R5A  RL4               LEFT ROTATE R5
1211  11 111 110 011 101 110 111              PSA R5M  R5A  RL4                BY 8-BITS IN R5
1212  10 111 100 001 111 110 101              PSI CTM  LWH  #12               PRESET THE COUNTER
1213  01 110 011 001 000 001 111              CAL      DEC  WRTP3             SUBROUTINE CALL
1214  10 111 100 001 111 110 011              PSI CTM  LWH  #14               PRESET THE COUNTER
1215  01 000 011 111 111 111 111              NOP      DEC                    NO-OPERATION
1216  01 110 011 001 000 001 101              CAL      DEC  WRTP1             SUBROUTINE CALL
1217  11 100 100 001 010 000 011              JFS F00  WLP16                  GO IN THE WRITE LOOP IF F0=1
1220  11 001 010 011 110 011 111              XOR R5M  DEC  R3B  R3A          ZERO OUT R5
1221  10 111 100 001 111 110 100              PSI CTM  LWH  #13               PRESET THE COUNTER
1222  01 110 011 001 000 001 101              CAL      DEC  WRTP1             SUBROUTINE CALL
1223  10 111 100 001 111 110 011              PSI CTM  LWH  #14               PRESET THE COUNTER
1224  01 110 011 001 000 001 101              CAL      DEC  WRTP1             SUBROUTINE CALL
1225  10 111 100 001 111 100 011              PSI CTM  LWH  #34               PRESET THE COUNTER
1226  10 111 011 001 101 001 111              PSI R2M  DEC  UPH  #260         R2(UPPER):=-80
1227  00 111 010 001 000 100 000              OTI UPH  DEC  D02  #337         SET F0 TO INDICATE POSTAMBLE CASE
1230  00 000 011 001 001 111 100              JMP      DEC  LPFM1             GOTO WRITE POSTAMBLE
                                        ******************************************************************************
                                        *         AN END OF BLOCK PULSE IS AWAITED AT FIN16 AFTER                     *
                                        *          WRITING OF DATA BLOCK OR FILE-MARK IS DONE.                        *
                                        *           TAPE ERROR OR FILE-MARK STATUS IS                                 *
                                        *            CHECKED TO ENSURE SUCCESSFUL                                     *
                                        *             WRITING(1600 BPI).                                              *
                                        ******************************************************************************
1231  00 111 100 000 000 000 001        FIN16 OTI LWH  D00  #376              SET ODD F/F
1232  11 100 100 101 010 011 101              JFS F02  FM166                  GOTO FM166 IF F2=1
1233  10 111 110 001 111 001 100              PSI UPH  CTM  #63               CNTR:=.155"+80 CHARACTER DELAY
1234  00 000 011 001 010 011 110              JMP *+2  DEC                    SKIP NEXT INSTRUCTION
1235  10 111 110 001 111 011 100        FM166 PSI UPH  CTM  #43               CNTR:=.155" + 20 CHARACTER DELAY
1236  11 100 001 111 010 100 001              JFS F07  DEC  *+3               SKIP 2 IF EOB=1
1237  01 010 001 001 010 011 110              JXZ RCS  DEC  *-1               STAY IN LOOP TILL CNTR. NON-ZERO
1240  00 000 111 000 001 111 111              JMP DROP                        CHARACTER DROPOUT CASE
1241  11 100 100 101 010 100 100              JFS F02  *+3                    SKIP 2 IF WFM COMMAND
1242  01 110 111 001 000 001 000              CAL ERR16                       SUB. CALL TO LOOK FOR TAPE ERROR
1243  00 000 111 000 010 000 010              JMP ODEND                       GOTO ODEND
1244  01 110 111 001 000 000 000              CAL FMP16                       SUB. CALL TO LOOK FOR TAPE MARK
1245  00 000 111 000 001 111 101              JMP FM816                       GOTO FM816
                                        ******************************************************************************
                                        *       SUBROUTINE TO CHECK PARITY OF EACH BYTE IN RDR CMD.                   *
                                        ******************************************************************************
1246  10 001 101 111 011 111 001        ERCHK XOI LWH  R0B  RDR               PERFORM PARITY CHECK ONLY
1247  00 011 101 001 010 101 010              JMZ RCS  *+3                     IF THE COMMAND IS 'RDR'
1250  11 100 110 011 010 101 010              JFS F11  *+2                    SKIP NEXT IF PARITY OK
1251  00 111 100 000 100 010 000              OTI LWH  C01  #357              SET TAPE ERROR F/F
1252  01 101 111 111 111 111 111              RTN                             SUBROUTINE RETURN
                                        ******************************************************************************
                                              SKP
```

Table 4-4. Magnetic Tape Subsystem Microprogram Listing (Continued)

```
                                   *********************************************************************************
                                   *                                                                               *
                                         ORG #1314
                                   *                                                                               *
                                   *********************************************************************************
1314  00 010 111 001 010 001 011   PTCH1 IOC INP  R3I  D22  UPH              GET STATUS BYTE IN UPPER R3
1315  10 110 111 111 111 101 111         ANI UPH  R3B  #20                   IS INT. FLAG=1?
1316  00 011 101 001 011 001 100         JMZ RCS  *-2                        YES. KEEP LOOKING AT THIS BIT
1317  10 111 111 011 111 001 100         PSI UPH  R1M  #63                   R1:=(TRYING TO SELECT UNIT)
1320  00 000 111 000 000 001 011         JMP CONT1                           GOTO CONT1 TO CONTINUE WITH THE PROGRAM
                                   *********************************************************************************
                                   *                                                                               *
                                         ORG #1327
                                   *                                                                               *
                                   *********************************************************************************
1327  00 010 111 001 010 001 011   PTCH2 IOC INP  R3I  D22  UPH              GET STATUS BYTE IN R3
1330  10 110 111 111 111 110 111         ANI UPH  R3B  #10                   LOOK FOR SIO OK BIT
1331  00 011 101 000 000 001 111         JMZ RCS  MAIN                       GOTO MAIN IF ALREADY IN SIO ROUTINE
1332  00 010 111 001 010 001 011         IOC INP  R3I  D22  UPH              GET STATUS BYTE IN R3
1333  10 110 111 111 111 101 111         ANI UPH  R3B  #20                   IS INT. FLAG=1?
1334  00 011 101 001 011 011 010         JMZ RCS  *-2                        YES. KEEP LOOKING AT THIS BIT
1335  00 000 111 000 000 110 101         JMP SCANO                           GO BACK TO SCANO
                                   *********************************************************************************
                                   *                                                                               *
                                         ORG #1361
                                   *                                                                               *
                                   *********************************************************************************
1361  10 111 100 001 100 010 001   PATCH PSI LWH  CTM  TCOST                 PRESET THE COUNTER WITH COAST DELAY
1362  11 100 111 101 011 110 100         JFS F16  *+2                        SKIP NEXT IF IN-XFER=1
1363  00 000 111 001 011 110 110         JMP *+3                             SKIP 2 INSTRUCTIONS
1364  00 111 110 001 000 001 000         OTI UPH  D02  #367                  SET DEVICE-END
1365  00 000 111 001 011 110 111         JMP *+2                             SKIP NEXT INSTRUCTION
1366  00 111 111 000 000 000 000         OTI UPH  D20  #377                  SET SERV. REQ.
1367  01 010 001 001 011 110 111         JXZ RCS  DEC  *                     TIME OUT THE COUNTER
1370  00 010 111 001 010 001 011         IOC INP  R3I  D22  UPH              GET STATUS BYTE IN UPPER R3
1371  10 110 111 111 111 101 111         ANI UPH  R3B  #20                   IS INT. FLAG=1?
1372  00 011 111 000 010 001 101         JMZ STOP1                           NO. GOTO STOP1
1373  00 000 111 000 000 000 100         JMP WAIT                            INTERRUPT NOT YET PROCESSED. GOTO WAIT
                                   *********************************************************************************
                                         END

  0  ERRORS
```

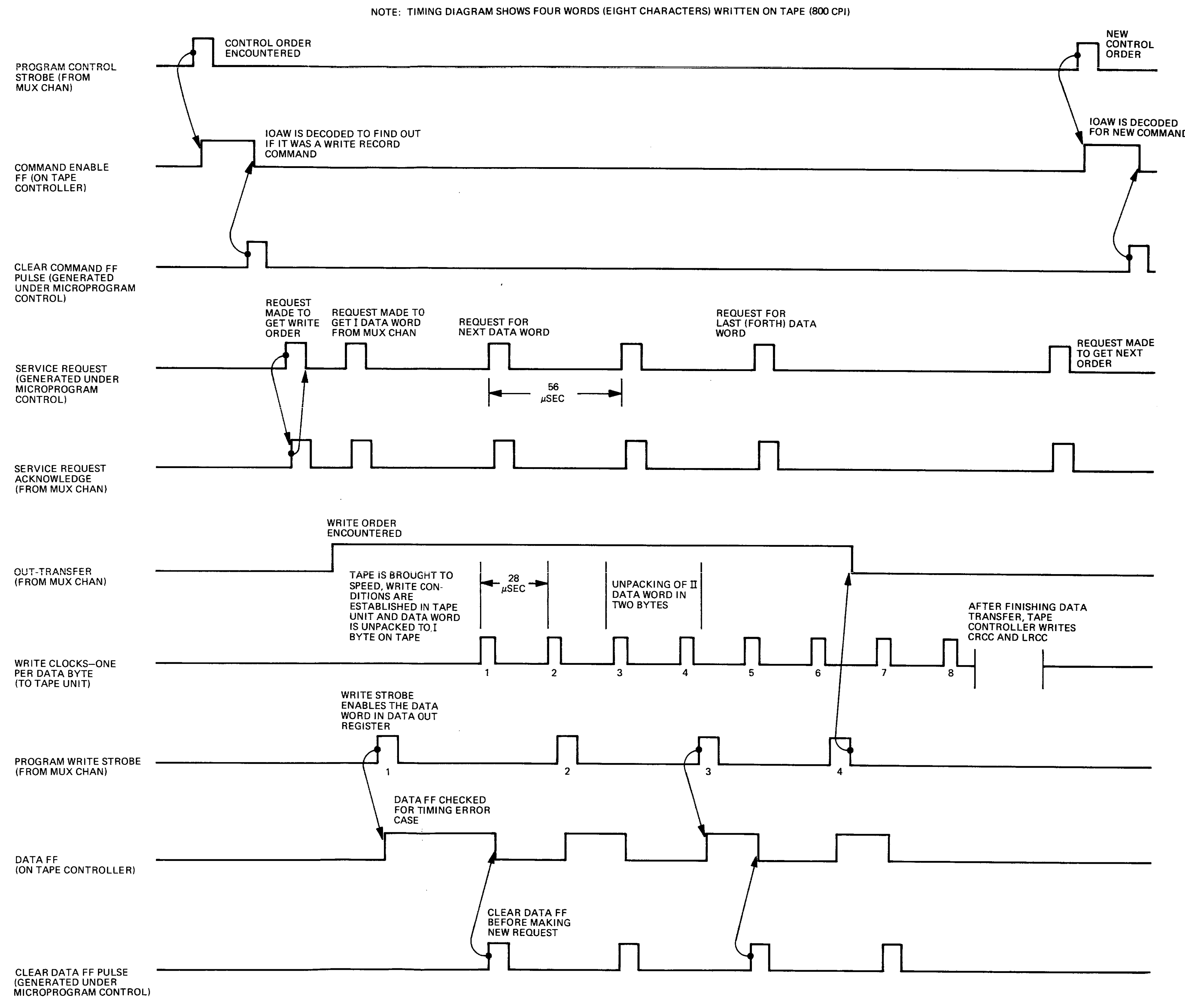


Figure 4-12. Typical Write Operation, Tape Controller Timing Diagram

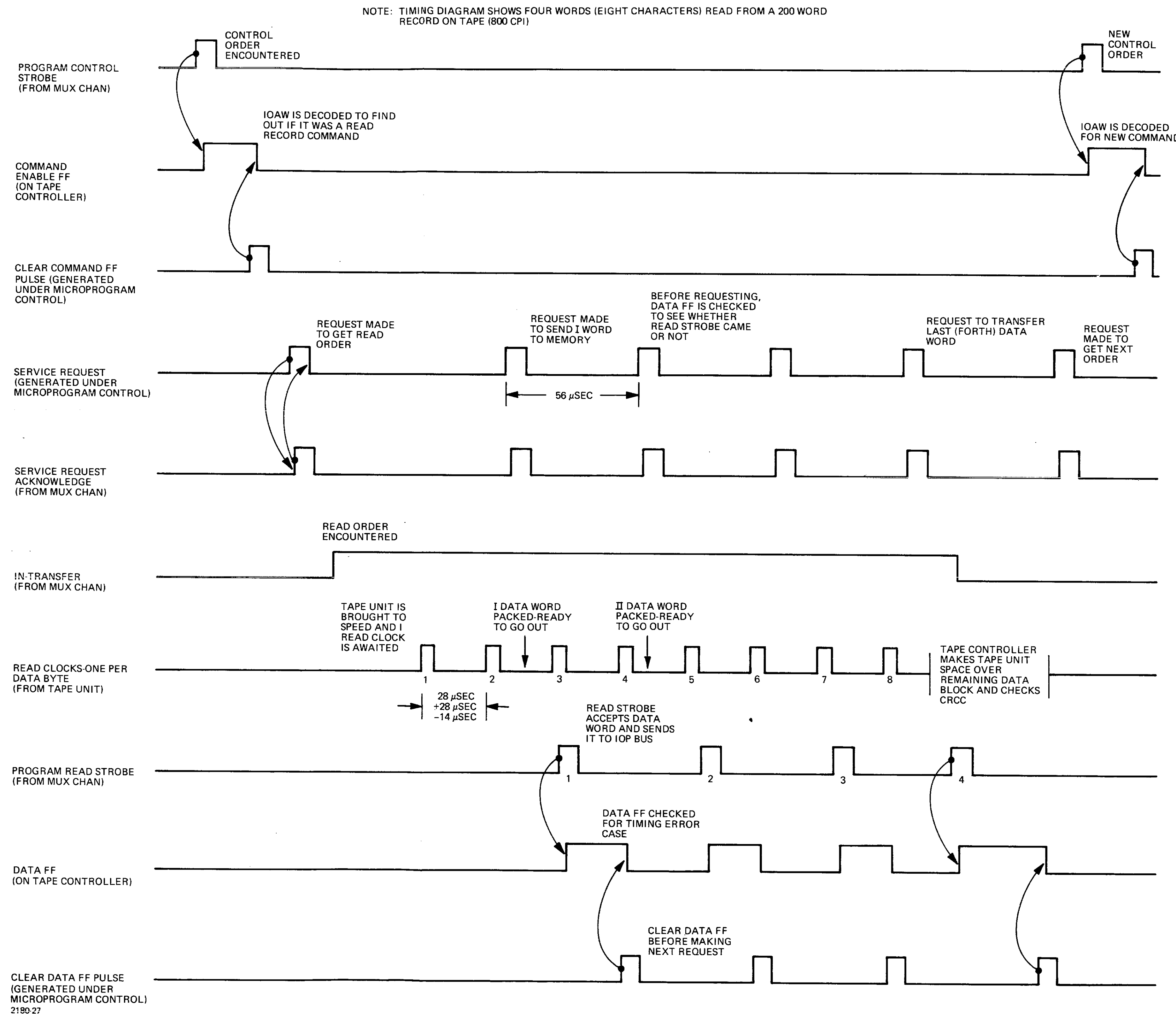


Figure 4-13. Typical Read Operation, Tape Controller Timing Diagram

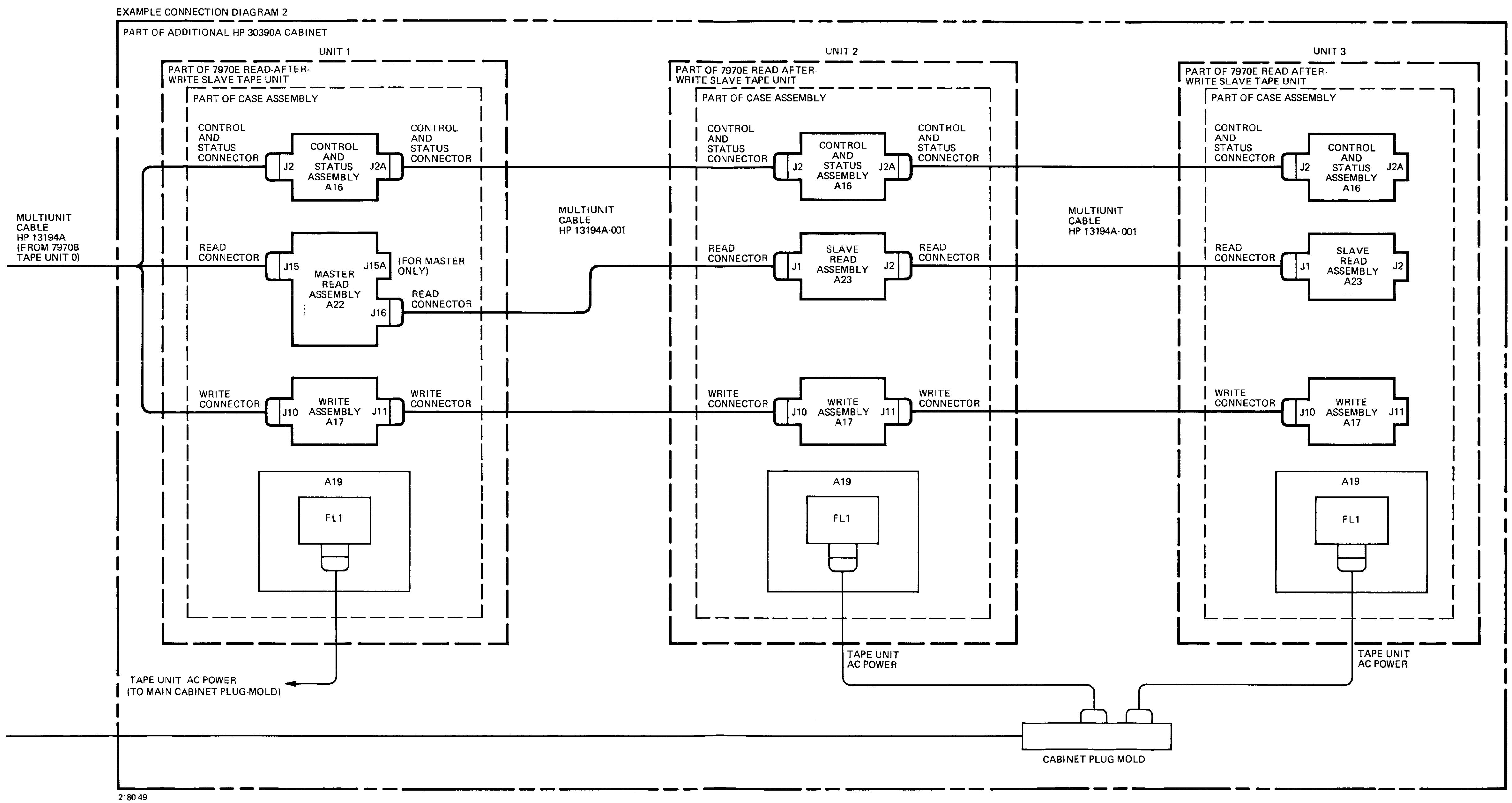


Figure 4-2. Magnetic Tape Subsystem, Example Multiple Tape Unit Cabling Diagram (Sheet 2 of 2)

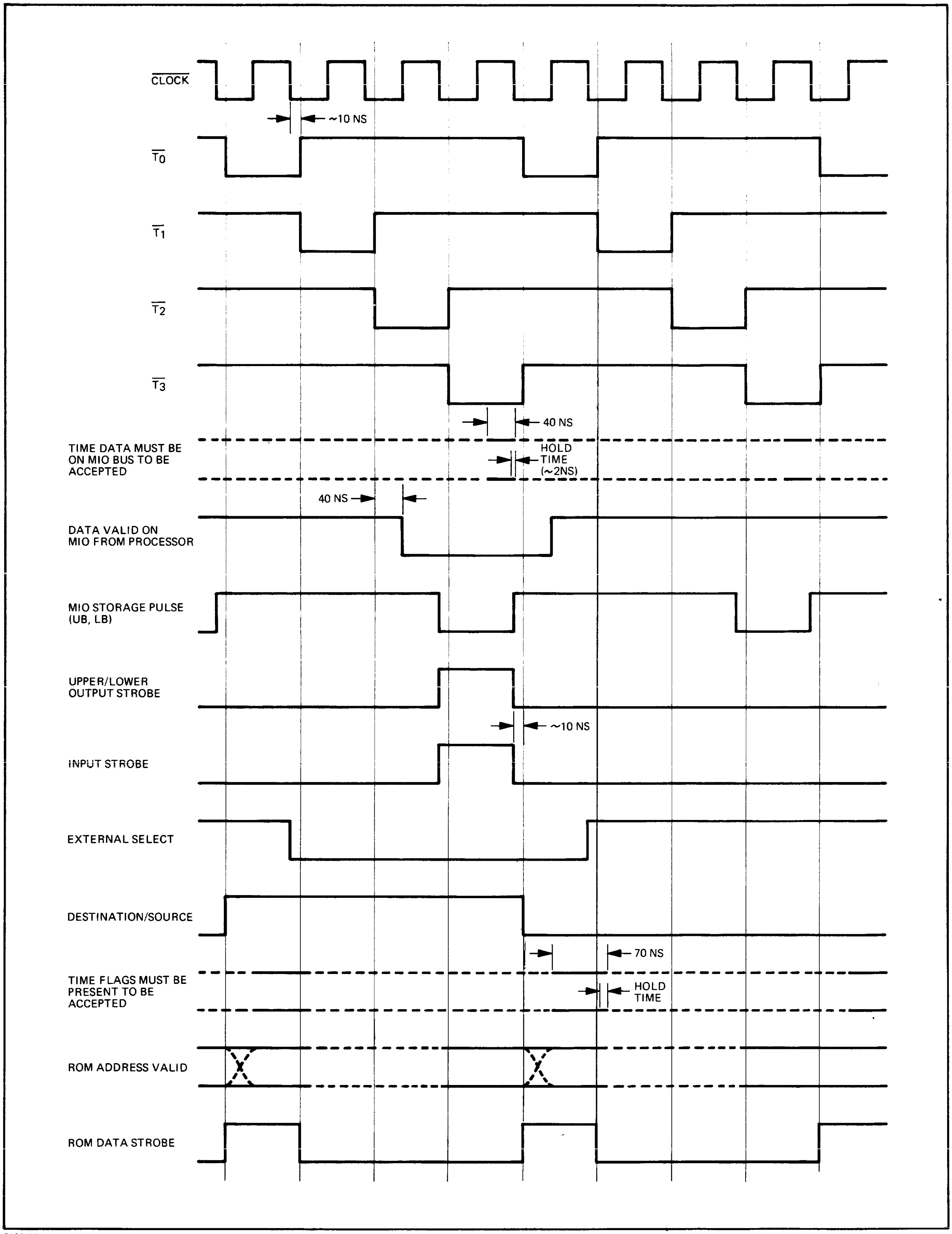


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Figure 4-14. Controller Processor Basic Timing Diagram

Table 4-5. Controller Processor Maintenance Connector, J1, Pin/Signal List

J1 PIN	SIGNAL	J1 PIN	SIGNAL
1	COMMON	26	$\overline{\text{LB}}$
2	COMMON	27	AS 2
3	$\overline{\text{CLK RST}}$	28	AS 3
4	FLG SWRG*	29	AS 1
5	$\overline{\text{ALTCK}}$	30	AS 0
6	$\overline{\text{DISP}}$	31	V
7	$\overline{\text{CKCTL}}$	32	W
8	$\overline{\text{PANEL RESET}}$*	33	T
9	ERA 7	34	U
10	–	35	ERA 1
11	$\overline{\text{LD ERA}}$	36	–
12	ERA 11	37	ERA 5
13	ERA 3	38	ERA 9
14	ERA 2	39	ERA 4
15	ERA 10	40	ERA 0
16	ERA 6	41	ERA 8
17	AT 0	42	–
18	CTL1	43	$\overline{\text{SIM RUN}}$*
19	AT 3	44	$\overline{\text{SIM HALT}}$*
20	AT 1	45	Z
21	AT 2	46	$\overline{\text{LDRG}}$
22	–	47	X
23	CTL2	48	Y
24	$\overline{\text{UB}}$	49	COMMON
25	AM	50	COMMON

NOTE: * appears only on maintenance interface card or ROM simulator buffer card.

Table 4-6. Power Bus/IOP Connector, P1, Pin/Signal List

56-PIN	20-PIN*	SIGNAL	56-PIN	20-PIN*	SIGNAL
1		+5V	31*		-20V
2		+5V	32*		-20V
3		+5V	33*		-20V
4		+5V	34*		-20V
5*	2	$\overline{\text{PF WARN}}$	35*		+20V
6*	1	ENTIMER	36*		+20V
7*	4	(SPARE)	37*		+20V
8*	3	(SPARE)	38*		+20V
9	6	PWR ON	39*		+20V
10	5	PWR ON COMMON	40*		+20V
11	8	IORESET	41*	12	$\overline{\text{HSREQ}}$
12	7	IORESET COMMON	42*	11	$\overline{\text{HSREQ}}$ COMMON
13*	10	$\overline{\text{MCUCLKS}}$	43		INTPOLL OUT COMMON
14*	9	$\overline{\text{MCUCLKS}}$ COMMON	44		INTPOLL OUT
15		COMMON	45*	14	(SPARE)
16		COMMON	46*	13	(SPARE) COMMON
17*		-5V	47		INTPOLL IN COMMON
18*		-5V	48		INTPOLL IN
19		COMMON	49	16	$\overline{\text{SI}}$
20		COMMON	50	15	$\overline{\text{SI}}$ COMMON
21*		+15V	51*		DATAPOLL OUT COMMON
22*		+15V	52*		DATAPOLL OUT
23*		+15V	53	18	$\overline{\text{SO}}$
24*		+15V	54	17	$\overline{\text{SO}}$ COMMON
25*		-15V	55*		DATAPOLL IN COMMON
26*		-15V	56*		DATAPOLL IN
27*		-15V		20	$\overline{\text{MSKRTRN}}$
28*		-15V		19	$\overline{\text{MSKRTRN}}$ COMMON
29		COMMON			
30		COMMON			

*Indicates not used in subsystem. Twenty-pin connector is used from PCA module-to-PCA module.

Table 4-7. Multiplexer Channel Bus Connector, P2, Pin/Signal List

PIN	SIGNAL	PIN	SIGNAL
1	CHAN SO	26	SR 13
2	COMMON	27	SR 12
3*	SR CLOCK	28	SR 11
4	COMMON	29	SR 10
5	DEV END	30	COMMON
6	COMMON	31	SR 9
7	ACK SR	32	SR 8
8	COMMON	33	SR 7
9	CHAN ACK	34	SR 6
10	COMMON	35	SR 5
11	DEVNO DB	36	COMMON
12	SIO ENABLE	37	SR 4
13	EOT	38	SR 3
14*	JMP MET	39	SR 2
15	COMMON	40	SR 1
16	TOGGLE INXFER	41	SR 0
17	TOGGLE SR	42	COMMON
18	TOGGLE OUTXFER	43	P CMD 1
19	TOGGLE SIO OK	44*	SET JMP
20	COMMON	45	P STATUS STB
21	XFER ERROR	46	P CONT STB
22	REQ	47*	RD NEXT WD
23	COMMON	48	P WRITE STB
24	SR 15	49	SET INT
25	SR 14	50	P READ STB

*Indicates not used in subsystem.

Table 4-8. IOP Bus Connector, P3, Pin/Signal List

PIN	SIGNAL	PIN	SIGNAL
1	IODPRTY	26	IOD 04
2*	IOD PE	27	IOD 05
3	COMMON	28	COMMON
4	IOCMD 00	29	IOD 06
5	IOCMD 02	30	IOD 07
6	IOCMD 01	31	COMMON
7	COMMON	32	IOD 08
8	DEVNO 00	33	IOD 09
9	DEVNO 01	34	COMMON
10	COMMON	35	IOD 10
11	DEVNO 02	36	IOD 11
12	DEVNO 03	37	COMMON
13	COMMON	38	IOD 12
14	DEVNO 04	39	IOD 13
15	DEVNO 05	40	COMMON
16	COMMON	41	IOD 14
17	DEVNO 06	42	IOD 15
18	DEVNO 07	43	COMMON
19	COMMON	44	INTREQ
20	IOD 00	45*	(SPARE)
21	IOD 01	46	COMMON
22	COMMON	47*	(SPARE)
23	IOD 02	48*	(SPARE)
24	IOD 03	49	COMMON
25	COMMON	50	INTACK

*Indicates not used in subsystem.

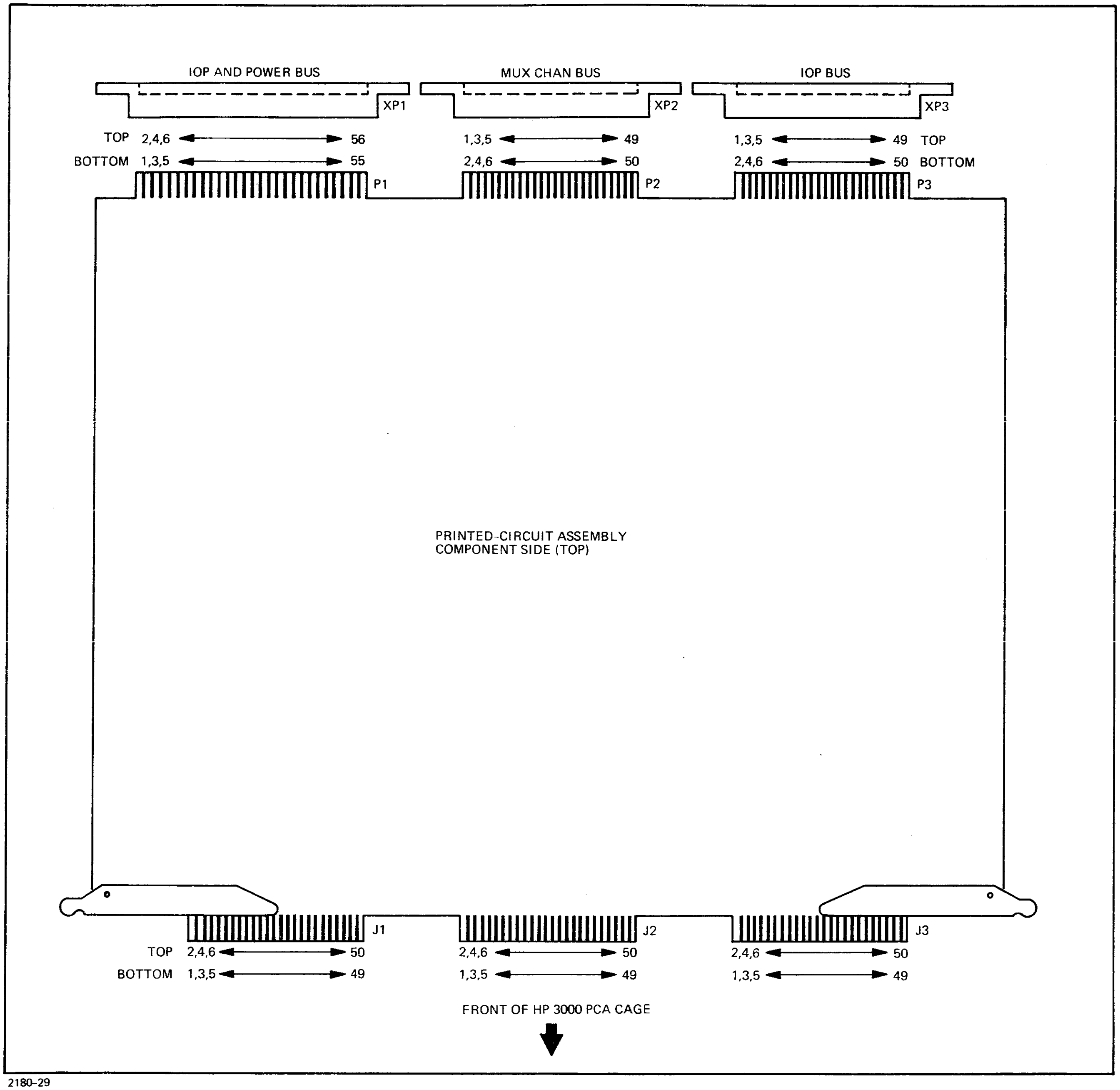

Figure 4-15. Printed Circuit Assembly Connector Pin Indexing Diagram

4-42. CORRECTIVE MAINTENANCE.

4-43. Corrective maintenance for the subsystem consists of adjustment procedures and repair instructions for the tape unit and repair procedures for the HP 30215A Magnetic Tape Unit Interface. These items are discussed in the following paragraphs.

4-44. ADJUSTMENT PROCEDURES.

4-45. There are no adjustments to be made on the printed-circuit assemblies of the HP 30215A Magnetic Tape Unit Interface. Jumper connections are described in paragraph 4-19. All adjustments to be made on the tape unit are described in the operating and service manual for the applicable tape unit.

4-46. REPAIR PROCEDURES.

4-47. As previously mentioned, refer to the tape unit manual for repair instructions applicable to the tape transport and electronic assemblies in that unit, if it is found that they need repair. If trouble is isolated to a PCA or cable of the HP 30215A Magnetic Tape Unit Interface, refer to the following paragraphs.

4-48. PRINTED-CIRCUIT ASSEMBLIES. When trouble has been isolated to a component on a PCA of the interface, replace the component with an identical part number item using information in the *HP 3000 Computer System Illustrated Parts Breakdown Manual.* Integrated-circuit packs may be unsoldered from the PCA and replaced with a new part using a controlled heat, wide-tip soldering tool to unsolder all leads simultaneously. Replace other faulty components on the PCA's in a like manner. Refer to the following paragraph for interface and connector cable repair instructions.

4-49. CABLE REPAIR. Figures 4-16 and 4-17 illustrate signals and wiring for the tape controller-to-tape unit interface cable, part no. 30215-60003. Figures 4-18 and 4-19 are interface cable connector disassembly and repair illustrations. Figure 4-20 is a signal and pin diagram for connector cables, part no. 30000-93052, that are used between the PCA's of the HP 30215A Magnetic Tape Unit Interface. Refer to the illustrations and to the text in the following paragraphs for cable disassembly, repair, and connection data. The illustrations may also be used for troubleshooting since all signals and pins are listed from PCA-to-PCA or from PCA-to-tape unit for all plugs and jacks in the interface. The cabling information in the general servicing paragraph will also prove helpful for maintenance. Connector pin/signal lists for the controller processor maintenance connector, J1, and for PCA connectors P1 through P3 are provided in tables 4-5 through 4-8.

4-50. Connector P1 Repair. Figures 4-17 and 4-18 show details of interface cable 30215-60003 connector P1 wiring and repair. The procedure for wiring the 50-pin connector is as follows:

a. Strip the outer jacket of each of the three cables back 3-½ inches (89 mm). Tag the cables to P2, P3, and P4 so that wires with the same color codes may be identified by connector destination.

b. Trim wires to proper length and strip them back approximately ¼ inch (6 mm) as they are to be connected. See figure 4-17 for wire color connection sequence applicable to connector P1.

c. Insert approximately 8 inches (203 mm) of cable into the P1 connector hood. Starting with the cables laid toward the cable entry point of the connector, attach and solder the white leads of the twisted pairs that will be attached to A2 through A7; to the 22 gauge bus wire. Install heat-shrink tubing as shown in figure 4-18 and attach the bus wire to A12. See the bus connection details in figure 4-18.

d. Attach and solder the white leads of the twisted pairs that will be attached to B1 through B6; to the 22 gauge bus wire. Install heat-shrink tubing over leads as shown in figure 4-18 and attach the bus wire to B12 as shown in figure 4-18.

e. Attach and solder the white leads of the twisted pairs that will be attached to A8 through A11; to the 22 guage bus wire. Install heat-shrink tubing as shown in figure 4-18 and attach the bus wire to A13.

f. Attach and solder the white leads of the twisted pairs that will be attached to B7 through B11; to the 22 guage bus wire. Install heat-shrink tubing and attach the bus wire to B13.

g. Follow the sequence established in steps c through f to attach all other white leads of twisted pairs to the bus wire and to the connector. The maximum is a group of six white wires. Be sure to see figures 4-17 and 4-18 for wiring details.

h. See figure 4-17 and connect colored wires to the P1 connector. Observe tags installed in step a to ensure that proper P2, P3, or P4 connector is wired when duplicate colored wires are encountered. Insulate each connection with heat-shrink tubing as shown in figure 4-18.

i. Install connector ends, hood, and clamps as shown in figure 4-18.

4-51. Connector P2, P3, P4 Repair. Figures 4-17 and 4-19 show details of interface cable 30215-60003 connector P2 through P4 wiring and repair. The procedure for wiring the 48-pin connectors is as follows:

a. Insert approximately 10 inches (254 mm) of cable into the connector hood.

b. Strip the outer jacket of the cable back 5 inches (127 mm).

c. Fold back twisted pairs that will not be used. See figure 4-17 for applicable connector data.

d. Cover cable and folded back twisted pairs with proper size heat-shrink tubing as shown in figure 4-19.

e. Starting at the end of the 48-pin connector nearest pins BB and 24, connect the twisted pairs as follows:

(1) Strip the first pair of wires to be connected back approximately ¼ inch (6 mm). See figure 4-17 for wire color connection sequence applicable to connector being repaired.

(2) Connect and solder the first pair of wires to their respective pins on the connector and insulate each pin with tubing as shown in figure 4-19. Note that the white wires in each pair connect to pins opposite their respective colored wire.

f. Repeat steps (1) and (2) in the previous step with the remaining groups of wires until all wires are soldered to the connector and insulated. Follow the connection sequence in figure 4-17 for the connector being repaired.

g. Install the wired 48-pin connector in the connector hood using the two self-tapping screws.

h. Install the cable clamp and tighten it in place with the set screw.

i. Insert keys, part no. 1251-1115, in connectors as follows:

(1) P2: between pins 18 and 19.

(2) P3: between pins 17 and 18.

(3) P4: between pins 5 and 6.

j. First cable strap, part no. 1400-0249 is to be approximately 2 feet (61 cm) from the connector. Then installed clamps every 2 feet (61 cm).

4-52. Flat-Ribbon Cables. Figure 4-20 illustrates connecting cable 30000-93052 wiring and connectors as used between J2 of each PCA and between J3 of each PCA in the HP 30215A Magnetic Tape Unit Interface. The connectors on the flat-ribbon cables are fabricated to the cable when the system is configured. These cables cannot be disassembled. If it becomes necessary to repair the connector or cable, a new cable must be fabricated. Two special tools will be required to accomplish this. These are:

a. The Scotchflex® Assembly Press manufactured by 3M Company, St. Paul, Minnesota. Used to press the Scotchflex® electronic connectors on to the 50-conductor flat-ribbon cable.

b. The hand operated accessory cable shear. Used to trim excess flat-ribbon cable after fabricating the cables.

CAUTION

The use of cutting instruments such as a pocket knife, an X-Acto® knife, or other single-bladed device may exert force against the pins in the 50-pin connector, thus causing damage to the connector. Do not use these tools to cut flat-ribbon cable.

CONNECTOR PIN/SIGNAL LIST

TAPE CONTROLLER CARD		TAPE UNIT BOARD			
J1-CARD PINS	P1-CONN. PINS(1)	P2-CONN. PINS(1)	WRITE BOARD PINS	SIGNAL	MNEMONIC (3)
33/27	17A/14A	L/10	10X/10	WRITE DATA 0 (MSB)	WD0
34/27	17B/14A	M/11	11X/11	WRITE DATA 1	WD1
39/27	20A/14A	N/12	12X/12	WRITE DATA 2	WD2
40/27	20B/14A	P/13	13X/13	WRITE DATA 3	WD3
37/28	19A/14B	R/14	14X/14	WRITE DATA 4	WD4
38/28	19B/14B	S/15	15X/15	WRITE DATA 5	WD5
35/28	18A/14B	T/16	16X/16	WRITE DATA 6	WD6
36/28	18B/14B	U/17	17X/17	WRITE DATA 7 (LSB)	WD7
10/28	5B/14B	K/9	9X/9	WRITE DATA PARITY	WDP
11/28	6A/14B	F/6	6X/6	WRITE STATUS	SW
30/27	15B/14A	J/8	8X/8	WRITE CLOCK	WC
22/27	11B/14A	H/7	7X/7(5)	WRITE RESET	WRS

TAPE CONTROLLER CARD		TAPE UNIT BOARD			
J1-CARD PINS	P1-CONN. PINS(1)	P3-CONN. PINS(1)	READ BOARD PINS	SIGNAL	MNEMONIC
47/50	24A/25B	L/10	10X/10	READ DATA 0 (MSB)	RD0
48/50	24B/25B	M/11	11X/11	READ DATA 1	RD1
45/50	23A/25B	N/12	12X/12	READ DATA 2	RD2
46/50	23B/25B	P/13	13X/13	READ DATA 3	RD3
43/49	22A/25A	R/14	14X/14	READ DATA 4	RD4
44/49	22B/25A	S/15	15X/15	READ DATA 5	RD5
41/49	21A/25A	T/16	16X/16	READ DATA 6	RD6
42/49	21B/25A	U/17	17X/17	READ DATA 7 (LSB)	RD7
9/25	5A/13A	K/9	9X/9	READ DATA PARITY	RDP
8/23	4B/12A	J/8	8X/8	READ CLOCK	RC
7/23	4A/12A	BB/24	24X/24 (2)	END-OF-BLOCK	EOB
12/26	6B/13B	V/18	18X/18 (2)	800/1600 CPI STATUS (4)	SD16
31/26	16A/13B	X/20	20X/20 (2)	MULTIPLE TRACK ERROR	MTE
32/26	16B/13B	Y/21	21X/21 (2)	TAPE MARK	TM
29/26	15A/13B	AA/23	23X/23 (2)	IDENTIFICATION BURST	IDB
2/26	1B/13B	Z/22	22X/22 (2)	SINGLE TRACK ERROR	STE

TAPE CONTROLLER CARD		TAPE UNIT BOARD			
J1-CARD PINS	P1-CONN. PINS(1)	P4-CONN. PINS(1)	MOTION CONTROL BOARD PINS	SIGNAL	MNEMONIC
3/23	2A/12A	P/13	13X/13	SELECT UNIT 0	CS0
4/23	2B/12A	N/12	12X/12	SELECT UNIT 1	CS1
5/24	3A/12B	M/11	11X/11	SELECT UNIT 2	CS2
6/24	3B/12B	L/10	10X/10	SELECT UNIT 3	CS3
13/23	7A/12A	B/2	2X/2	LOAD POINT STATUS	SLP
16/23	8B/12A	D/4	4X/4	END-OF-TAPE STATUS	SET
14/24	7B/12B	E/5	5X/5	READY STATUS	SR
15/24	8A/12B	F/6	6X/6	FILE PROTECT STATUS	SFP
17/24	9A/12B	T/16	16X/16	FORWARD COMMAND	CF
21/24	11A/12B	R/14	14X/14	REWIND COMMAND	CRW
18/25	9B/13A	U/17	17X/17	REVERSE COMMAND	CR
20/25	10B/13A	S/15	15X/15	OFF-LINE COMMAND	CL
19/25	10A/13A	W/19	19X/19	SET WRITE COMMAND	WSW

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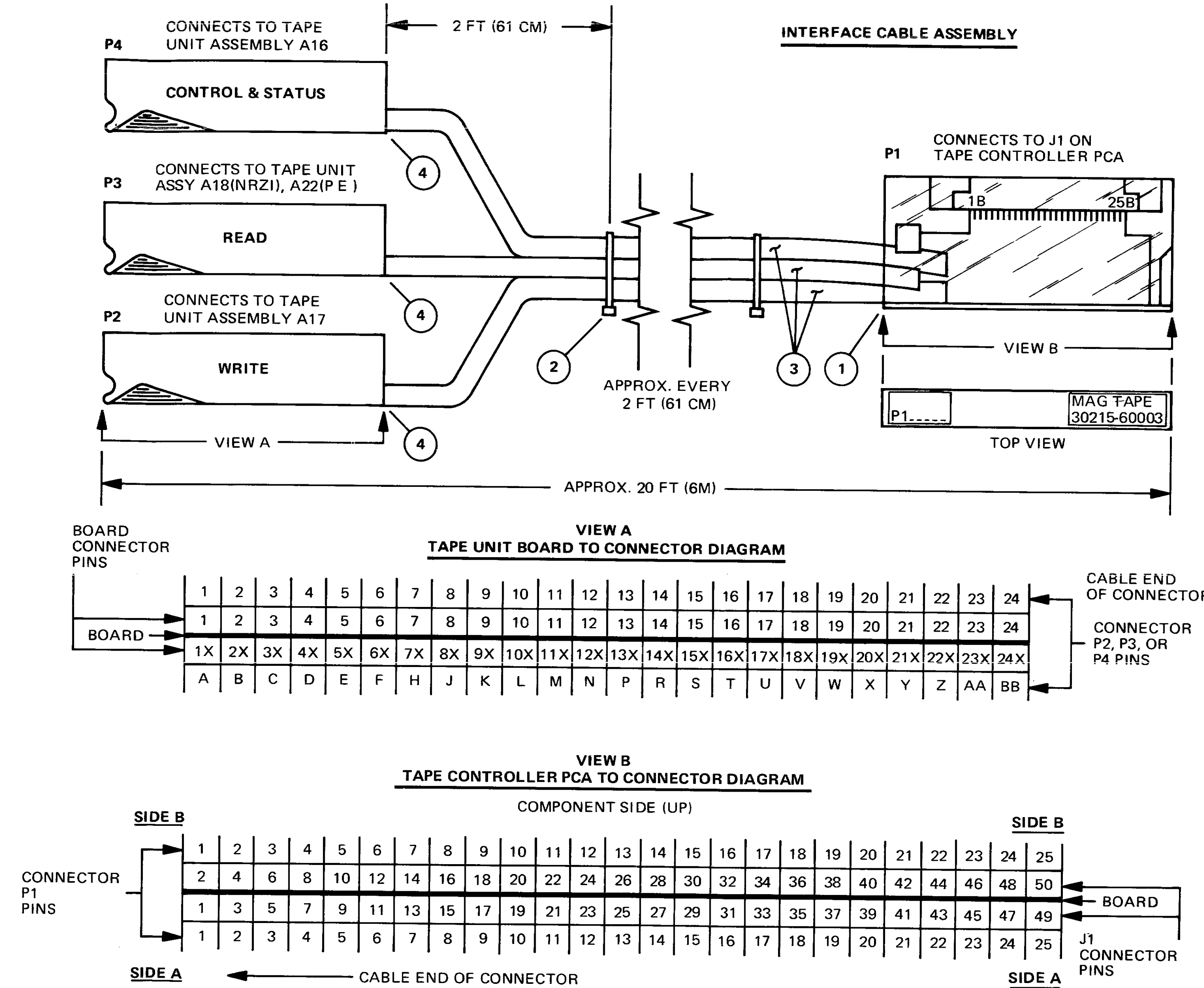


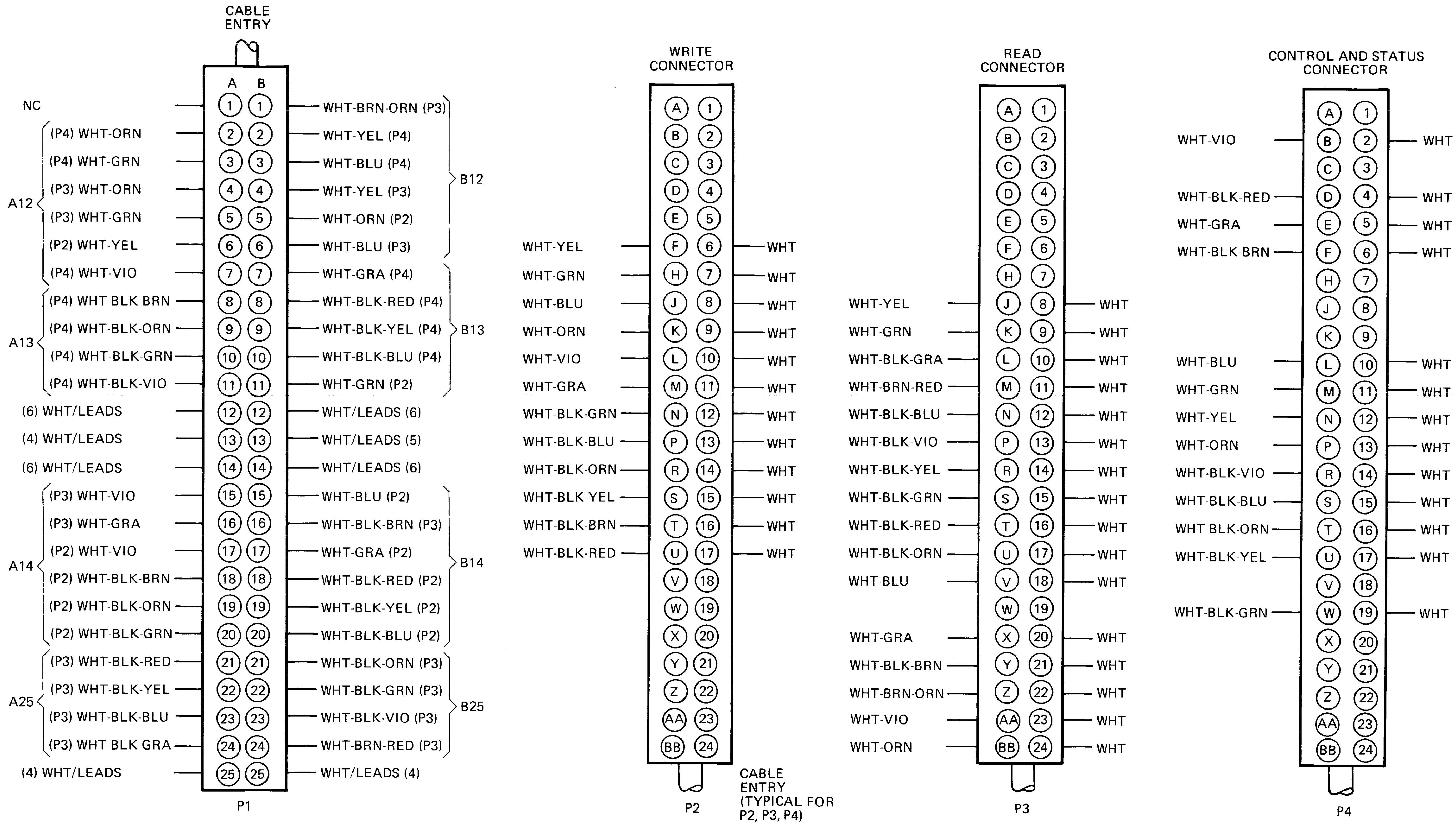
CABLE 30215-60003 PARTS

ITEM	QUANTITY	DESCRIPTION	PART NO.
1	1	50-PIN, P.C. KIT CONN. (6)	5060-8326
2	10	CABLE STRAP	1400-0249
3	60 FT (18M)	CABLE, 3-20 FT (6M) LENGTHS	8120-1863
4	3	48-PIN, P.C. CONNECTOR (7)	1251-2518

NOTES:

1. CABLE COMPOSED OF TWISTED PAIRS. PIN CONNECTIONS DESIGNATED: SIGNAL LEAD/COMMON LEAD.
2. SIGNALS NOT USED IN NINE TRACK NRZI UNITS.
3. ALL SIGNALS GO LOW TO INDICATE CONDITION NAMED.
4. 800 CPI IS NRZI, 1600 CPI IS PHASE ENCODED (PE) TAPE.
5. SIGNAL NOT USED IN NINE TRACK PE UNITS.
6. SEE CONNECTOR DISASSEMBLY DIAGRAM FOR DETAILS.
7. ONLY THE CONNECTOR PART NUMBER IS LISTED. SEE CONNECTOR DISASSEMBLY DIAGRAM FOR COMPLETE DETAILS.

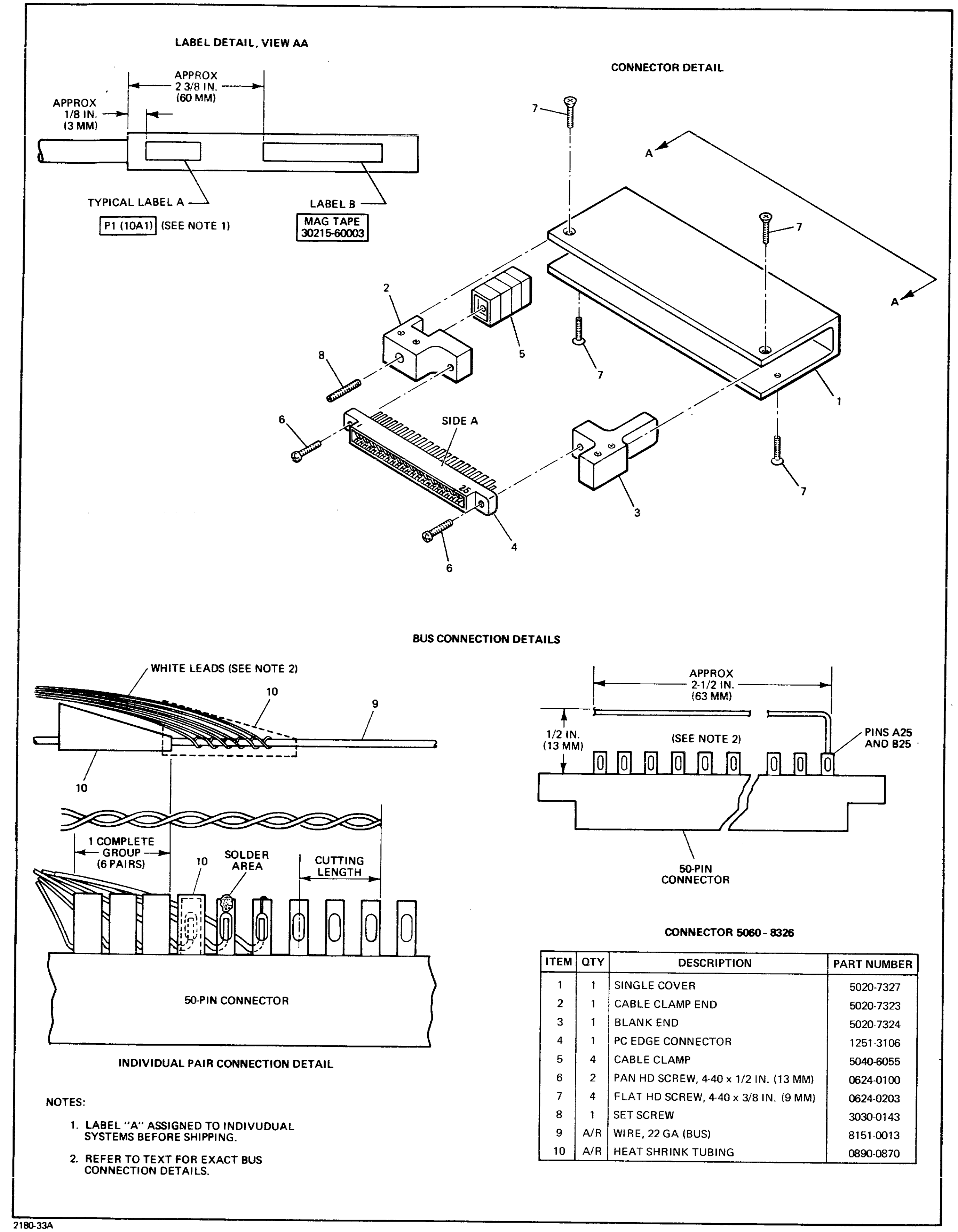
Figure 4-16. Interface Cable, Tape Controller-to-Tape Unit



NOTE: PIN NUMBERS INDICATED BY BRACES ARE COMMON LEAD CONNECTIONS TO PIN INDICATED (SEE TEXT).

2180-32A

Figure 4-17. Interface Cable Connector Wiring



NOTES:

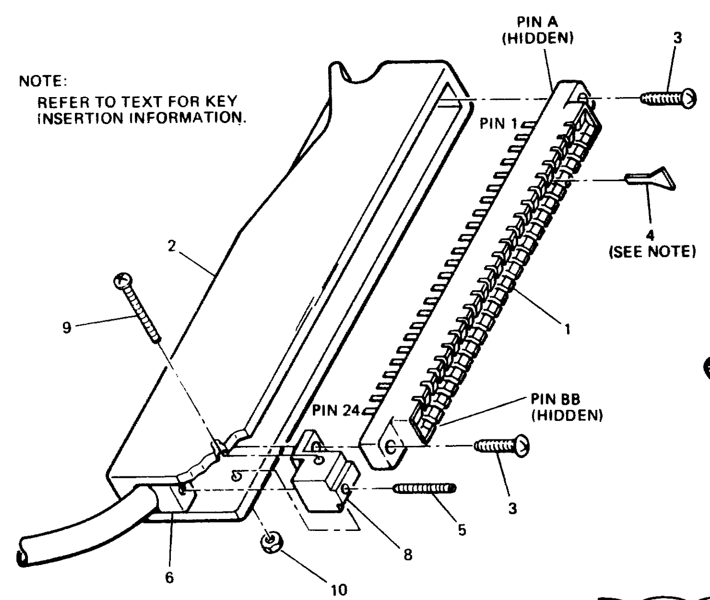
1. LABEL "A" ASSIGNED TO INDIVUDUAL SYSTEMS BEFORE SHIPPING.
2. REFER TO TEXT FOR EXACT BUS CONNECTION DETAILS.

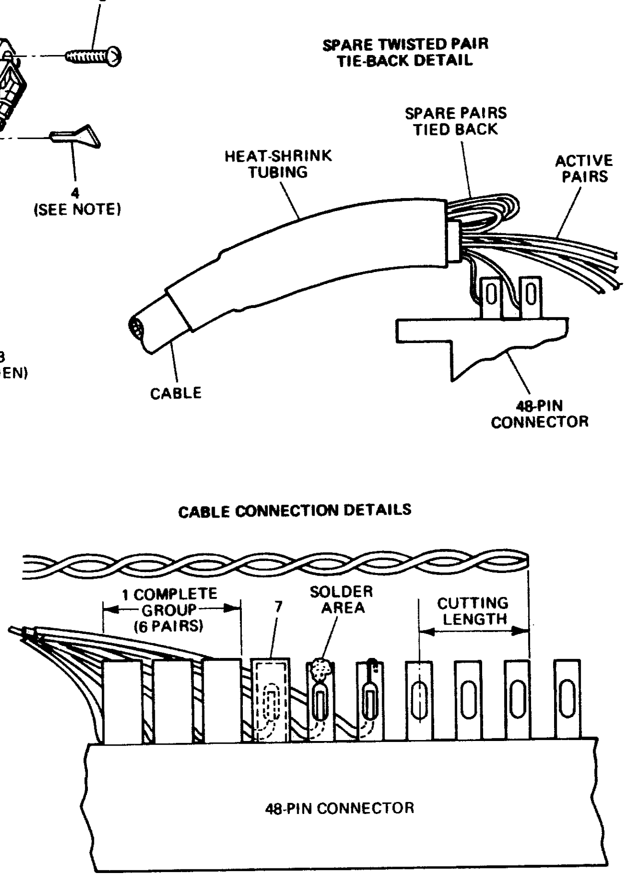
CONNECTOR 5060 - 8326

ITEM	QTY	DESCRIPTION	PART NUMBER
1	1	SINGLE COVER	5020-7327
2	1	CABLE CLAMP END	5020-7323
3	1	BLANK END	5020-7324
4	1	PC EDGE CONNECTOR	1251-3106
5	4	CABLE CLAMP	5040-6055
6	2	PAN HD SCREW, 4-40 x 1/2 IN. (13 MM)	0624-0100
7	4	FLAT HD SCREW, 4-40 x 3/8 IN. (9 MM)	0624-0203
8	1	SET SCREW	3030-0143
9	A/R	WIRE, 22 GA (BUS)	8151-0013
10	A/R	HEAT SHRINK TUBING	0890-0870

Figure 4-18. Interface Cable Connector P1, Disassembly and Repair Diagram

CONNECTOR DETAILS





ITEM	QTY	DESCRIPTION	PART NUMBER
1	1	48-PIN PC CONNECTOR	1251-2518
2	1	HOOD	5040-6071
3	2	TAPPING SCREW	0624-0098
4	1	PC CONNECTOR KEY	1251-1115
5	1	SET SCREW	3030-0143
6	1	CABLE CLAMP; SMALL	5040-6003
7	A/R	HEAT SHRINK TUBING	0890-0870
8	1	BLOCK, CONN., MTG.	5040-6072
9	1	SCREW, 4-40 X 0.562	2200-0091
10	1	HEX NUT, 4-40 X 3/16	2260-0002

2180-34A

Figure 4-19. Interface Cable Connectors P2 through P4 Disassembly and Repair Diagram

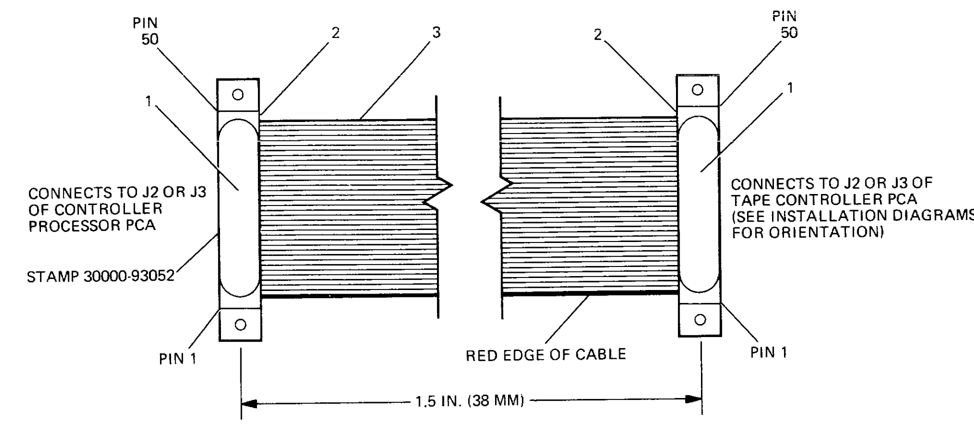
CONNECTOR PIN/SIGNAL LIST

CONTROLLER PROCESSOR-TO-TAPE CONTROLLER

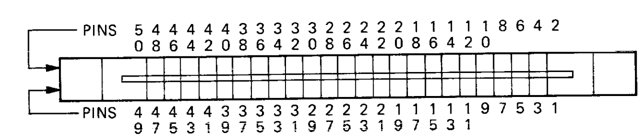
J2-TO-J2, ROM DATA			J3-TO-J3 CONTROL AND DATA		
J2[1] PIN	SIGNAL	MNEMONIC	J3[1] PIN	SIGNAL	MNEMONIC
1	COMMON	–	1	COMMON	–
2	COMMON	–	2	CLEAR	$\overline{CLR}$
3	ROM OUTPUT BIT 4	ROM 4	3[2]	CLOCK PHASE 0	$\overline{T0}$
4	BLANK	–	4[2]	CLOCK PHASE 3	$\overline{T3}$
5	ROM OUTPUT BIT 5	ROM 5	5[2]	CLOCK PHASE 2	$\overline{T2}$
6	BLANK	–	6	DESTINATION BIT 9	ROR 9
7	ROM OUTPUT BIT 6	ROM 6	7	UPPER OUTPUT STROBE	UOS
8	BLANK	–	8	INPUT STROBE	IS
9	ROM OUTPUT BIT 7	ROM 7	9	READ CLOCK	F10[3]
10	BLANK	–	10	LOWER OUTPUT STROBE	LOS
11	ROM OUTPUT BIT 8	ROM 8	11	DATA FF	F14[3]
12	BLANK	–	12	OUT XFER	F12[3]
13	ROM OUTPUT BIT 9	ROM 9	13	IN XFER	F16[3]
14	BLANK	–	14	INTERRUPT CONDITION	F15[3]
15	ROM OUTPUT BIT 10	ROM 10	15	DESTINATION BIT 8	ROR 8
16	BLANK	–	16	COMMAND ENABLE[4]	F17[3]
17	ROM OUTPUT BIT 11	ROM 11	17	(LSB) DESTINATION BIT 11	ROR 11
18	BLANK	–	18	DESTINATION BIT 7 (MSB)	ROR 7
19	ROM OUTPUT BIT 12	ROM 12	19[2]	WORD TYPE ONE	WT1
20	BLANK	–	20	DESTINATION BIT 10	ROR 10
21	ROM OUTPUT BIT 13	ROM 13	21	READY STATUS	F13[3]
22	BLANK	–	22	TAPE ERROR[4]	F11[3]
23	ROM OUTPUT BIT 14	ROM 14	23	READ/WRITE PARITY[5]	F06[3]
24	BLANK	–	24	END OF BLOCK FF[6]	F07[3]
25	ROM OUTPUT BIT 15	ROM 15	25	800/1600[7]	F04[3]
26	BLANK	–	26	WRITE STATUS	F05[3]
27	ROM OUTPUT BIT 16	ROM 16	27	FLAG 2	F02[3]
28	ROM OUTPUT BIT 0 (MSB)	ROM 0	28	LOAD POINT (BOT)	F03[3]
29	ROM OUTPUT BIT 17	ROM 17	29	FLAG 0	F00[3]
30	ROM OUTPUT BIT 1	ROM 1	30	FLAG 1	F01[3]
31	ROM OUTPUT BIT 18	ROM 18	31	MIO BUS BIT 12	$\overline{M12}$
32	ROM OUTPUT BIT 2	ROM 2	32[2]	EXTERNAL SELECT	EXT SEL
33	ROM OUTPUT BIT 19 (LSB)	ROM 19	33	MIO BUS BIT 13	$\overline{M13}$
34	ROM OUTPUT BIT 3	ROM 3	34	MIO BUS BIT 11	$\overline{M11}$
35	BLANK	–	35	MIO BUS BIT 14	$\overline{M14}$
36	ROM ENABLE	ENB	36	MIO BUS BIT 10	$\overline{M10}$
37[2]	ROM ADDRESS BIT 0 (MSB)	RAR 0	37	MIO BUS BIT 15 (LSB)	$\overline{M15}$
38[2]	ROM ADDRESS BIT 1	RAR 1	38	MIO BUS BIT 9	$\overline{M9}$
39	ROM ADDRESS BIT 2	RAR 2	39[2]	CLOCK PHASE 1	$\overline{T1}$
40	ROM ADDRESS BIT 3	RAR 3	40	MIO BUS BIT 8	$\overline{M8}$
41	ROM ADDRESS BIT 4	RAR 4	41	MIO BUS BIT 3	$\overline{M3}$
42	ROM ADDRESS BIT 5	RAR 5	42	MIO BUS BIT 4	$\overline{M4}$
43	ROM ADDRESS BIT 6	RAR 6	43	MIO BUS BIT 2	$\overline{M2}$
44	ROM ADDRESS BIT 7	RAR 7	44	MIO BUS BIT 5	$\overline{M5}$
45	ROM ADDRESS BIT 8	RAR 8	45	MIO BUS BIT 1	$\overline{M1}$
46	ROM ADDRESS BIT 9	RAR 9	46	MIO BUS BIT 6	$\overline{M6}$
47	ROM ADDRESS BIT 10	RAR 10	47	MIO BUS BIT 0	$\overline{M0}$
48	ROM ADDRESS BIT 11 (LSB)	RAR 11	48	MIO BUS BIT 7	$\overline{M8}$
49	COMMON	–	49[2]	FROM MAINT. PANEL	RUN
50	COMMON	–	50	COMMON	–

2180-30

CONNECTOR CABLE ASSEMBLY



CONNECTOR DIAGRAM



CABLE 30000-93052 PARTS

ITEM	QUANTITY	DESCRIPTION	PART NO.
1	2	PLASTIC HANDLE	5040-6059
2	2	50 PIN PC CONN. WITH MTG. EARS	1251-2755
3	1.5 IN. (38 MM)	CABLE FLAT RIBBON	8120-1595

NOTES:

1. CONNECTOR PIN NUMBERS ON PRINTED-CIRCUIT ASSEMBLIES MATCH CONNECTOR CABLE PIN NUMBERS AT BOTH ENDS.
2. INDICATES SIGNAL NOT USED IN SUBSYSTEM OPERATION.
3. LETTER "F" IN MNEMONIC INDICATES CONTROLLER PROCESSOR PCA FLAG INPUT.
4. REVERSE SENSE; SIGNAL GOES LOW TO INDICATE CONDITION.
5. REVERSE SENSE (LOW SIGNAL) FOR WRITE PARITY.
6. USED IN 1600 CPI ONLY.
7. LOW INDICATES 800 CPI.

Figure 4-20. Connector Cable, Tape Controller-to-Controller Processor ROM and Control and Data