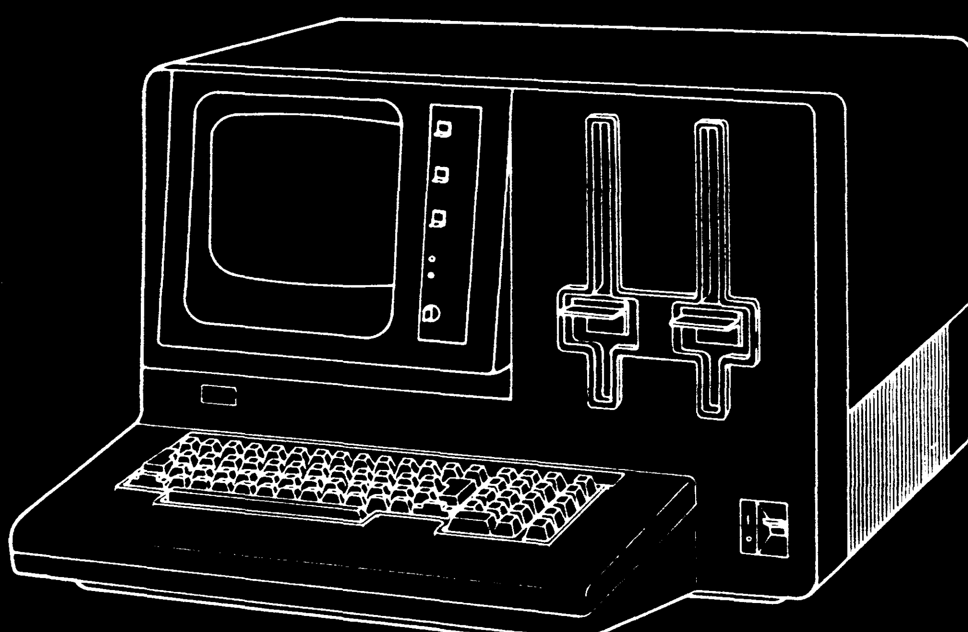
IBM

5120

IBM 5110 Model 3 Computer
Maintenance Information Manual



IBM 5110 Model 3 Computer
Maintenance Information Manual

SY34-0192-0

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Maintenance Information Manual

5120

Preface

This maintenance information manual, SY34-0192, is intended to be used for servicing the 5110 Model 3 Computer. Service personnel using this manual are assumed to have completed the 5110 Model 3 training course. The information within this manual applies to the 5110 Model 3 only.

To service the 5110, use this manual with the MAPs (maintenance analysis procedures), SY34-0194 and the 5120 System Logic Manual, SY34-0193. It is important that you begin your call with the Start MAP, which leads you to other MAPs and eventually to the failing FRU (field-replaceable unit).

First Edition (December 1979)

Use this publication only for the purpose stated in the Preface.

Changes are periodically made to the information herein; any such changes will be reported in subsequent revisions or Technical Newsletters.

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Contents

The information contained in this manual is to be used as reference material when you are diagnosing machine failures. The maintenance information manual consists of location drawings, maintenance procedures, diagnostic aids, and theory. An appendix provides information on installation, tools and test equipment, and numbering systems.

The format for page numbering is XXX-YYY.Z; XXX indicates the section number, YYY indicates the page number, and Z (although not normally used) is used to number newly added pages when it is not feasible to renumber previously numbered pages.

Referencing techniques used within the maintenance information manual are as follows:

MAP three-digit references
Page-to-page
On-page

MAP three-digit reference numbers are assigned to location drawings and maintenance procedures that are referred to in the MAPs and MDIs. For example, 237 refers to the diskette control card pin assignments. Page-to-page references within a section refer to the specific page containing the remaining information. For example, see page 2-16. Examples of on-page references include the following: this page, see below, etc, or for graphics with callouts, to the specific callout.

MAINTENANCE

This section consists of location drawings and maintenance procedures used in repairing or replacing field replaceable units. The location drawings are of two types: an overall 5110 reference drawing showing the major functional units, and detail location drawings showing the FRUs within a functional unit. Maintenance procedures consist of service checks, removals, replacements, and adjustment procedures. All procedures and drawings have three digit reference numbers assigned to them.

THEORY

The theory section contains descriptions of the 5110 Model 3 functional units and features. These descriptions are preceded by a system overview that gives you a general picture of the 5120 system overall operation and explains the relationship of each function or feature to the overall operation.

DIAGNOSTIC AIDS

Diagnostic program descriptions, procedures explaining how to use them, and the options available when the programs are in control are found in this section. MDI information for the printer, diskette unit, and communications functions are also located here. To further aid you in diagnosing machine failures, a list of halt codes and error conditions is included in this section. An intermittent failures procedure is provided to help you determine the cause of intermittent failures.

APPENDIXES

Several appendixes are provided for your use in servicing the 5110. One appendix contains the installation procedures for the 5110. Another contains the tools and test equipment. The numbering systems used on the 5110 are also covered in an appendix. A Glossary containing definitions of uncommon terms and abbreviations used within the MIM and MAPs is also in an appendix.

INDEX

The index is a detailed listing of all topics discussed within the maintenance information manual.

Related Publications

The operating procedures for the 5110 Model 3 are found in the following manuals:

IBM 5120 Computing System Operator's Guide, GA32-0132
IBM 5110 System BASIC Introduction, SA21-9306
IBM 5110 System APL Introduction, SA21-9301

Information about the attachable features is located in the following manuals:

IBM 5103 Printer Maintenance Information Manual, SY31-0414
IBM 5114 Diskette Unit Maintenance Information Manual, SY31-0551
IBM 5110 Serial I/O Adapter Feature Maintenance Information Manual, SY31-0582
IBM 5110 Asynchronous Communications Feature Maintenance Information Manual, SY31-0557
IBM 5110 Binary Synchronous Communications Feature Maintenance Information Manual, SY31-0558

The logic diagrams for the 5110 Model 3 Computer, 5114 Diskette Unit, 5103 Printer, and other attachable features are located in the *IBM 5120 System Logic Manual,* SY34-0193.

CE SAFETY PRACTICES

All Customer Engineers are expected to take every safety precaution possible and observe the following safety practices while maintaining IBM equipment:

1. You should not work alone under hazardous conditions or around equipment with dangerous voltage. Always advise your manager if you MUST work alone.
2. Remove all power, ac and dc, when removing or assembling major components, working in immediate areas of power supplies, performing mechanical inspection of power supplies, or installing changes in machine circuitry.
3. After turning off wall box switch, lock it in the Off position or tag it with a "Do Not Operate" tag, Form 229-1266. Pull power supply cord whenever possible.
4. When it is absolutely necessary to work on equipment having exposed operating mechanical parts or exposed live electrical circuitry anywhere in the machine, observe the following precautions:
   a. Another person familiar with power off controls must be in immediate vicinity.
   b. Do not wear rings, wrist watches, chains, bracelets, or metal cuff links.
   c. Use only insulated pliers and screwdrivers.
   d. Keep one hand in pocket.
   e. When using test instruments, be certain that controls are set correctly and that insulated probes of proper capacity are used.
   f. Avoid contacting ground potential (metal floor strips, machine frames, etc.). Use suitable rubber mats, purchased locally if necessary.
5. Wear safety glasses when:
   a. Using a hammer to drive pins, riveting, staking, etc.
   b. Power or hand drilling, reaming, grinding, etc.
   c. Using spring hooks, attaching springs.
   d. Soldering, wire cutting, removing steel bands.
   e. Cleaning parts with solvents, sprays, cleaners, chemicals, etc.
   f. Performing any other work that may be hazardous to your eyes. REMEMBER – THEY ARE YOUR EYES.
6. Follow special safety instructions when performing specialized tasks, such as handling cathode ray tubes and extremely high voltages. These instructions are outlined in CEMs and the safety portion of the maintenance manuals.
7. Do not use solvents, chemicals, greases, or oils that have not been approved by IBM.
8. Avoid using tools or test equipment that have not been approved by IBM.
9. Replace worn or broken tools and test equipment.
10. Lift by standing or pushing up with stronger leg muscles—this takes strain off back muscles. Do not lift any equipment or parts weighing over 60 pounds.
11. After maintenance, restore all safety devices, such as guards, shields, signs, and grounding wires.
12. Each Customer Engineer is responsible to be certain that no action on his part renders products unsafe or exposes customer personnel to hazards.
13. Place removed machine covers in a safe out-of-the-way place where no one can trip over them.
14. Ensure that all machine covers are in place before returning machine to customer.
15. Always place CE tool kit away from walk areas, where no one can trip over it; for example, under desk or table.
16. Avoid touching moving mechanical parts when lubricating, checking for play, etc.
17. When using stroboscope, do not touch ANYTHING – it may be moving.
18. Avoid wearing loose clothing that may be caught in machinery. Shirt sleeves must be left buttoned or rolled above the elbow.
19. Ties must be tucked in shirt or have a tie clasp (preferably nonconductive) approximately 3 inches from end. Tie chains are not recommended.
20. Before starting equipment, make certain fellow CEs and customer personnel are not in a hazardous position.
21. Maintain good housekeeping in area of machine while performing and after completing maintenance.

Knowing safety rules is not enough.
An unsafe act will inevitably lead to an accident.
Use good judgment—eliminate unsafe acts.

ARTIFICIAL RESPIRATION

General Considerations

1. Start Immediately – Seconds Count
   Do not move victim unless absolutely necessary to remove from danger. Do not wait or look for help or stop to loosen clothing, warm the victim, or apply stimulants.
2. Check Mouth for Obstructions
   Remove foreign objects. Pull tongue forward.
3. Loosen Clothing – Keep Victim Warm
   Take care of these items after victim is breathing by himself or when help is available.
4. Remain in Position
   After victim revives, be ready to resume respiration if necessary.
5. Call a Doctor
   Have someone summon medical aid.
6. Don't Give Up
   Continue without interruption until victim is breathing without help or is certainly dead.

Rescue Breathing for Adults

1. Place victim on his back immediately.
2. Clear throat of water, food, or foreign matter.
3. Tilt head back to open air passage.
4. Lift jaw up to keep tongue out of air passage.
5. Pinch nostrils to prevent air leakage when you blow.
6. Blow until you see chest rise.
7. Remove your lips and allow lungs to empty.
8. Listen for snoring and gurglings – signs of throat obstruction.
9. Repeat mouth to mouth breathing 10-20 times a minute. Continue rescue breathing until victim breathes for himself.

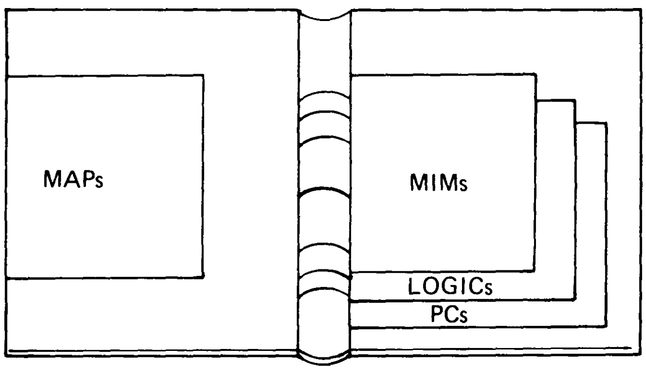
Thumb and finger positions

Final mouth-to-mouth position

Contents

IBM 5120 Computing System Maintenance Library

The 5120 Computing System maintenance library (MLM) consists of maintenance analysis procedures (MAPs), maintenance information manuals (MIMs), system logic manual, parts catalogs (PCs), and diagnostic tools. These publications and diagnostic tools are all contained in a single binder.

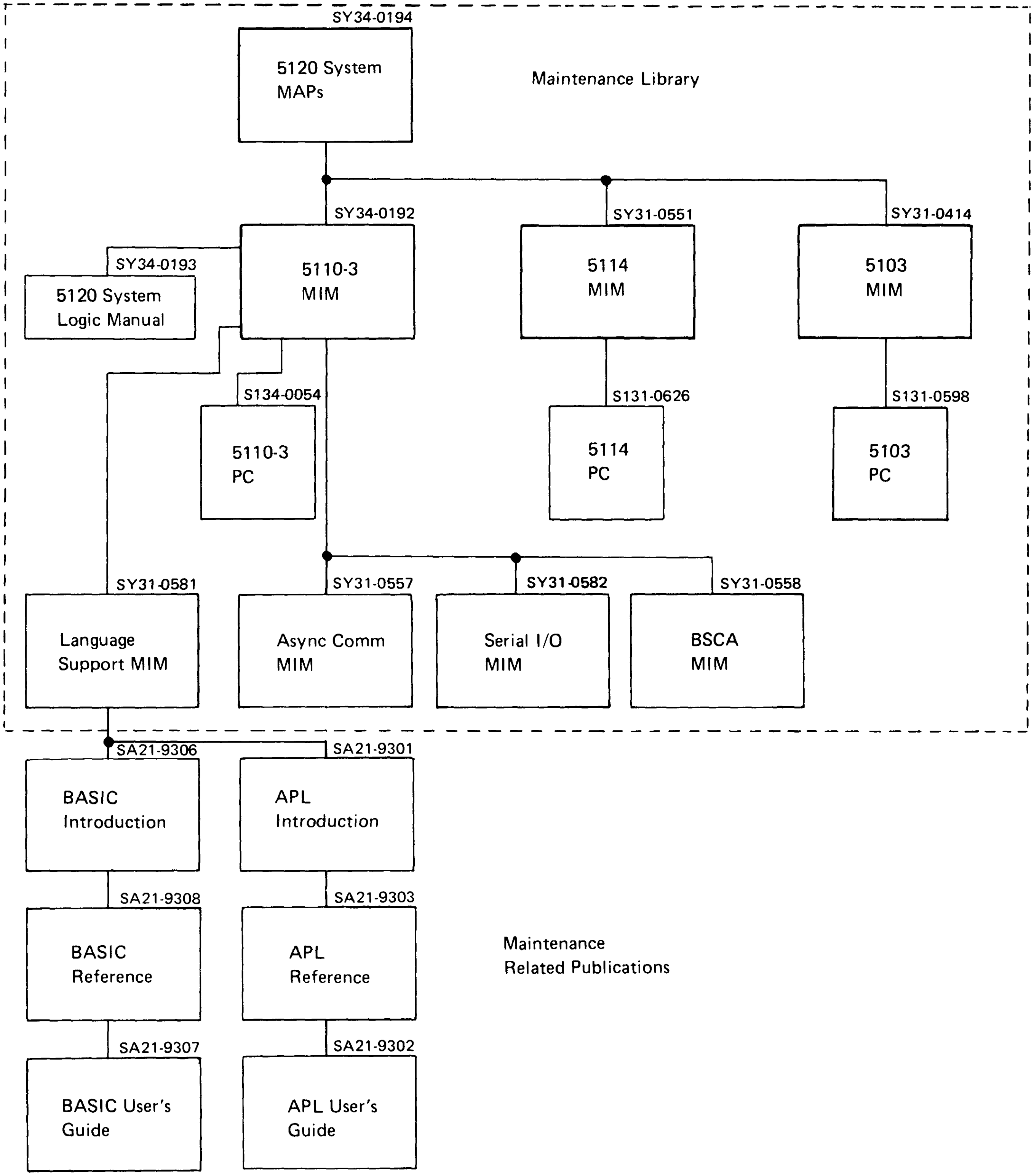


The diagnostic tools contained in the 5120 Computing System MLM are:

- Diagnostic diskette
- Logic board jumpers
- Wrap connectors

The following chart shows the relationship between the publications contained in the maintenance library and some other related publications. The related publications contain the operating procedures and language information *(APL—A Programming Language, BASIC—Beginners All-Purpose Symbolic Instruction Code)* for the 5110.

IBM 5120 COMPUTING SYSTEM PUBLICATIONS



When necessary, MAPs and MIMs are updated to provide the latest information for diagnosing 5120 system problems. Updates to these documents are made through technical newsletters (TNLs) or periodic major revisions. It is important that the MAPs and MIMs be at compatible levels. Never mix publications from system to system; always use the publications shipped with the system.

The contents of the entire 5120 system maintenance library are shown in the chart on the following page. Notice that the chart lists the topics alphabetically. The numbers or letters to the right of the topics indicate the section or appendix containing the information. Look at the column heading at the top of the chart to determine the publication that contains the information.

MAINTENANCE LIBRARY CONTENTS

Publication/Section Number

	MAPs SY34-0194	5110-3 Computer SY34-0192	5114 SY31-0551	5103 Printer SY31-0414	Asynchronous Comm SY31-0557	Binary Synchronous SY31-0558	Serial I/O SY31-0582	Language Support SY31-0581	5120 System Logic SY34-0193
Circuits									X
Communications									
Asynchronous					X				
Binary Synchronous						X			
Character Code Chart								A	
Diagnostic Aids		4			X	X	X		
Glossary		D	C	D	X	X	X		
Installation Procedures		A	A	A					
Logic Card Part Numbers And Jumpering	050								
Maintenance		2	2	1					
MAPs									
Bring Up	400								
Cable Checkout	210								
Communications	830								
Internal Diskette Unit	310								
5114 Diskette Unit	880								
Display	500								
Keyboard	600								
Machine Checkout	900								
Power	700								
Process Check	420								
Serial I/O	830								
Start	200								
TV Monitor	510								
5103 Printer	810								
Numbering Systems		C							
Print Character Information				B					
Preventive Maintenance				C					
Theory		3	3	3	X	X	X		
Tools and Test		B							
Using the Maintenance Library	100	1	1						

MAPs

The MAPs guide you through the service call using step-by-step procedures that require you to follow trace lines when responding to questions or when leaving or entering a page. The MAPs use a logical approach for isolating the possible causes of machine problems and point you to that part of the 5120 system that requires adjustment or replacement.

Two types of MAPs are used in the 5120 system maintenance library. First, there are the hard-copy (printed) MAPs within the MLM binder. These MAPs are contained in a separate removable binder. The second type of MAP is the MDI (MAP diagnostic integration). These MAPs are located on the diagnostic diskette and are shown on the display screen. The system automatically pages through the MAPs when you respond to the questions on the display.

Using the Maint Library

MAP ORGANIZATION

START

- Start MAP 200
- Record the Error Code Displayed
- For Intermittent Failures → Diagnostic Aid Section; System Function Test
- Indicator Lights—Use MAP 200
- Bring Up Diagnostic Failures → MAP 400—Bring Up
- Process Checks → MAP 420—Process Check
- Display Failures → MAP 500—Display
- Other Reported Failures → or MAP 500—Display
- No Symptoms → MAP 900—Checkout Procedures

Other Reported Failures (or):

- MAP 310—Internal Diskette Drives → MDI 871
- MAP 700—Power
- MAP 510—TV Monitor
- MAP 600—Keyboard
- MAP 810—5103 → MDI 800, 801, 802, 803, 804, 805
- MAP 830—Communications, SIO → MDI 821—BSCA; MDI 820—Asynchronous Communications—Serial I/O; MDI 890—Communications Routines
- MAP 880—5114 Diskette Drive → MDI 881 through 888
- MAP 900—Checkout Procedures

Begin each call with Start MAP 200. This MAP ensures that the system is operating sufficiently to use other MAPs or MDIs.

Start MAP 200 asks you to record the status bytes, error logs, and history logs because this information is lost on power down or RESTART. The Start MAP either fixes or directs you to a MAP that tells you how to fix any of the following problems:

- Indicator lights
- Bring up failures
- Process checks
- Display failures

For other failures, the Start MAP directs you to the correct MAP through an error code. If you are certain the failure is not covered in the Start MAP, you can go directly to the other MAPs as indicated by the OR in the chart.

All MDIs have a MAP as an entry. For example, MAP 810-5103 is an entry for MDI 800 through 805. These MAPs provide the setup instructions for running the MDIs.

The MDIs are a combination of MAPs and diagnostics. The MDIs call in and run the appropriate diagnostics and answer most of the MAP questions automatically.

The procedures for diagnosing intermittent failures contain a more detailed description of what part of the system each MDI checks.

USING THE MAPS

When using the MAPs, you must:

READ CAREFULLY. The MAPs can help you find the problem only if you follow instructions and answer questions accurately.

FOLLOW THE SEQUENCE. Proceed step-by-step at all times. At times, the MAP instructions might seem irrelevant. However, they can be important in determining the correct error indications.

FOLLOW INSTRUCTIONS. Instructions must be carried out exactly in the order given. Questions are based on instructions immediately preceding the questions. Do not change the conditions established by the instructions before answering the questions. Do not press the RESTART switch until you are told to do so in the MAPs.

When you are asked to prove a line in the MAPs, the line name and its active level are given. For example:

- Probe H2-G06 (– machine check).

The – (minus) in front of machine check indicates that this line is active at a down level.

MAP EXAMPLE

MAP name and number

PROCESS CHECK MAP 0420

Entry and exit points—show all entry and exit points to and from this MAP.

PAGE 1 OF 75

ENTRY POINTS

FROM	ENTER THIS MAP		
MAP NUMBER	ENTRY POINT	PAGE NUMBER	STEP NUMBER
0200	A	1	001
0300	A	1	001
0600	A	1	001
0810	A	1	001
0830	A	1	001
0900	A	1	001
830C	A	1	001

EXIT POINTS

EXIT THIS MAP		TO	
PAGE NUMBER	STEP NUMBER	MAP NUMBER	ENTRY POINT
5	044	0400	A
18	218	0400	A
75	828	0500	A

001 — Step number

(Entry Point A) — Entry point—indicates a possible starting point in this MAP. It is usually referenced from a step within a MAP.

Is the PROCESS CHECK light on?

Y N — Y=yes, N=no

002

Can you create the PROCESS CHECK?

Y N

003

The MAPs depend on having the PROCESS CHECK on the machine or being able to create the PROCESS CHECK. Gather and record all available information pertaining to the PROCESS CHECK. Advise the customer that if the PROCESS CHECK appears again,to leave the machine in the failing condition until you arrive.

004

Is the PROCESS CHECK intermittent?

Y N

Off-page reference—identifies the page and trace on which this MAP leg continues. The 2 indicates that this leg continues on page 2. The C indicates that this leg continues at trace C.

2 2 2
A B C

MAP EXAMPLE (continued)

A B C
1 1 1

PROCESS CHECK MAP

On-page reference—indicates the trace and page from which this MAP leg came. The 1 indicates that this leg came from page 1. The C indicates that this leg came from trace C.

005
Create the PROCESS CHECK.

Did the PROCESS CHECK come on as a result of pressing RESTART or powering on the 5110?
Y N

006
We will assume that the PROCESS CHECK comes on as a result of running a job.
Go to Step 010,
Entry Point H.

Internal exit point—indicates the page, step, and entry point to go to within this MAP.

007
We will use the RESTART condition to create the PROCESS CHECK.
Go to Map 0400, Entry Point A.

External exit point—indicates the MAP and entry point to go to.

008
Create the PROCESS CHECK
Go to the INTERMITTENT FAILURE CHART in the 5110 SERVICE AIDS.

Instruction—establishes conditions for answering the next question.

009
Is the PROCESS CHECK intermittent?
Y N

Question—answer either yes or no. Continue from your answer to the next question or instruction.

010
(Entry Point H)

Bad RESTART switch.
Check/replace Z3 (display and control panel) cable (see MAP 0210 and MIM 210, 241).

Action—possible fixes for the failure. Replace, repair, or adjust in the order given. (Check/replace means to check first, then replace if defective.)

Is the display blank or dark?
Y N

011
Are there any devices attached to the 5110 I/O interface port? (see MIM 271)
Y N

Reference number—refers to a location graphic, maintenance procedure, chart, or other pertinent information in the maintenance section.

7 7 1
5 5 8
D E F G

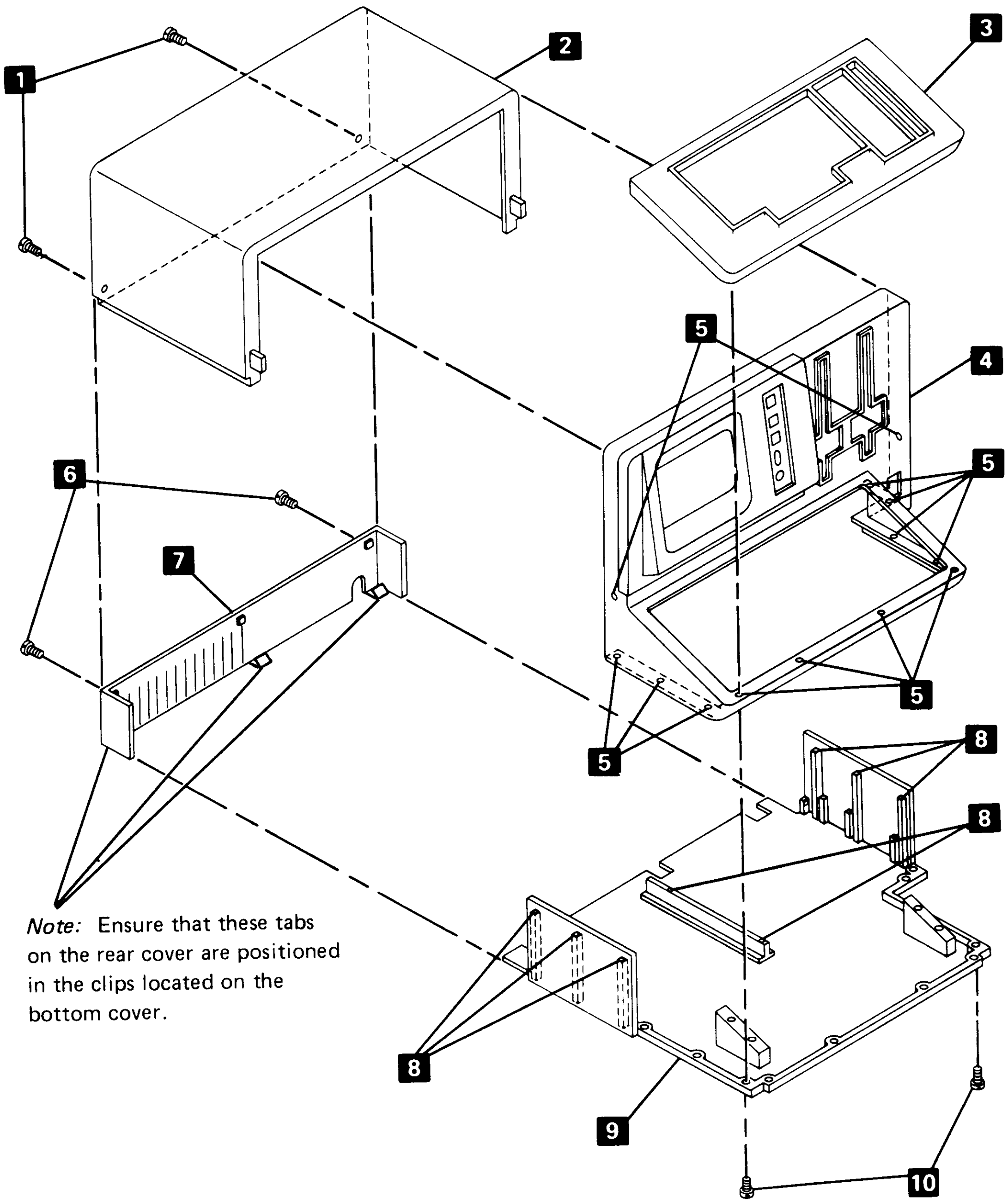
On-page reference—indicates the trace on this page from which this leg of the MAP continues.

Maintenance

Locations

200 COVERS

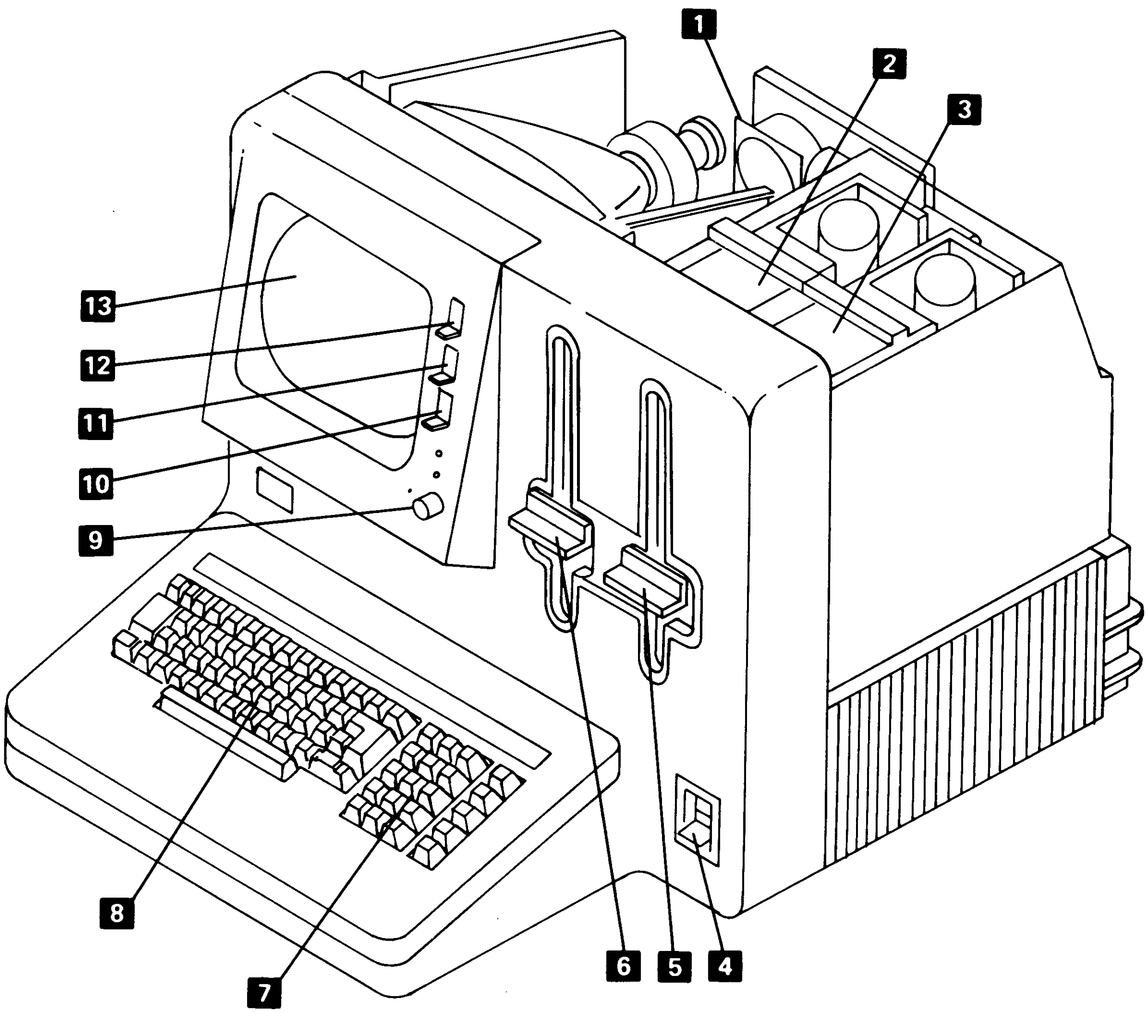
1 Top Cover Screws
2 Top Cover
3 Keyboard Cover
4 Front Cover
5 Front Cover Screws
6 Rear Cover Screws
7 Rear Cover
8 Bottom Cover Screws
9 Bottom Cover
10 Keyboard Cover Screws



Note: Ensure that these tabs on the rear cover are positioned in the clips located on the bottom cover.

201 5110 MODEL X3X (Front View)

1 Cooling Fan
2 Diskette Drive 1
3 Diskette Drive 2
4 Power On/Off Switch
5 Drive 2 Diskette Latch
6 Drive 1 Diskette Latch
7 Numeric Keyboard
8 Alphameric Keyboard
9 Display Brightness Control
10 BASIC/APL Switch
11 Restart Switch
12 Display Registers/Normal Switch
13 Display

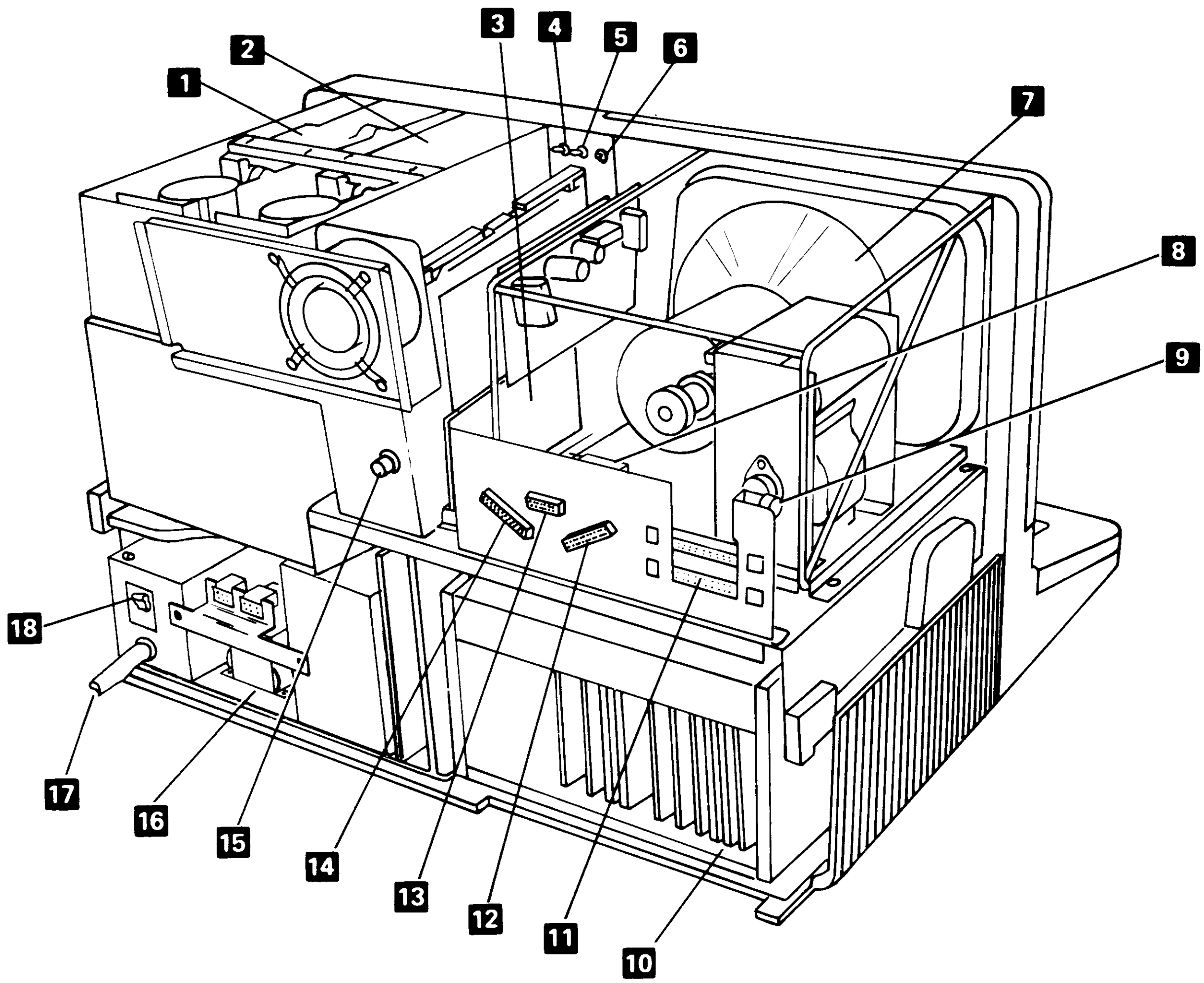


201 5110 MODEL X3X (Rear View)

- **1** Diskette Drive 2
- **2** Diskette Drive 1
- **3** Diskette Adapter Board B1
- **4** CE Reverse Display Switch
- **5** CE Run Switch
- **6** CE Step Switch
- **7** Display
- **8** Resistor RL1
- **9** Fuse F1
- **10** Processor Logic Board A1
- **11** Communications Connectors B1, B2
- **12** Signal Connector A3
- **13** Power Connector A1
- **14** Signal Connector A2

(12, 13, 14: A terminator must be installed if there are no I/O devices attached to the 5110 Model 3 Computer.)

- **15** External Video Connector
- **16** Power Supply
- **17** AC Line Cord
- **18** Circuit Breaker CB1



Maintenance

1 Audible Alarm

2 CE Switch Panel

3 Display PC Board

4 Logic Fan

5 Cross Connectors (X2-top, X4-bottom)

6 Logic Box (A1 Board)

7 I/O Cable Driver Card-A1A2

8 Power Supply PC Card A2

9 Power Supply

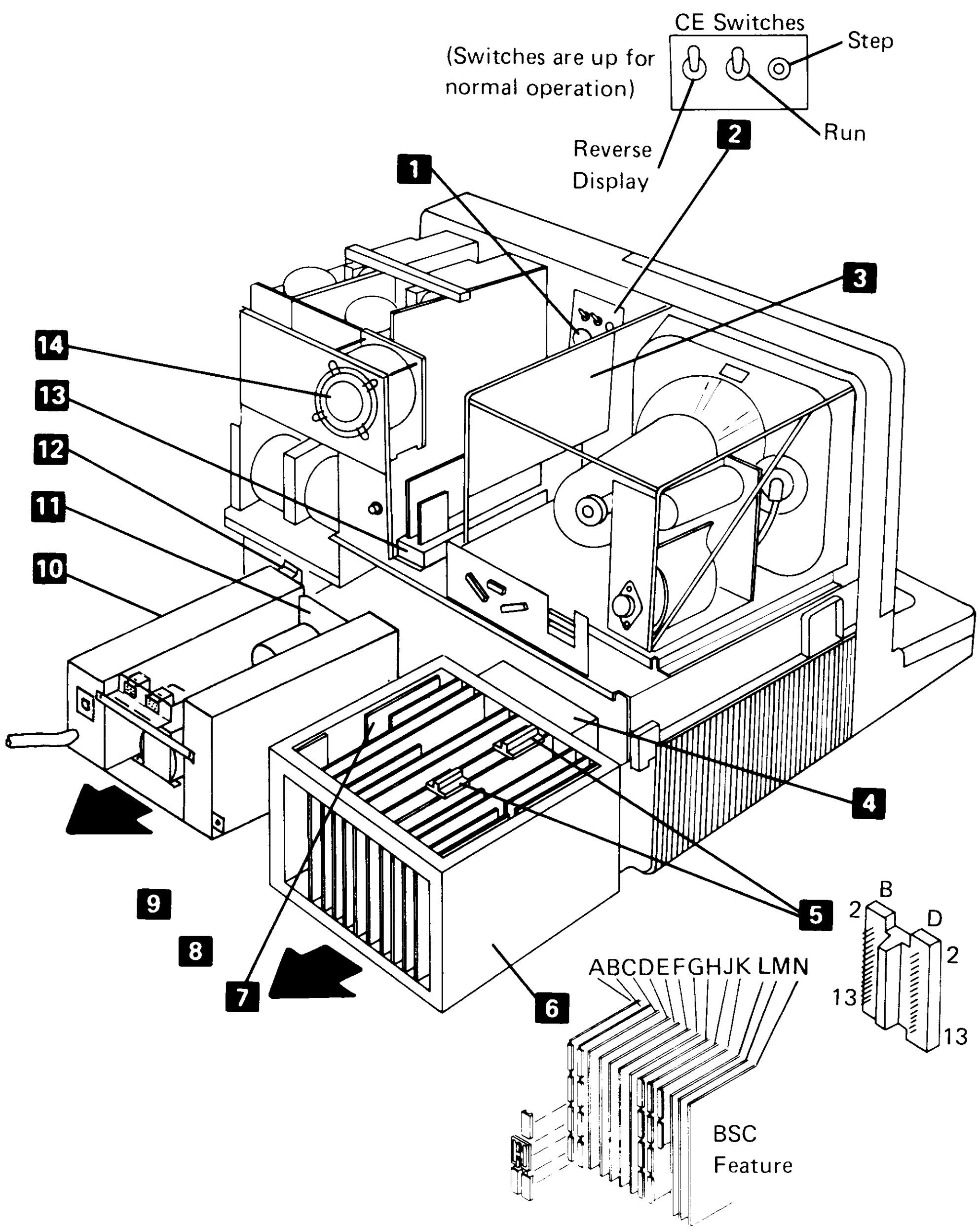
10 AC Box

11 Power Supply PC Card A1

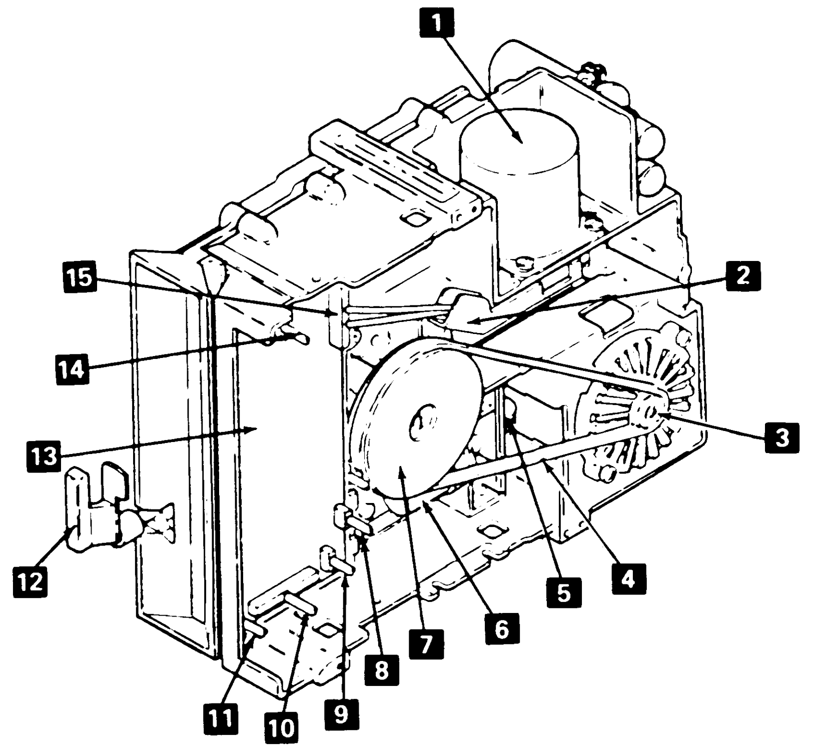
12 Power On/Off Switch

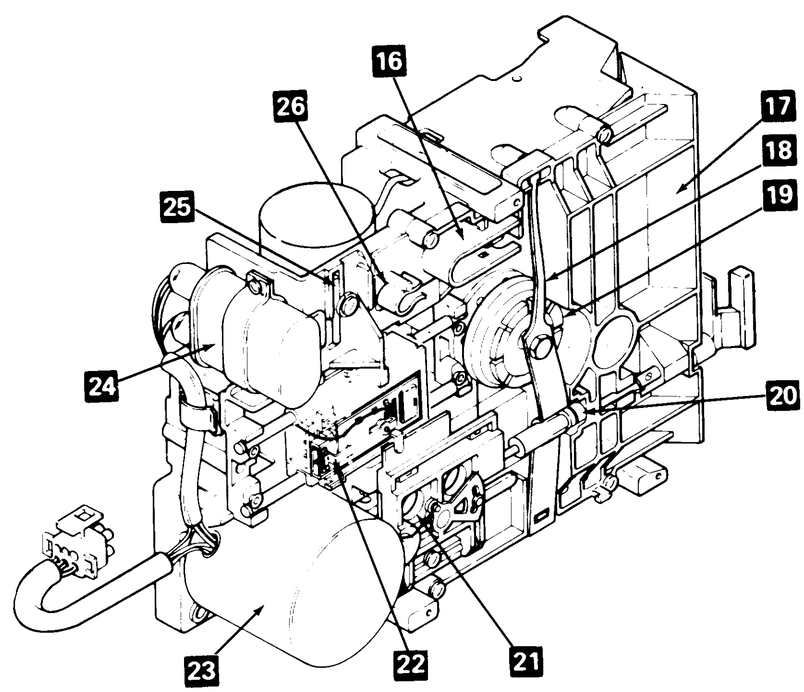
13 Diskette Adapter Board B1

14 Top Fan

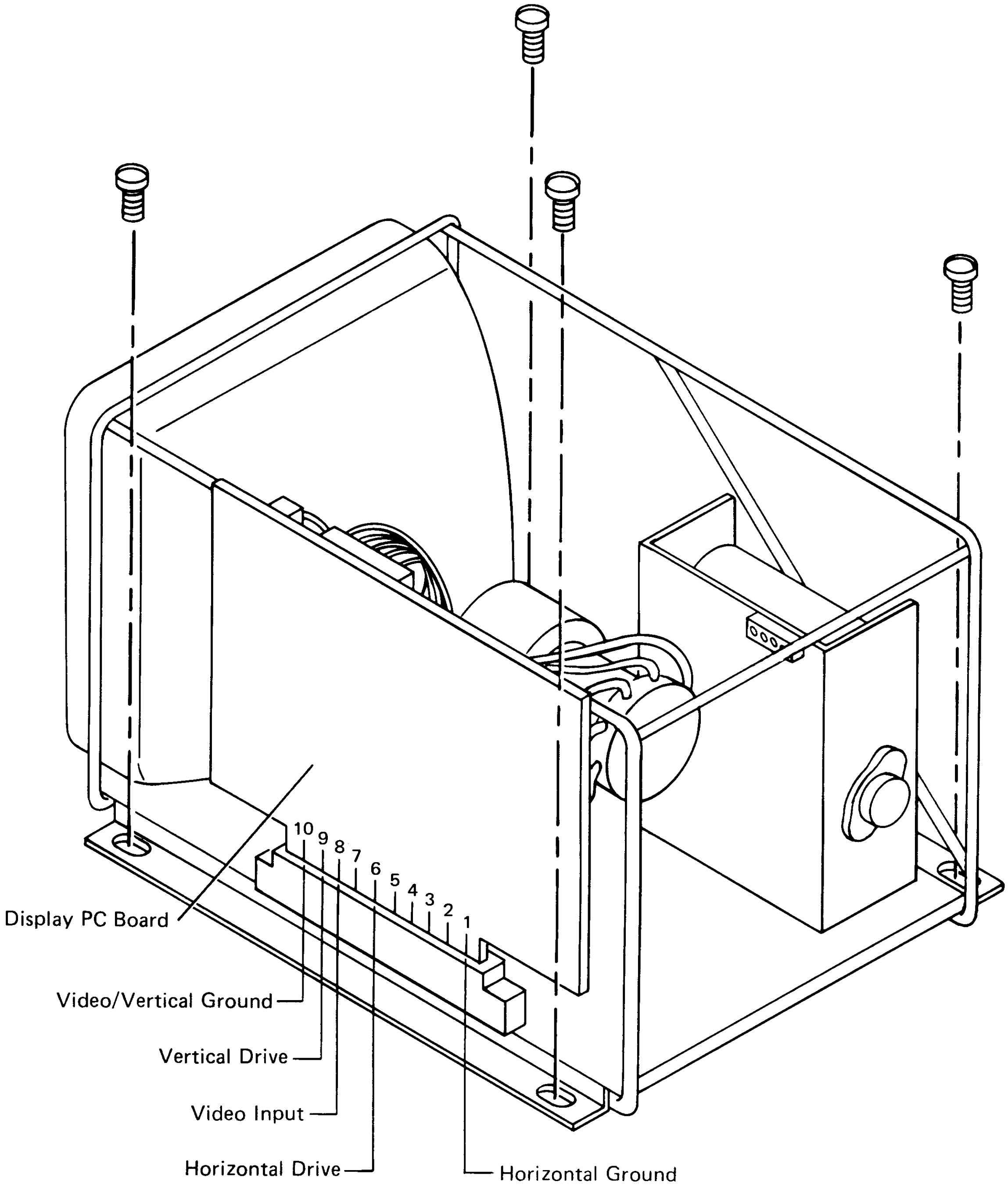


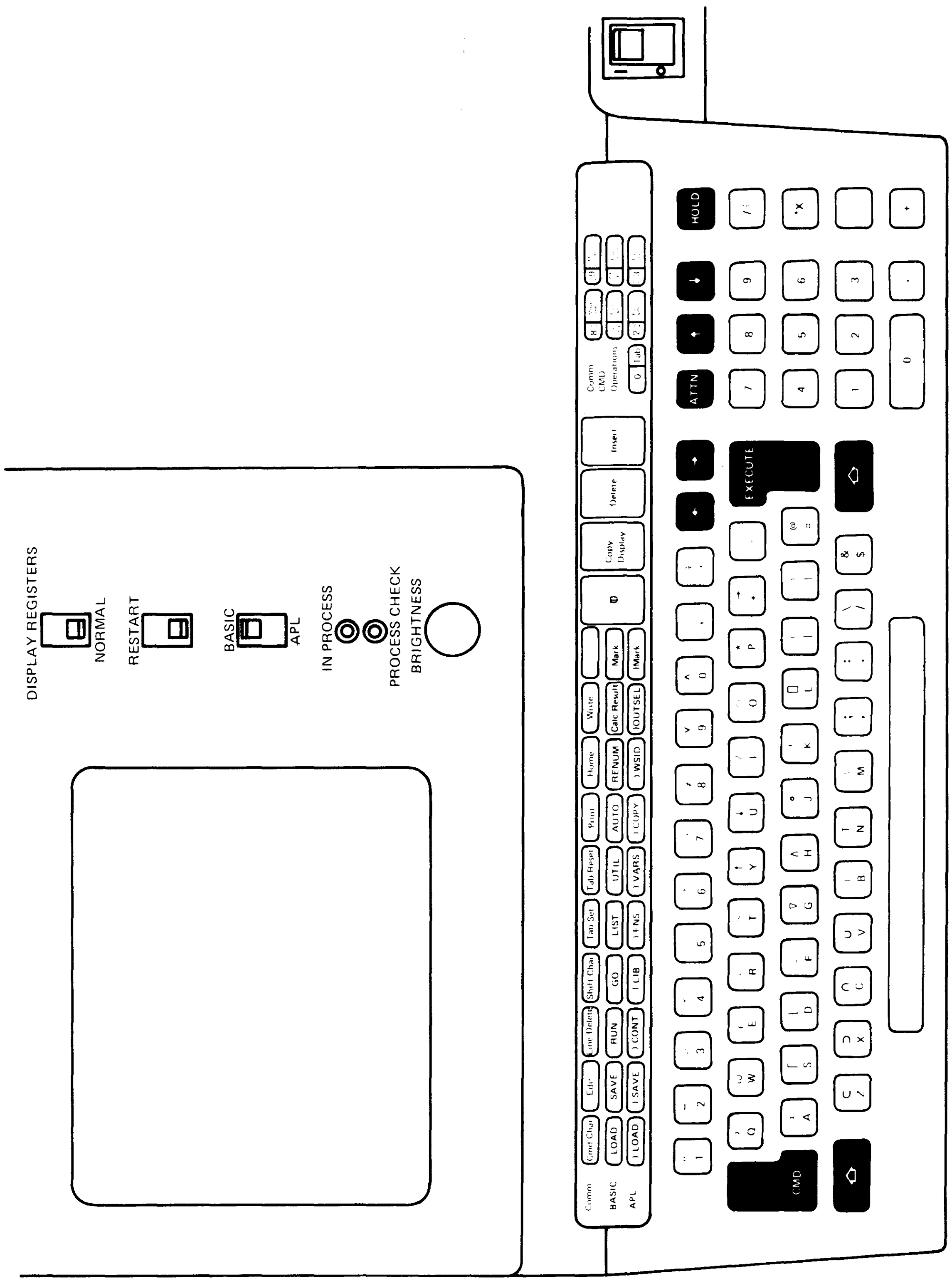
203 DISKETTE UNIT



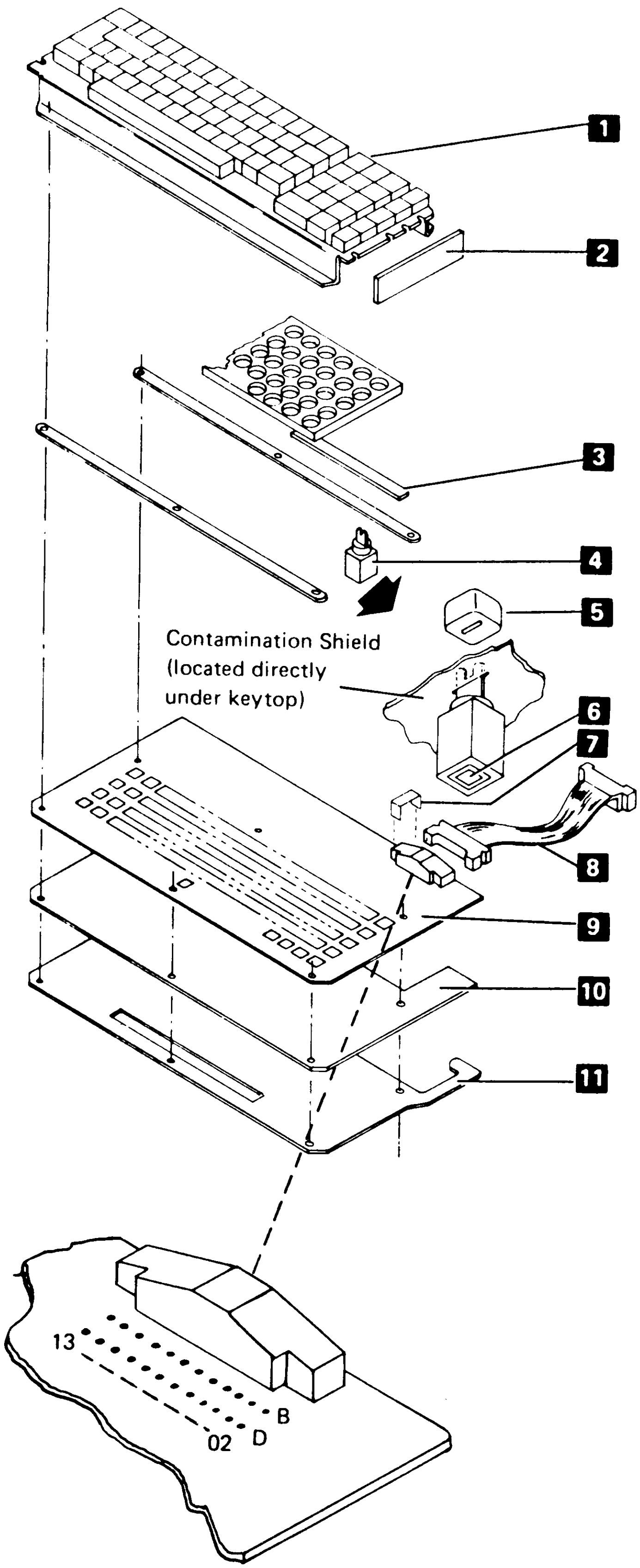


1. Stepper Motor
2. Cable Guide
3. AC Drive Pulley
4. AC Drive Belt
5. Solenoid Idler
6. Head Load Solenoid
7. Spindle Pulley
8. Solenoid Cable
9. LED Cable
10. Attachment Cable
11. PTX Cable
12. Diskette Latch
13. Drive Control Card
14. Stepper Motor Cable
15. Head Cable
16. Carriage Pressure Spring (Tool)
17. Diskette Guide
18. Collet Flat Spring
19. Collet
20. Pressure Roll
21. Head Load Bail
22. Head/Carriage Assembly
23. AC Drive Motor
24. AC Capacitor
25. Timing Pin (Tool)
26. Retaining Clip (Tool)


10
9
8
7
6
5
4
3
2
1
Display PC Board
Video/Vertical Ground
Vertical Drive
Video Input
Horizontal Drive
Horizontal Ground


DISPLAY REGISTERS
NORMAL
RESTART
BASIC
APL
IN PROCESS
PROCESS CHECK
BRIGHTNESS
HOLD
ATTN
EXECUTE
CMD
Insert
Delete
Copy Display
LOAD
SAVE
RUN
GO
LIST
UTIL
AUTO
RENUM
Calc Result
Mark
BASIC
APL

206 KEYBOARD



- **1** All Keys Assembly
- **2** Foam End Seals
- **3** Foam PC Board Seals
- **4** Key Module
- **5** Keytop
- **6** Flyplate
- **7** Cable Retainer
- **8** Signal Cable (see 255 for pin assignments)
- **9** PC Board
- **10** Insulator
- **11** Base Plate

207 AC BOX

1 Power On/Off Switch

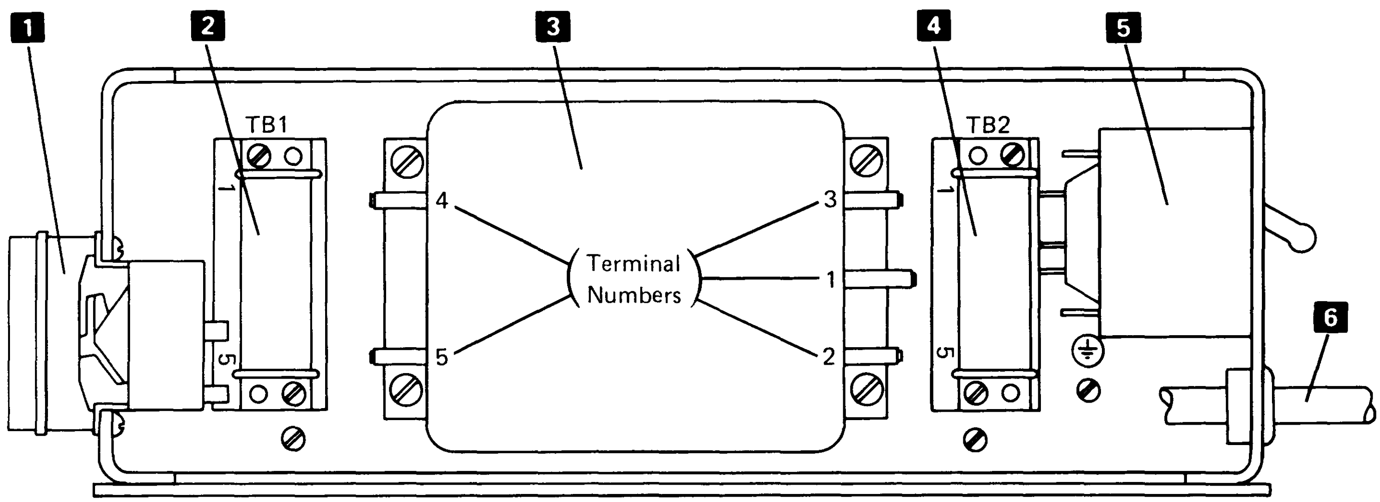
2 Terminal Block TB1

3 Line Filter

4 Terminal Block TB2

5 Circuit Breaker CB1

6 AC Line Cord



Right Side View of Power Supply

Maintenance

1 Power On/Off Switch

2 AC Box

3 PC Board A1

4 Resonant Capacitor C4

5 PC Board A2

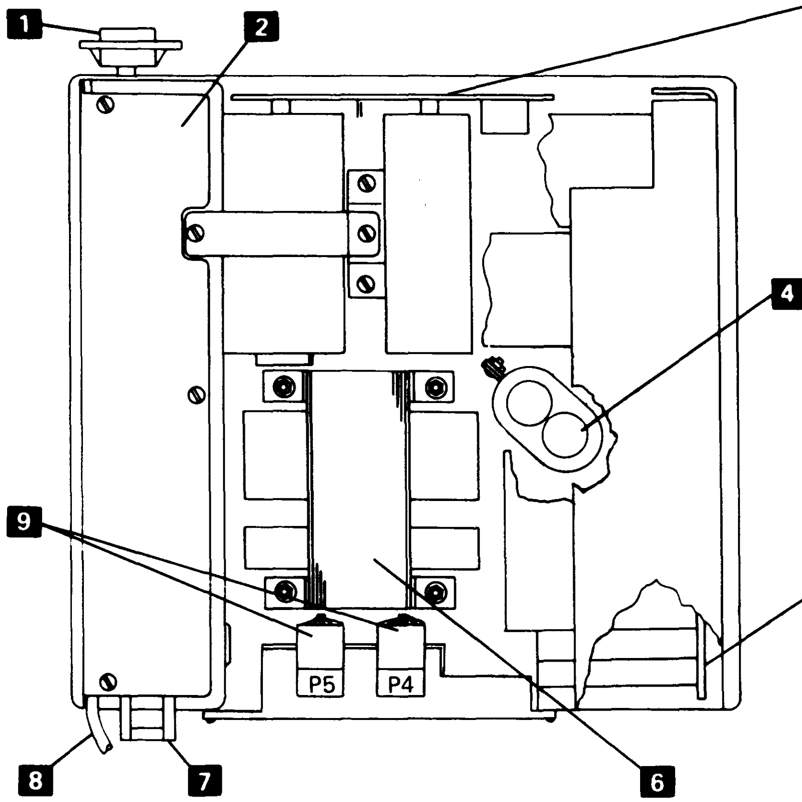
6 Transformer T1

7 Circuit Breaker CB1

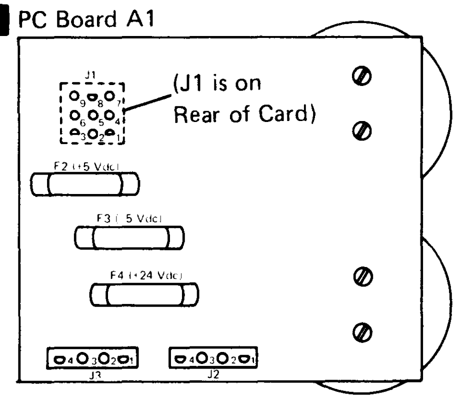
8 AC Line Cord

9 Diskette AC Connectors P4, P5

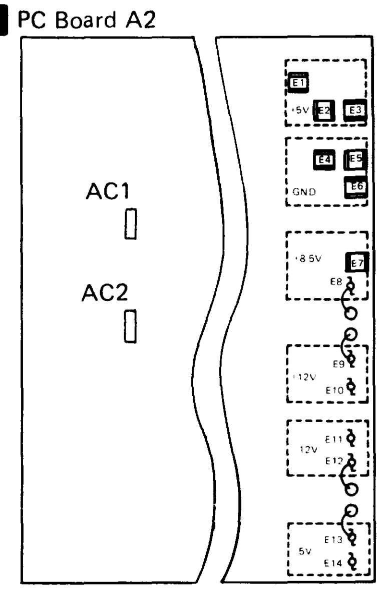
Top View of Power Supply



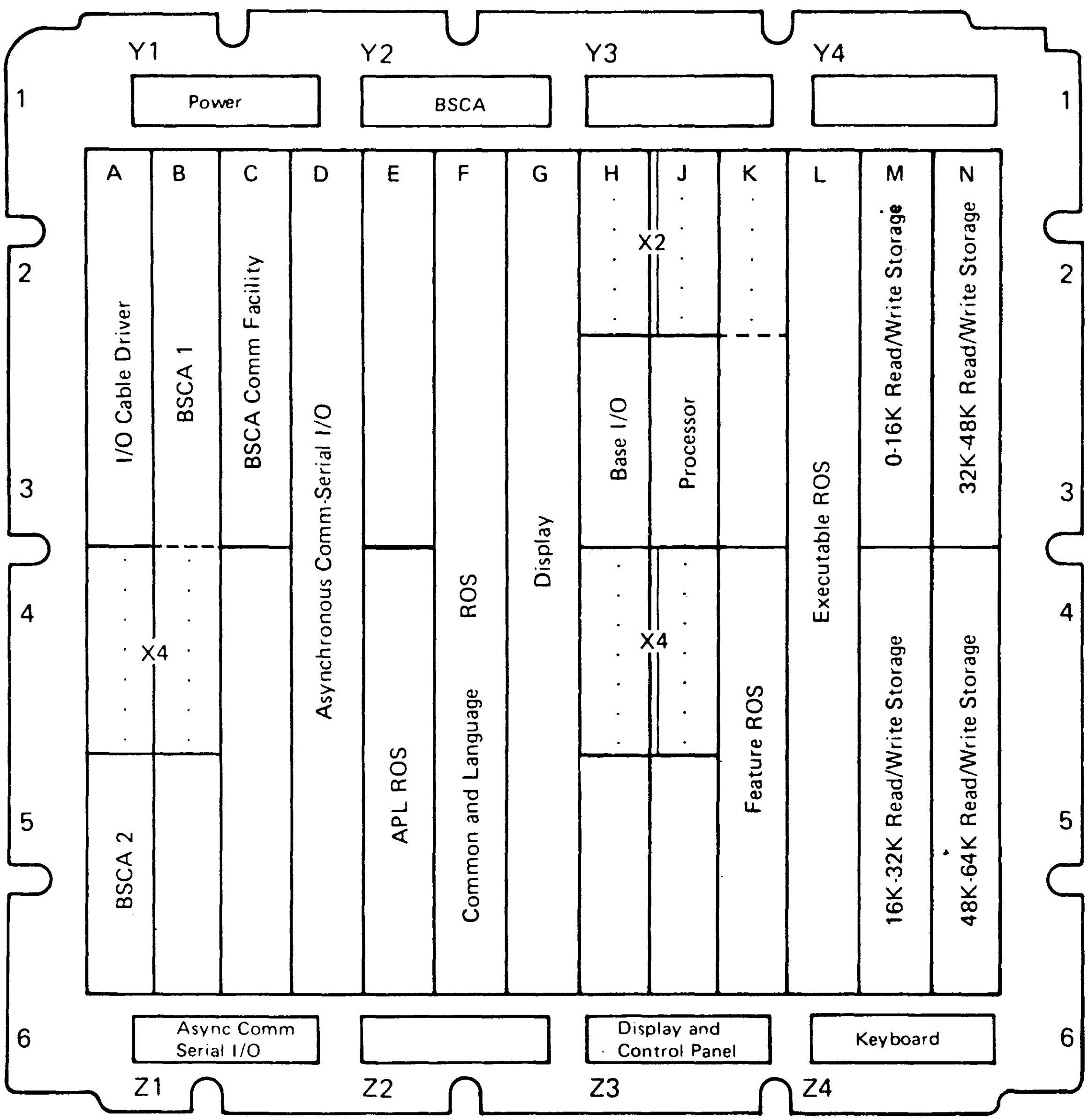
3 PC Board A1



5 PC Board A2



209 A1 BOARD (CARD SIDE)



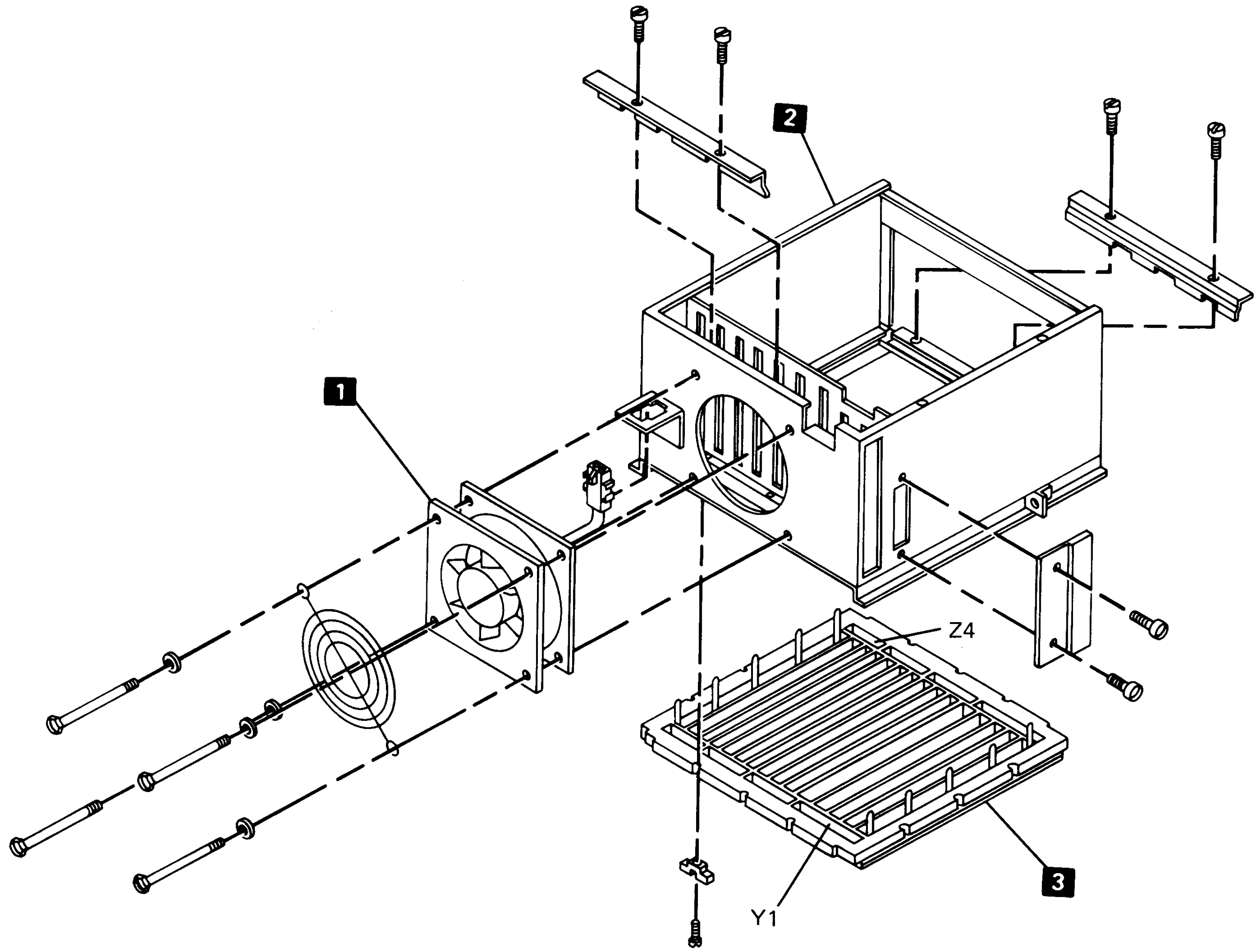
Note: See Section 050 in the Map binder for card part numbers and jumpering.

210 A1-BOARD, LOGIC BOX, AND FAN

1 Logic Fan

2 Logic Box

3 A1 Board



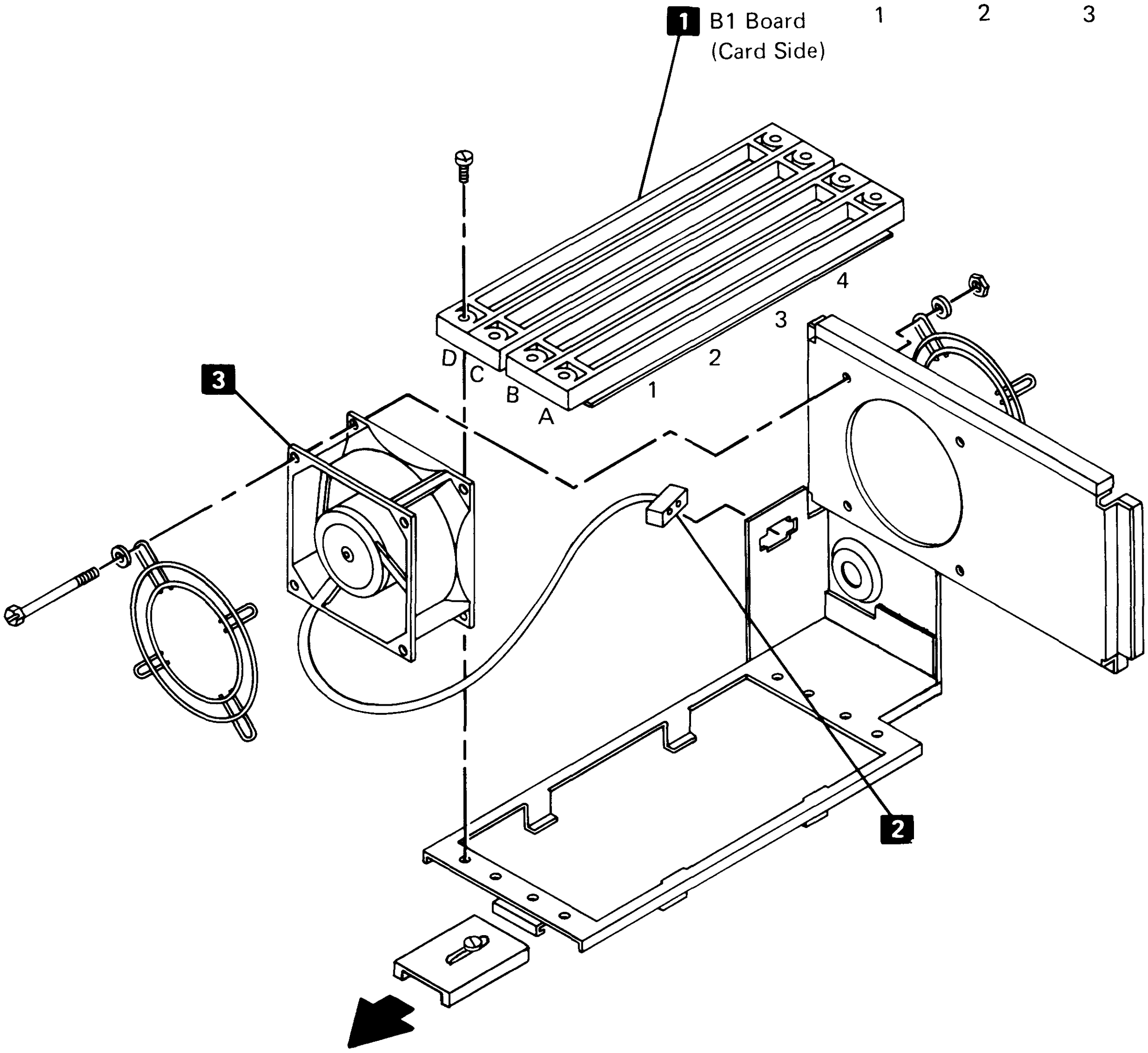
211 B1 BOARD, GATE, AND FAN

1 B1 Board

2 Fan AC Connector P3

3 Fan

	1	2	3	4
D	I/O Cable to A3 Signal Connector		I/O Cable to A2 Signal Connector	Drive 1 Converter and Cable
C	Diskette Adapter (Drives 1 and 2)			
B				Drive 2 Converter and Cable
A	I/O Signal Cable from A1 A2	Power Cable	I/O Signal Cable from A1 A1	Power Cable



212 CONTROL PANEL AND LED INDICATORS

1 Mounting Bracket

2 Display Registers/Normal Switch

3 Restart Switch

4 APL/BASIC Switch

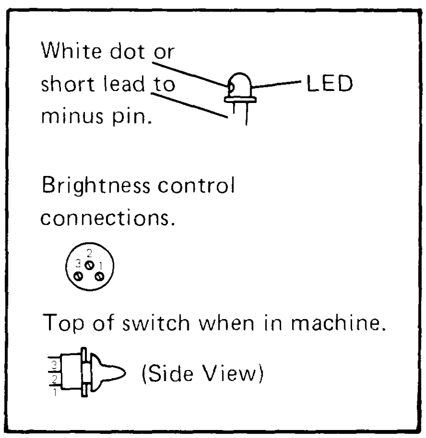
5 Brightness Control

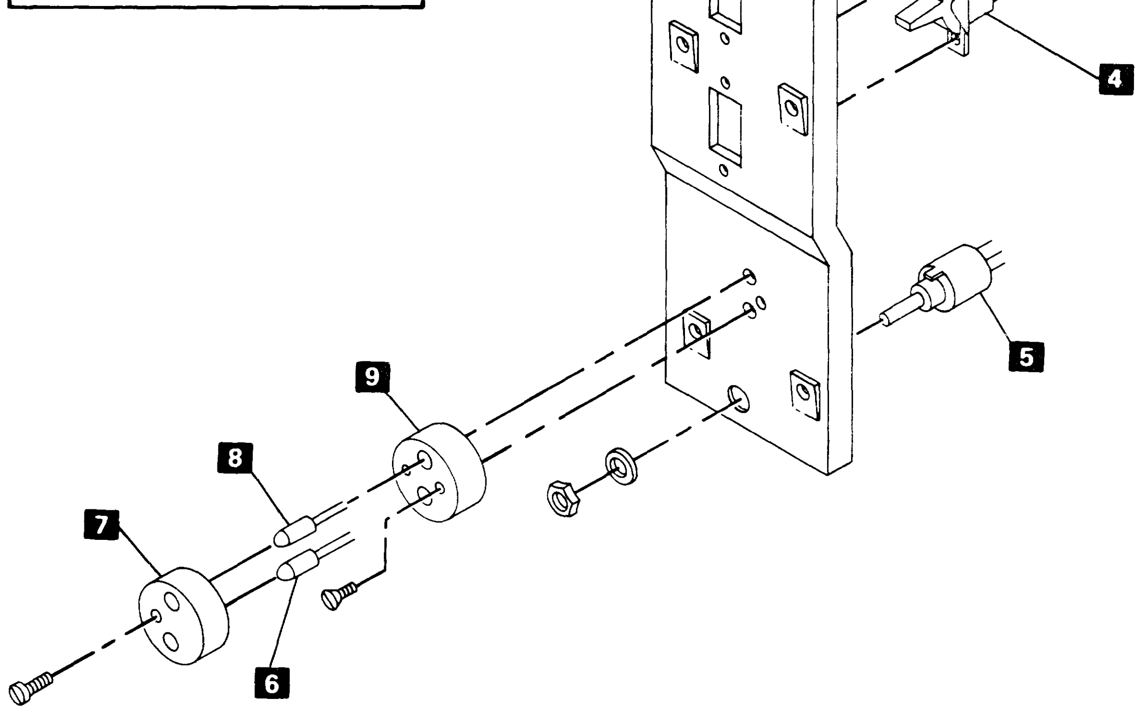
6 Process Check LED

7 LED Cap

8 In Process LED

9 LED Receptacle





213 CE PANEL AND AUDIBLE ALARM

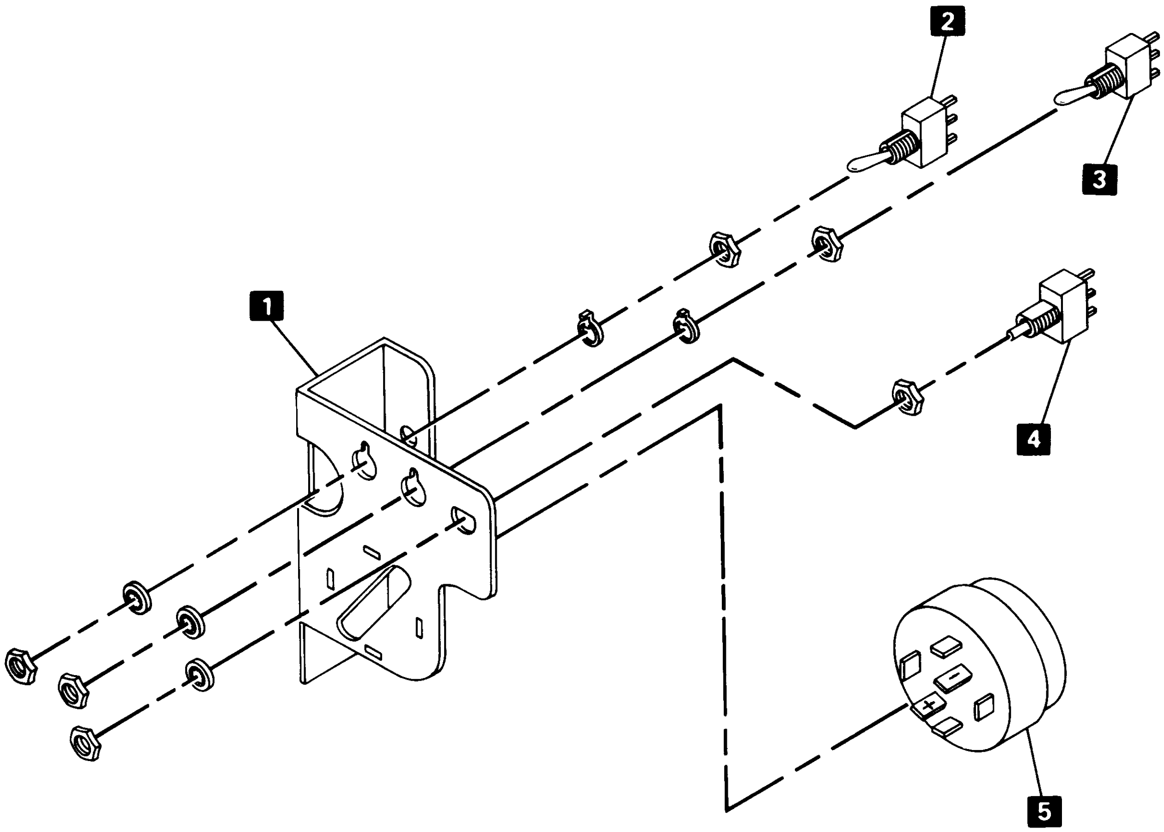
1 Mounting Bracket

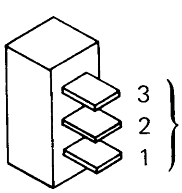
2 Reverse Display Switch

3 Run Switch

4 Step Switch

5 Audible Alarm





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220 DISKETTE UNIT (Page 1 of 3)

Maintenance Preface

There is no scheduled maintenance for the diskette unit. To repair the diskette unit, adjust the internal components or install the field replaceable units (FRUs) as directed by the maintenance analysis procedure (MAPs).

Diagnosis, repairs, adjustments, service checks, or verifying a problem can be done online (using a dedicated system) or offline (diskette unit disconnected). Always use the machine diagnostics to verify machine repairs.

All procedures assume that the diskette unit has been removed from the 5110 and is fully accessible on a work surface. Ensure that the diskette casting does not damage or scratch the work surface.

The head/carriage assembly and the drive hub and pulley assembly are adjusted and tested at the factory. The drive hub and pulley assembly are not field replaceable. If either the track 40 adjustment surface or the drive hub and pulley assembly is damaged, replace the entire diskette drive assembly. The head/carriage assembly is replaceable in the field. However, do not repair or clean any part of this assembly.

Removal

1. Switch off the 5110 power.

2. Remove the rear and top covers (200).

3. Slide the power supply out (271) far enough to lift connectors P4 and P5 H out of the slots in the mounting bracket. Extend the power cables to their maximum length.

4. Loosen the screw and clip that are in front of the B1 board; pivot the hinged B1 board and fan assembly G away from the diskette units as shown.

5. Remove the Allen screw I.

   Note: Allen screw I is the only screw that secures the diskette units in the 5110.

CAUTION
Before lifting the diskette units out of the 5110, close the diskette latches to prevent damaging the latches and the front of the 5110. Protect the work surface so it will not be damaged or scratched.

6. Slide the diskette units and the shield out of the slots in the rails J; lift the assembly out of the 5110.

7. Turn the assembly upside down on the work surface; remove the six mounting screws and the rear shield F.

8. Remove the front shoulder screw K and the top screws B and L.

9. Remove the two slotted screws C and the bracket E.

10. Remove the shield from the diskette units.

11. Remove the three clips A, to separate the diskette units.

12. Position the diskette units as far as possible from the power supply, to prevent electrical interference in the diskette units.

Replacement

1. Switch off the 5110 power.

2. Place the power cables in the power supply; install P4 and P5 H in the mounting bracket slots.

3. Install the three clips A to fasten the diskette units together.

4. Turn the diskette units upside down; install the shield. Install the bracket E with the slotted screws C.

   Note: The shield must be installed. Exchange the shield if it is damaged.

5. Install the two top screws B and L; install the front shoulder screw K.

6. Install the rear shield F with the six mounting screws.

CAUTION
Before installing the diskette units in the 5110, close the diskette latches to prevent damaging them.

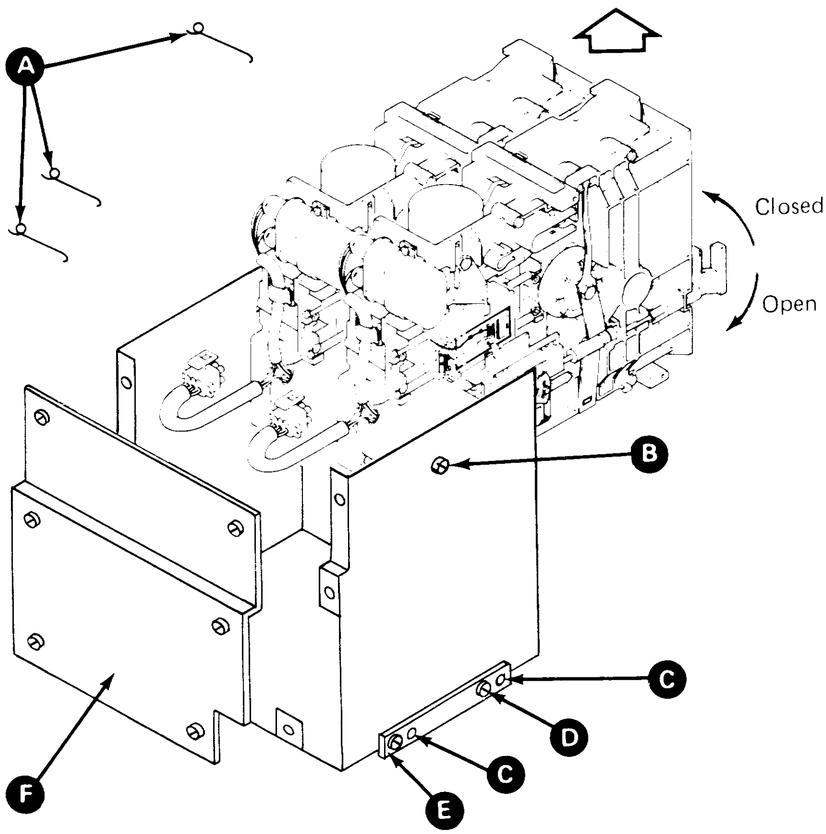
7. Slide the front shoulder screws D and K into the slots in the rails J; install the Allen screw I.

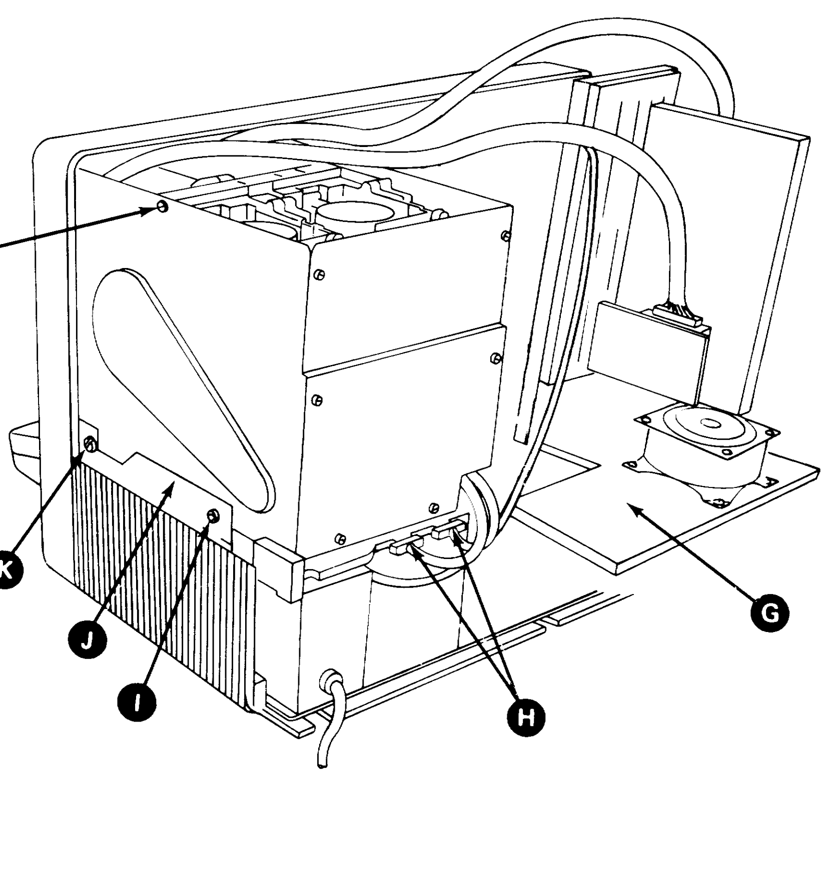
8. Pivot the B1 board and fan assembly G up; secure the assembly with the clip and screw.

   Note: Carefully apply pressure to the top of the B1 board and position the clip over the front edge of the B1 board.

9. Slide the power supply into the operating position (271).

10. Install the top and rear covers (200).


A
Closed
Open
B
C
D
C
E
F


L
K
J
I
H
G

221 ATTACHMENT CABLE

Removal

1. Switch off the 5110 power; remove the diskette units from the 5110 (220).

2. Unplug the drive 1 or drive 2 attachment cable from the converter card A and the drive control card C. Note the cable path.

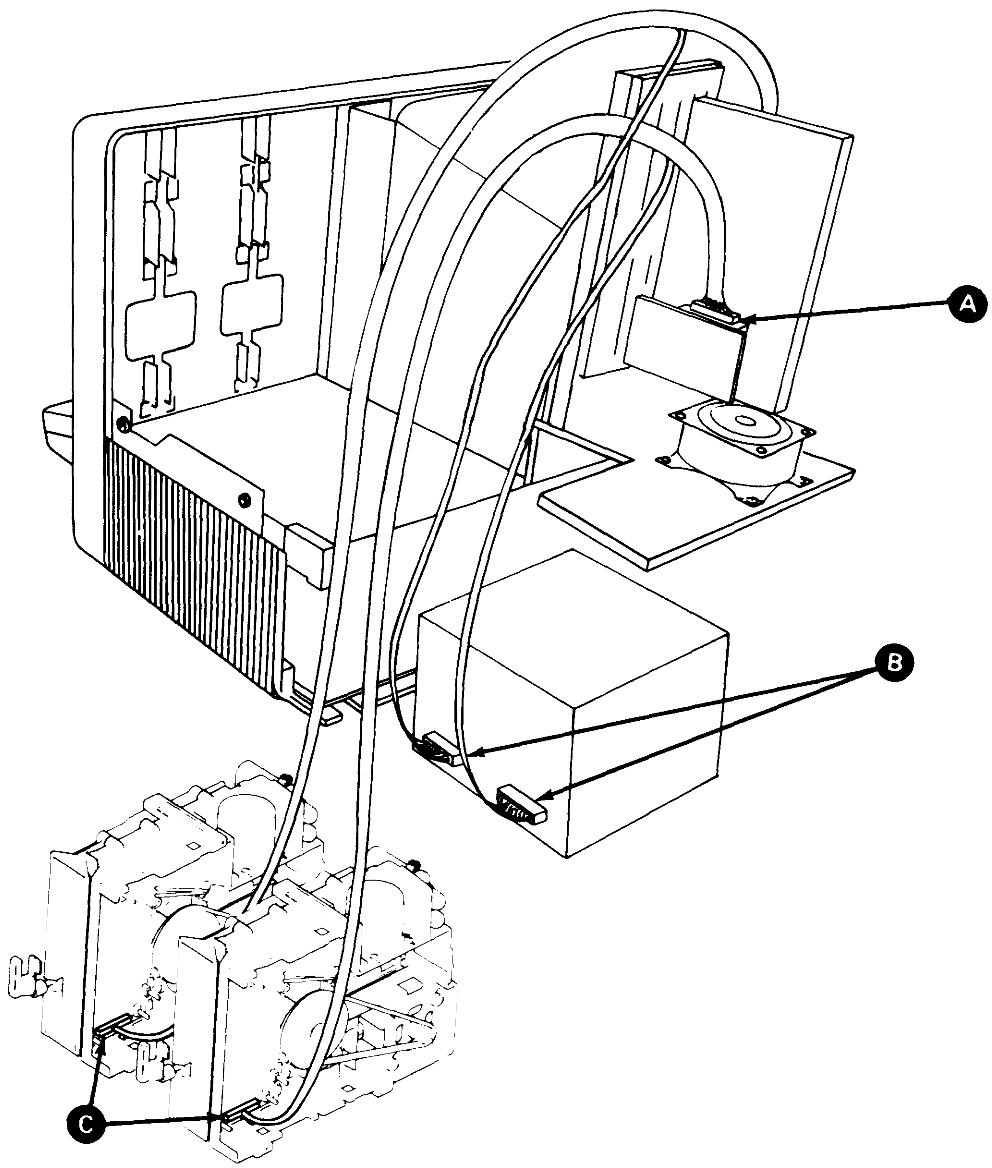
3. Slide the power supply out all the way; unplug J2 or J3 B from the front of the power supply.

Replacement

1. Connect J2 or J3 B to the power supply; slide the power supply back into the 5110.

2. Connect the attachment cable to the drive control card C and the converter card A.

3. Install the diskette units in the 5110 (220).



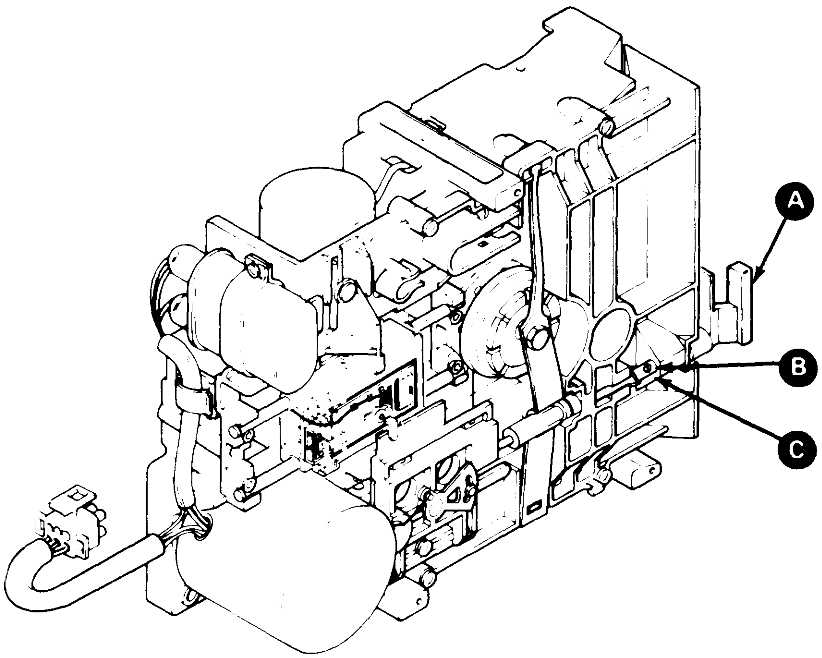
222 DISKETTE LATCH

Removal

1. Switch off the 5110 power.
2. Remove the diskette units from the 5110 (220).
3. Remove the screw B and nut C from the diskette latch A; remove the diskette latch.

Replacement

1. Install the diskette latch A with screw B and nut C. Adjust the diskette latch for a maximum gap of 0.1 mm (0.004 in.) between the latch and the front surface of the diskette guide.
2. Install the diskette units in the 5110 (220).



Maintenance

223 DISKETTE GUIDE

Removal

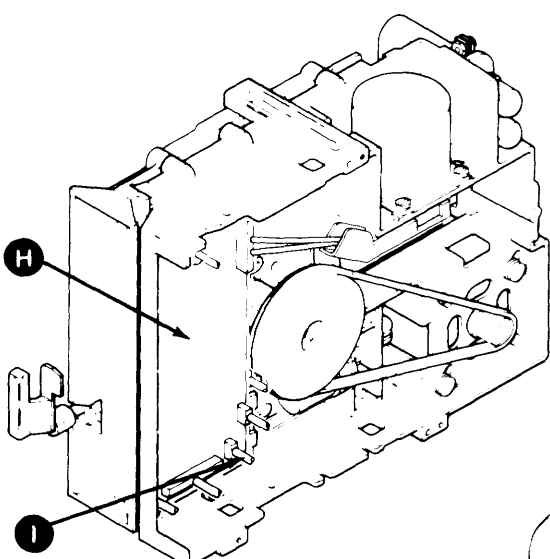
1. Switch off the 5110 power; move the head/carriage to the rear of the machine.
2. Disconnect the LED cable I from the drive control card H; note the cable path for the replacement.
3. Insert a clean piece of paper between the heads A.
4. Close the diskette latch D.
5. Push the bail G in slightly and disconnect the bail actuating cable eyelet F from the bail.
6. Open the diskette latch D.
7. Remove the four diskette guide mounting screws E.

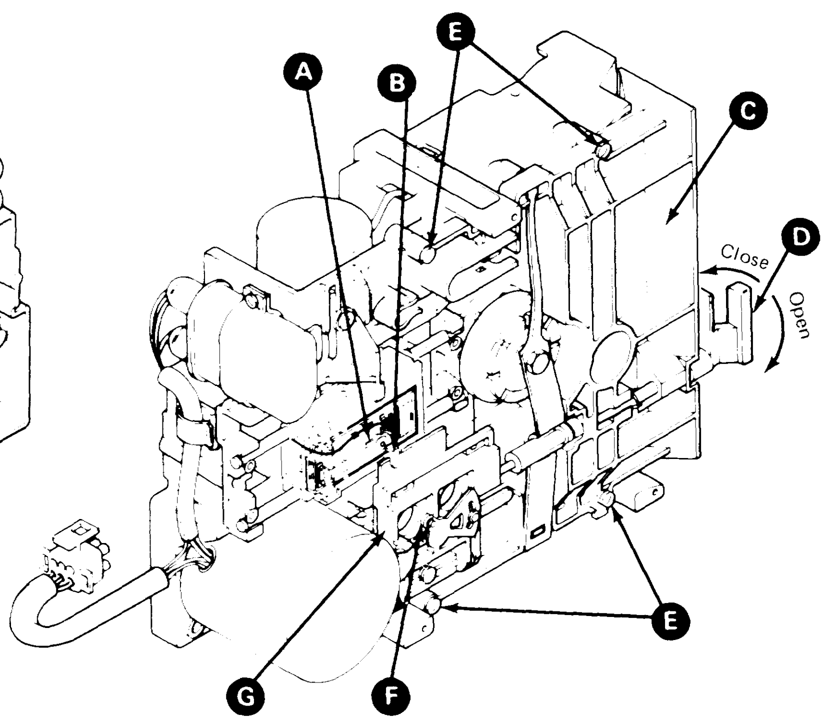
CAUTION
Do not let the heads snap together when the bail is removed from under the head assembly.

8. Remove the diskette guide C; gently lift it up and carefully slide the bail out from under the tab B on the head assembly.

Replacement

1. Open the diskette latch D.
2. Install the diskette guide C; carefully slide the bail G under the tab B of the head assembly.
3. Install the four diskette guide mounting screws E.
4. Close the diskette latch D.
5. Push the bail G in slightly and connect the bail actuating cable eyelet F.
6. Open the diskette latch D.
7. Connect the LED cable I to the drive control card H.
8. Remove the paper from between the heads A.





224 COLLET AND SPRING ASSEMBLY

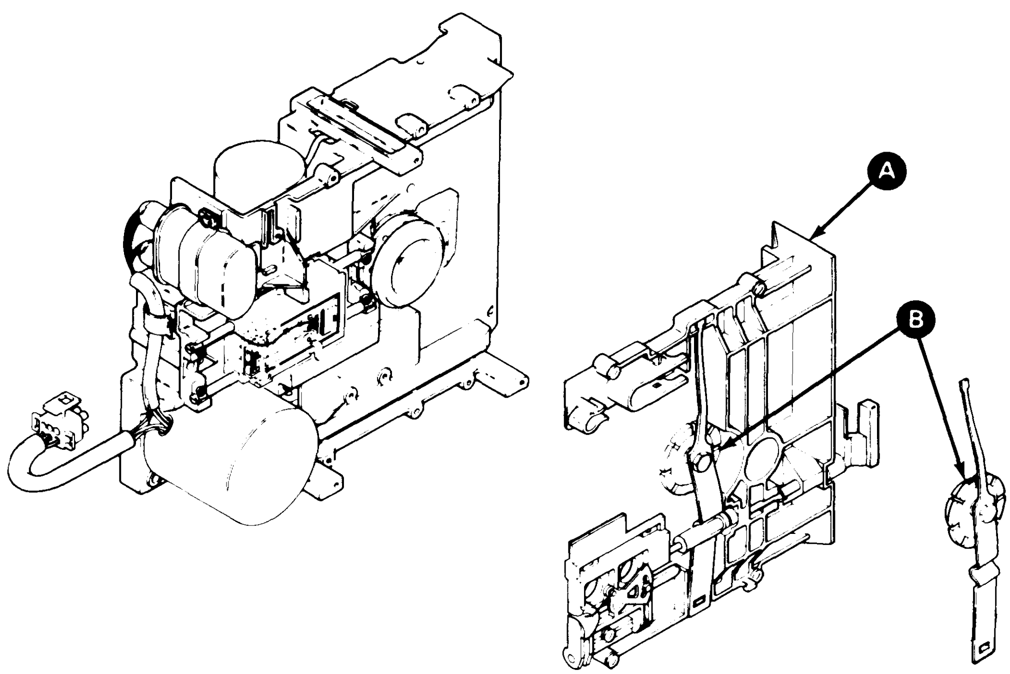
Removal

1. Remove the diskette guide (223).
2. Remove the diskette latch (222).
3. Remove the head load bail (227).
4. Remove the collet and spring assembly **B** from the diskette guide **A**.

Note: If the collet and spring assembly is damaged, exchange the assembly.

Replacement

1. Install the collet and spring assembly **B** on the diskette guide **A**.
2. Install the head load bail (227).
3. Install the diskette latch (222).
4. Install the diskette guide (223).



Note: The head/carriage assembly is adjusted and tested at the factory. Do not repair or clean any part of this assembly.

If the head/carriage assembly is removed from the machine for any reason, insert a piece of clean paper between the heads so that the head surfaces do not touch each other.

Service Check

CAUTION
Perform the head/carriage service check with the diskette drive installed (or in the same position as when installed) or else the service check may not be accurate.

1. Switch off the 5110 power.

2. Disconnect the ac drive motor power cable G.

   DANGER
   Voltage is present at power supply connectors P4 and P5 when the 5110 power is switched on.

3. Move the head/carriage to approximately align the timing pointer with the timing block on the casting; the head/carriage is now at cylinder 40. Insert the timing pin F; ensure the timing pin goes into the slot in the casting.

4. Remove the timing pin F; switch on the 5110 power.

CAUTION
To prevent card damage, the jumpers to be inserted in the following steps must be on the correct pins.

5. Connect a jumper from D (ground) to C (disable stepper motor).

6. Detent the stepper motor at cylinder 40 by connecting a jumper from E (ground) to B (MC-0).

7. Check that the timing pin F passes freely through the stepper motor pulley into the timing slot in the casting. If it does not, remove the timing pin and perform the head/carriage adjustment starting with step 3.

8. If the timing pin passes freely through the stepper motor pulley into the slot in the casting, remove the timing pin F.

9. Remove the jumper end from B (MC-0) and install it on A (MC-3); this moves the stepper motor to cylinder 39.

10. Verify that this is cylinder 39 by checking for no gap I between the timing pointer and the timing block.

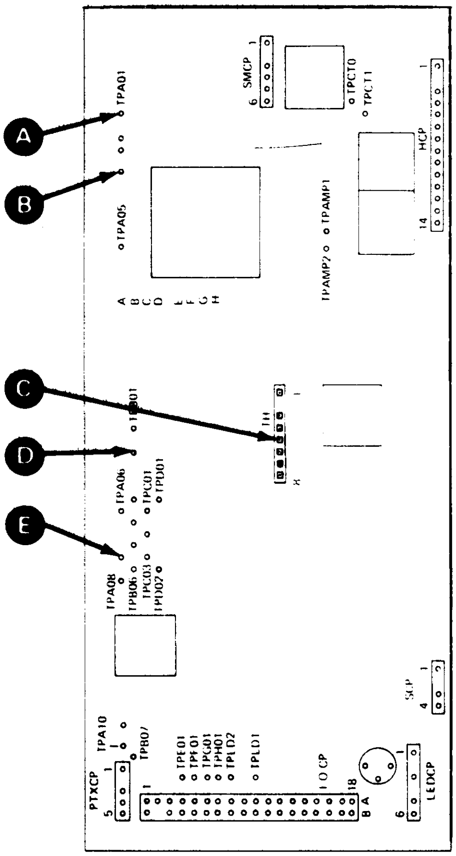
11. Remove the jumper end from A (MC-3) and install it on B (MC-0); this again moves the stepper motor to cylinder 40.

12. Verify that this is cylinder 40 by checking that the timing hole in the pulley lines up with the timing slot in the casting.

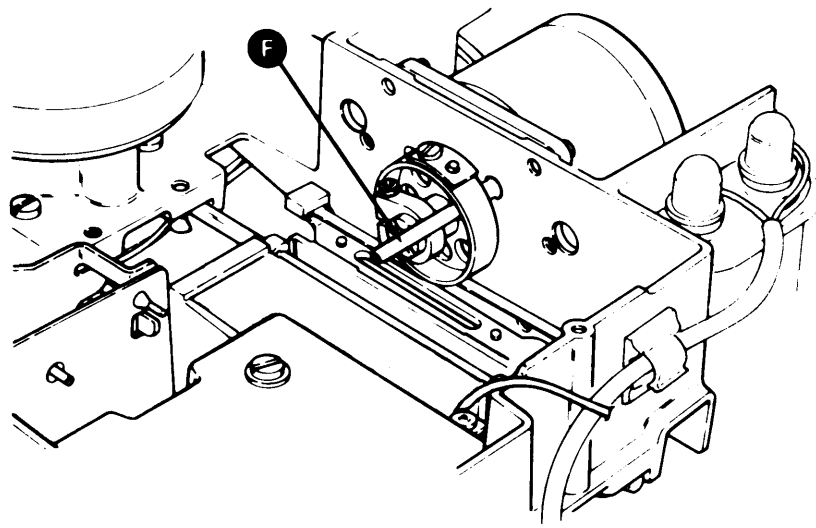
13. Check the gap I between the timing pointer and the timing block as follows:
    a. A 0.51-mm (0.020-in) gauge H should fit snugly.
    b. A 0.53-mm (0.021-in) gauge should not fit.

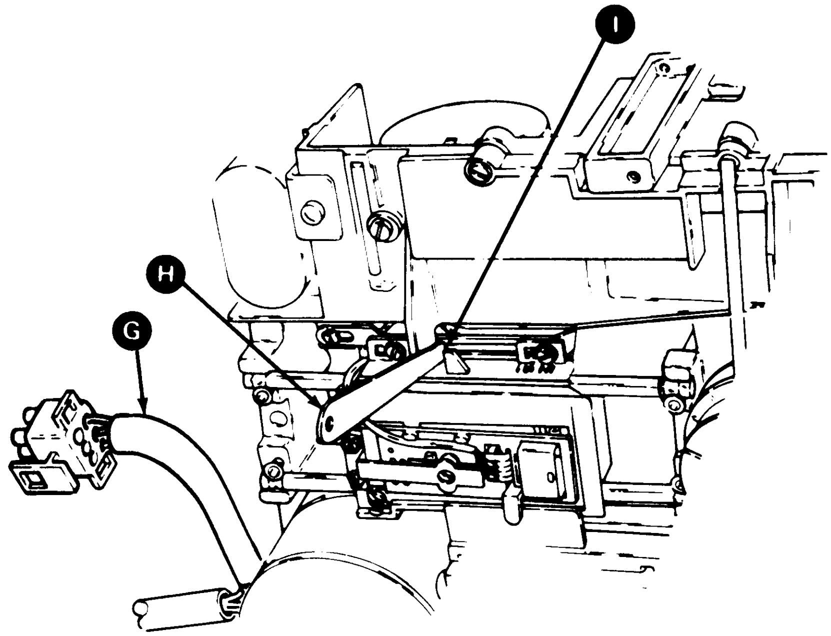
Note: Because of the torque characteristics of the stepper motor, if step 13 must be repeated, start the sequence with step 9 of this service check.

14. If the gap I between the timing pointer and the timing block is correct, remove the jumpers, switch off the 5110 power, and connect the ac drive motor power cable G.



Drive Control Card





Adjustment

CAUTION
Adjust the head/carriage assembly with the diskette drive installed (or in the same position as when installed), or else the adjustment may not be accurate.

1. Switch off the 5110 power.

2. Disconnect the ac drive motor power cable N.

   DANGER
   Voltage is present at power supply connectors P4 and P5 when the 5110 power is switched on.

3. Remove the cable guide G (squeeze at F; push the cable guide down).

4. Measure and record the gap J between the stepper motor pulley and the casting.

5. Loosen the pulley clamp screw H so that the stepper motor shaft can turn inside the pulley.

6. Move the head/carriage to approximately align the timing pointer with the timing block on the casting; the head/carriage is now at cylinder 40. Insert the timing pin I.

7. Switch on the 5110 power.

CAUTION
To prevent card damage, the jumpers to be inserted in the following steps must be on the correct pins.

8. Connect a jumper from D (ground) to C (disable stepper motor).

9. Connect a jumper from E (ground) to B (MC-0) to detent the stepper motor at cylinder 40.

10. Maintain the gap J at the casting (recorded in step 4); tighten the pulley clamp screw H. Ensure that the timing pin I passes freely through the stepper motor pulley into the timing slot in the casting.

11. Remove the timing pin I.

12. Loosen the two carriage clamping screws K.

13. Remove the jumper end from B (MC-0); install it on A (MC-3) to move the stepper motor to cylinder 39.

14. Remove the jumper end from A (MC-3); install it on B (MC-0). This moves the stepper motor back to cylinder 40.

Note: Steps 13 and 14 set up the required torque condition of the stepper motor for the following steps.

15. Verify that this is cylinder 40 by checking that the timing hole in the pulley lines up with the timing slot in the casting.

16. Insert a 0.51-mm (0.020-in) gauge P between the timing pointer on the carriage and the timing block. Clip the gauge to the casting with the retaining clip Q provided (the clip is stored on the diskette guide).

17. Apply a light finger pressure at the front of the head/carriage M so that it just touches, but is not forced against, the gauge. Insert the carriage pressure spring L between the casting and carriage to hold the head/carriage assembly against the gauge (the pressure spring is stored on the diskette guide).

18. Tighten the two screws K that hold the carriage to the bracket; remove the carriage pressure spring L and the retaining clip Q.

19. Verify the gap between the timing pointer and the timing block as follows:
    a. A 0.51-mm (0.020-in) gauge P should fit snugly.
    b. A 0.53-mm (0.021-in) gauge should not fit.

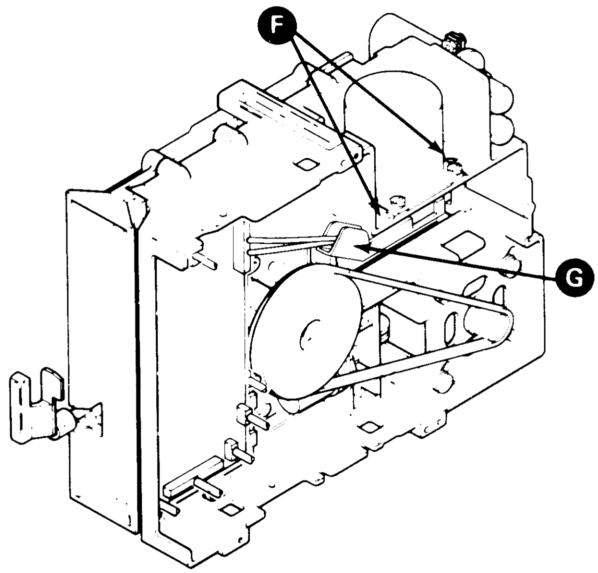
Note: Because of the torque characteristics of the stepper motor, if step 19 must be repeated, start the sequence with step 13.

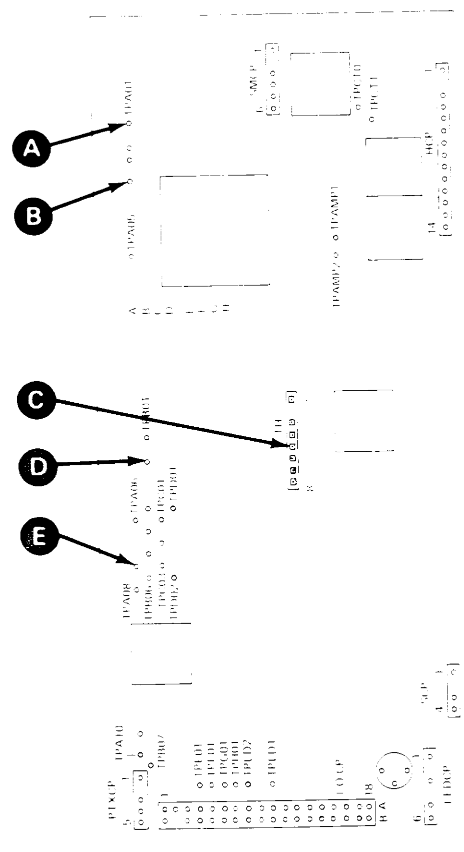
20. Switch off the 5110 power; remove the jumpers.

21. Snap the cable guide G into the holes in the casting.

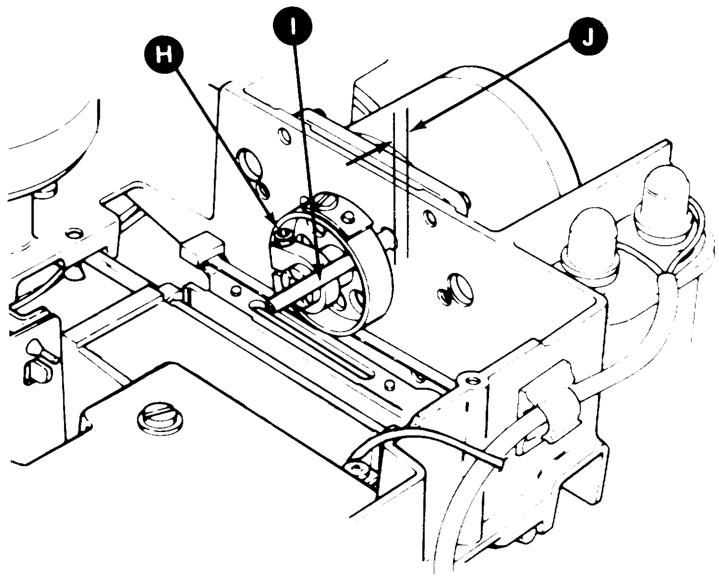
22. Connect the ac drive motor power cable N.

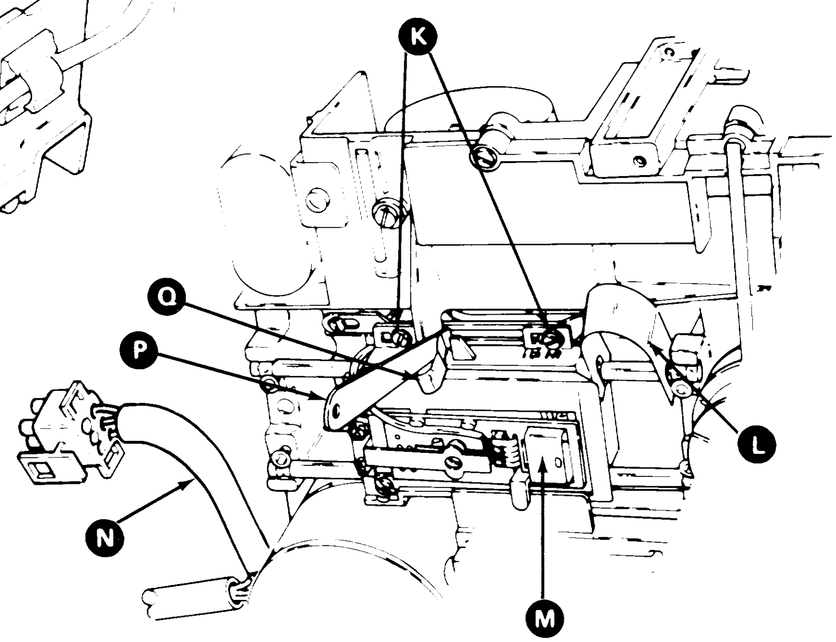
23. Store the retaining clip Q, the carriage pressure spring L, and the timing pin I on the diskette guide.





Drive Control Card





Removal

1. Switch off the 5110 power.

2. Remove the cable guide C from the casting (squeeze at B and push the guide down); carefully disconnect the head cable A from the drive control card.

CAUTION
The drive band must not be bent or damaged in any way.

3. Remove the two screws I that hold the head/carriage K to the carriage bracket F. To prevent damaging the drive band, give support to the carriage bracket F when the screws I are removed.

4. Remove the Allen screws M (one at each end of the upper guide rod); slide the upper guide rod G out.

5. Carefully lift and turn the head/carriage assembly K; remove it from the lower guide rod H.

Replacement

1. Disconnect the ac drive motor power cable O.

DANGER
Voltage is present at power supply connectors P4 and P5 when the 5110 power is switched on.

CAUTION
When installing the head/carriage assembly, ensure that the bail N is under the tab J of the carriage assembly. To prevent head damage, insert a strip of clean paper between the head surfaces during installation.

2. Carefully install the head/carriage assembly K on the lower guide rod H.

3. Install the upper guide rod G; tighten the two screws M. Ensure that the guide rod notch L is aligned with the screw and is seated as shown in Q.

4. Move the head/carriage assembly to approximately align the timing pointer with the timing block on the casting.

5. Install the screws I in the carriage bracket F so the screws are centered in the slots.

6. Connect the head cable A to the drive control card.

7. Snap the cable guide C up into the casting; ensure that the cable is loose enough to let the heads move freely.

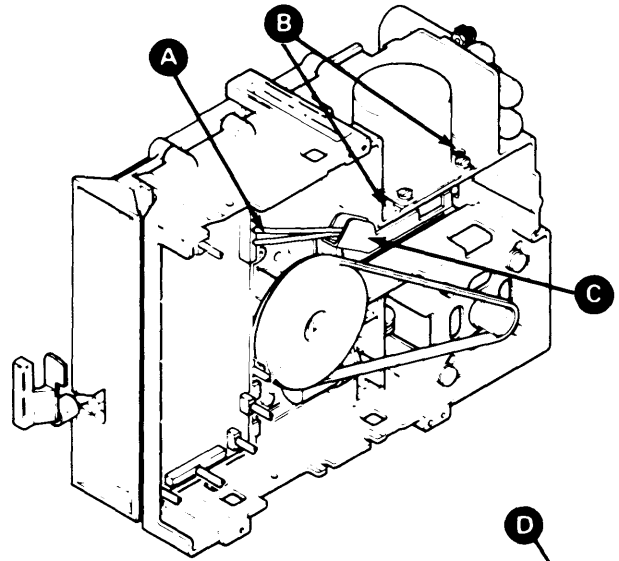
8. Loosen the drive band screw E (at the slotted end of the carriage bracket).

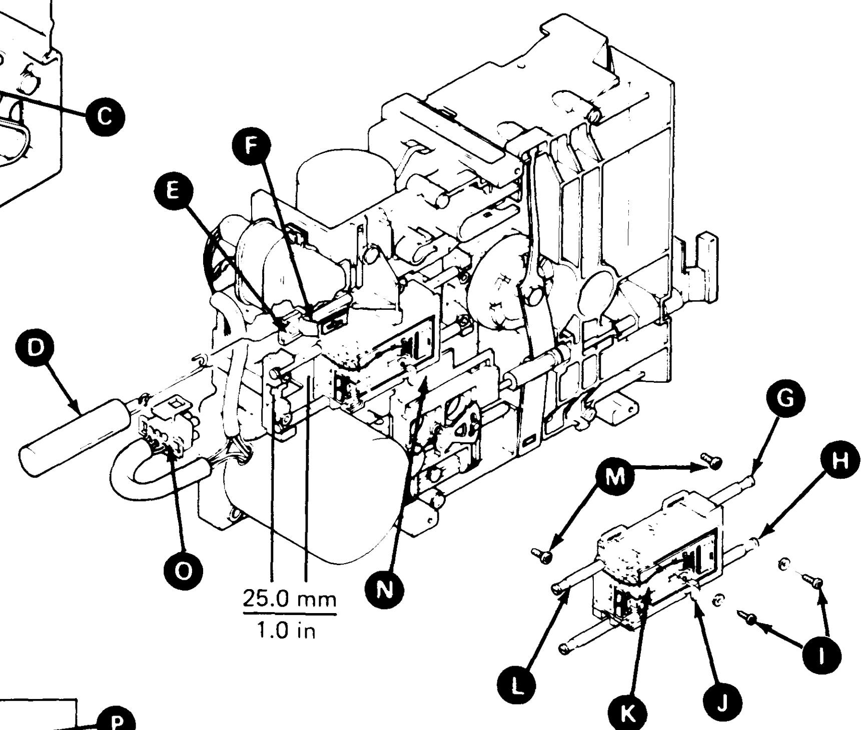
9. Block the head/carriage assembly K approximately 25.0-mm (1.0-in) from the rear of the casting.

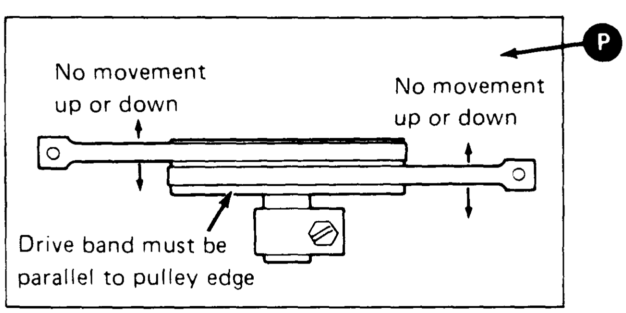
10. With the force gauge D (part 460870), pull on the slotted end of the drive band with 0.907 ± 0.113 kg (2.5 ± 0.25 lbs) of force; tighten the band clamping screw E. Ensure that the band is parallel to the bracket.

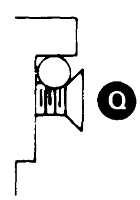
11. Move the head/carriage assembly back and forth and ensure that the drive band tracks properly and that there is no movement up or down P. If the drive band tracking is not correct, adjust the drive band (234) starting with step 3.

12. If the drive band tracking is correct, perform the head/carriage adjustment, starting with step 4.


A
B
C


D
E
F
G
H
I
J
K
L
M
N
O
25.0 mm
1.0 in


P
No movement
up or down
No movement
up or down
Drive band must be
parallel to pulley edge


Q

Service Check

1. Switch off the 5110 power.

2. Disconnect the ac drive motor power cable F.

3. Insert a diskette; close the diskette latch.

DANGER
Voltage is present at power supply connectors P4 and P5 when the 5110 power is switched on.

4. Switch on the 5110 power.

CAUTION
To prevent card damage, the jumpers to be inserted in the following steps must be on the correct pins.

5. Connect a jumper from B (ground) to C (head load); the head load solenoid should be energized.

6. Connect a jumper from A (ground) to D (disable stepper motor).

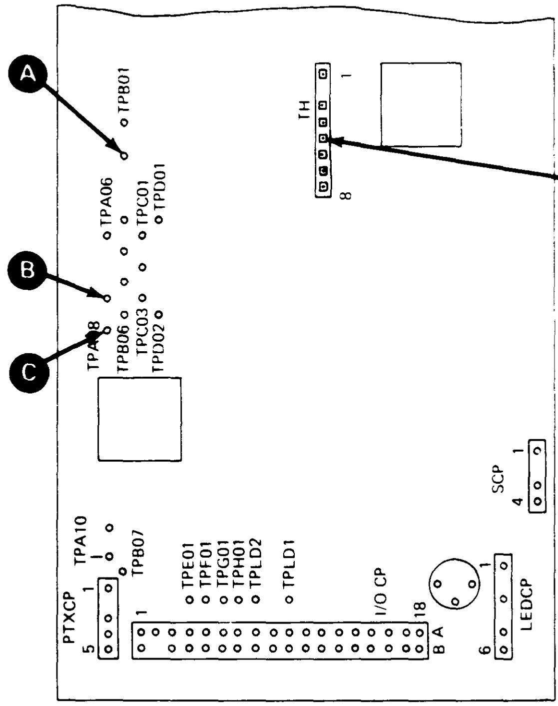
DANGER
The solenoid case becomes hot after continuous use.

7. Check for a 0.3 to 0.7-mm (0.012 to 0.028-in) gap E between the bail and the tab on the carriage assembly for all of the carriage travel (cylinder 00 to cylinder 76).

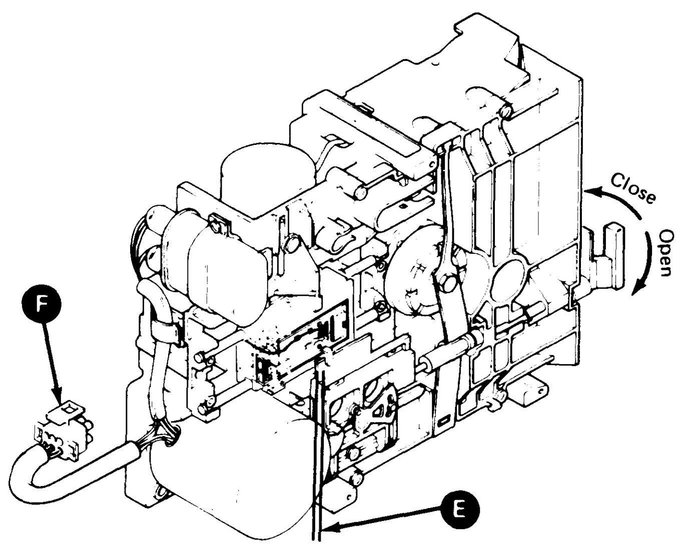
8. Remove the jumpers installed in steps 5 and 6; remove the diskette.

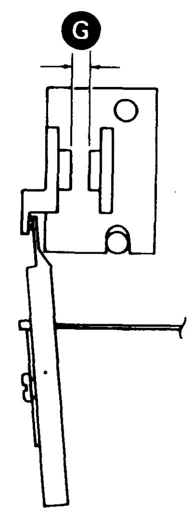
9. Switch off the 5110 power.

10. With the head load solenoid deactivated and the diskette latch closed, visually check for a gap G of approximately 2.0 to 3.0-mm (0.079 to 0.118-in) between the head surfaces (this gap cannot be measured).



Drive Control Card





Adjustment

1. Switch off the 5110 power.

2. Disconnect the ac drive motor power cable G.

3. Insert a diskette; close the diskette latch.

   DANGER
   Voltage is present at power supply connectors P4 and P5 when the 5110 power is switched on.

4. Switch on the 5110 power.

CAUTION
To prevent card damage, the jumpers to be installed in the following steps must be on the correct pins.

5. Connect a jumper from B (ground) to C (head load); the head load solenoid should be energized.

6. Connect a jumper from A (ground) to D (disable stepper motor).

   DANGER
   The solenoid case becomes hot after continuous use.

7. Loosen the solenoid locking screw H.

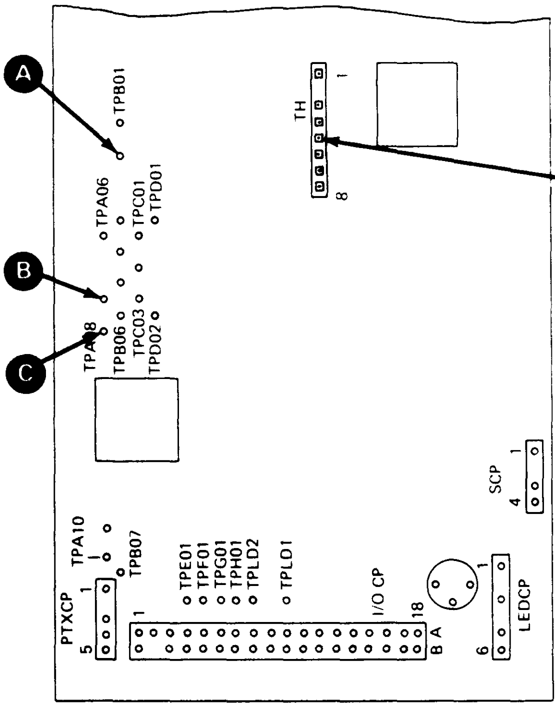
8. Turn the solenoid in the mounting bracket to obtain a gap E of 0.3 to 0.7-mm (0.012 to 0.028-in) between the bail and the tab on the carriage assembly. Tighten the locking screw H.

9. Remove the jumpers installed in steps 5 and 6; remove the diskette.

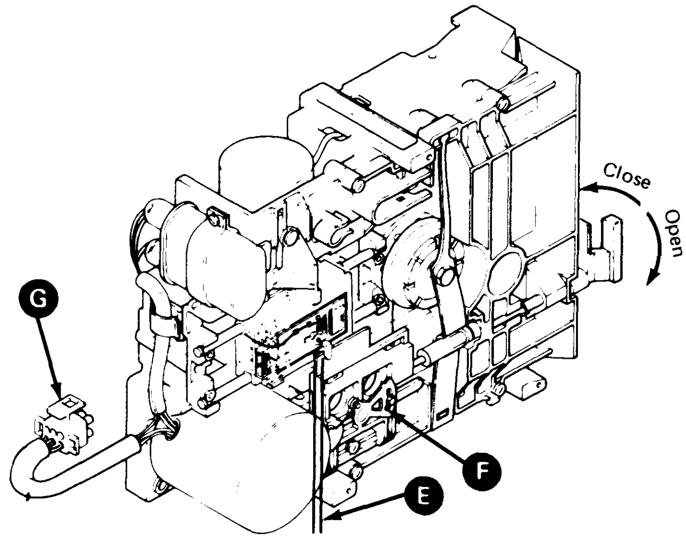
10. Switch off the 5110 power.

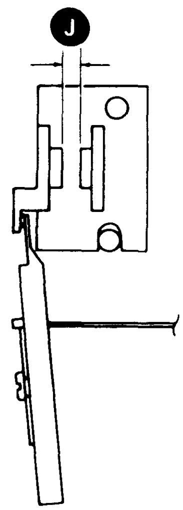
11. With the head load solenoid deactivated and the diskette latch closed, loosen the adjustment lever locking screw F one-half turn. Move the lever to obtain a gap J of 2.0 to 3.0-mm (0.079 to 0.118-in) between the head surfaces (this gap cannot be measured).

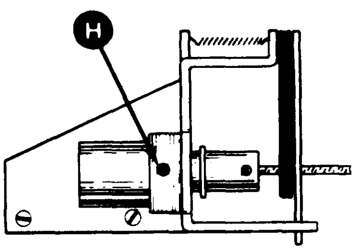
12. Connect the ac drive motor power cable G.



Drive Control Card







Maintenance

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227 HEAD LOAD BAIL

Removal

1. Remove the diskette guide A (223).

2. Remove the bail C: loosen screw B; slide the pivot rod D out to the left. Note that the bail return spring E is located between the bail C and the diskette guide A).

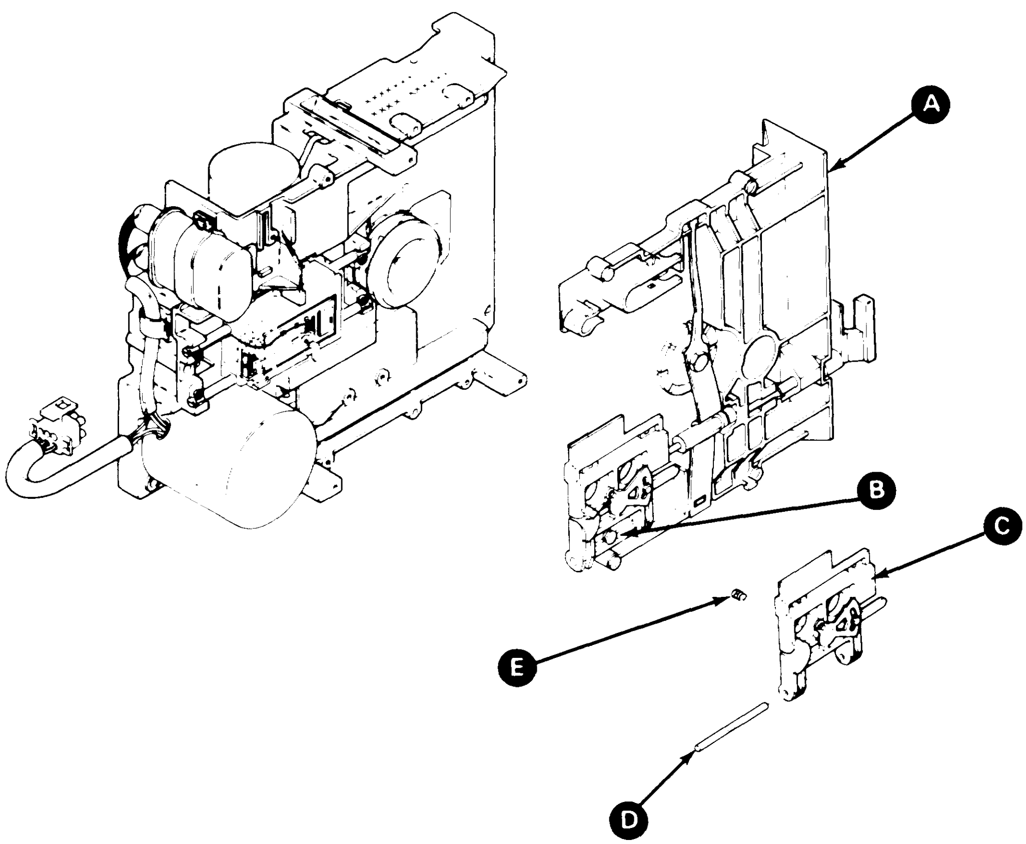
Replacement

1. Install the bail C on the diskette guide A: slide the pivot rod D into the bail and tighten screw B. Ensure that the bail return spring E is placed properly between the bail C and the diskette guide A.

2. Install the diskette guide (223).

3. Perform the head load solenoid and bail service check (226).

Maintenance



228 HEAD LOAD SOLENOID AND IDLER
(Page 1 of 2)

Removal

1. Switch off the 5110 power.

2. Disconnect the ac drive motor power cable C.

   DANGER
   Voltage is present at power supply connectors P4 and P5 when the 5110 power is switched on.

3. Close the diskette latch.

4. Insert a clean piece of paper between the heads.

5. Push the bail B in slightly and disconnect the bail actuating cable eyelet from the bail.

6. Open the diskette latch.

7. Remove the ac drive motor belt D.

8. Disconnect the solenoid cable A from the control card.

9. Remove the solenoid, bracket, and cable as a unit G.

10. Remove the idler pulley E.

11. Loosen the solenoid locking screw F; unscrew the solenoid H from the bracket (the solenoid and bail actuating cable are one unit).

Replacement

1. Install the idler pulley E.

2. Install the solenoid and bail actuating cable H on the bracket.

3. Install the solenoid, bracket, and cable as a unit G.

4. Connect the solenoid cable A to the control card.

5. Install the ac drive motor belt D.

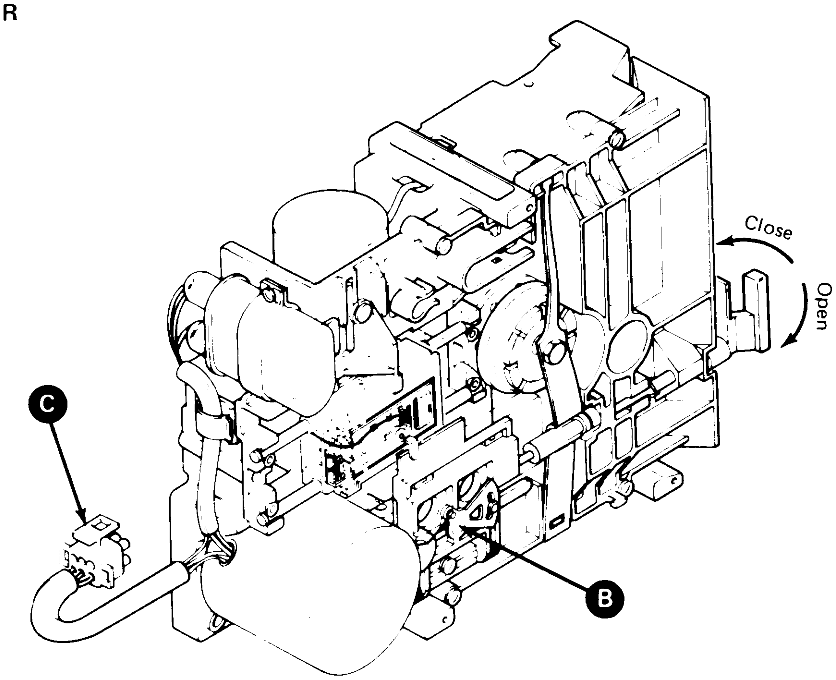
6. Close the diskette latch.

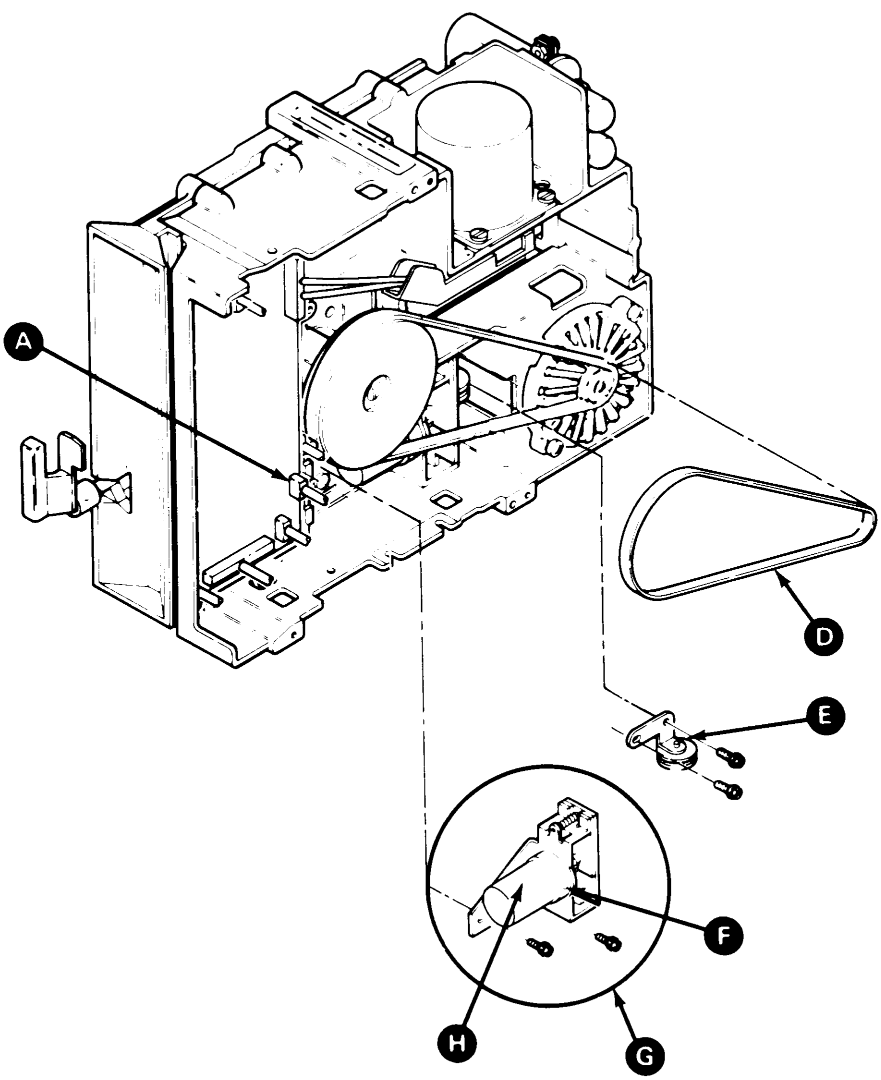
7. Push the bail in slightly and connect the bail actuating cable eyelet to the bail B; ensure that the cable is around the solenoid idler pulley.

8. Adjust the head load solenoid and bail (226), starting with step 3.

HEAD LOAD SOLENOID AND IDLER

(Page 2 of 2)





Maintenance

Removal

1. Switch off the 5110 power; disconnect the 5110 power cord.
2. Disconnect the ac drive motor power cable **B**.
3. Remove the drive belt **I**.

DANGER
The drive motor case becomes hot after continuous use.

4. Remove the two enclosure mounting screws **J**; remove the fan enclosure **H**.
5. Loosen the setscrew **F**; remove the drive motor fan and pulley assembly **G**.

DANGER
High voltage may be present at the capacitor terminals **E**.

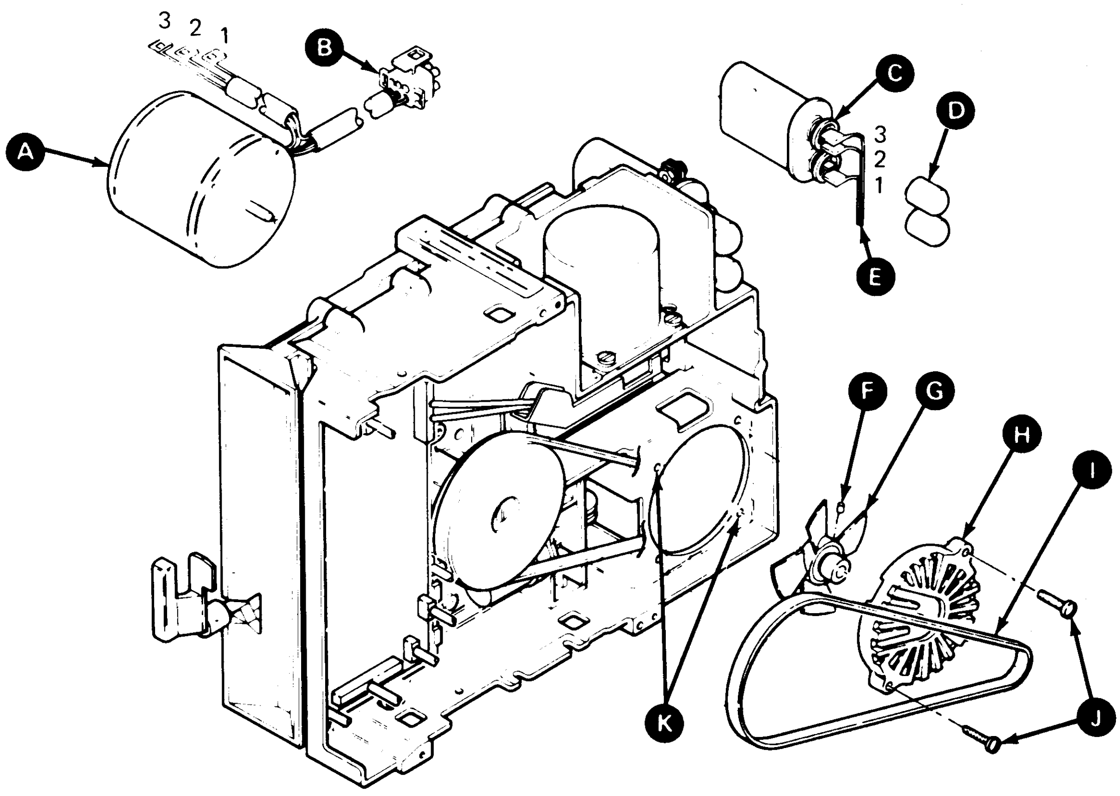
6. Remove the two insulator caps **D** from the capacitor terminals **C**.
7. Discharge the capacitor by shorting out its terminals with a large-bladed screwdriver.
8. Remove the drive motor leads **E** from the capacitor terminals **C**.
9. Remove the motor leads from the cable guide on the casting.
10. Remove the insulator caps **D** from the motor leads.
11. Remove the two remaining mounting screws **K**; remove the motor **A**.

Replacement

1. Install the ac drive motor **A** with the two mounting screws **K**.
2. Install the drive motor fan and pulley **G** on the motor shaft. Ensure that the setscrew **F** is centered on the flat surface of the motor shaft; leave the setscrew loose.
3. Position the fan and pulley on the motor shaft with a gap of 0.5-mm (0.020-in) between the motor and the fan hub; tighten the setscrew.

CAUTION
Ensure that the fan enclosure is installed so that the drive belt fits in the recessed portion of the enclosure.

4. Install the fan enclosure **H** with the two screws **J**.
5. Install the drive belt **I**.
6. Install the two insulator caps **D** on the motor leads **E** (one cap on lead 1 and one cap on leads 2 and 3).
7. Install the motor leads **E** in the cable guide on the casting.
8. Connect motor leads 2 and 3 to the top capacitor terminal; connect motor lead 1 to the bottom capacitor terminal.
9. Install the insulator caps **D** on the capacitor terminals **C**.
10. Connect the ac drive motor power cable **B**.
11. Connect the 5110 power cord.


3
2
1
A
B
C
D
3
2
1
E
F
G
H
I
J
K

230 CAPACITOR

Removal

1. Switch off the 5110 power; disconnect the 5110 power cord.

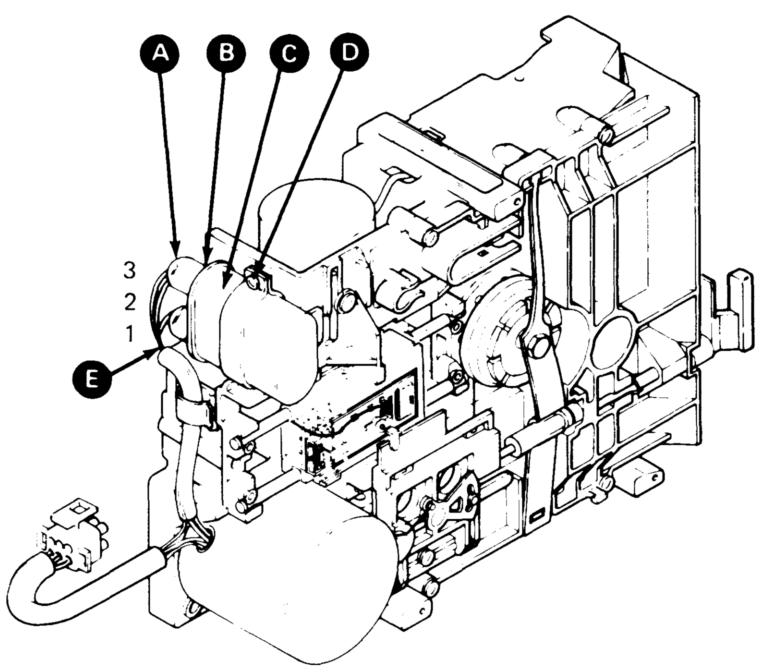
   DANGER
   High voltage may be present at the capacitor terminals.

2. Remove the insulator caps A from the capacitor terminals B.

3. Discharge the capacitor by shorting out its terminals with a large-bladed screwdriver.

4. Disconnect the motor leads E from the capacitor terminals.

5. Loosen the capacitor clamp screw D; remove the capacitor C.



Replacement

1. Install the capacitor C in its clamp and tighten the clamp screw D; ensure the capacitor terminals face the pulley side of the diskette unit.

2. Connect motor leads 2 and 3 to the upper capacitor terminal.

3. Connect motor lead 1 to the lower capacitor terminal.

4. Install the insulator caps A on the capacitor terminals B.

5. Connect the 5110 power cord.

231 AC DRIVE BELT AND PULLEY

Removal

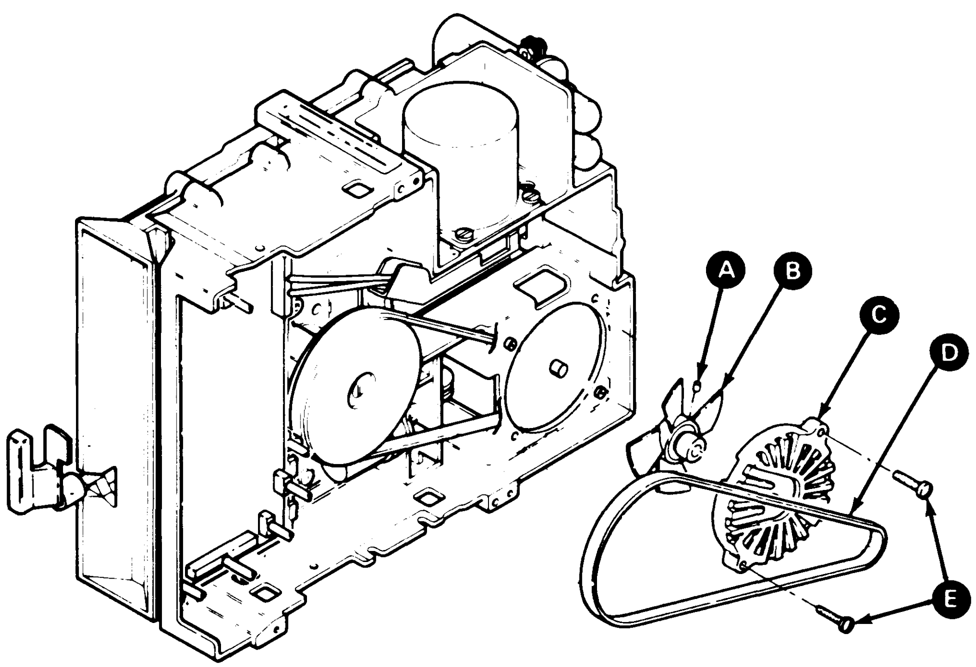
1. Switch off the 5110 power.
2. Remove the drive belt D.
3. Remove the two enclosure mounting screws E; remove the fan enclosure C.
4. Loosen the setscrew A; remove the drive motor fan and pulley assembly B.

Replacement

1. Install the drive motor pulley and fan B on the motor shaft, with the setscrew A centered on the flat surface of the shaft (leave the setscrew loose).
2. Position the fan and pulley on the motor shaft with a gap of 0.5-mm (0.020-in) between the motor and the fan hub; tighten the setscrew.

   CAUTION
   Ensure that the fan enclosure is installed so that the drive belt fits in the recessed portion of the enclosure.

3. Install the fan enclosure C with the two screws E.
4. Install the drive belt D.



STEPPER DRIVE MOTOR (Page 1 of 2)

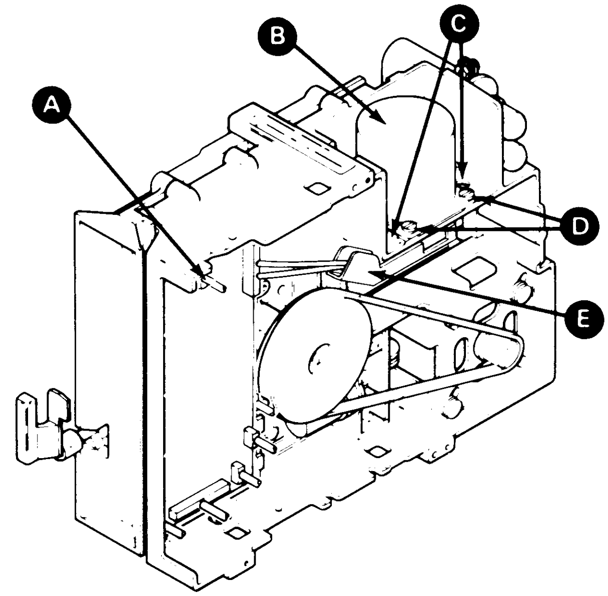
Removal

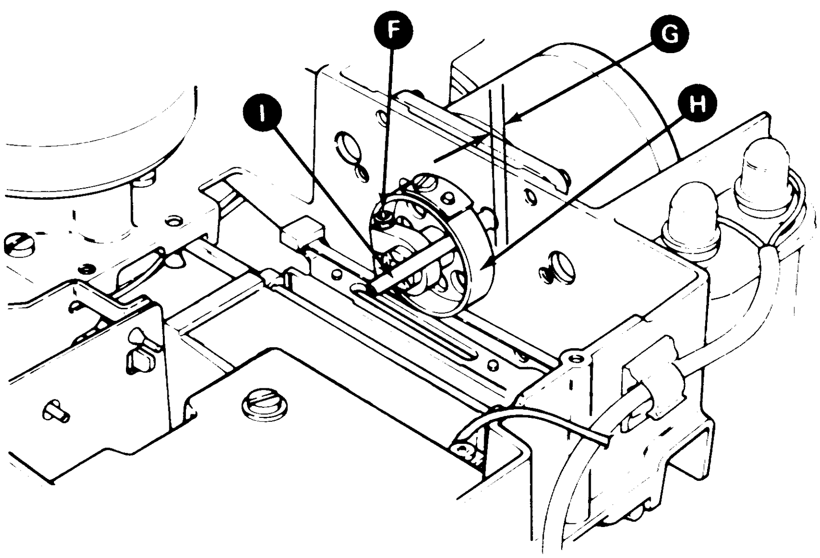
CAUTION
The drive band assembly can be easily damaged. Be careful not to bend, dent, or scratch the band.

1. Switch off the 5110 power.
2. Disconnect the stepper motor cable A from the control card.
3. Remove the cable guide E: squeeze at C and push the cable guide down.
4. Measure and record the gap G between the stepper motor pulley H and the casting.
5. Loosen the clamp screw F. To prevent damaging the drive band, give support to the pulley H before removing the stepper motor.
6. Remove the four stepper motor mounting screws D.
7. Remove the stepper motor B.

Replacement

1. Install the stepper motor B using the four mounting screws D; position the motor cable toward the control card.
2. Connect the stepper motor cable A to the control card.
3. Set the gap G (recorded in step 4 of the stepper drive motor removal) and tighten the clamp screw F.
4. Snap the cable guide E into the casting.
5. Perform the head/carriage assembly service check (225).


A
B
C
D
E


F
G
H
I

233 STEPPER MOTOR PULLEY AND CLAMP
(Page 1 of 2)

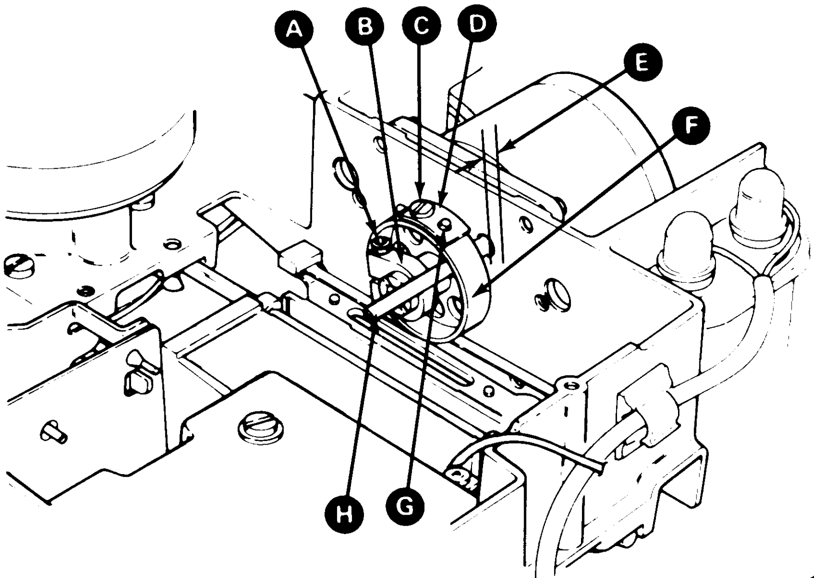
Removal

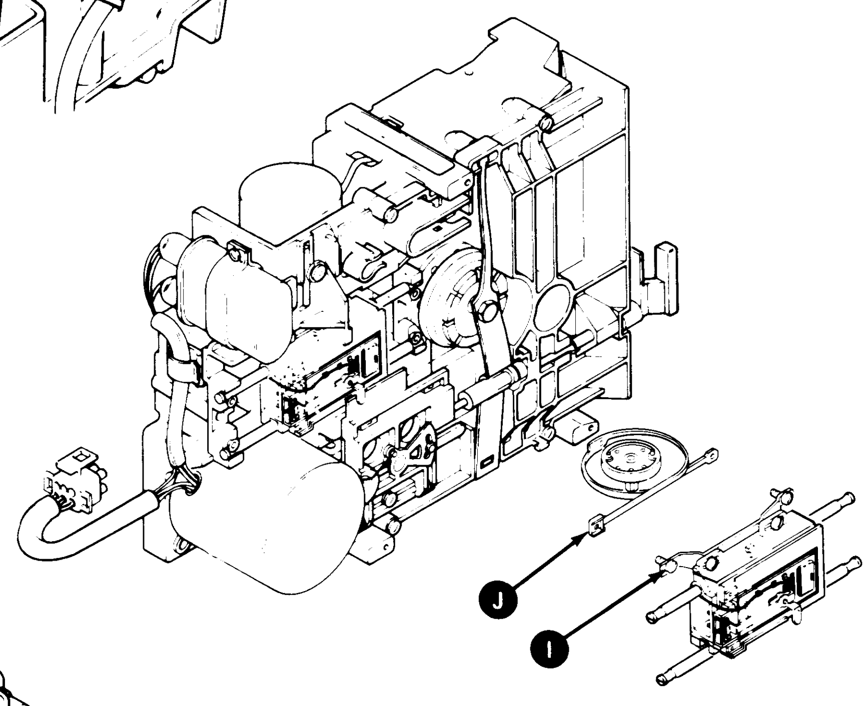
1. Switch off the 5110 power.
2. Remove the cable guide L (squeeze at K; push the cable guide down).
3. Remove the drive band screw C and clamp D.
4. Loosen the drive band screw I; leave the drive band end J loose to release the drive band tension on the pulley pin G.
5. Measure and record the gap E between the stepper motor pulley F and the casting.
6. Loosen the clamp screw A; remove the clamp B and the pulley F.

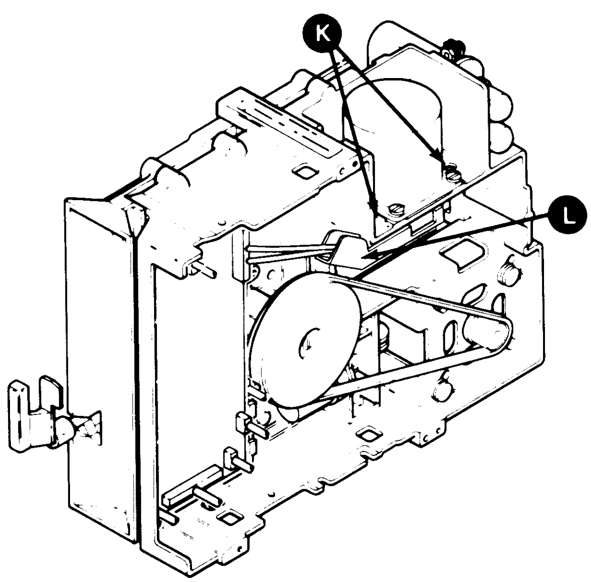
Replacement

1. Install the pulley F and the clamp B. Set the gap E (recorded in step 5 of the removal procedure) and tighten the clamp screw A.
2. Install the drive band end on the pulley pin G; install the clamp D and the drive band screw C.
3. Tighten the drive band screw C; ensure the drive band is parallel to the edge of the pulley F.
4. Adjust the drive band (234), starting with step 7.

233 STEPPER MOTOR PULLEY AND CLAMP
(Page 2 of 2)







Maintenance

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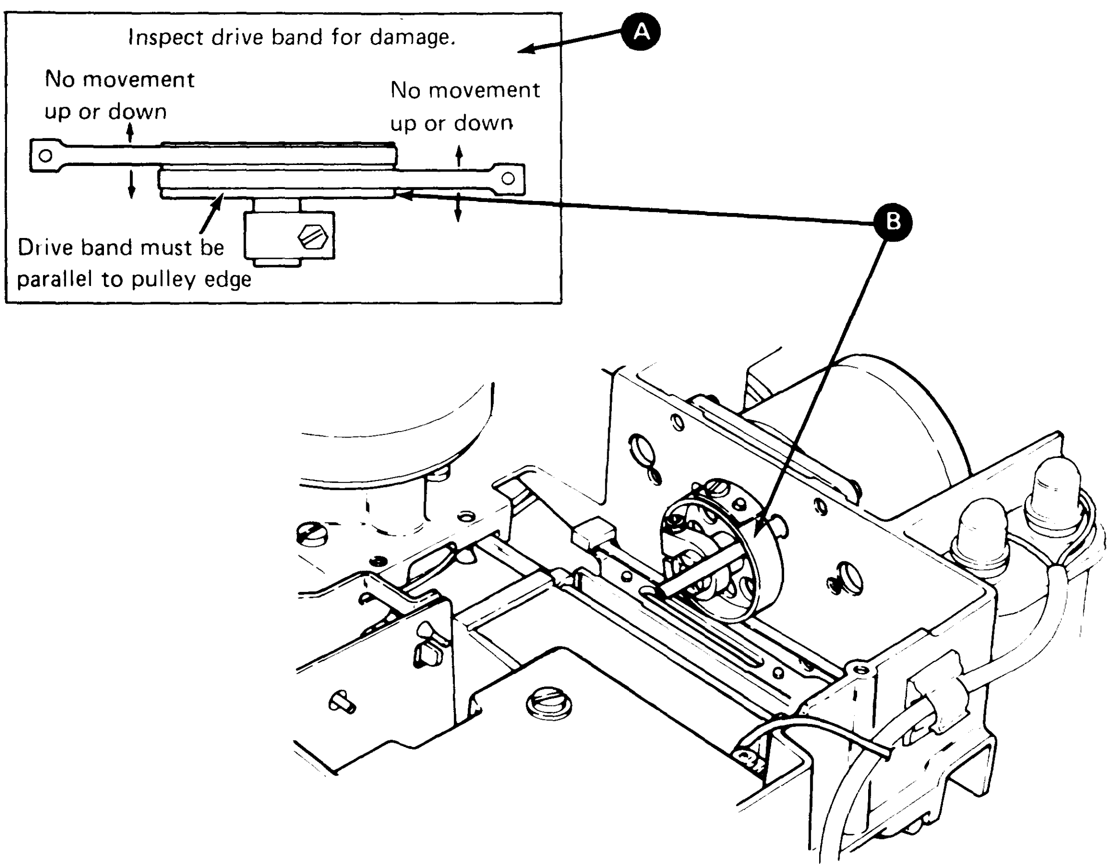
234 DRIVE BAND (Page 1 of 5)

Service Check

1. Switch off the 5110 power.
2. Move the head/carriage assembly by hand between cylinders 00 and 76. The drive band should track without moving up or down on the pulley B as shown in A.
3. If the drive band does not track properly, adjust the drive band.
4. Replace the drive band if it is damaged.



Adjustment

1. Switch off the 5110 power.

2. Remove the cable guide B (squeeze at A; push the guide down).

3. Place the head/carriage assembly E at cylinder 40.

4. Loosen the two carriage bracket mounting screws D and F and the pulley screw H.

5. Tighten the screw D; ensure that the drive band is parallel to the carriage bracket C.

6. Tighten the screw H; ensure that the drive band I is parallel to the edge of the pulley J.

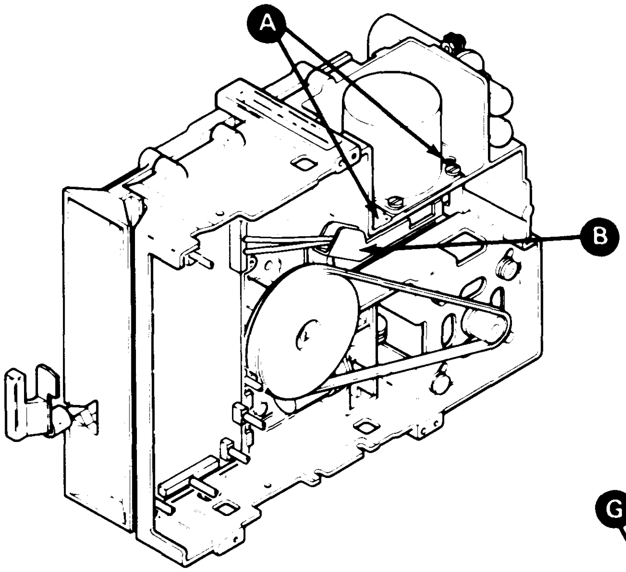
7. Block the head/carriage approximately 25.0-mm (1.0-in) from the rear of the casting.

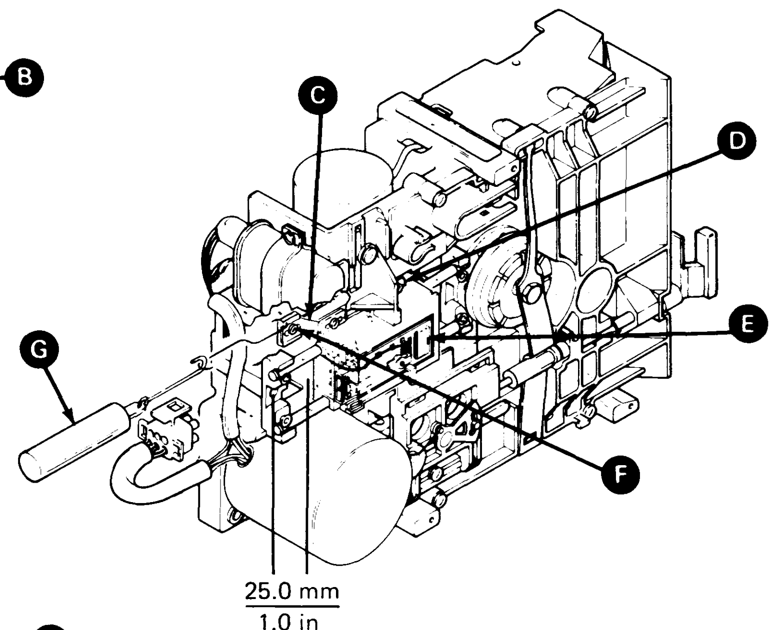
8. With the force gauge G (part 460870), pull on the loose end of the drive band with 0.907 ± 0.113 kg (2.5 ± 0.25 lbs) of force. Tighten the screw F; ensure that the drive band is parallel to the carriage bracket C.

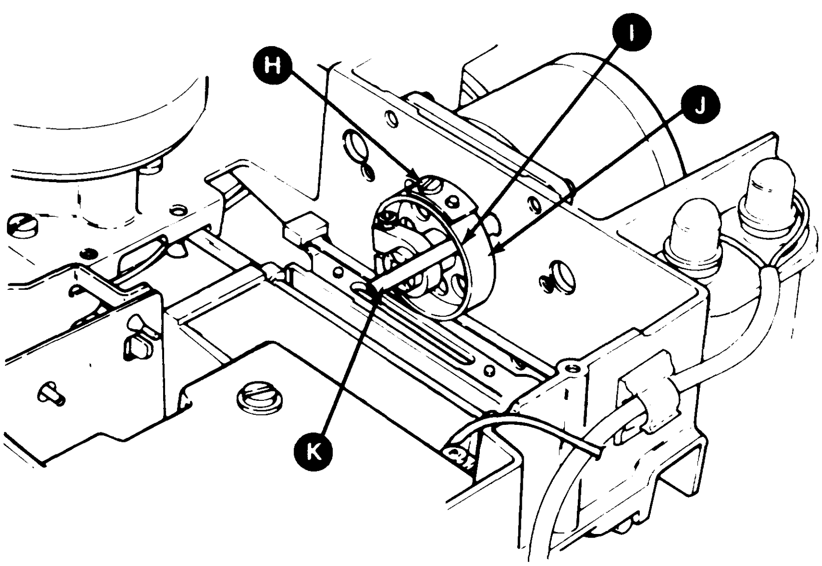
9. Move the carriage back and forth; ensure that the drive band tracks properly as shown in L.

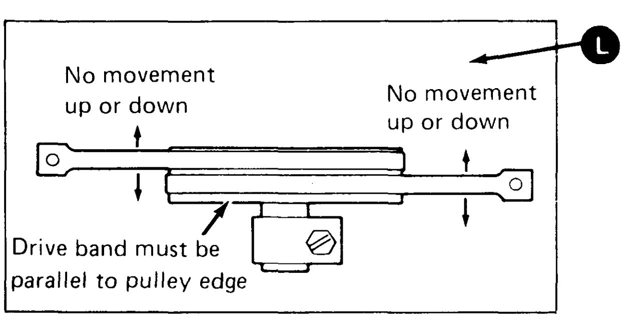
10. Adjust the head/carriage (225), starting with step 4.

234 DRIVE BAND (Page 3 of 5)









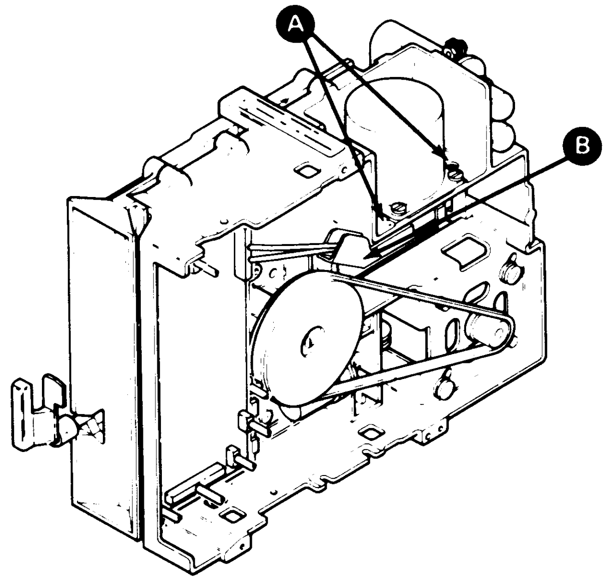
Removal

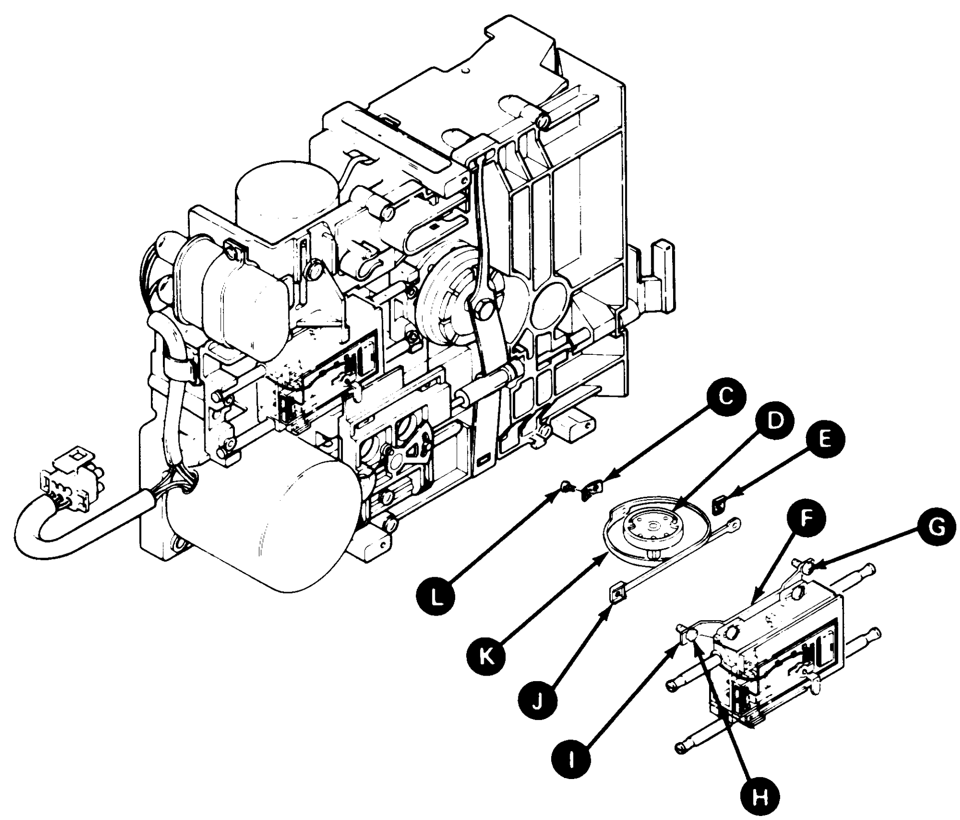
CAUTION
The drive band assembly can be easily damaged. Be careful not to bend, dent, or scratch the drive band.

1. Switch off the 5110 power.
2. Remove the cable guide B (squeeze at A; push the guide down).
3. Remove the three mounting screws G, L, and H; remove the clamps C and E that attach the drive band K to the stepper motor pulley D and the carriage bracket F.
4. Remove the drive band K.

Replacement

1. Attach the end of the drive band with the welded adapter J to the slotted end I of the carriage bracket; leave the screw H loose.
2. Attach the drive band to the stepper motor pulley D with the screw L and the clamp C; leave the screw L loose.
3. Attach the other end of the drive band to the carriage bracket F with screw G and clamp E; leave the screw G loose.
4. Perform the drive band adjustment, starting with step 5.


A
B


C
D
E
F
G
L
K
J
I
H

235 LED (Page 1 of 2)

Service Check

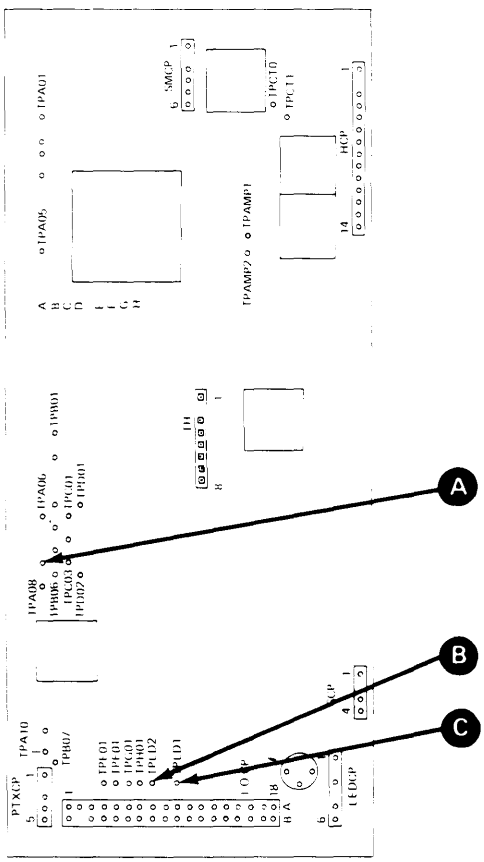
1. Connect the negative probe of the CE meter to A (ground).

2. Set the CE meter scale to 5 Vdc; connect the positive probe to C (31SD LED voltage).

3. Check for a voltage level of 1 Vdc to 2 Vdc.

4. Move the positive probe to B (51TD LED voltage).

5. Check for a voltage level of 1 Vdc to 2 Vdc.



Drive Control Card

Removal

1. Remove the diskette guide (223).

2. Remove the LED mounting screw C and the nut A.

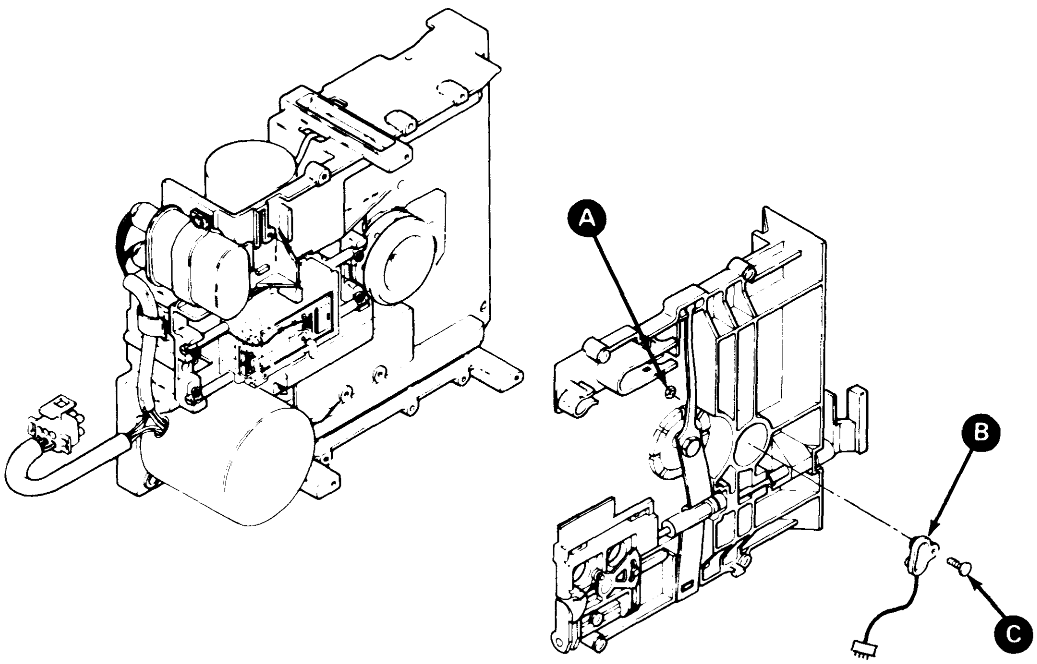
3. Remove the LED assembly and the cable B (note the cable path for the replacement procedure).

Replacement

1. Install the LED assembly and the cable B, the mounting screw C, and the nut A onto the diskette guide (position the cable in the diskette guide).

2. Install the diskette guide (223).

Maintenance



Service Check

1. Switch off the 5110 power.

2. Disconnect the ac drive motor power cable F.

3. Disconnect the PTX cable connector G from the control card.

> **DANGER**
> Voltage is present at power supply connectors P4 and P5 when the 5110 power is switched on.

4. Switch on the 5110 power.

5. Set the CE meter scale to 5 Vdc and connect the positive probe to C (index).

6. Connect the negative probe of the CE meter to A (ground).

7. Check for a voltage level of less than 1 Vdc.

8. Connect one end of a jumper to E (Diskette 2, 2D PTX emitter). Do not connect the other end.

9. Watch the CE meter; touch the other end of the jumper to B (Diskette 1 collector) several times. The CE meter should read 2.5 Vdc or more when B is touched (a false reading can occur the first time B is touched).

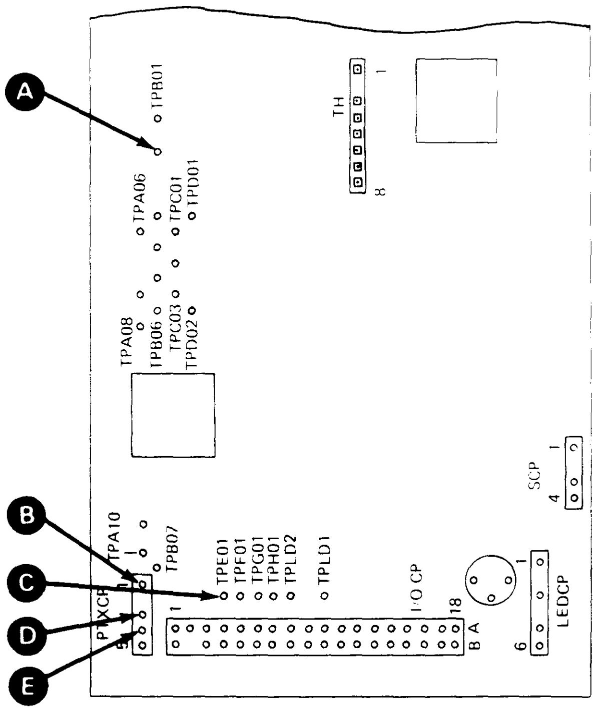
10. Repeat steps 8 and 9 with the jumper on D (Diskette 1 PTX emitter).

11. Switch off the 5110 power.

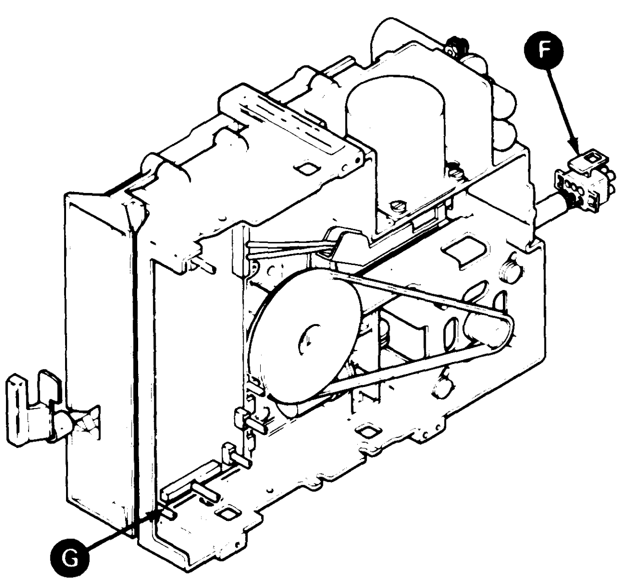
12. Remove the jumper.

13. Connect the PTX cable connector G to the control card.

14. Connect the ac drive motor power cable F.



Drive Control Card



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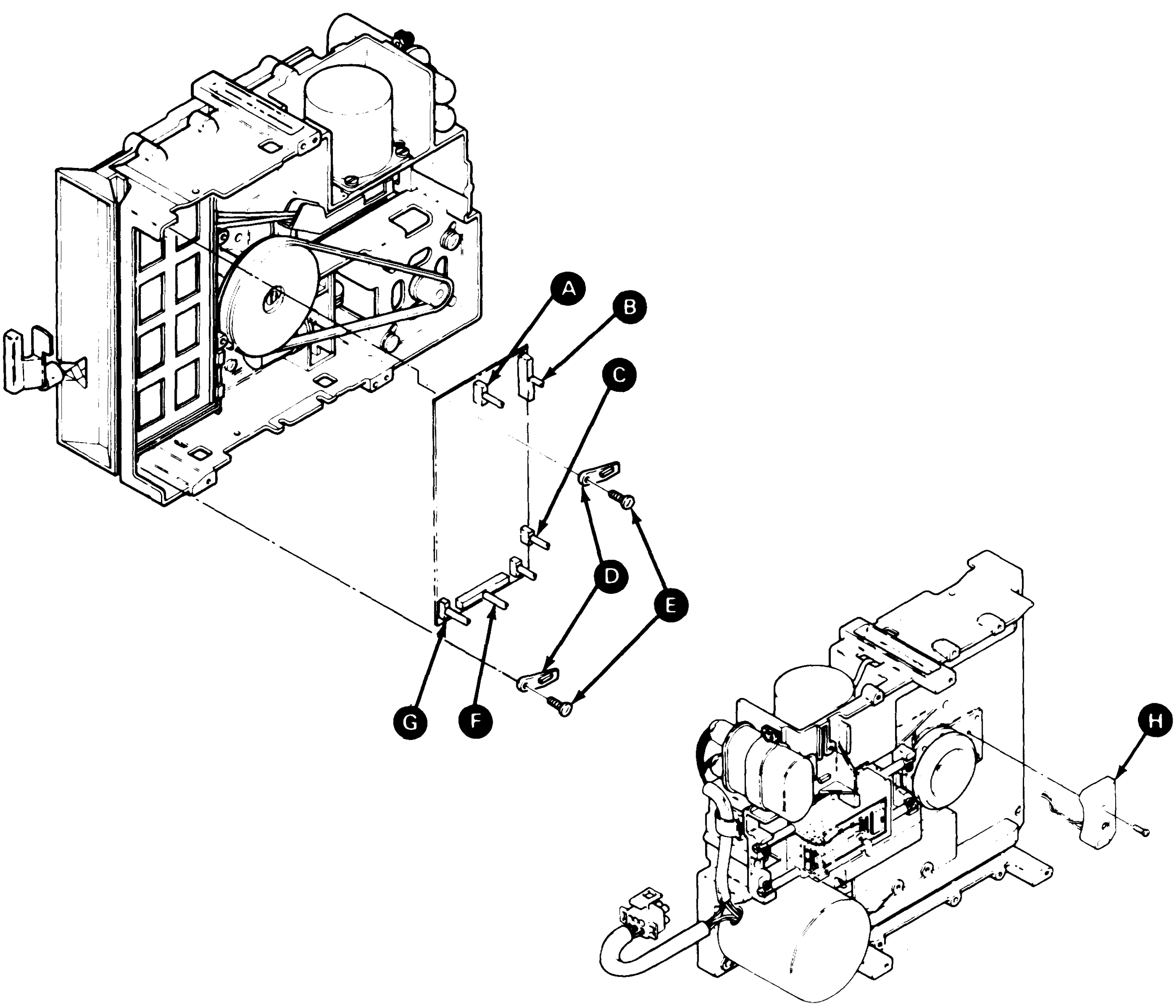
Removal

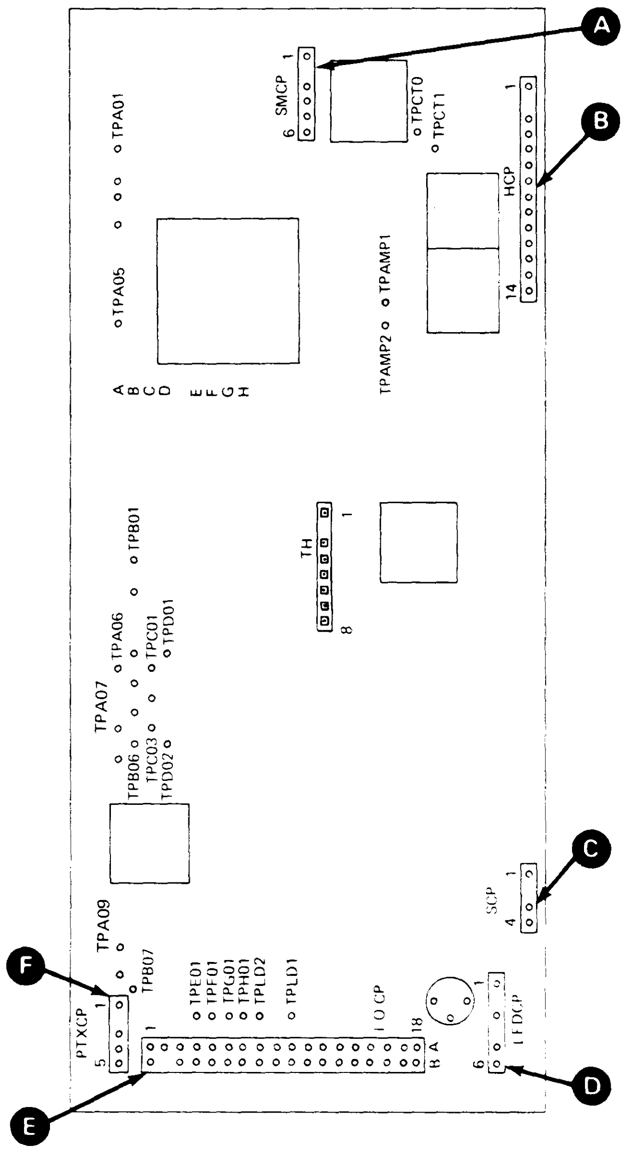
1. Remove the diskette guide (223).
2. Remove the remaining cable connectors (stepper drive motor A, head cable B, solenoid cable C, attachment cable F, and PTX cable G from the drive control card. Note the connector locations and cable paths for the replacement procedure.
3. Loosen the two control card retaining screws E.
4. Turn the two card retainers D out of the way; remove the control card.
5. Remove the PTX assembly H.

Replacement

1. Install the PTX assembly H.
2. Install the control card; turn the two retainers D to hold the card in place.
3. Tighten the two retaining screws E.
4. Connect the cable connectors A, B, C, F, and G.
5. Install the diskette guide (223).



Pin Assignments



TH01	Diff Read B
TH02	Blank
TH03	Diff Read A
TH04	High Gain
TH05	Disable Stepper Motor
TH06	+14V
TH07	Access Clamp Voltage
TH08	Oscillator

TPA01	MC-3
TPA02	MC-1
TPA03	MC-2
TPA04	MC-0
TPA05	Ground*
TPA06	Erase Gate
TPA07	Ground*
TPA08	Head Load
TPA09	+5 Vdc*
TPA10	51TD PTX
TPB01	+24 Vdc
TPB02	Ground
TPB03	Select Head 1
TPB04	Write Gate
TPB05	Head Engage
TPB06	Write Data

TPB07	31SD PTX
TPC01	Access 0
TPC02	Inner Tracks
TPC03	–5 Vdc
TPD01	Access 1
TPD02	Switch Filter
TPE01	Index
TPF01	Diskette Sense
TPG01	Write/Erase Enabled
TPH01	File Data
TPLD2	51TD LED Voltage
TPLD1	31SD LED Voltage
TPAMP2	Preamp TP2
TPAMP1	Preamp TP1
TPCT0	Center Tap Head 0
TPCT1	Center Tap Head 1

*Connection for general logic probe (GLP)

A Stepper Motor Connector

A01 +24 Volts Common
A02 Blank (key)
A03 MC-3
A04 MC-2
A05 MC-1
A06 MC-0

B Head Connector

A01 NC
A02 Blank (key)
A03 Head 0 Read/Write Coil
A04 Head 0 Center Tap
A05 Head 0 Read/Write Coil
A06 Head 0 Erase
A07 Head 0 Erase Common
A08 Ground
A09 Ground
A10 Head 1 Erase Common
A11 Head 1 Erase
A12 Head 1 Read/Write Coil
A13 Head 1 Center Tap
A14 Head 1 Read/Write Coil

C Solenoid Connector

A01 NC
A02 Blank (key)
A03 +Head Load
A04 -Head Load

D LED Connector

A01 Diskette 2, 2D Ground
A02 Blank (key)
A03 Diskette 2, 2D Anode
A04 Blank
A05 Diskette 1 Ground
A06 Diskette 1 Anode

E Attachment Cable Connector

A01 –5 Volts
A02 Power Supply Ground
A03 to A18 ground
B01 +5 Volts
B02 Blank (key)
B03 +24 Volts
B04 Index
B05 Diskette Sense
B06 Write/Erase Enabled
B07 File Data
B08 Inner Tracks
B09 Erase Gate
B10 Access 0
B11 Select Head 1
B12 NC
B13 Access 1
B14 Write Gate
B15 Head Engage
B16 Switch Filter
B17 Write Data
B18 NC

F PTX Connector

A01 Diskette 1 Collector (+5 Volts)
A02 Blank (key)
A03 Diskette 1 PTX Emitter
A04 Diskette 2, 2D PTX Emitter
A05 Diskette 2, 2D Collector (+5 Volts)

Removal

1. Switch off the 5110 power.

2. Remove the cable connectors (stepper drive motor cable A, head cable B, solenoid C, LED cable F, attachment cable G, and PTX cable H from the control card. Note the connector locations and cable path for the replacement procedure.

3. Loosen the two control card retaining screws E.

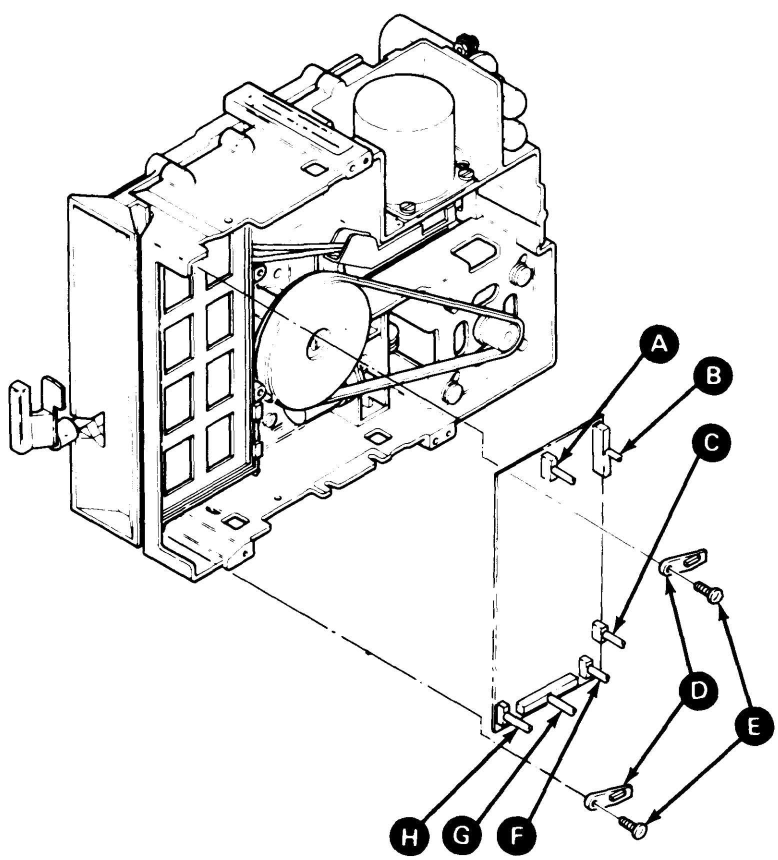
4. Turn the two card retainers D out of the way; remove the control card.

Replacement

1. Install the control card; turn the two retainers D to hold the card in place.

2. Tighten the two retaining screws E.

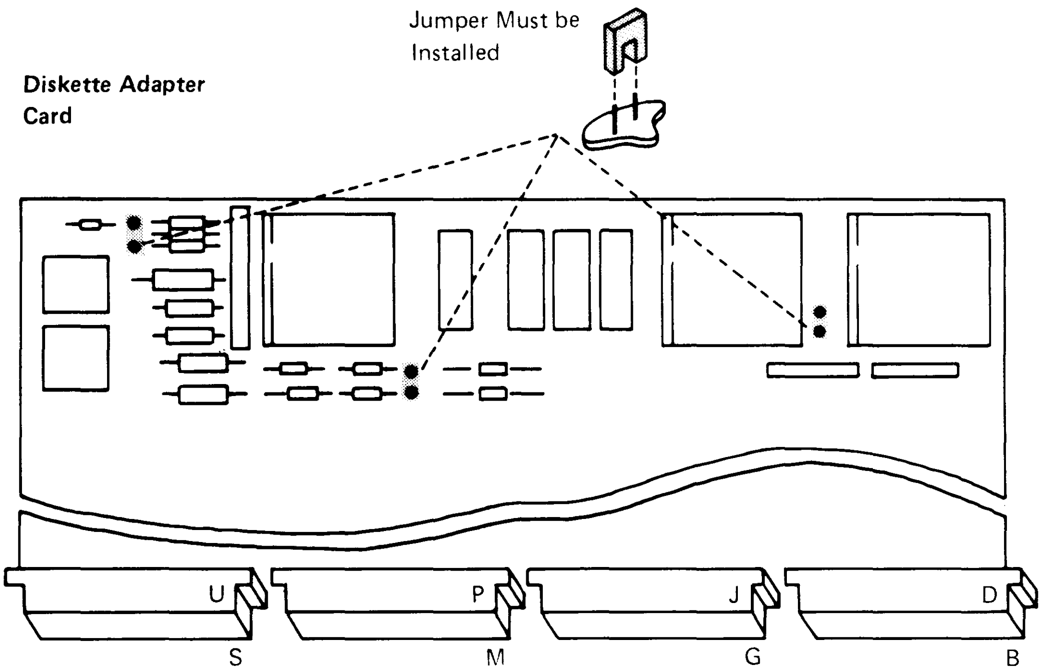
3. Connect the cable connectors A, B, C, F, G, and H.



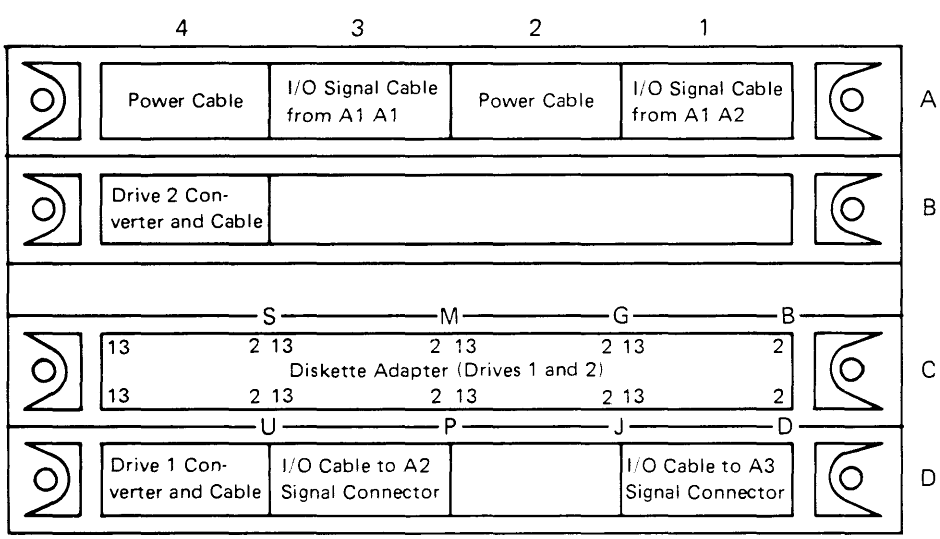
238 ADAPTER CARD

Card and Board Pin Assignments

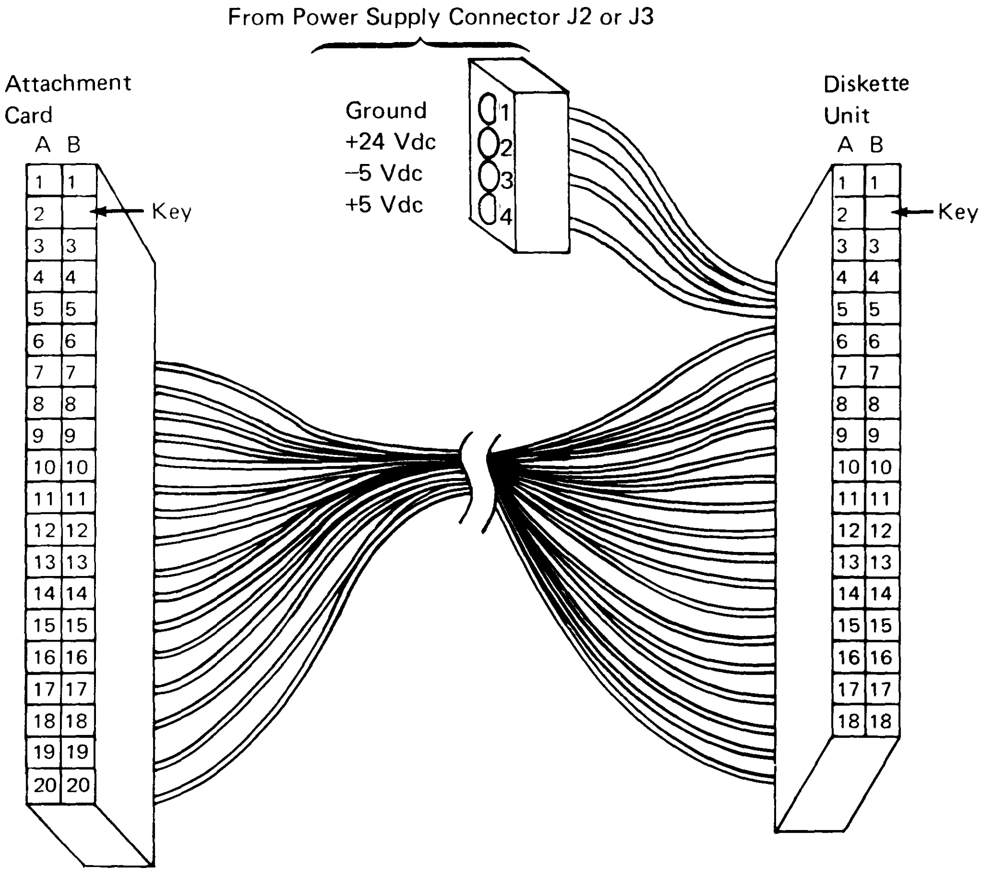
Diskette Adapter Card



B1 Board



239 DISKETTE ATTACHMENT CABLE AND SOCKET PIN ASSIGNMENTS



Pin	Line name	Pin
*	–5 Vdc	A01
*	Ground	A02
*	+5 Vdc	B01
*	+24 Vdc	B03
A04 Through A18	Ground (twisted pair)	A04 Through A18
B04	Index	B04
B05	Diskette sense	B05
B06	Write/erase enabled	B06
B07	File data	B07
B08	Inner tracks	B08
B09	Erase gate	B09
B10	Access 0	B10
B11	Select head 1	B11
B13	Access 1	B13
B14	Write gate	B14
B15	Head engage	B15
B16	Switch filter	B16
B17	Write data	B17

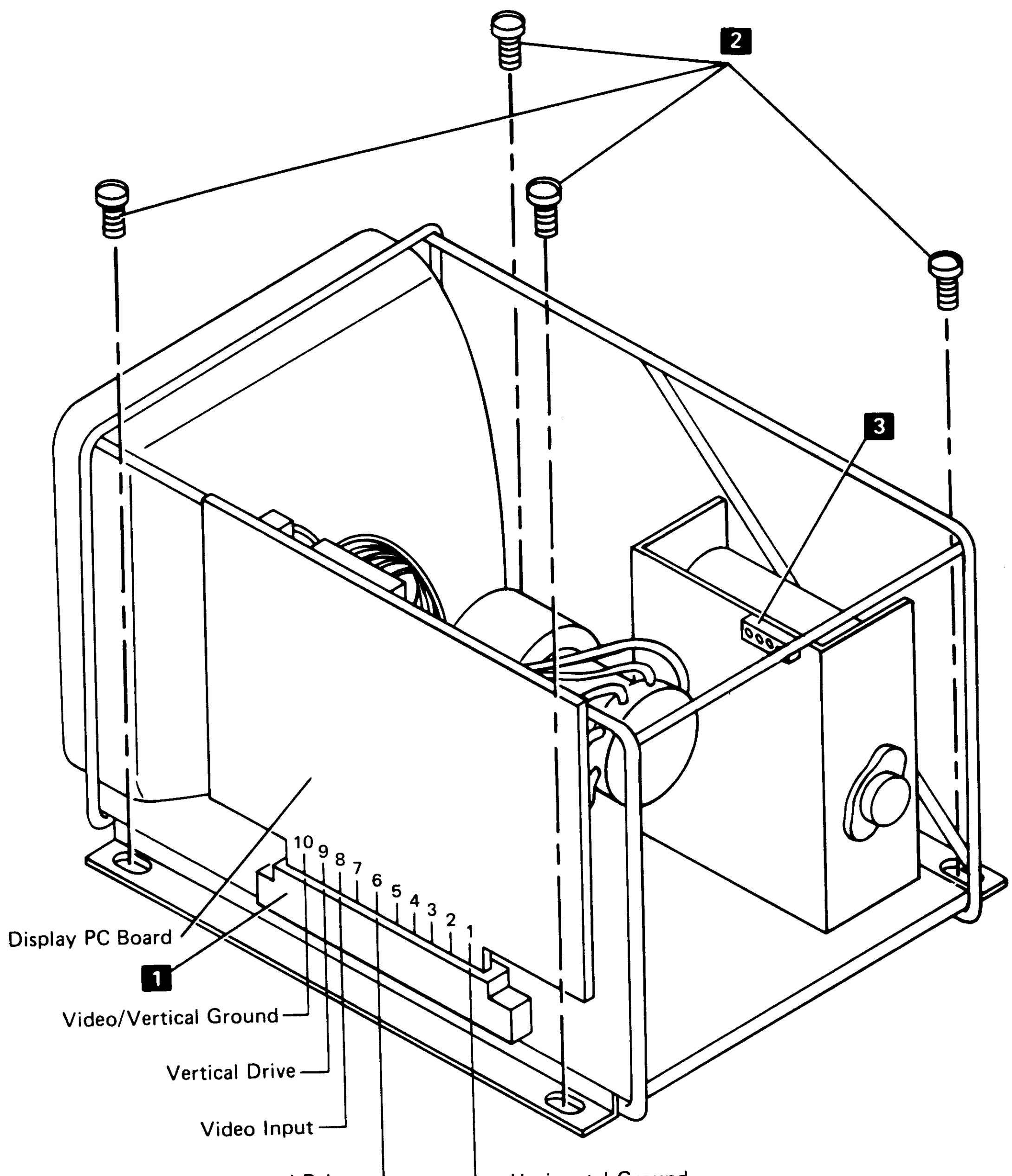
*From Power Supply Connector J2 or J3

240 DISPLAY REMOVAL

Removal

DANGER
Display assembly voltages:
Display PC board 340 V
CRT 13 KV

1. Switch off the 5110 power.
2. Remove the connector **1** at the display PC board.
3. Remove the ac power plug **3**.
4. Remove the four mounting screws **2**.
5. Remove the display assembly.



241 BRIGHTNESS CONTROL

Service Check

The Brightness control adjusts the brightness of the white characters on the dark background.

242 REVERSE DISPLAY SWITCH
(Located on the CE panel)

Service Check

1. With the Brightness control set to the center of its range, set the Reverse Display toggle switch to display black characters on a white background.

2. Set the Reverse Display toggle switch to display white characters on a black background.

243 DISPLAY REGISTERS/NORMAL SWITCH

Service Check

1. Set the Display Registers/Normal switch to the Normal position.

2. Operate the Restart switch. LOAD0 or CLEAR WS should appear on the display after 25 seconds.

3. Switch to the Display Registers position. The display shows the first 512 bytes of read/write storage. All 16 lines should be filled with hex characters, some of which will change rapidly.

245 RESTART SWITCH AND LAMP TEST

Service Check

1. The Restart switch resets all circuits and initiates the bring up program. When operated, it supplies voltage to test the lamps.

2. Operate and hold the Restart switch. The Process Check and the In Process lights should be on.

3. Release the Restart switch. Both lights should go off. After 25 seconds, LOAD0 or CLEAR WS should appear on the display.

246 BASIC – APL SWITCH

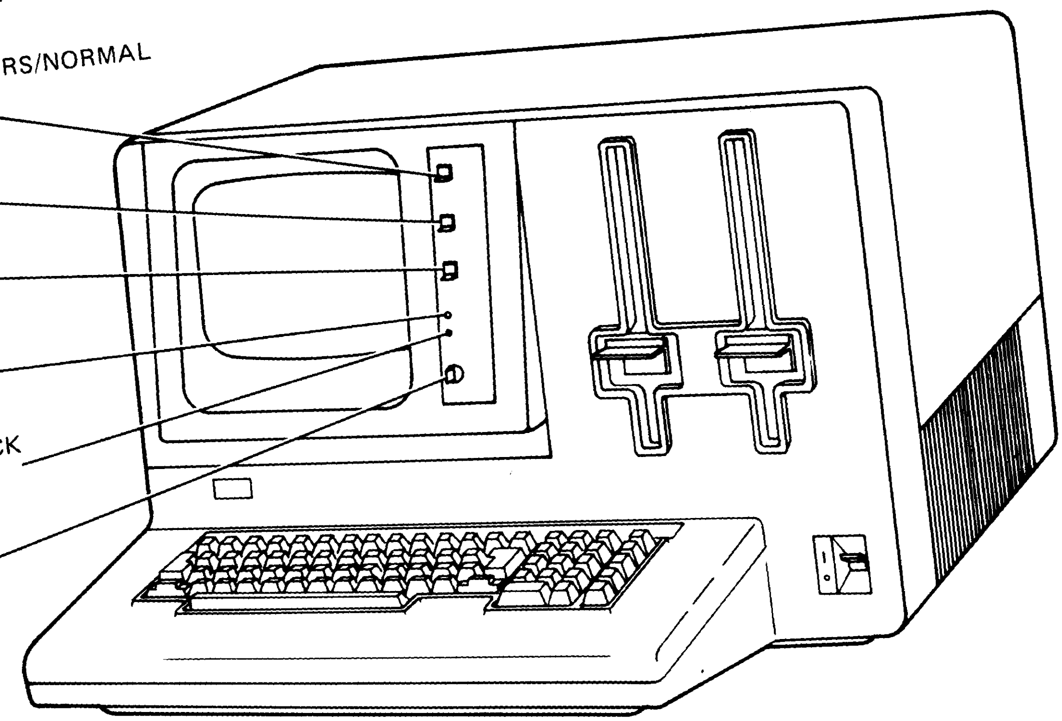
Service Check

1. The position of this switch is sensed only during a power up or restart operation.

2. Set the BASIC–APL switch to the BASIC position, set the Restart switch. LOAD0 should appear on the display within 25 seconds.

3. Set the BASIC–APL switch to the APL position, set the Restart switch. CLEAR WS should appear on the display within 25 seconds.

247 DISPLAY RASTER ADJUSTMENTS
(Page 1 of 3)



The potentiometers for making the raster adjustments are on the display PC board (see 240). Labeling on the PC board identifies the potentiometers.

DANGER
The display unit contains high voltages; therefore, use extreme caution when making internal adjustments.

Brightness

To adjust the contrast of the display screen, use the Brightness control on the control panel. Brightness is used instead of contrast because brightness better describes what is happening to the display screen.

Adjust the brightness potentiometer on the display PC board until the white retrace lines just disappear.

Focus

The focus potentiometer on the PC board adjusts the sharpness of the characters on the display screen.

247 DISPLAY RASTER ADJUSTMENTS
(Page 2 of 3)

Centering

Ring magnets determine the horizontal and vertical position of the 16 lines on the display screen. If the display is simply tilted, do not adjust the ring magnets. Instead, rotate the entire yoke **2**.

To correct positioning problems:

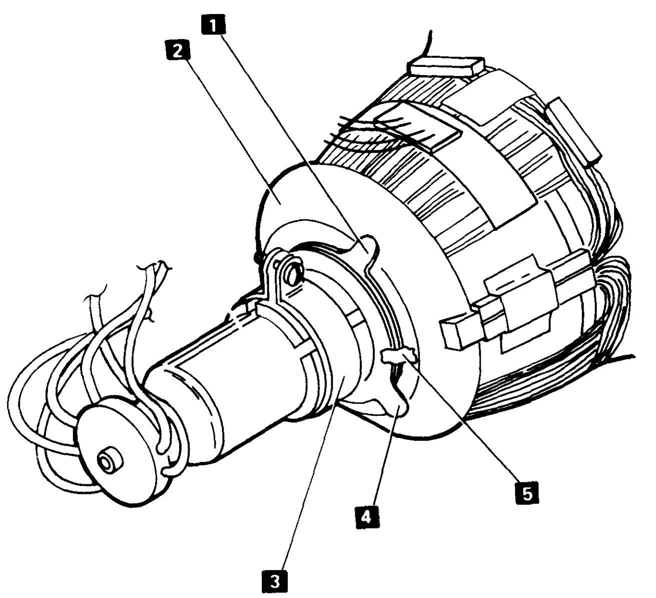
1. Set the Reverse Display toggle switch (located on the CE panel) down to the Reverse Display position.
2. Break the adhesive **5** that seals the ring magnets in place.
3. Adjust the rear ring magnet **4** for horizontal centering.
4. Adjust the front ring magnet **1** for vertical centering.
5. Place a small spot of light adhesive on each of the ring magnets to seal them in place.

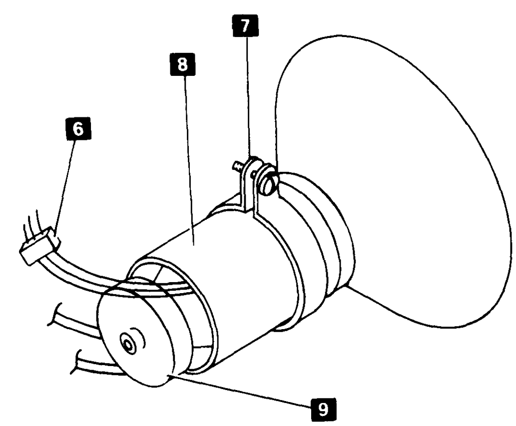
To correct a tilted display:

1. Loosen the yoke collar **3**.
2. Adjust the yoke to correct the tilted display.
3. Tighten the yoke collar.

If the display screen has a shield:

1. Disconnect the cable connector **6**.
2. Remove the connector **9**.
3. Loosen the clamp **7**; remove the rear shield **8**.
4. Reverse the removal steps to install the shield.





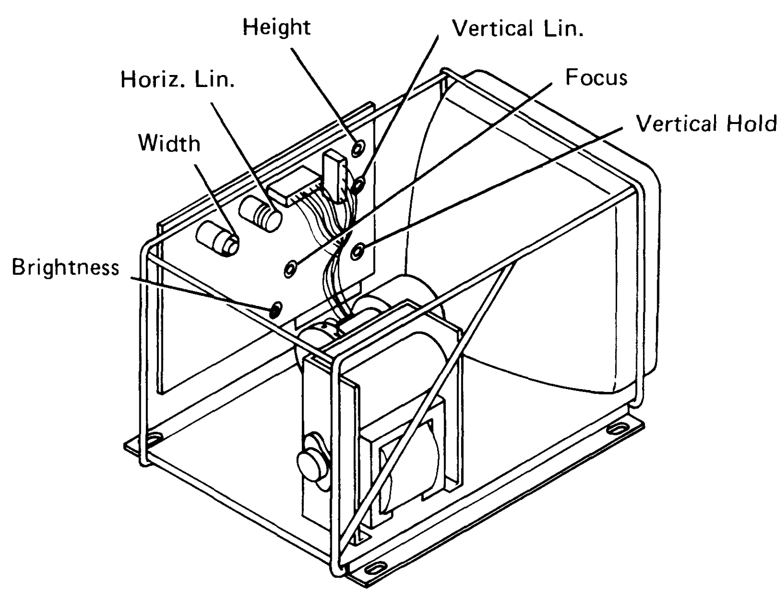
Horizontal

The horizontal adjustment determines the overall width of the 16 lines on the display screen. Use the width coil on the display PC board for making this adjustment. Before adjusting the width coil, adjust the horizontal linearity coil to center the display horizontally.

Vertical

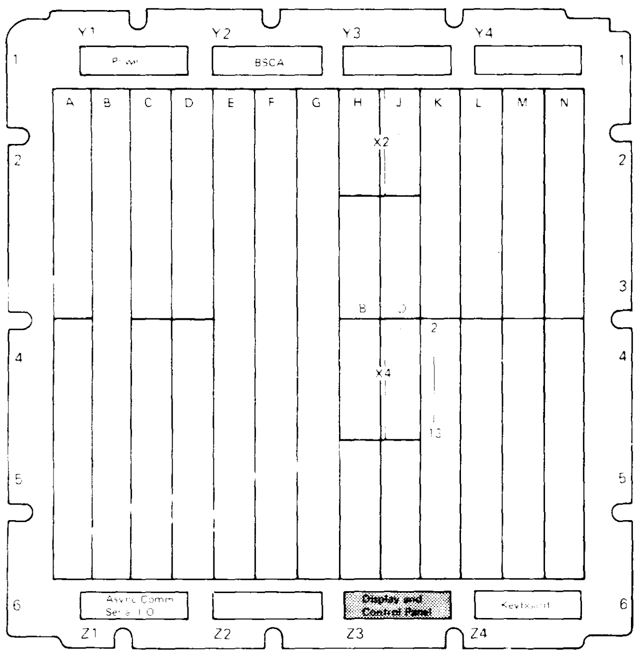
The vertical adjustments (height, linearity, and hold) determine the overall height of the 16 lines of characters, the height of the individual characters, and the stability of the entire display screen. The vertical adjustment potentiometers are located on the display PC board.

1. Adjust the vertical hold potentiometer for a stable display.
2. Adjust the vertical height potentiometer until the desired overall height of the 16 lines is achieved. The vertical hold might have to be adjusted to keep the display from rolling.
3. Adjust the vertical linearity potentiometer until all characters in the display appear to be the same height. This adjustment and the height adjustment are interactive and might require repeated adjustments.
4. Adjust the vertical hold potentiometer until the display begins to roll, then reverse the adjustment until the rolling stops.
5. Recheck the height and the linearity.

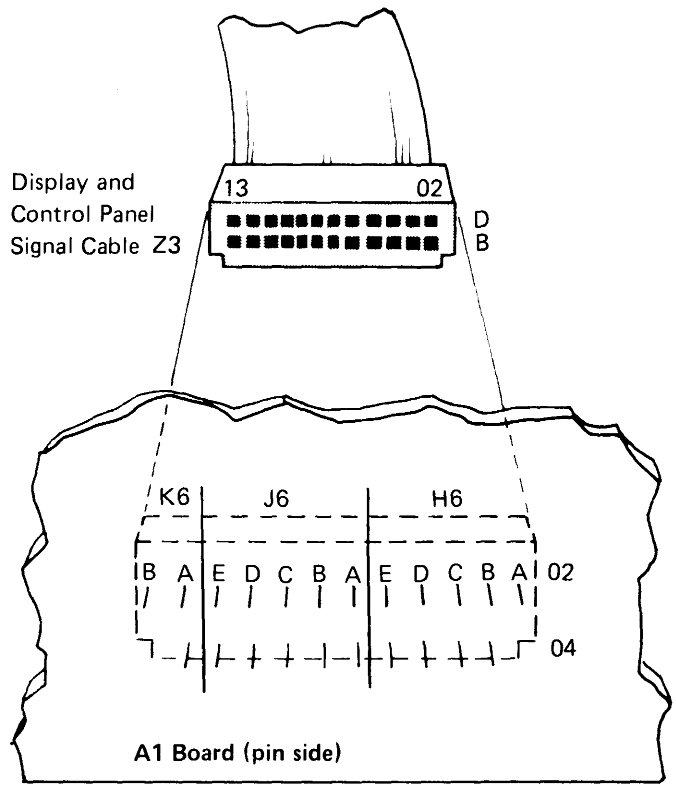


248 DISPLAY – Z3 SOCKET PIN ASSIGNMENTS

A1 Board (card side)



See 204, 249

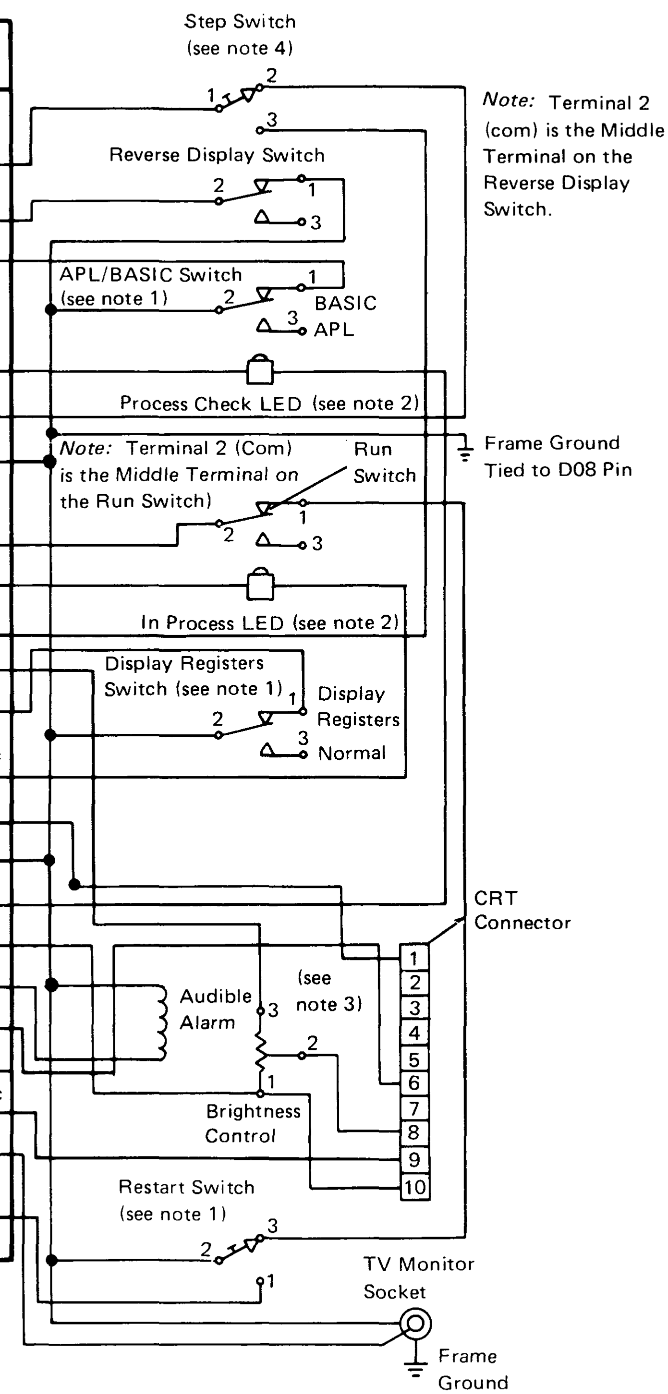


Z3 Cable Pin	A1 Board Pin	Line Name	Z3 Cable Pin	A1 Board Pin	Line Name
D02	H6A02	-Reverse Display	B02	H6A04	+Single Instruction Switch (common)
D03	H6B02	+5 Vdc	B03	H6B04	+APL Switch
D04	H6C02	-Run Switch and Not IPL	B04	H6C04	-Single Instruction Switch (N/C)
D05	H6D02	+Single Instruction Switch (N/O)	B05	H6D04	+In Process LED
D06	H6E02	-Display Reg	B06	H6E04	-Machine Video
D07	J6A02	-Normal 64	B07	J6A04	-I/O Display Off
D08	J6B02	Ground	B08	J6B04	Ground
D09	J6C02	Ground	B09	J6C04	-Machine Check LED
D10	J6D02	+Alarm On	B11	J6E04	(not used)
D11	J6E02	-External Horizontal Drive	B12	K6A04	(not used)
D12	K6A02	-External Vertical Sync	B13	K6B04	+Monitor Video
D13	K6B02	-Power On Reset Switch			

249 DISPLAY AND CONTROL PANEL CABLE

Z3 Connector to CRT Connector and Control Panel Switches

A1 Board Card Pin	Z3 Connector A1 Board Pin	Z3 Connector Cable Pin	Line Name
H2D12	H6A04	B02	+Single Instr Switch (Comm)
G2M03	H6A02	D02	–Reverse Display
H2504	H6B04	B03	+APL Switch
See 274	H6B02	D03	+5V
J2D05	H6C04	B04	–Single Instr Switch (N/C)
G2G11	J6A02	D07	–Norm 64
J2B03	H6C02	D04	–Run Switch and Not IPL
L2B07	H6D04	B05	+In-Process LED
J2D02	H6D02	D05	+Single Instr Switch (N/O)
G2B12	H6E04	B06	–Mach Video
G2B06	H6E02	D06	–Disp Reg
G2B03 L2D07	J6A04	B07	–I/O Display Off
See 274	J6B04	B08	Ground
See 274	J6B02	D08	Ground
L2D11	J6C04	B09	–Machine Check LED
See 274	J6C02	D09	Ground
G2P05	J6D02	D10	+Alarm On
G2B09	J6E02	D11	+Ext Hor Drive
	K6A04	B12	Unused
G2J02	K6A02	D12	–Ext Vertical Sync
G2B13	K6B04	B13	+Monitor Video
H2G02 L2D05	K6B02	D13	–Power On Reset Switch



Notes:

1. Top of switch when in machine. (side view)
2. White dot or short lead to minus pin. LED
3. Brightness control connections.
4. Step switch connections. Flat NC NO COM

Maintenance

250 KEY CODES

Note: All keyboard models provide the same code. If a key code is displayed during bring up and is not shown on this page, the code is for more than one key.

Alphameric Keyboard / Numeric Keyboard

	Alphameric														Numeric			
CMD	45	07	C7	A7	27	E7	67	77	F7	87	37	B7	14	94	96	D7	47	16
Shift	4C	0E	CE	AE	2E	EE	6E	7E	FE	8E	3E	BE	74	F4	F6	DE	4E	76
No Shift	4D	0F	CF	AF	2F	EF	6F	7F	FF	8F	3F	BF	34	B4	B6	DF	4F	36
													*	*	ATTN	*	*	HOLD

CMD	05	C5	A5	25	E5	65	75	F5	85	35	B5	12	92	57	D5	17	97
Shift	0C	CC	AC	2C	EC	6C	7C	FC	8C	3C	BC	72	F2	5E	DC	1E	9E
No Shift	0D	CD	AD	2D	ED	6D	7D	FD	8D	3D	BD	32	B2	5F	DD	1F	9F
													EXECUTE				

CMD	03	C3	A3	23	E3	63	73	F3	83	33	B3	10		55	D3	15	95
Shift	0A	CA	AA	2A	EA	6A	7A	FA	8A	3A	BA	70		5C	DA	1C	9C
No Shift	0B	CB	AB	2B	EB	6B	7B	FB	8B	3B	BB	30		5D	DB	1D	9D

CMD	01	C1	A1	21	E1	61	71	F1	81	B1	43	53	D1	13	93
Shift	08	C8	A8	28	E8	68	78	F8	88	B8	4A	5A	D8	1A	9A
No Shift	09	C9	A9	29	E9	69	79	F9	89	B9	4B	5B	D9	1B	9B

CMD	31	51	11	91
Shift	38	58	18	98
No Shift	39	59	19	99
	*			

See the keyboard theory

*Typamatic Key

Example: C = Key Code A 9

Key Code	X—A—X				X—9—X				
Keyboard Bits (see 255)	8	4	2	1	8	4	2	1	
	-Kbd0	-Kbd1	-Kbd2	-Kbd3	-Kbd4	-Kbd5	-Kbd6	-Kbd7	P
Level	+	-	+	-	+	-	-	+	-

251 KEYBOARD

Removal

1. Switch off the 5110 power.

2. Remove the keyboard cover (200).

3. Remove the keyboard cable retainer **4**.

4. Remove the keyboard cable **5**.

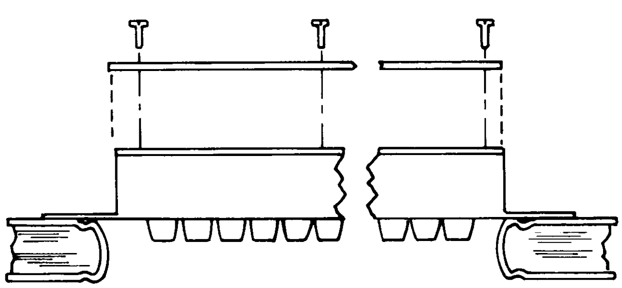
5. If you plan to remove a key module **1**, pull the keytop first **2**.

6. Lift the keyboard out of the machine.

Disassembly

Important! Work cleanly. The keyboard assembly *must* be kept free of dirt.

1. Set the keyboard (upside down) on two books or similar objects at least 1 inch (25.4 mm) thick, or fasten it upside down in the machine.



2. Check that there is no pressure on any of the keys.

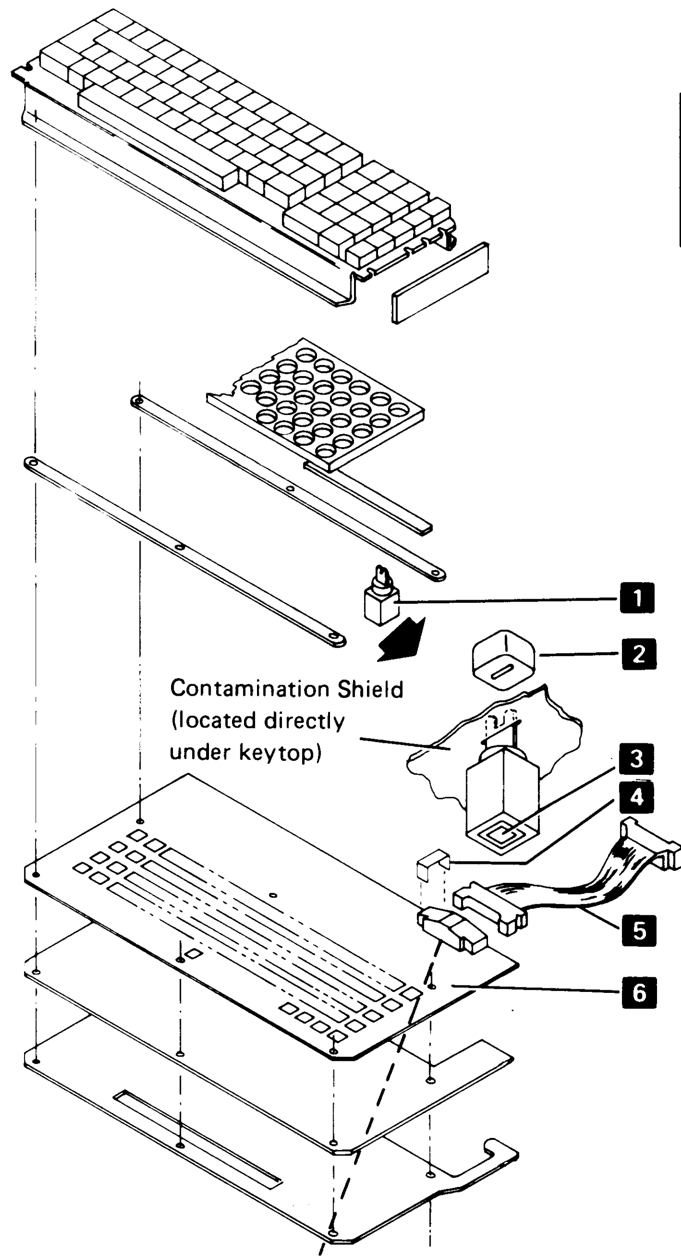
   CAUTION
   Removing the keyboard PC board with a key pressed allows the flyplate **3** to jump out of the module.

3. Remove six screws from the PC board **6** and lift it from the all keys assembly.

4. To assemble, follow the removal procedure in reverse order.

Cleaning

Clean the PC board **6** with water and a lint free cloth. Check the flyplates **3** for dirt; only clean the flyplates that are dirty or causing failures.



252 SPACEBAR

Removal

1. Hold the ends of the spacebar and pull up to slide the spacebar off the key stems.

2. If the pivots need to be removed, insert a screwdriver tip in the slot in the side of the frame and twist the screwdriver slightly until the pivot is removed.

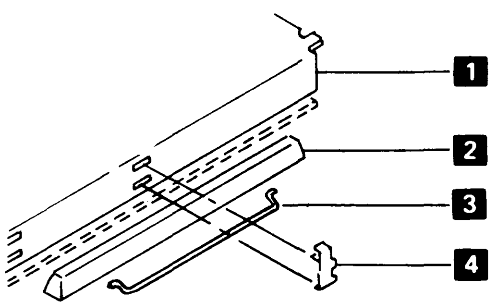
Installation

1. Press the pivots **4** into place in the frame **1**.

2. Place the spacebar **2** in position over its key modules.

3. Guide the stabilizer **3** into the slots in the pivots.

4. Press the spacebar down onto the key stems.



253 KEY MODULE

Removal

1. Remove the keyboard (251).

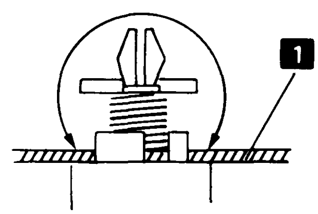
2. Use the keytop pulling tool (part 9900373) to lift the keytop buttons from the keys to be removed.

3. Lift one edge of the all keys unit about 0.5 inch (12.7 mm) and push and wiggle the failing key modules down until they snap free.

   Note: The module retaining ears must clear the frame **1** as shown.

4. **CAUTION**
   Be sure that no keys are pressed.

   Lift the all keys unit, leaving the loosened modules.



Installation

1. Set the key module upright and place the all keys unit in position over it. Align the slot in the module with the orientation lug in the mounting hole.

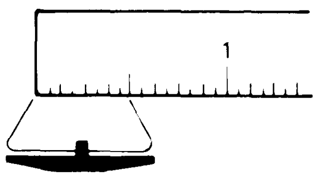
2. Press down on the ends of the all keys unit to snap the module into place.

3. Position the contamination shield if required.

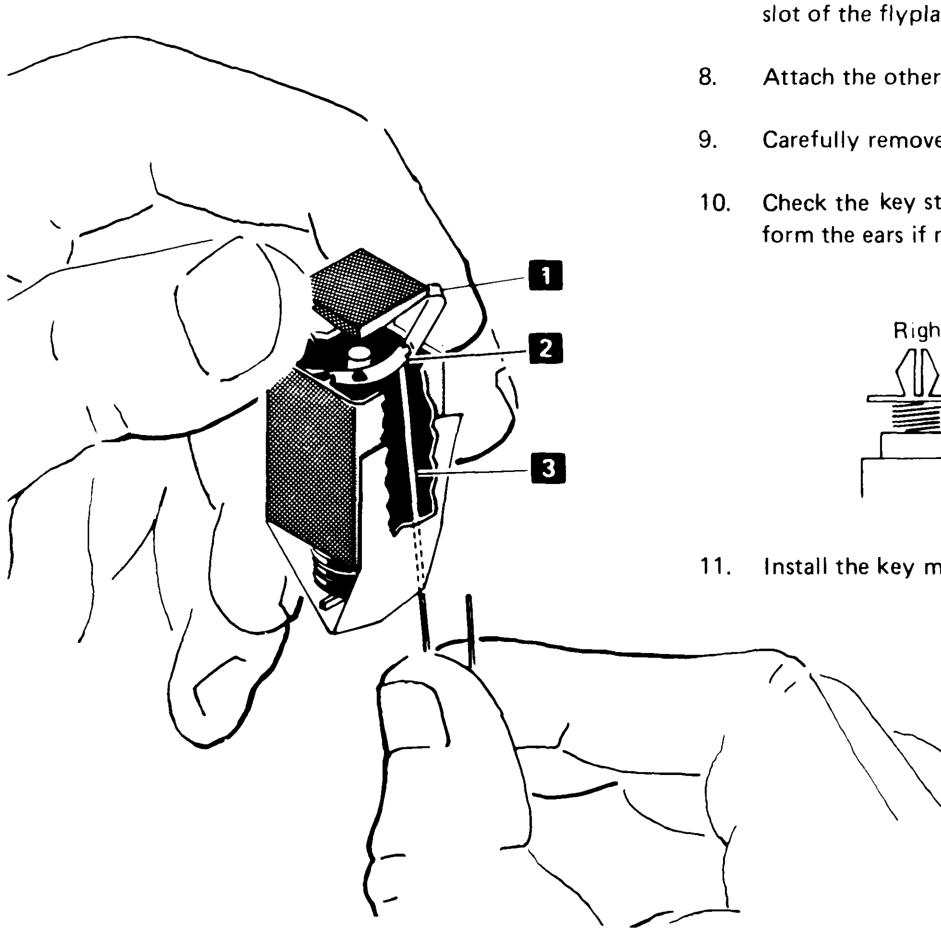
254 FLYPLATE REPLACEMENT

Replacing a dislodged flyplate in a key module is not recommended. However, if replacement is necessary because a new key module is not available, inspect the flyplate to make sure the joint between the spring and flyplate is not loose or the flyplate is not cracked or damaged.

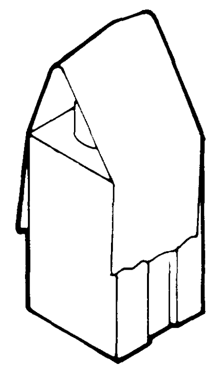
1. Form the spring on the flyplate so that there is 0.5 inch (12.7 mm) between the ends of the spring.



2. Remove the keybutton from the key module and remove the module from the keyboard.



3. Tape the key stem down as shown.



4. Holding the key module and flyplate as shown, line up the ends of the flyplate spring 1 with the tips of the flat spring 2 attached to the key stem.

5. Insert a small stylus or straightened paper clip through one of the access holes in the key module 3.

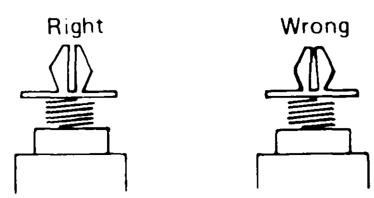
6. Push the tip of the flat spring up on the inside of the flyplate spring.

7. Ease the flat spring down until the tab drops into the slot of the flyplate spring.

8. Attach the other end of the spring in the same way.

9. Carefully remove the tape holding the key stem.

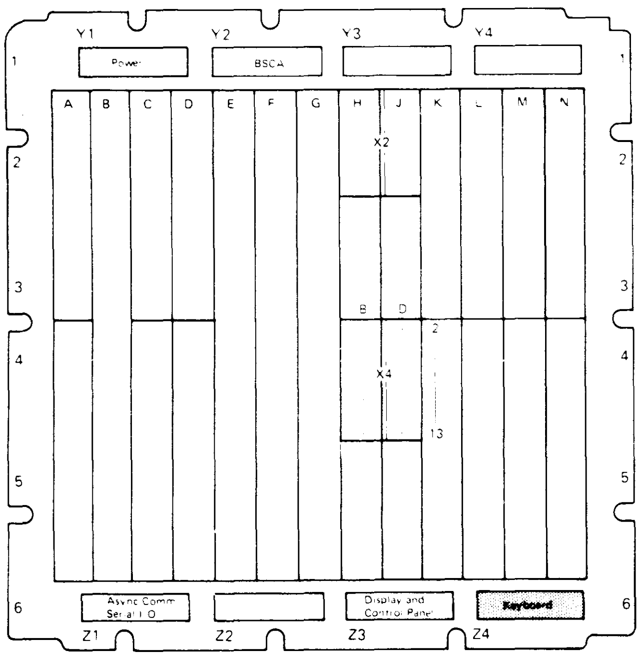
10. Check the key stem ears for taper in the center slot and form the ears if necessary.



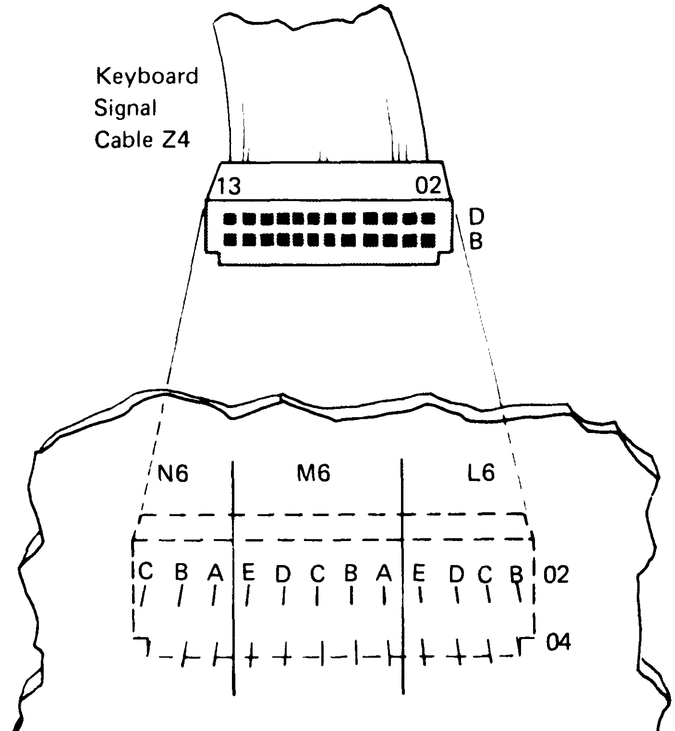
11. Install the key module in the all keys assembly.

255 KEYBOARD – Z4 SOCKET PIN ASSIGNMENTS

A1 Board (card side)



See 206 for Keyboard end



A1 Board (pin side)

Z4 Cable Pin	A1 Board Pin	Line Name	Z4 Cable Pin	A1 Board Pin	Line Name
D02	L6B02	(not used)	B02	L6B04	(not used)
D03	L6C02	+5 Vdc	B03	L6C04	(not used)
D04	L6D02	(not used)	B04	L6D04	-Kbd P
D05	L6E02	(not used)	B05	L6E04	-Kbd O
D06	M6A02	-Kbd 1	B06	M6A04	(not used)
D07	M6B02	-Power On Reset	B07	M6B04	-Kbd Strobe
D08	M6C02	Ground	B08	M6C04	-Kbd 3
D09	M6D02	+Typamatic	B09	M6D04	-Kbd 4
D10	M6E02	(not used)	B10	M6E04	-Kbd 5
D11	N6A02	-Keyboard Lockout	B11	N6A04	+8.5 Vdc
D12	N6B02	(not used)	B12	N6B04	-Kbd 7
D13	N6C02	-Kbd 2	B13	N6C04	-Kbd 6

270 CE METER CALIBRATION CHECK

1. When measuring voltages, set the CE meter on the 15 Vdc scale and zero the meter.

2. Ground the CE meter at G2-D08 and measure the voltage at G2-S02. Your CE meter is measuring the reference voltage (ref vol). A zener diode provides a +6 Vdc reference (see logic 420).

3. If your meter does not read exactly +6 Vdc, it is not calibrated, and you must use the following formula to determine the actual voltage (act vol).

$$\text{Act Vol} = \frac{6 \times \text{Mea Vol}}{\text{Ref Vol}}$$

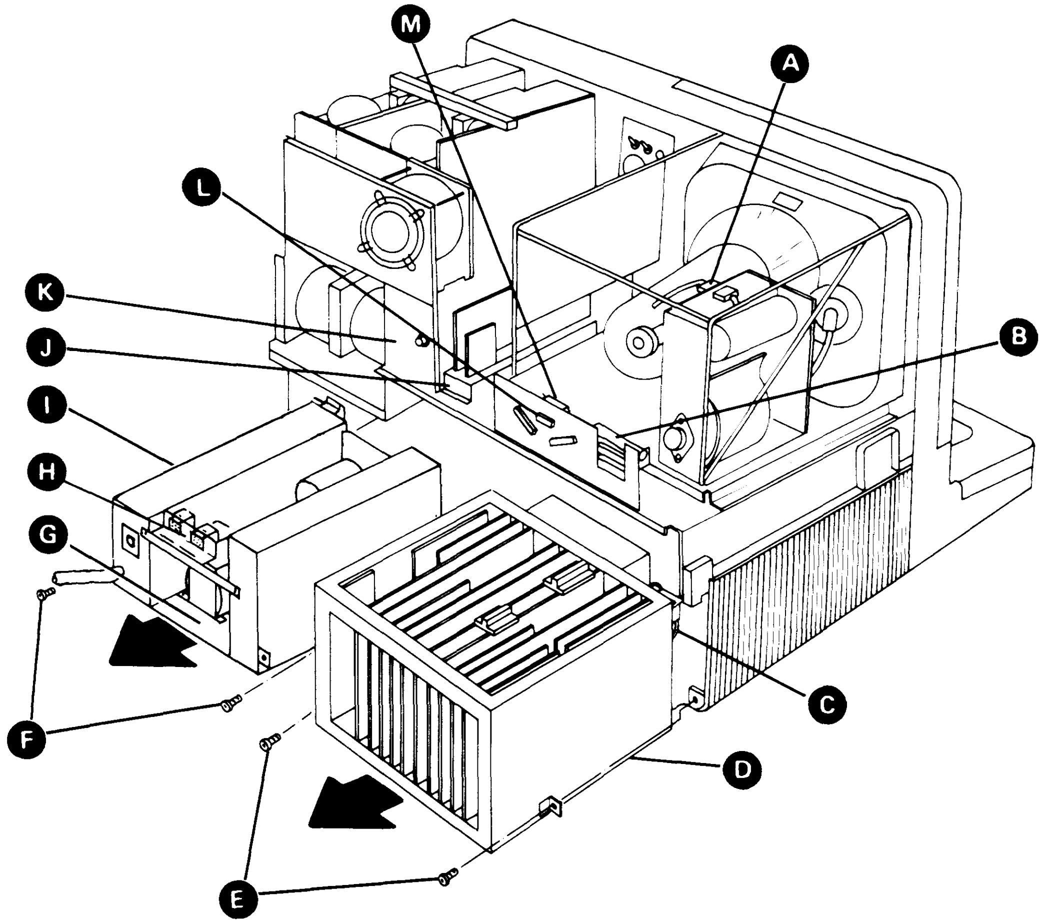
   Mea Vol = measured voltage (reading on CE meter of voltage being measured)

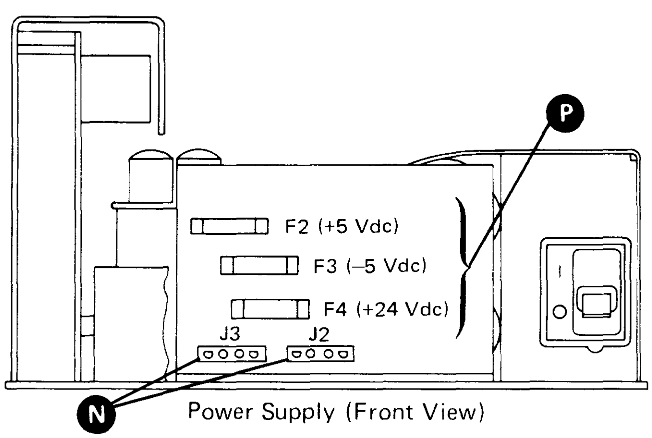
Example:

Ref Vol = 5.8 Vdc (value of reference voltage at G2-S02 as measured by the CE meter)

When you measure the +5 Vdc, your meter reads +4.8 Vdc.

$$\text{Act Vol} = \frac{6 \times 4.8}{5.8} = 4.97 \text{ Vdc}$$





Power Supply (Front View)

271 POWER SUPPLY (Page 2 of 3)

DANGER
AC line voltage is present in the power supply when the power switch is off. Always unplug the ac line cord from the ac receptacle when working on the power supply.

Power Supply Removal

1. Switch off the 5110 power and unplug the ac line cord from the ac receptacle.
2. Remove the 5110 top and rear covers (MIM 200).
3. Remove the two logic box holding screws **E** and the two power supply holding screws **F**.
4. Slide the logic box **D** out from the rear of the 5110. If necessary, unplug the cable from the keyboard to allow the logic box to slide out completely.
5. Slide the power supply **G** out from the rear of the 5110.

Note: The power supply is now in the service position. Parts replacement and power checks can be made with the power supply in this position. Proceed with the following steps only if the entire power supply is to be replaced. Notice the position and routing of the power supply cables as an aid when the power supply is replaced.

6. Unplug the logic fan power cable P2 **C** from the connector on the front of the logic box. Remove the power cable ground wire and screw from the front of the logic box.
7. Remove the top cover from the logic box. Loosen the two screws on the A1 board front cable retainer and slide the cable retainer away from the cables. Unplug the dc power cable from Y1 on the A1 board. Remove the cable strain relief from the side of the logic box and slip the dc power cable out from the cable slot.
8. Unplug the two dc power cables from A2 and A4 of the diskette adapter board B1 **J**.
9. Unplug the two diskette dc power cables from connectors J2 and J3 **N** on the front of the power supply.
10. Unplug the rear fan power cable P3 from the connector on the fan bracket **K**. Disconnect the two cable ground wires from the fan bracket and the main chassis.
11. Unplug the two diskette ac power cables P4 and P5 **H** from the power supply.
12. Unplug the display unit ac power cable P6 **A**. Remove the display unit fuse holder **B** from the fuse bracket.
13. Remove the I/O power connector A1 **L** and cable from the interface cable bracket by removing the two connector mounting screws. Unsolder the two wires of this cable that connect to the load resistor **M**.
14. Remove the power supply.

Power Supply Replacement

1. If the replacement power supply does not have an ac line cord, remove the line cord from the removed power supply and install it in the replacement power supply. (Refer to "Power Supply Line Cord" on the following page.)
2. Install the ac box cover **I** from the removed power supply onto the replacement power supply.
3. Plug the two diskette dc power cables into connectors J2 and J3 **N** on the front of the power supply.
4. Install the I/O power connector A1 **L** onto the interface cable bracket. Connect and solder the two wires of this cable to the load resistor **M**.
5. Plug the display unit power cable P6 **A** into the display unit cable connector. Install the display unit fuse holder **B** into the fuse bracket.
6. Plug the rear fan power cable P3 into the connector on the fan bracket **K**. Connect the two cable ground wires to the fan bracket and the main chassis.
7. Plug the two dc power cables into A2 and A4 of the diskette adapter board B1 **J**.
8. Route the dc power cable for the A1 board through the slot in the side of the logic box, and plug it into Y1 on the A1 board. Position the cable retainer and tighten the retainer screws. Install the cable strain relief and logic box cover.
9. Slide the power supply into position in the 5110.
10. Plug the logic fan power cable P2 **C** into the connector on the front of the logic box. Connect the cable ground wire to the front of the logic box.

11. Plug the two diskette ac power cables P4 and P5 H into the connectors on the power supply.

12. Slide the logic box into position in the 5110. Ensure that the flat cable (logic box to keyboard) is not pinched between the logic box and the 5110 frame. Install the two power supply holding screws F and the two logic box holding screws E.

13. Install the 5110 top and rear covers (200). Install the terminator or I/O connector on the rear of the 5110.

14. Plug the ac line cord into the ac receptacle.

Power Supply Fuses (F2, F3, F4) Removal and Replacement

Power supply fuses F2, F3, and F4 P are located on the printed-circuit card PSA1 at the front of the power supply. To provide access to the fuses, remove the keyboard (251).

Power Supply Line Cord Removal and Replacement

1. Do steps 1 through 5 of the power supply removal procedure.

2. Remove the cover from the ac box I.

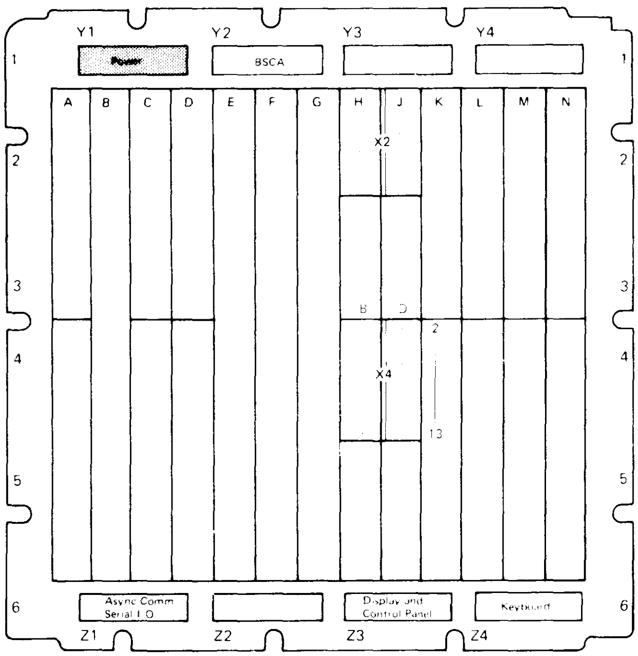
3. Unsolder and remove the line cord leads that connect to the line filter and the ground lead and screw from the power supply frame.

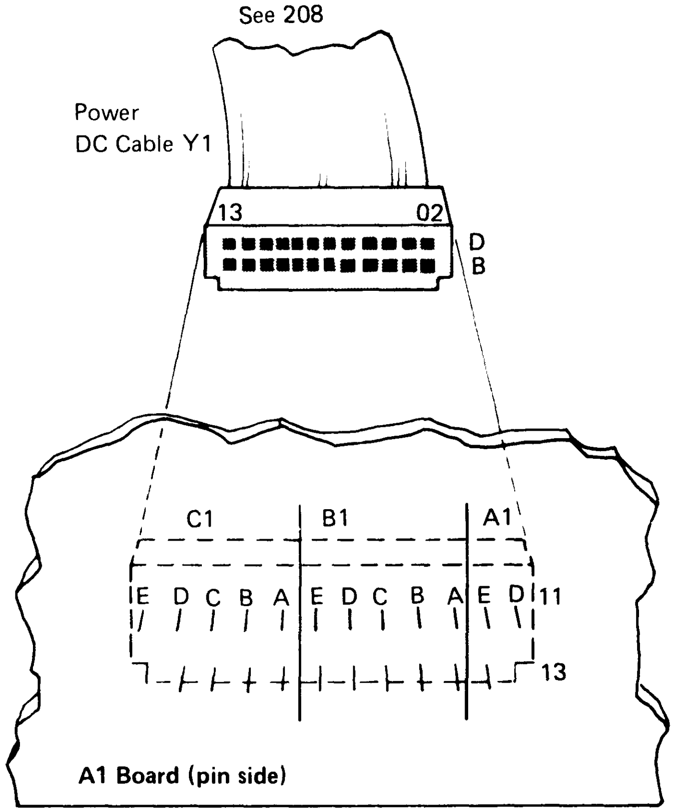
4. Install the leads of the replacement line cord to the same positions on the line filter and power supply frame.

5. Install the ac box cover I and the power supply.

272 POWER – Y1 SOCKET PIN ASSIGNMENTS

A1 Board (card side)





Y1 Cable Pin	A1 Board Pin	Line Name	Y1 Cable Pin	A1 Board Pin	Line Name
D02	A1D11	+5 Vdc	B02	A1D13	+5 Vdc
D03	A1E11	+5 Vdc	B03	A1E13	+5 Vdc
D04	B1A11	+5 Vdc	B04	B1A13	+5 Vdc
D05	B1B11	+5 Vdc	B05	B1B13	+5 Vdc
D06	B1C11	Ground	B06	B1C13	Ground
D07	B1D11	Ground	B07	B1D13	Ground
D08	B1E11	Ground	B08	B1E13	Ground
D09	C1A11	Ground	B09	C1A13	Ground
D10	C1B11	Ground	B10	C1B13	(not used)
D11	C1C11	+8.5 Vdc	B11	C1C13	+8.5 Vdc
D12	C1D11	+12 Vdc	B12	C1D13	+12 Vdc
D13	C1E11	-5 Vdc	B13	C1E13	-12 Vdc

Voltage	Tolerance	
	Loaded	Unloaded (Y1 disconnected)
+5 Vdc	4.6 to 5.5	5.5 to 6.5
+8.5 Vdc	7.9 to 9.35	7.4 to 9.0
+12 Vdc	11.0 to 13.2	9.8 to 12.2
-5 Vdc	-4.6 to -5.5	-3.7 to -4.7
-12 Vdc	-11.0 to -13.2	-9.0 to -11.5

Maintenance

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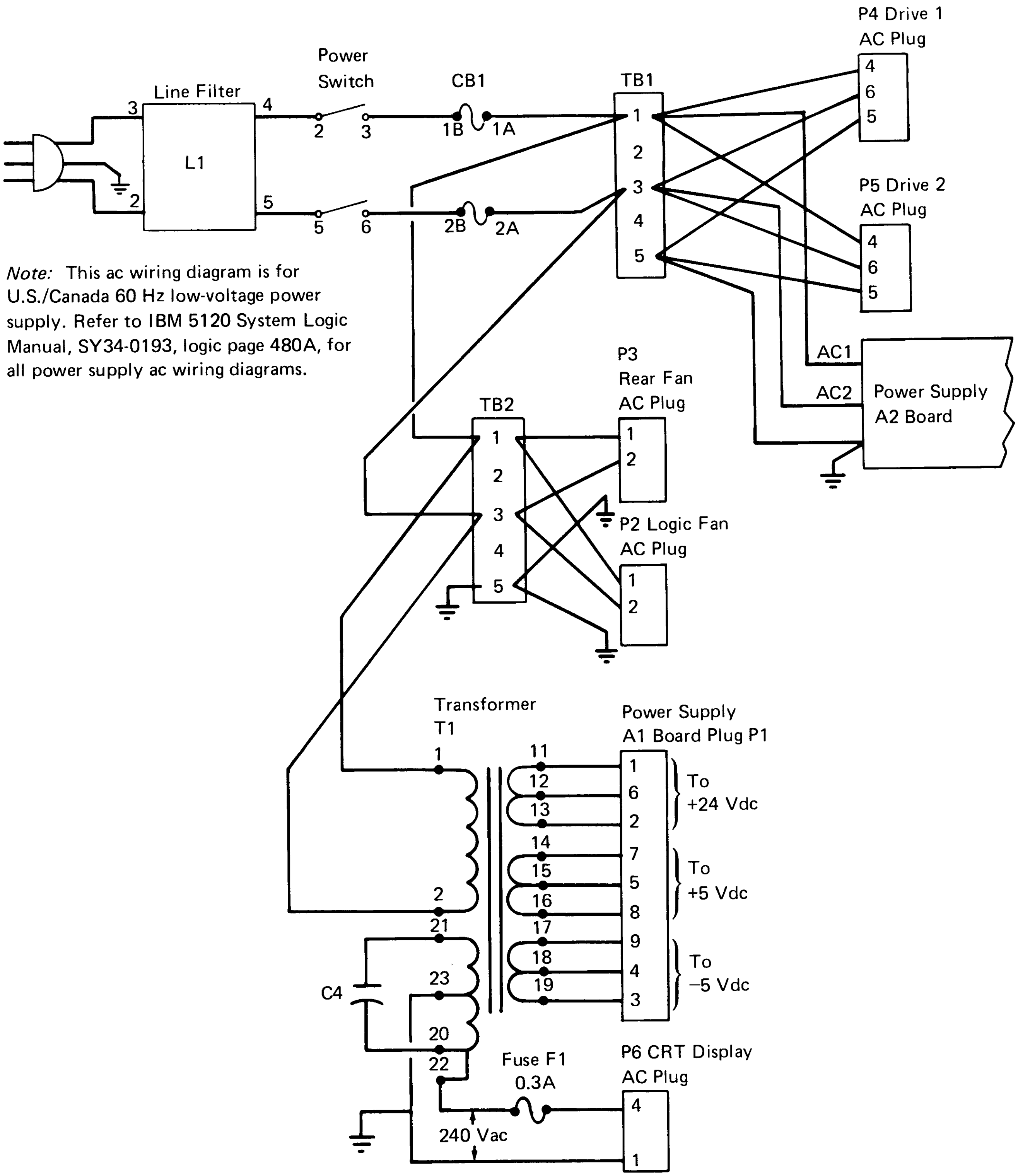
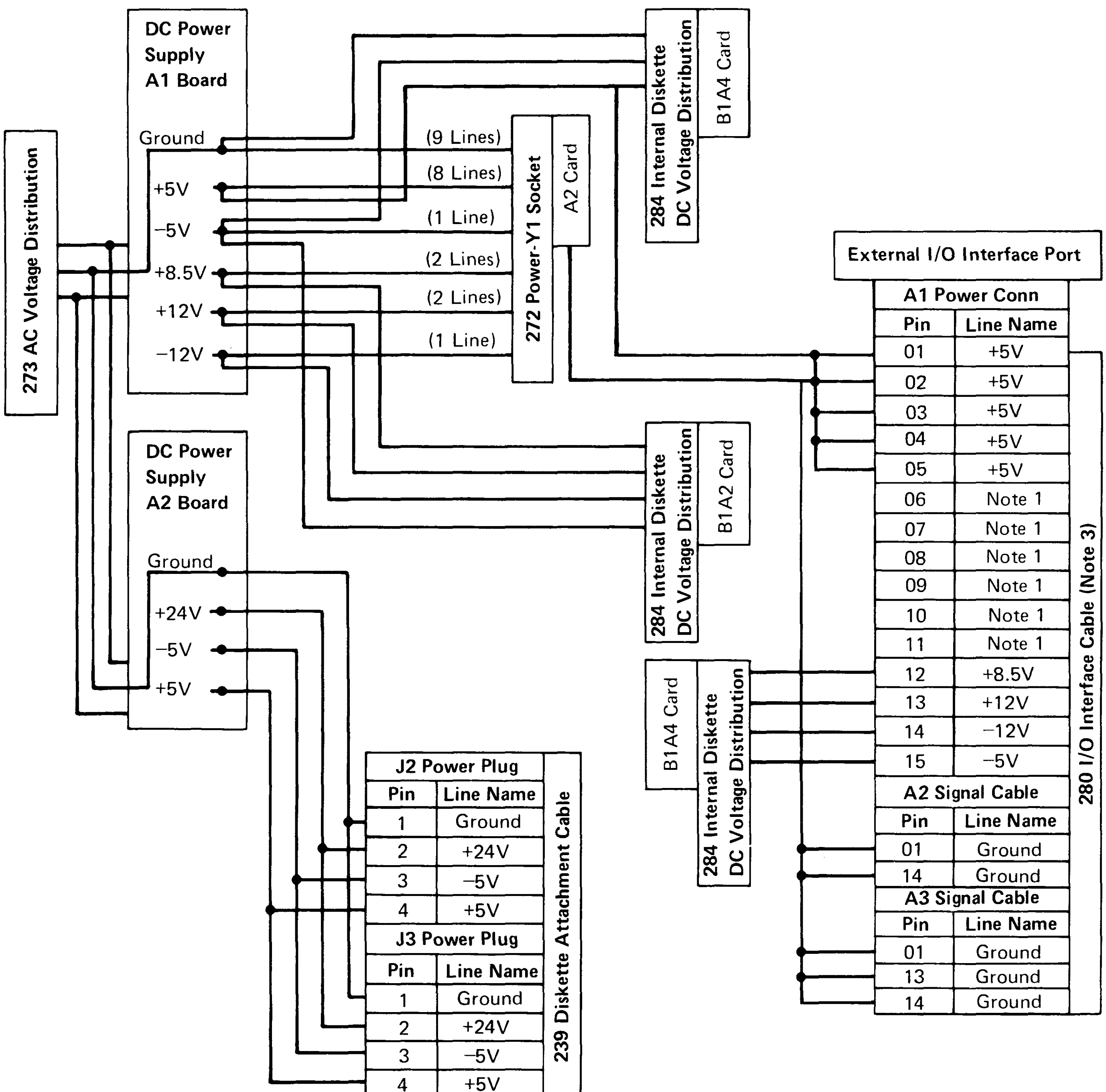
AC VOLTAGE DISTRIBUTION



Note: This ac wiring diagram is for U.S./Canada 60 Hz low-voltage power supply. Refer to IBM 5120 System Logic Manual, SY34-0193, logic page 480A, for all power supply ac wiring diagrams.

Maintenance

274 DC VOLTAGE DISTRIBUTION
(Page 1 of 2)

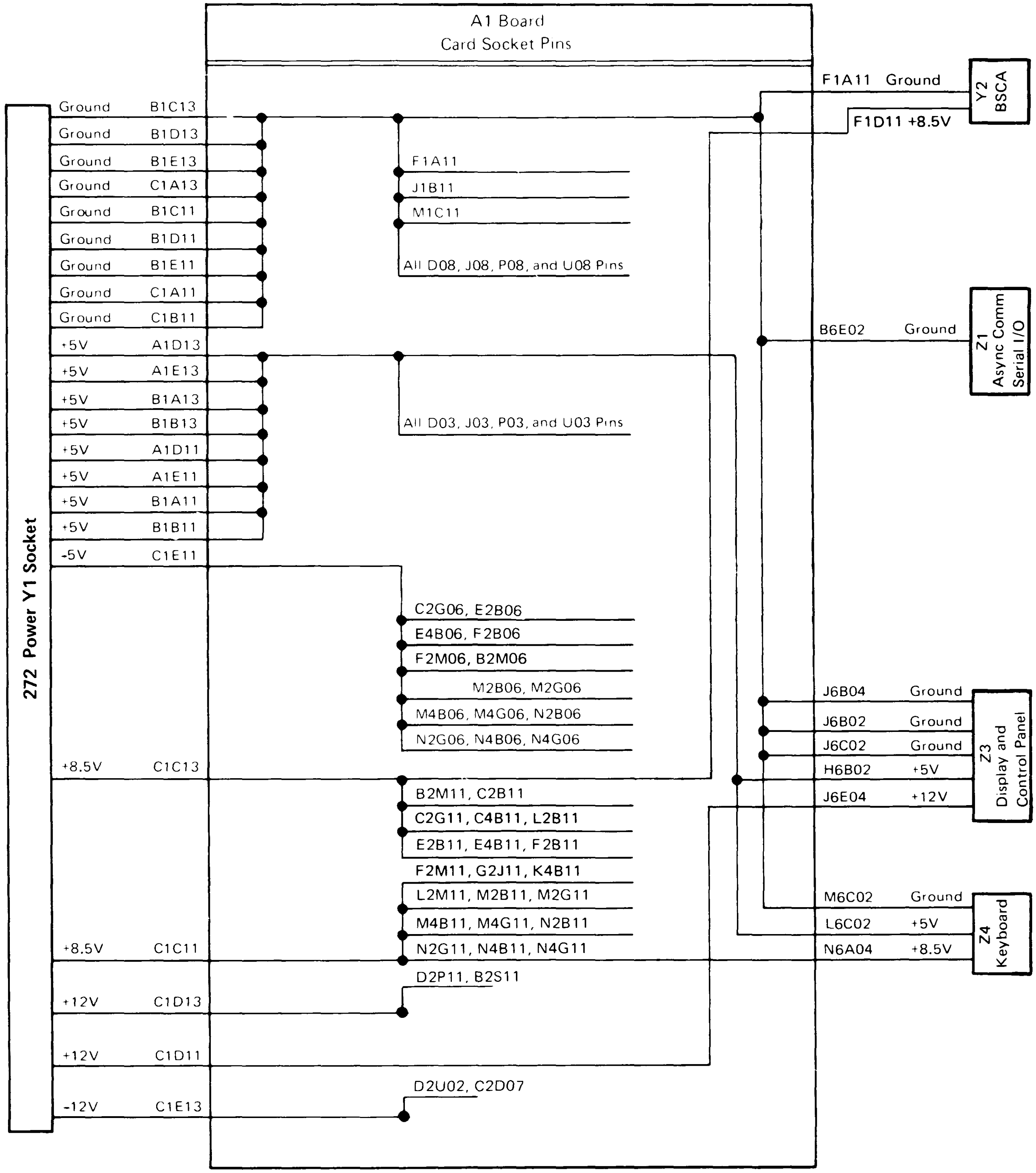


Notes:
1. The I/O interface cable does not have wires connected to this pin.
2. The power supply will automatically shut down if *all* loads are removed.
3. If there are no I/O devices attached to the 5110 Model 3, a terminator MUST be installed at the I/O interface port.

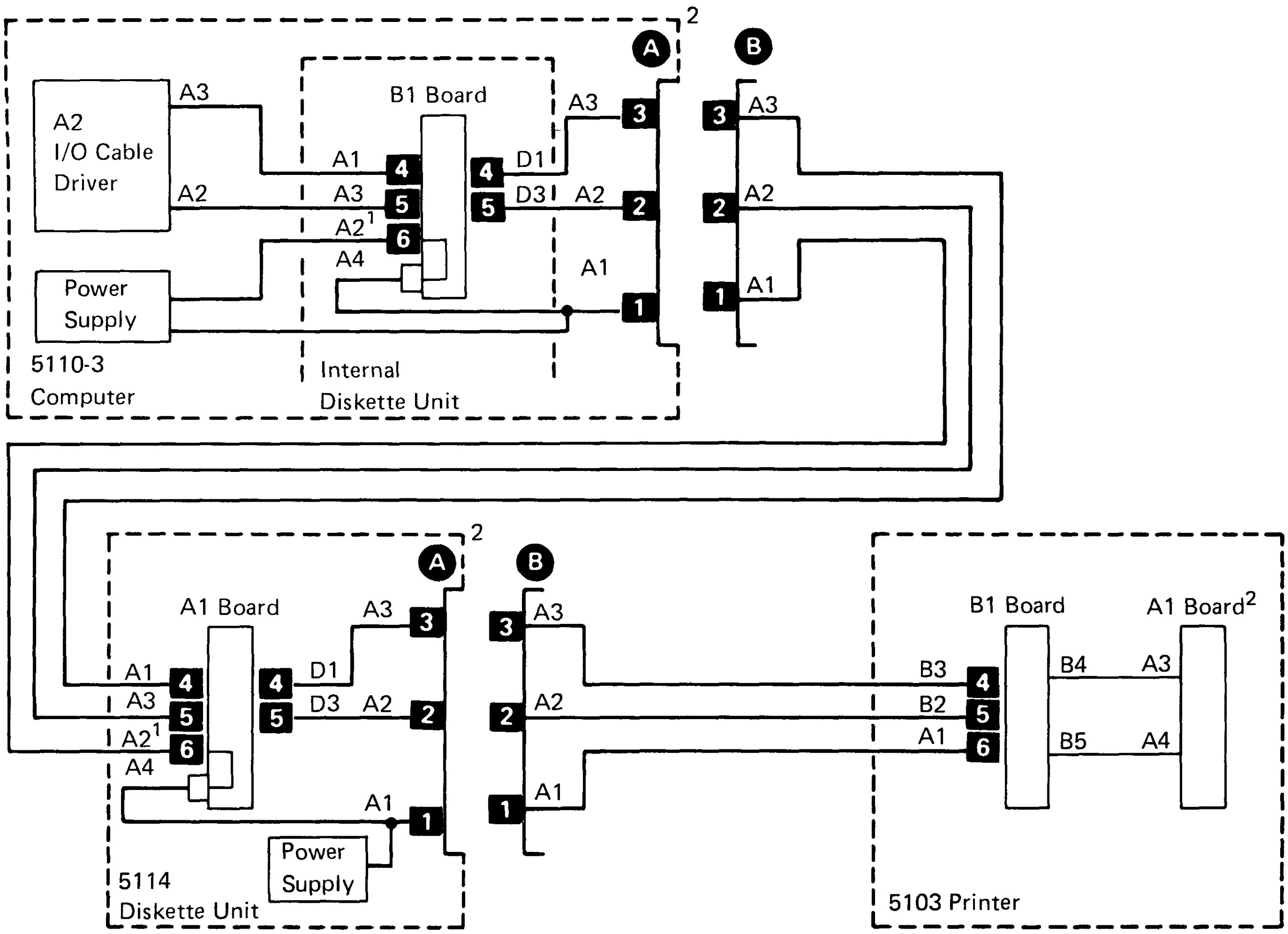
Voltage Specifications

Voltage	With Load	No Load (Note 2) (Y1 removed)	Ripple P-P
+5V	4.6 to 5.5	5.5 to 6.5	.1
–5V	4.6 to 5.5	–3.7 to –4.7	.1
+8.5V	7.9 to 9.35	7.4 to 9.0	.17
+12V	11.0 to 13.2	9.8 to 12.2	.24
–12V	11.0 to 13.2	–9.0 to –11.5	.24
+24V	22.0 to 26.4		

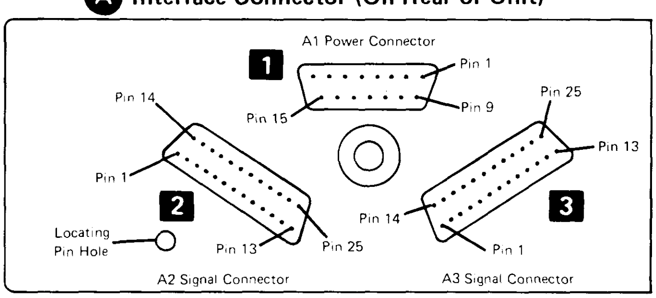
274 DC VOLTAGE DISTRIBUTION
(Page 2 of 2)



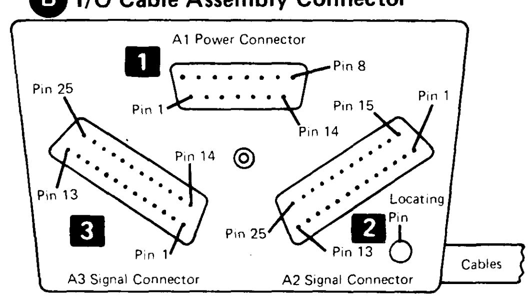
280 I/O INTERFACE CABLE PIN ASSIGNMENTS
(Page 1 of 2)



A Interface Connector (On Rear of Unit)



B I/O Cable Assembly Connector



[1] The 5110 +5 Vdc stops here. The 5114 provides its own +5 Vdc, and +5 Vdc for attaching devices.

[2] The cable terminator is permanently wired to the 5103 printer adapter card. If the printer is not in the system, a terminator must be installed on the last device (5114 or 5110).

280 I/O INTERFACE CABLE PIN ASSIGNMENTS
(Page 2 of 2)

1 Power Connector

Pin	Line Name
1	+5 Vdc
2	+5 Vdc
3	+5 Vdc
4	+5 Vdc
5	+5 Vdc
6	Unused
7	Unused
8	Unused
9	Unused
10	Unused
11	Unused
12	+8.5 Vdc
13	+12 Vdc
14	-12 Vdc
15	-5 Vdc

2 Signal Connector

Pin	Line Name
1	Ground
2	-Put Strobe
3	-Control Strobe
4	-Get Strobe
5	+DA Y3
6	+DA Y2
7	+DA Y1
8	+DA Y0
9	+DA X3
10	+DA X2
11	+DA X1
12	+DA X0
13	Unused
14	Ground
15	+Op Code E
16	+Bus In P
17	+Bus In 7
18	+Bus In 6
19	+Bus In 5
20	+Bus In 4
21	+Bus In 3
22	+Bus In 2
23	+Bus In 1
24	Unused
25	+Bus In 0

3 Signal Connector

Pin	Line Name
1	Ground
2	+Osc/4
3	-Interrupt Req 2
4	+Bus Out P
5	-Bus Out 0
6	-Bus Out 1
7	-Bus Out 2
8	-Bus Out 3
9	-Bus Out 4
10	-Bus Out 5
11	-Bus Out 6
12	-Bus Out 7
13	Ground
14	Ground
15	Unused
16	Unused
17	Unused
18	Unused
19	Unused
20	+Start Execute Bit
21	-Machine Check
22	+External Horz Drive
23	+Printer Clock
24	Unused
25	-Power On Reset (see note 2)

Device Address Lines	Device
X1Y1	= 5103 Printer
X3Y1	= Internal and 5114 Diskette Units

4 Signal Cable

Pin	Line Name
B02	Unused
B03	-Bus Out 7
B04	-Bus Out 6
B05	-Bus Out 5
B06	-Bus Out 4
B07	-Bus Out 3
B08	-Bus Out 2
B09	-Bus Out 1
B10	-Bus Out 0
B11	+Bus Out P
B12	-Interrupt Req 2
B13	+Osc/4
D02	-Power On Reset (see note 2)
D03	Unused (see note 1)
D04	+Printer Clock
D05	+External Horz Drive
D06	-Machine Check
D07	+Start Execute Bit
D08	Ground
D09	Unused
D10	Unused
D11	Unused
D12	Unused
D13	Unused

5 Signal Cable

Pin	Line Name
B02	Unused
B03	+DA X0
B04	+DA X1
B05	+DA X2
B06	+DA X3
B07	+DA Y0
B08	+DA Y1
B09	+DA Y2
B10	+DA Y3
B11	-Get Strobe
B12	-Control Strobe
B13	-Put Strobe
D02	+Bus In 0
D03	Unused
D04	+Bus In 1
D05	+Bus In 2
D06	+Bus In 3
D07	+Bus In 4
D08	Ground
D09	+Bus In 5
D10	+Bus In 6
D11	+Bus In 7
D12	+Bus In P
D13	+Op Code E

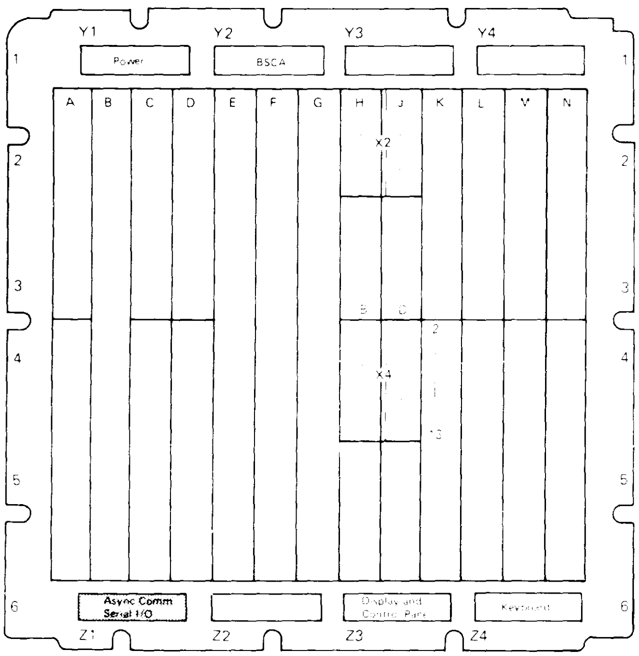
6 Power Cable

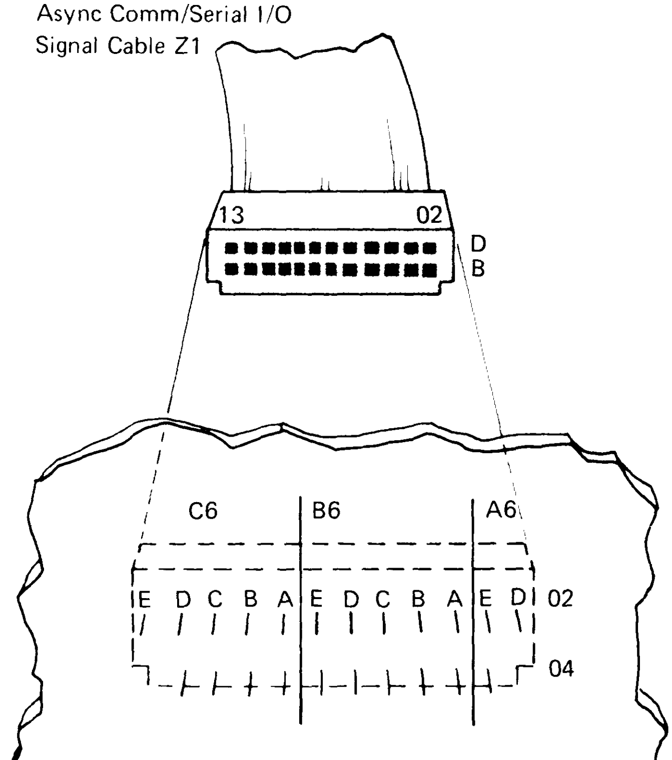
Pin	Line Name
B02	+5 Vdc
B03	+5 Vdc
B04	Unused
B05	Unused
B06	Unused
B07	Unused
B08	Unused
B09	Unused
B10	Unused
B11	+8.5 Vdc
B12	+12 Vdc
B13	Unused
D02	+5 Vdc
D03	+5 Vdc
D04	+5 Vdc
D05	Unused
D06	Unused
D07	Unused
D08	Unused
D09	Unused
D10	Unused
D11	-5 Vdc
D12	-12 Vdc
D13	Unused

Notes:
1. This line is grounded at the internal diskette B1-D1 socket. The 5114 Diskette Unit uses this signal to recognize its subdevice address.
2. The internal diskette or the 5114 Diskette Unit (if attached) generates a power-on reset for use by the 5103 Printer.

282 ASYNC COMM/SERIAL I/O ADAPTERS– Z1 SOCKET PIN ASSIGNMENTS (Page 1 of 2)

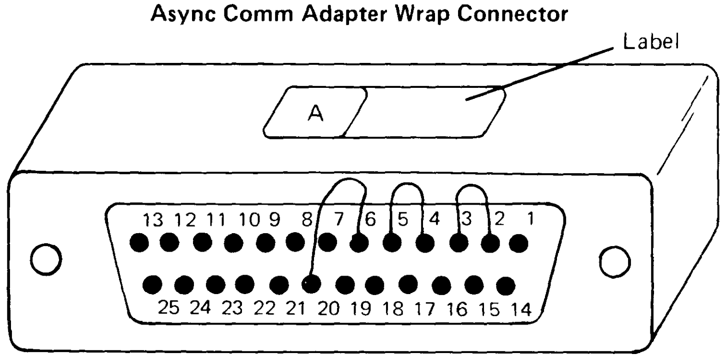
A1 Board (card side)



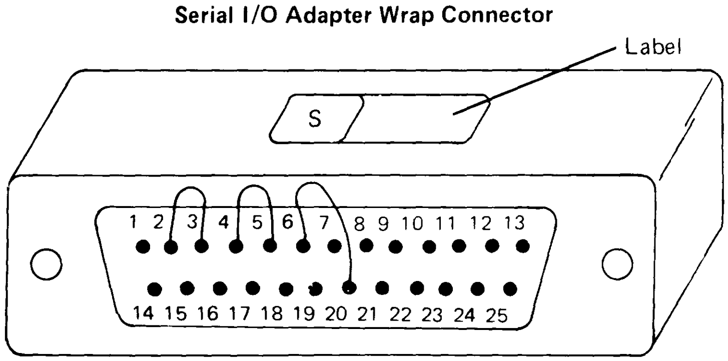


A1 Board (pin side)

Async Comm Adapter Wrap Connector



Serial I/O Adapter Wrap Connector



282 ASYNC COMM/SERIAL I/O ADAPTERS— Z1 SOCKET PIN ASSIGNMENTS (Page 2 of 2)

A1 Board Pin	Z1 Cable Pin	Line Name	D2 Card Pin	Async Comm Connector Pin	Serial I/O Connector Pin
A6D02	D02	(not used)	–	–	–
A6E02	D03	(not used)	–	–	–
B6A02	D04	+Comm Transmit Data	M03	2	–
B6B02	D05	+Comm Request to Send	P13	4	–
B6C02	D06	+Comm Data Set Ready	S03	6	–
B6D02	D07	+Receive Mode	P04	11	–
B6E02	D08	Ground	–	7	7
C6A02	D09	+SIO Transmit Data	G02	–	3
C6B02	D10	+SIO Request to Send	J02	–	5
C6C02	D11	+SIO Data Terminal Ready	B13	–	6
C6D02	D12	+SIO Receive Line Signal Detector	B12	–	8
C6E02	D13	(not used)	–	–	–
A6D04	B02	(not used)	–	–	–
A6E04	B03	(not used)	–	–	–
B6A04	B04	(not used)	–	–	–
B6B04	B05	+Comm Received Data	M12	3	–
B6C04	B06	+Comm Clear to Send	S02	5	–
B6D04	B07	+Comm Data Terminal Ready	P12	20	)
B6E04	B08	(not used)	–	–	–
C6A04	B09	+SIO Received Data	D11	–	2
C6B04	B10	+SIO Clear to Send	B10	–	4
C6C04	B11	+SIO Data Set Ready	B11	–	20
C6D04	B12	(not used)	–	–	–
C6E04	B13	(not used)	–	–	–
		Frame Ground	–	1	1

See IBM 5120 Logic Manual logic 450 for wrap connector pin assignments.

Maintenance

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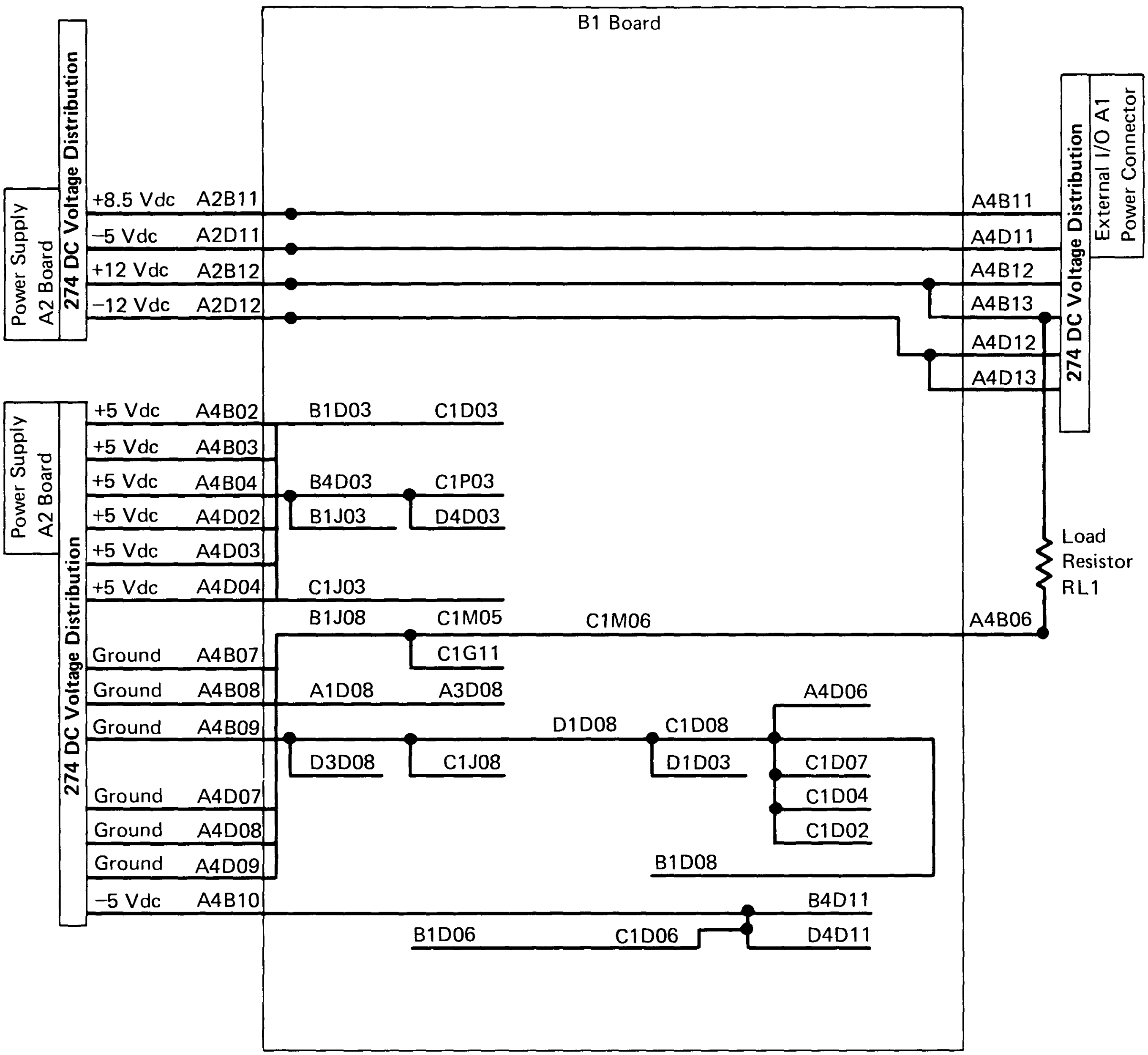
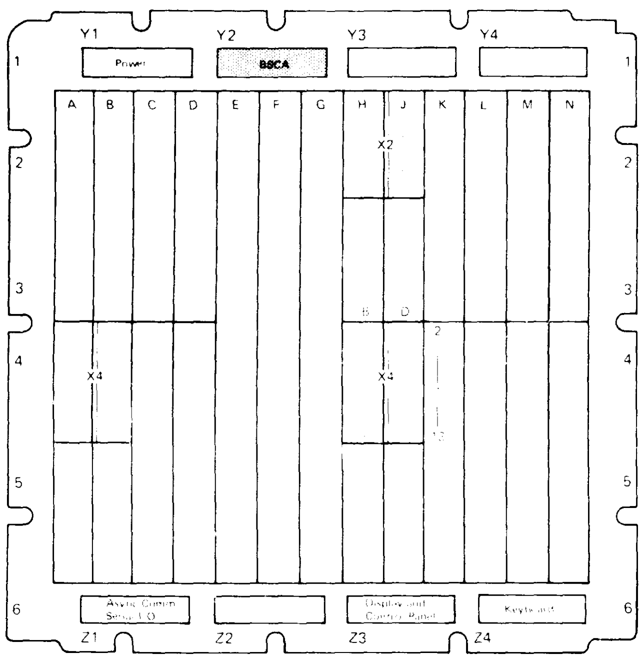
284 INTERNAL DISKETTE DC VOLTAGE DISTRIBUTION

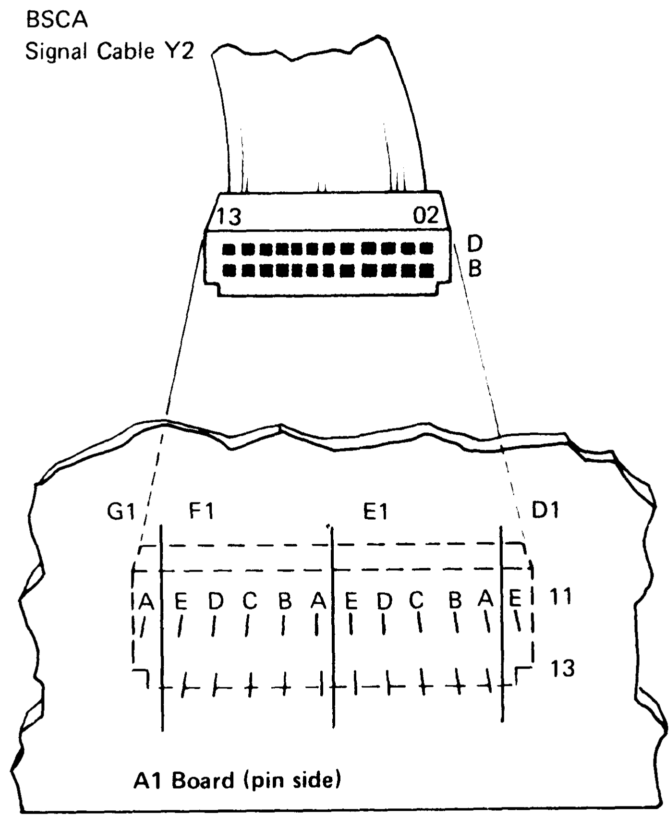


Maintenance

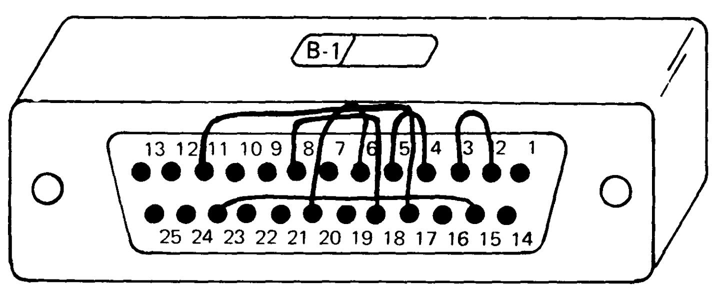
285 BSCA–Y2 SOCKET AND WRAP CONNECTOR PIN ASSIGNMENTS
(Page 1 of 2)

A1 Board (card side)





EIA/CCITT Wrap Connector[1]



[1] This is the only wrap connector that can be used with BSCA MDI 821 for an EIA/CCITT communications facility.

285 BSCA–Y2 SOCKET PIN ASSIGNMENTS
(Page 2 of 2)

A1 Board Pin	Y2 Cable Pin	Line Name	C2 Card Pin	BSCA Connector Pin
D1E11	D02	Receive Data	G04	3
E1A11	D03	Clear to Send	G10	5
E1B11	D04	(not used)	–	–
E1C11	D05	Transmit Line (DR)	J05	9
E1D11	D06	Select Standby	G05	11
E1E11	D07	Receive Line (DR1)	J13	13
F1A11	D08	Signal Ground	D08	7
F1B11	D09	Receive Clock (DCE)	J10	17
F1C11	D10	(not used)	–	–
F1D11	D11	+8.5 volts	G11	21
F1E11	D12	Data Rate Selector	J06	23
G1A11	D13	(not used)	–	–
D1E13	B02	Transmit Data	G07	2
E1A13	B03	Request to Send	G03	4
E1B13	B04	Data Set Ready	J09	6
E1C13	B05	Carrier Detected	J12	8
E1D13	B06	Transmit Line (DT)	G02	10
E1E13	B07	Receive Line (DT1)	G09	12
F1A13	B08	Transmit Clock (DCE)	J04	15
F1B13	B09	Data Tip	D06,D05	16
F1C13	B10	Test Control	J07	18
F1D13	B11	Data Terminal Ready	J02	20
F1E13	B12	Ring Indicate	G13	22
G1A13	B13	(not used)	–	–

Note:
See *IBM 5120 System Logic Manual* logic 465 for EIA/CCITT wrap connector pin assignments.

Maintenance

IBM 5103 PRINTER

Printer reference numbers that support the printer MAPs are 300 numbers and are located in the *IBM 5103 Printer Maintenance Information Manual,* SY31-0414.

IBM 5114 DISKETTE UNIT

Diskette reference numbers that support the diskette MAPs and MDIs are 100 numbers and are located in the *IBM 5114 Diskette Unit Maintenance Information Manual,* SY31-0551.

Maintenance

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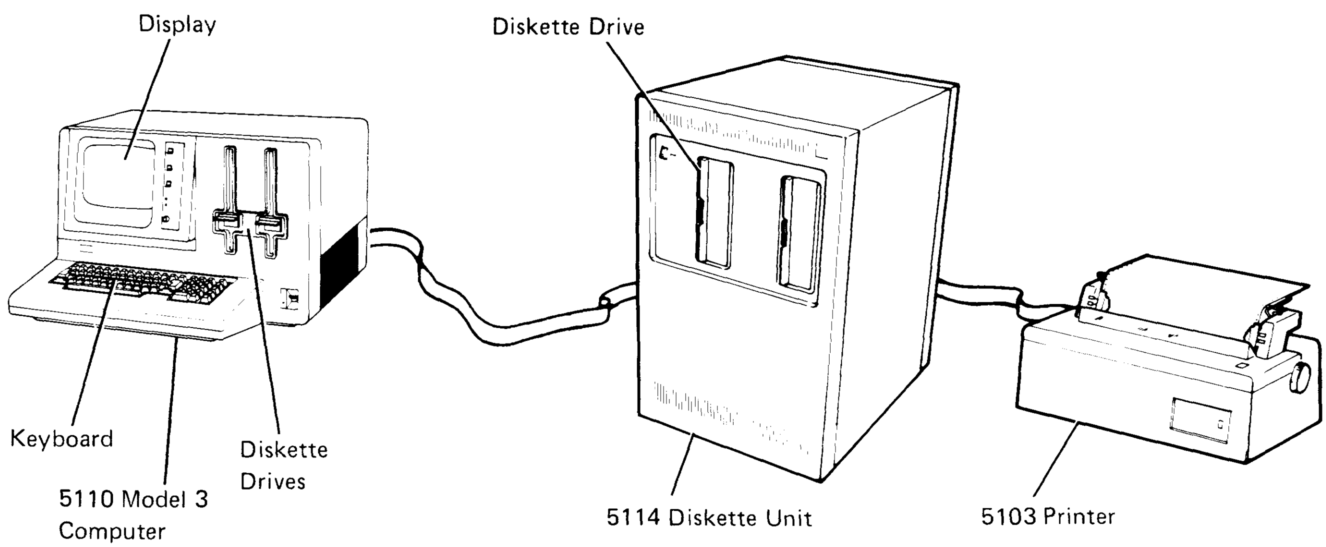
Contents

Theory

Introduction



The IBM 5120 Computing System consists of the IBM 5110 Model 3 Computer and the input/output devices that are attached to the 5110 Model 3.

The 5110 Model 3 computer is composed of a keyboard, two diskette drives, a display unit, a processor, storage, and an integral power supply. The keyboard and the 9" screen are the interface between the user and the processor. The display adapter connects the display unit (or an attached TV monitor) to the processor. The base I/O connects the processor to the keyboard and to the attached I/O devices and features.

The programming languages used by the computer are APL and BASIC. Microprograms within read only storage and programs that are loaded into read/write storage are used to control the 5120 computing system.

The input/output devices include two internal diskette units, a 5103 printer, and a 5114 diskette unit.

The features include the Serial I/O Adapter feature, the Asynchronous Communications feature, the Binary Synchronous Communications feature, and the Diskette Sort feature.

I/O DEVICES

The 5103 Printer

The 5103 printer is a wire matrix printer used by the 5120 computing system. The 5103 printer provides a hard copy of the data at a rate of 80 characters per second or 120 characters per second. For additional details on the 5103 printer, see the *IBM 5103 Printer Maintenance Information Manual*, SY31-0414.

The 5114 Diskette Unit

The 5114 diskette unit attaches to the 5110 Model 3 computer through the I/O channel; one 5114 unit can be attached to the 5120 computing system. The 5114 unit stores up to 1.2 megabytes of data on each diskette drive and may contain two drives. See the *IBM 5114 Diskette Unit Maintenance Information Manual*, SY31-0551 for additional information.

FEATURES

The Serial I/O Adapter Feature

The Serial I/O Adapter feature allows the 5120 computing system to communicate with other devices via a serial I/O bus. The user must load the controlling microprogram into R/W storage.

The Asynchronous Communications Feature

The Asynchronous Communications feature allows the 5120 computing system to act as a 2741 terminal and to communicate with remote systems. During communications, the 5110 computer is dedicated and cannot perform APL or BASIC operations. The user must load the controlling microprogram into R/W storage.

The Binary Synchronous Communications Adapter Feature

The Binary Synchronous Communications Adapter feature (BSCA) allows the 5110 to communicate with remote systems. The 5110 acts as a 2770 or 3741 terminal. The feature is attached to the line through an external modem using EIA RS232C or CCITT V.24 V.28 interface standard. The user must load the feature microprogram into R/W storage.

The Diskette Sort Feature

The Diskette Sort feature sorts the records in a file into an increasing or decreasing sequence.

The Katakana Feature

This feature provides the special Katakana graphics for the display and the printer, in place of the normal country select graphics.

5110 MODEL 3 COMPUTER FUNCTIONAL UNITS

Keyboard

The 5110 keyboard consists of a standard typewriter keyboard and a 10-key pad. There are additional control keys used to communicate with the computer and to modify the input.

Internal Diskette Units

The two internal diskette units can store and retrieve data by writing data onto diskettes for later use and by reading data from diskettes for immediate use. The data capacity of each diskette is a maximum of 1.2 megabytes.

Display Adapter Card

The display data register located in the display adapter card receives data from the display buffer in read/write storage. The data from the display data register is used to select a dot pattern on the display card. The display adapter card generates all signals required for the synchronization of the display.

Audible Alarm

The audible alarm is a programmable device used to signal the operator when the computer requires operator intervention.

Processor

The processor card (J2) controls the data flow throughout the 5110. The processor communicates directly with read/write storage, executable ROS, the base I/O adapter, and the display adapter.

Storage

Read Only Storage (ROS)

ROS contains the code used to develop the APL and BASIC language functions, the microprograms used to control the operation of the various features, and the microprograms used to direct the overall operation of the 5120 computing system.

Read/Write Storage

R/W storage is used to temporarily store data and programs. R/W storage is also used to store status information.

Base I/O Card

The base I/O card is a distribution point between I/O units and the computer. This card provides repowered signals to more remotely located components. It also contains the adapter for the keyboard.

I/O Cable Driver

The I/O cable driver card (A2) repowers the signal lines for the 'bus in' line, the 'bus out' line, and the control lines to the internal diskette drives and to the external I/O devices.

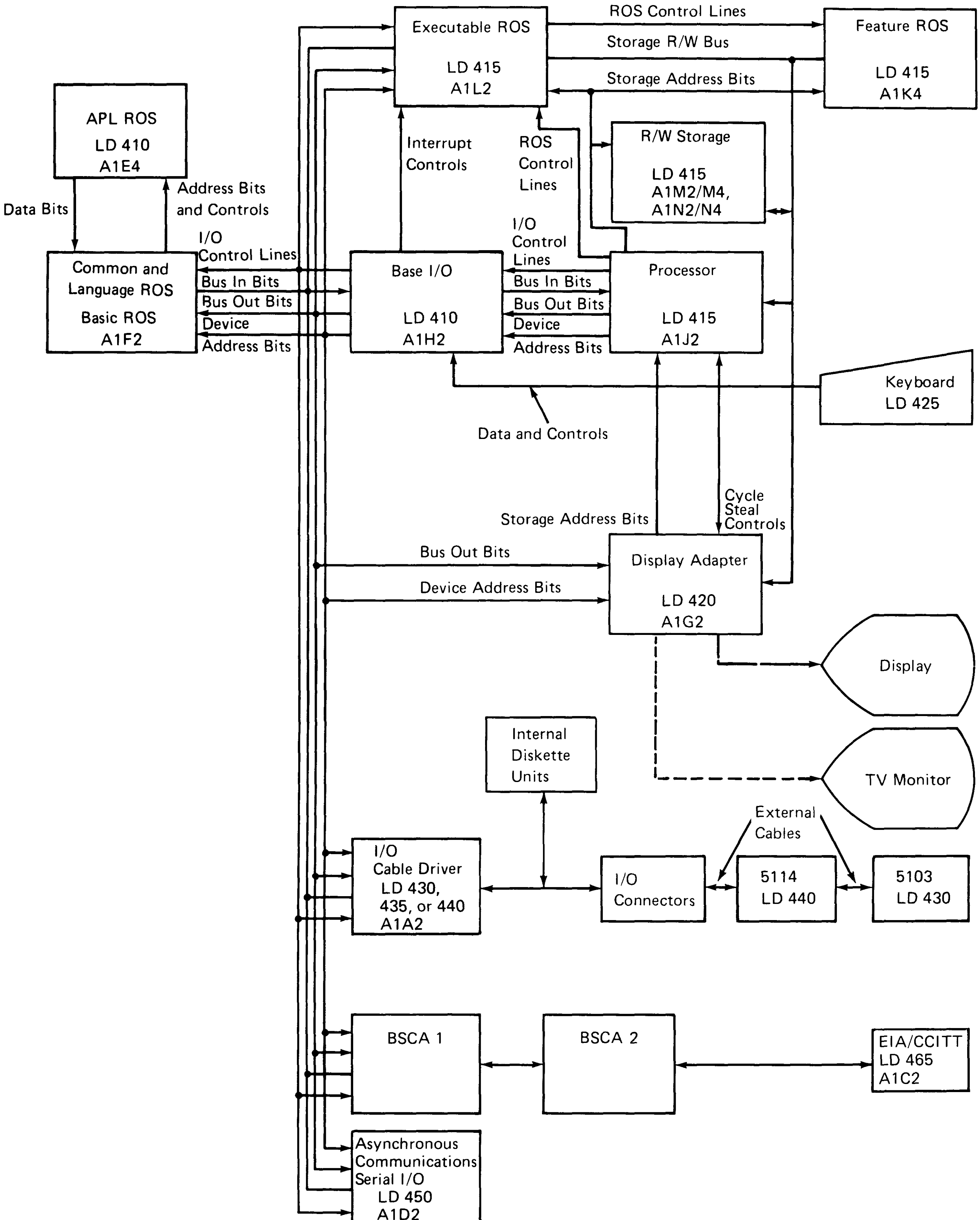
Microprogramming

Most 5110 operations are controlled by microprograms located in ROS. Some feature microprograms are loaded into read/write storage from the diskette.

Internal Operation of the 5110

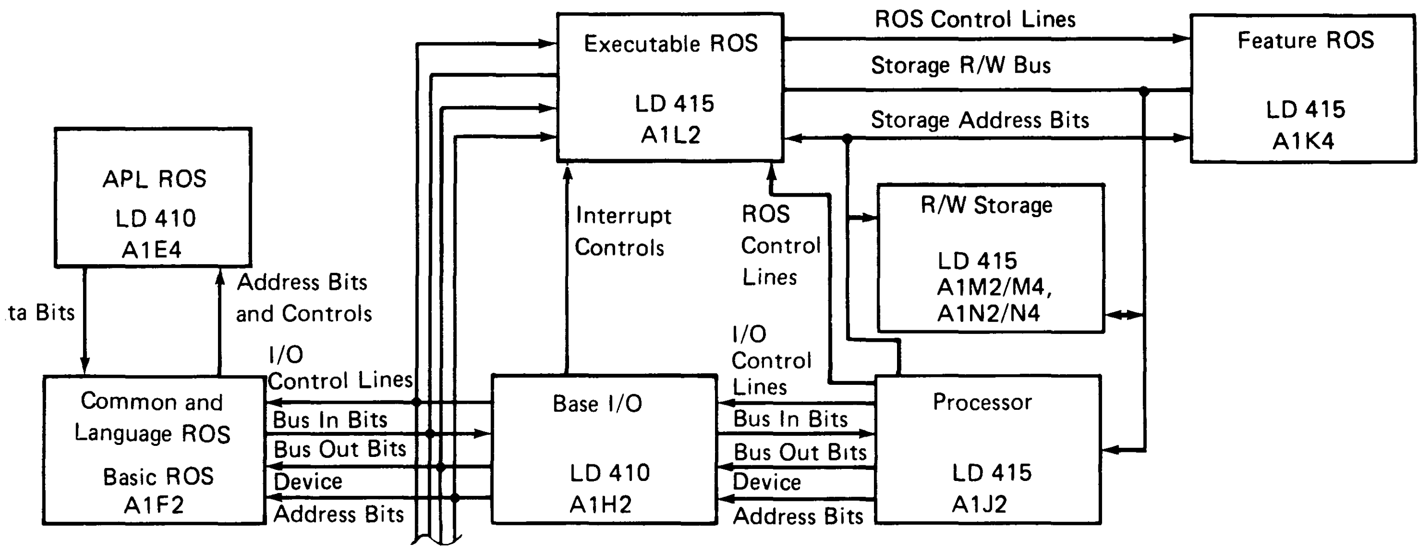
The 5110 computer uses both IBM programs and user written programs. These programs are loaded into read/write storage from diskette. These programs are processed by microprograms to control all the computing and input/output operations of the 5120 computing system. An overview of the 5120 computing system is shown on the following page.

Theory


Executable ROS
LD 415
A1L2
ROS Control Lines
Storage R/W Bus
Storage Address Bits
Feature ROS
LD 415
A1K4
APL ROS
LD 410
A1E4
Data Bits
Address Bits
and Controls
Interrupt
Controls
ROS
Control
Lines
R/W Storage
LD 415
A1M2/M4,
A1N2/N4
I/O
Control Lines
I/O
Control
Lines
Common and
Language ROS
Basic ROS
A1F2
Bus In Bits
Bus Out Bits
Device
Address Bits
Base I/O
LD 410
A1H2
Bus In Bits
Bus Out Bits
Device
Address Bits
Processor
LD 415
A1J2
Keyboard
LD 425
Data and Controls
Storage Address Bits
Cycle
Steal
Controls
Bus Out Bits
Device Address Bits
Display Adapter
LD 420
A1G2
Display
Internal
Diskette
Units
TV Monitor
External
Cables
I/O
Cable Driver
LD 430,
435, or 440
A1A2
I/O
Connectors
5114
LD 440
5103
LD 430
BSCA 1
BSCA 2
EIA/CCITT
LD 465
A1C2
Asynchronous
Communications
Serial I/O
LD 450
A1D2

The Common and Language ROS areas contain translation tables, I/O diagnostics, and the APL and BASIC interpreters.

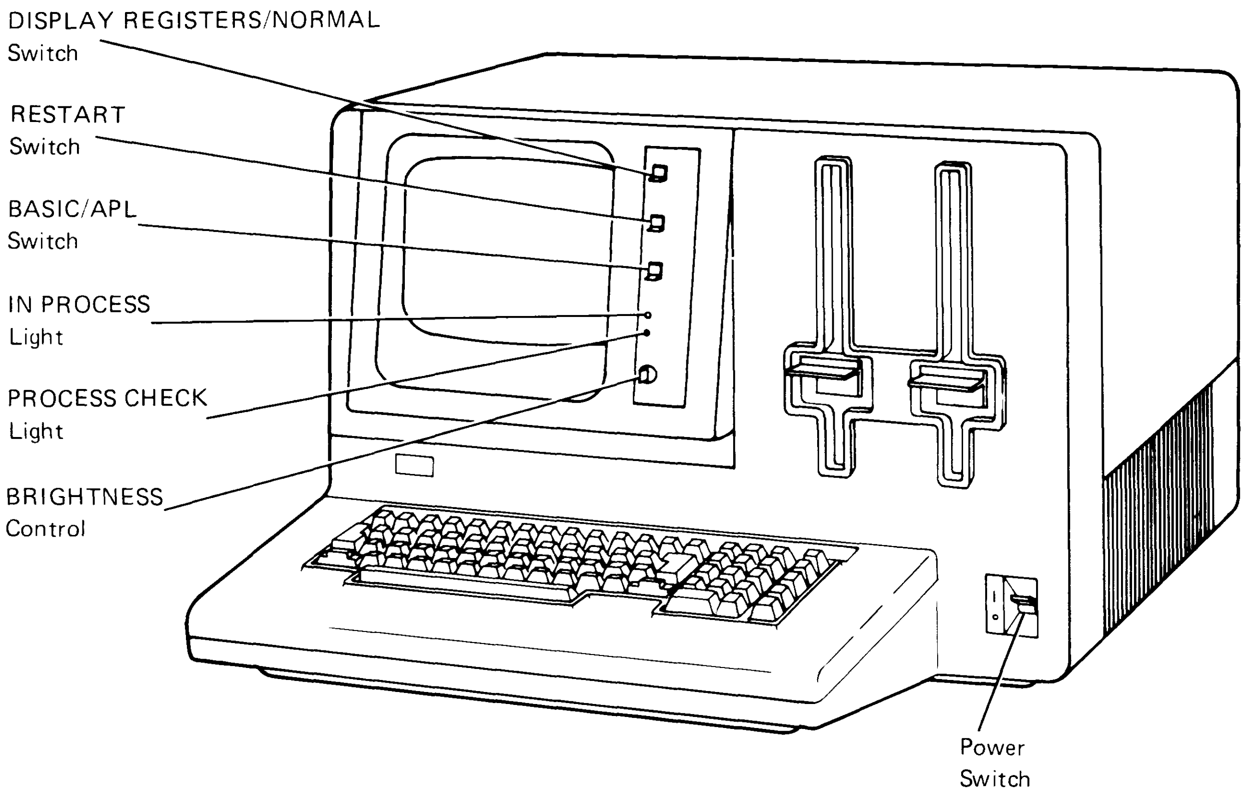
Read/write storage is used to temporarily store data and diagnostics that are loaded from ROS and customer and IBM supplied programs that are loaded from diskette. Data in the display buffer portion of read/write storage is available to the display adapter card via cycle steal and to the processor card via data transfers that are controlled by the processor. Output data is transferred to the processor from storage via the 'read/write bus' lines. It is then sent via the 'data bus out' lines to the base I/O card. Input data is sent to the base I/O card and is sent via the 'data bus in' lines to the processor card. This data is then transferred to read/write storage via the 'read/write storage bus' lines.



A common bidirectional bus is used to transfer data to or from read/write storage. During a read operation, the two bytes of data addressed by the microinstruction of the controlling microprogram are transferred via the read/write storage bus' lines to the processor. During a write operation, either one or two bytes of data are transferred into storage via this same bus. The processor checks for odd parity of all data read from storage and gives a process check when it detects incorrect parity.

Theory

KEYBOARD AND CONTROL PANEL



Switches and Controls

The switches and controls of the 5110 allow the user to control the operation of the 5110 and to manipulate the information on the display screen.

BRIGHTNESS Control: This controls the brightness of the display.

POWER ON-OFF Switch: This switch controls the power to the 5110. The 5110 is ready to use about 25 seconds after the switch is turned on. If the 5110 has been turned off, wait five seconds before you restore the power.

BASIC-APL Switch: This switch is present only on APL-BASIC machines. The switch is used to select the programming language that will be in operation after the RESTART switch is operated or when the power is turned on. To change languages after the machine power has been turned on, change the BASIC-APL switch setting and then operate the RESTART switch.

RESTART Switch: This momentary switch sends the power on reset (POR) signal to the system that resets all logic circuits and starts the bring up diagnostic. When operated and held up, this switch is also used as a lamp test switch for the PROCESS CHECK and IN PROCESS lights.

DISPLAY REGISTERS Switch: This switch has two positions, DISPLAY REGISTERS and NORMAL. When this switch is in the DISPLAY REGISTERS position, the first 512 bytes of storage are displayed in hexadecimal code on the display screen (see *Display Registers* in the *Diagnostic Aids* section). When this switch is in the NORMAL position, bring up diagnostic data or APL/BASIC data that is stored in read/write storage locations X'0200' through X'05FF' is displayed. (See the *Diagnostic Aids* section for more information about the bring up diagnostic.)

Lights

PROCESS CHECK Light: This light indicates that a parity error exists in the system. All data processing stops and further operation cannot be attempted.

IN PROCESS Light: This light indicates that the processor is processing data and that the cycle steal controls are disabled. When this light is on, the display is blank.

KEYBOARD DATA FLOW

Keyboard Operation

When a key is pressed, a flyplate in the key module moves away from the printed circuit pads on the keyboard PC board and decreases the capacitance at that key position. (A pressed key is sensed when a sample pulse is not transmitted. That is, the absence of the sample pulse indicates that a key is pressed.) Releasing the key restores the flyplate to its normal position.

When a key is pressed its code is detected. This code or key data is created from the number in the scan counter and from other data, such as a shift or command key being pressed. This key data is placed into a character register on the keyboard PC board. The key data, which includes an odd parity check bit, remains in the character register until the key is released.

The keyboard interfaces with the processor card (J2) through the base I/O card keyboard adapter. The keyboard adapter receives the key data, including the parity check bit, from the keyboard PC board. The data is stored in the keyboard data latch. The keyboard PC board strobe indicates to the processor that data is available. The strobe also gates the data from the keyboard latch to the data select register and requests a program level 3 interrupt. The level 3 interrupt initiates the transfer of data to the processor. The '-keyboard strobe' line signals the keyboard adapter that the keyboard has data ready for transfer. The data is set in the keyboard data latch.

The strobe pulse that accompanies the data performs three functions:

1. It generates the 'key pending status' line and signals the processor that keyboard data is available in the adapter.

2. It gates the data out of the keyboard data latch and into the data select register. The selection of a device address then makes the data available on the 'bus in bits' line.

3. It drives a program level interrupt from the keyboard adapter after keyboard interrupts have been enabled.

Keyboard Code Translation

When a key or combination of keys are pressed, a level 3 microprogram converts the key code to the 5110 internal code through a translation table located in Common and Language ROS (F2). The program looks up the character and stores the character code in a register in read/write storage. The interrupt associated with the keystroke is then reset, and the character is processed by the level 0 microprogram.

Typamatic Keys: Certain keys of the 5110 keyboard are assigned as typamatic keys, such as the space bar, the scroll up, the scroll down, the backspace, and the forward space keys. When the microprogram recognizes a typamatic key code, the interrupt generated by the key is reset and a '-keyboard strobe' pulse is repeated every 100 ms (after an initial 700 ms delay) for as long as the key is held down. The repetition of the '-keyboard strobe' pulse causes the reentry of the key code for as long as the key is held down.

Key Functions

In addition to the alphabetic and numeric data keys, there are keys used to control the operation of the 5110 and to manipulate the information on the display screen.

EXECUTE Key: This key starts the user program and passes control of previously entered data to the user program. The user program then acts upon this data.

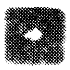
HOLD Key: This key stops the computing system upon completion of the current I/O function. The system is restarted when the key is pressed again.

HOLD/CMD Key: When the HOLD key and the CMD key are pressed simultaneously, the system immediately stops, all I/O operations are reset, and the display is forced on. There is no predictable operational recovery from the CMD HOLD action during I/O operations; a system RESTART must be performed.

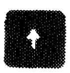
Attention (ATTN) Key: This key causes the display to blank all data from the cursor (including the cursor position) to above the status line (the bottom line). Pressing the key during the execution of an APL user defined function causes the function to stop when it is completed. Pressing the ATTN key during the execution of a BASIC user defined function causes the program to stop at the end of an instruction. To continue the interrupted operation, enter the GO command.

Scroll Keys: The scroll up, the scroll down, the backspace, and the forward space keys are used to position the cursor. Each key appears to move the cursor in the indicated direction, even though the up and down movement is performed by the content of the display. During BASIC operations, only the top 15 lines of the display are moved. The status line at the bottom of the display does not move.

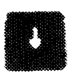
Backspace (left arrow key)—Moves the cursor one character to the left.



Forward Space (right arrow key)—Moves the cursor one position to the right.



Scroll Up (up arrow key)—Moves each line on the display up one line. (See the note in the scroll down description.)

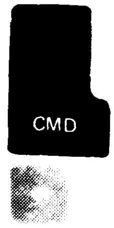


Scroll Down (down arrow key)—Moves each line on the display down one line.

Note: If the machine is processing in BASIC, only the top 15 lines move; the bottom line is the status line and does not move.

Insert (combination of the CMD key and the forward space key)—Inserts a blank into the cursor position you select and shifts all the characters to the right of the cursor one position to the right. This creates a space for inserting a character as shown in the following illustration.

```
        ┌──────── flashing
1 2 3 4 6 7

1 2 3 4 _ 6 7
        └──────── flashing

1 2 3 4 5 6 7
          └────── flashing
```



Delete (combination of the CMD key and the backspace key)—Deletes the character above the cursor and shifts all the characters to the right of the cursor one position to the left.

```
        ┌──────── flashing
1 2 3 4 4 5 6

1 2 3 4 5 6
        └──────── flashing
```

Keyboard Error Checking

The keyboard adapter checks for odd parity on the 'bus out' and 'keyboard data' lines. The base I/O card checks for even parity on the 'device address' lines. An error in either set causes a process check, which stops all data processing. For more information on errors that cause process checks, see *Process Check Chart* in *IBM 5120 System Logic Manual,* logic 405.

MICROPROGRAMMING

An internal machine program controls the 5110. This internal machine program consists of several microprograms, which the 5110 processor uses to accomplish given tasks. Because the 5110 processor cannot process an APL or BASIC user program directly, it must emulate the APL or BASIC program to the internal machine microcode by means of the APL or BASIC emulators on the executable ROS card (L2).

When an APL or BASIC language statement is decoded by the 5110 computer, the machine microcode performs a series of microinstructions that accomplish the required emulation of the user language.

Note: Because the 5110 cannot operate directly from a user language, the computer emulates or appears to have the attributes of the user's language, while each instruction is translated into a language that the computer can use.

Microprograms completely control the I/O hardware. There are several separate microprograms that perform specific functions within the 5110 computer.

The various microprograms that are used on the 5110 are the emulators (APL and BASIC), the Diskette Sort feature, the I/O controller interface (printer I/O, diskette I/O, and keyboard I/O), the diagnostic control program (DCP), and the IPL and I/O supervisor microprograms.

The following special function microprograms are also loaded into R/W storage:

- Asynchronous communications
- Serial I/O
- BSCA
- Print/Plot
- All loadable diagnostic MDIs
- Customer utilities

The languages or applications (such as asynchronous communications or a customer utility) for all I/O functions interface with a common system entry point (IOS). This interface is defined by an input/output control block (IOCB), that is 20 bytes long and is set up in R/W storage. The IOCB has the following format:

Byte	Content
0	Device address
1	Sub-device address
2	Command code
3	Function flags
4,5	Buffer start address
6,7	Buffer size
8,9	Control information
10,11	I/O work area address
12,13	Return code from I/O support
14,15	Control information
16,17	Device status
18,19	Device status

The first three bytes of the IOCB contain the following information:

Byte 0: Device Address

00	Video display and processor
01	Common and language ROS
02	Not used
03	Diskette sort
04	Keyboard
05	Printer
06	BSCA
07	Not used
08	Not used
09	Not used
0A	Serial I/O
0B	Not used
0C	Print plot
0D	Diskette drive
0E	Not used
0F	Not used

Byte 1: Address for Diskette

		Diskette
80	Subdevice 1	1
40	Subdevice 2	2
20	Subdevice 3	3
10	Subdevice 4	4
08	Subdevice 5	Not used
04	Subdevice 6	Not used
02	Subdevice 7	Not used
01	Subdevice 8	Not used

Theory

Byte 2: Command Code (controls the various I/O devices)

	Printer	Diskette
00	Sense	Sense
01	Invalid	Read
02	Print	Write
03	Print	Write last
04	Invalid	Find
05	Invalid	Mark
06	Invalid	Invalid
07	Invalid	Invalid
08	Invalid	Invalid
09	Invalid	Invalid
0A	Invalid	Invalid
0B	Invalid	Write header
0C	Invalid	Scan
0D	Plot function	Invalid
0E	Invalid	Invalid
0F	Invalid	Invalid
10	Invalid	Find ID
11	Invalid	Initialize head
FD	Diagnostic	Invalid
FF	Invalid	Invalid

A diskette read operation consists of the following IOCBs and commands:

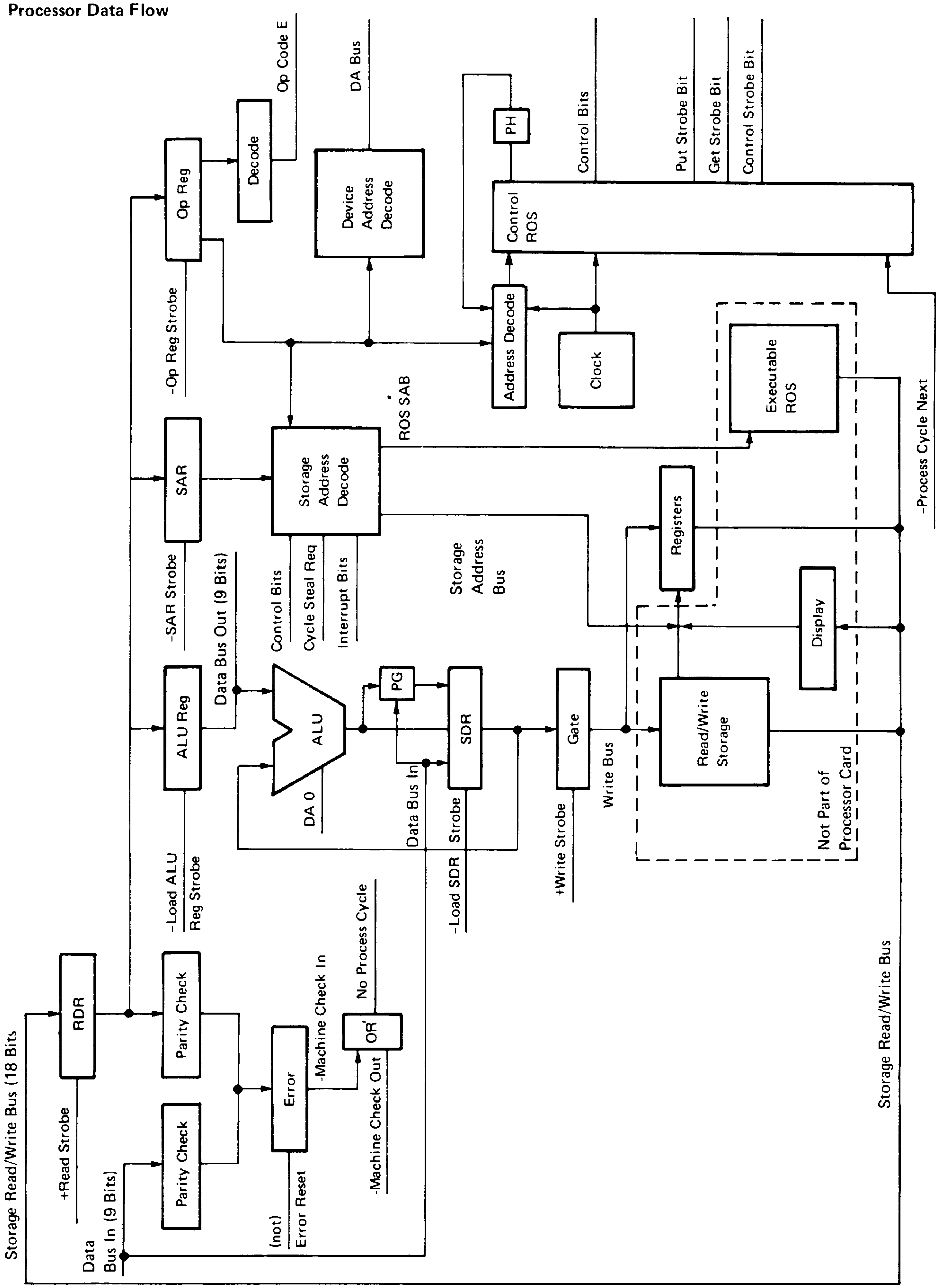
Command	IOCB Bytes 0 1 2	Action
Sense	OD 80 00	Checks the VOL ID and ensures that the diskette is on the specified drive
Find	OD 80 04	Reads the diskette header to locate the specified file
Read	OD 80 01	Reads the data by sector (Multiple sectors can be read.)

The diskette read operation reads one sector of data from a diskette. If successive sectors are to be read from the same file, the IOCB can be coded to read more than one sector without the need for another read IOCB.

A diskette write operation consists of the following IOCBs and commands:

Command	IOCB Bytes 0 1 2	Action
Sense	OD 80 00	Checks the VOL ID and ensures that the diskette is on the specified drive
Find	OD 80 04	Reads the diskette header to locate the specified file
Write	OD 80 02	Writes the data by sector (Multiple sectors can be written.)
Write last	OD 80 03	Writes the last sector of data
Find	OD 80 04	Locates the file header so the diskette file can be used
Write	OD 80 OB	Updates the end of data (EOD) and completes the closing of the file

Processor Data Flow



5110 PROCESSOR

The processor *Data Flow* diagram in the *IBM 5120 System Logic Manual,* logic 400, shows the organization of the processor.

The 5110 processor card (J2) controls the data flow throughout the computing system. The processor communicates with executable ROS, feature ROS, base I/O, read/write storage, and the display adapter. Control pulses and clock pulses are also generated on the processor card.

Storage R/W Bus

The storage R/W bus is an 18-bit bus used to transfer 2 bytes of data having even parity. The storage R/W bus is used during the following operations:

- Reading from executable ROS
- Reading from R/W storage
- Writing into R/W storage
- Sending information from R/W storage to the display unit

Data Bus In

The Data Bus In is a 9-bit bus used to transfer 1 byte of data plus parity from the base I/O card to the processor.

Data Bus Out

The Data Bus Out is a 9-bit bus used to transfer 1 byte of data plus parity from the processor to the base I/O card.

Storage Address Bus

The Storage Address Bus is a 16-bit bus used to supply addresses to read/write storage or executable ROS. The display adapter sends storage addresses to the processor via the storage address bus by cycle steal transfers.

Internal Processor Organization

(Refer to the *IBM 5120 System Logic Manual,* logic 400.)

Read Data Register: The RDR registers receive two bytes of data on each storage read operation via the Storage R/W Bus.

From the read data register, operands can be transferred to the storage address register (SAR), the operations register (Op Reg), the storage data register (SDR), or the arithmetic logic unit register (ALU Reg).

Storage Address Register (SAR): The storage address register is a 16-bit register used to address storage.

Operation Register (Op Reg): The operation register is a 16-bit register used to decode the Op code.

Storage Data Register (SDR): The storage data register is an 8-bit (1 byte) register used to receive data through the Data Bus In. The register also provides the second operand input to the ALU.

Arithmetic and Logic Unit Register (ALU Reg): The arithmetic and logic unit register is an 8-bit register that receives 1 byte operands from the read data register. The output of the ALU register provides the first operand input to ALU and also provides data for the Data Bus Out.

Arithmetic and Logic Unit (ALU): The arithmetic and logic unit is an 8-bit (1 byte) binary unit. When two 8-bit operands are presented to its inputs, the ALU produces an 8-bit arithmetic or logical result at its output.

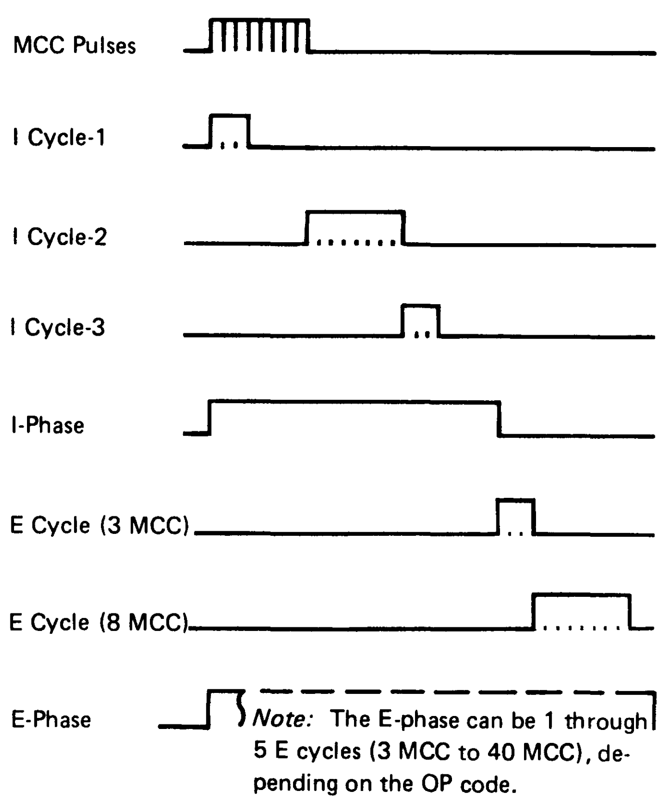
Control ROS Unit: The control ROS unit generates the necessary control lines and gating signals for the instruction being executed.

Registers: The registers on the processor card are addressed as the first 128 bytes of R/W storage and are associated with the four interrupt levels in which processing occurs.

Oscillators/Clocks: The processor uses a 15.1 MHz oscillator to generate 66.2 nanosecond clock pulses. These multiclock cycle (MCC) pulses are used to control data throughout the computing system. MCC pulses make up the I phase (instruction) and E phase (execute) machine cycles.

Machine Cycles

Every machine cycle consists of an I-phase (instruction) and an E-phase (execute). Each I-phase consists of three I cycles. I cycles 1 and 3 consist of 3 MCC pulses. I-cycle 2 consists of 8 MCC pulses. Every I-phase is followed by an E-phase. Each E-phase consists of one through five E cycles. E cycles can be either 3 MCC or 8 MCC pulses, depending on the instruction being executed. The relationship is shown in the following chart.



I-Phase: Each I-phase consists of three I cycles for each microinstruction.

I cycle 1	The contents of program level register 0 are loaded into SAR.
I cycle 2	SAR addresses either R/W storage or executable ROS and transfers the microinstruction located at that address into the operation register.
I cycle 3	The address in the SAR is incremented by two and read back into register 0 of the current program level.

E Phase: During the E phase, the processor performs the operation specified in the Op register. E cycles continue until the operation is completed. Only R/W storage can be addressed during execute cycles.

Interrupts

The 5110 can interrupt microprograms being processed by the I/O devices. There are four program levels in which processing occurs. The program levels and their associated I/O devices are as follows:

- Level 0—Normal operation level
- Level 1—BSCA and asynchronous communications adapter
- Level 2—Diskette, printer, and serial I/O adapter
- Level 3—Keyboard

Each of these levels has 16 two-byte registers. These registers are addressable as the lowest 128 bytes of read/write storage and are located on the processor card. Register 0 of each level acts as an instruction address register. (See *Microinstruction Processing* in this section.) The remaining 15 registers in each program level can be used as general purpose registers.

The bring up diagnostic initializes the processor and begins program execution in level 0. Switching between program levels is controlled by the I/O devices through the interrupt request lines. The I/O devices are assumed by the processor to be connected in a priority sequence. The highest priority is connected to the highest numbered line. When two or more interrupt requests are active simultaneously, the processor responds first to the one with the highest number. The system is designed to prevent more than one active request on each level.

After completing each microinstruction, the processor inspects the interrupt request lines for a higher numbered interrupt. For example, if the processor is operating in level 0 and, upon completion of the current microinstruction, finds that interrupt request lines 1 and 3 are active, three levels (0, 1, and 3) are in contention for the processor. The processor selects level 3 because it is the highest number; it then uses the registers associated with level 3 to execute the next microinstruction.

Error Checking

All errors that cause processor checks, that stop the machine with the PROCESS CHECK light on, are funneled through the processor card. A process check can be caused by any of the following errors or checks:

- Rd data error—This indicates that a parity error exists on data in the read data register of the processor.

  Note: Read data errors can be caused if you attempt to read from a read/write storage address in which the read/write storage cards were not installed.

- -Bus in error—This indicates that a parity error exists on data received via the 'bus in bits' lines. In addition, this error can be caused by the printer or the diskette.
- +Address check, base I/O card—This indicates that a device address check occurred on the base I/O card (H2).
- + Address check, common and language ROS adapter—This indicates that a device address check occurred on the common and language ROS card (F2).
- +Address check, async comm/serial I/O—This indicates that a device address check occurred on the async comm/serial I/O card (D2).
- +Address check, printer—This indicates that a device address check occurred on the printer adapter card within the 5103 printer.
- +Address check, executable ROS—This indicates that a device address check occurred on the executable ROS card (L2).
- Device address check—This indicates that an odd number of all eight device address lines are active when a device is being addressed. Only one of the device address lines X0, X1, X2, or X3 and only one of the device address lines Y0, Y1, Y2, or Y3 are supposed to be active when a device is being addressed.
- +Bus out parity check, base I/O card—This indicates that a parity check occurred on the bus out on the base I/O card (H2). The processor card (J2) or the base I/O card (H2) can cause this error.
- +Bus out parity check, common and language ROS card—This indicates that a parity check occurred on the bus out of the common and language ROS card (F2).
- +Bus out parity check, async comm/serial I/O card—This indicates that a parity check occurred on the bus out of the async comm/serial I/O card (D2).
- +Bus out parity check, printer—This indicates that a parity check occurred on the bus out of the printer adapter card.
- +Bus out parity check, executable ROS—This indicates that a parity check occurred on the bus out of the executable ROS card (L2).

I/O Data Flow Control

The processor receives data from the I/O devices on the 9-bit (8 data, 1 parity) bus in from the base I/O card. Data is sent to the I/O devices on the 9-bit bus out to the base I/O card. The control, put, and get strobe pulses and the 'op code E tag' line signal the I/O devices when I/O microinstructions are executed.

The control strobe has two purposes. It identifies the data on the Data Bus Out as control data. The strobe also serves as a timing pulse to indicate to the I/O device exactly when the Bus Out data is valid.

The put strobe also has two purposes. Besides serving as a timing pulse, it indicates that the Data Bus Out contains data for a put instruction.

The get strobe signals the I/O device that the data placed on the Data Bus In by the device was sampled by the processor.

The op code signal is a decode of the get byte microinstruction. The get byte microinstruction (op code E) occurs well before the get strobe and is used to transfer data. The logical get microinstruction (op code 0) is used to transfer status. The timing relative to the strobe identifies the type of information that has been requested.

Read Only Storage

Read Only Storage (ROS) contains programs and data used to control the 5120 computing system.

Executable ROS

Executable ROS on the L2 card provides microprograms to the processor. These microprograms are directly executed by the processor; they control the operation of the 5110. Executable ROS contains the bring up diagnostic, the I/O control microprograms for the disk and printer, and the language emulator microprograms.

The language emulator microprograms in executable ROS are executed by the processor. These microprograms analyze the input data for the language interpreter so the processor can perform the APL or BASIC operations requested by the user.

The I/O control microprogram in executable ROS controls all I/O functions. When an I/O function is specified, the language sets up an input/output control block (IOCB) to request an I/O function and passes control to the I/O supervisor. The I/O supervisor checks the IOCB to determine which I/O device has been requested and passes control to the device I/O microprogram that performs the requested I/O function.

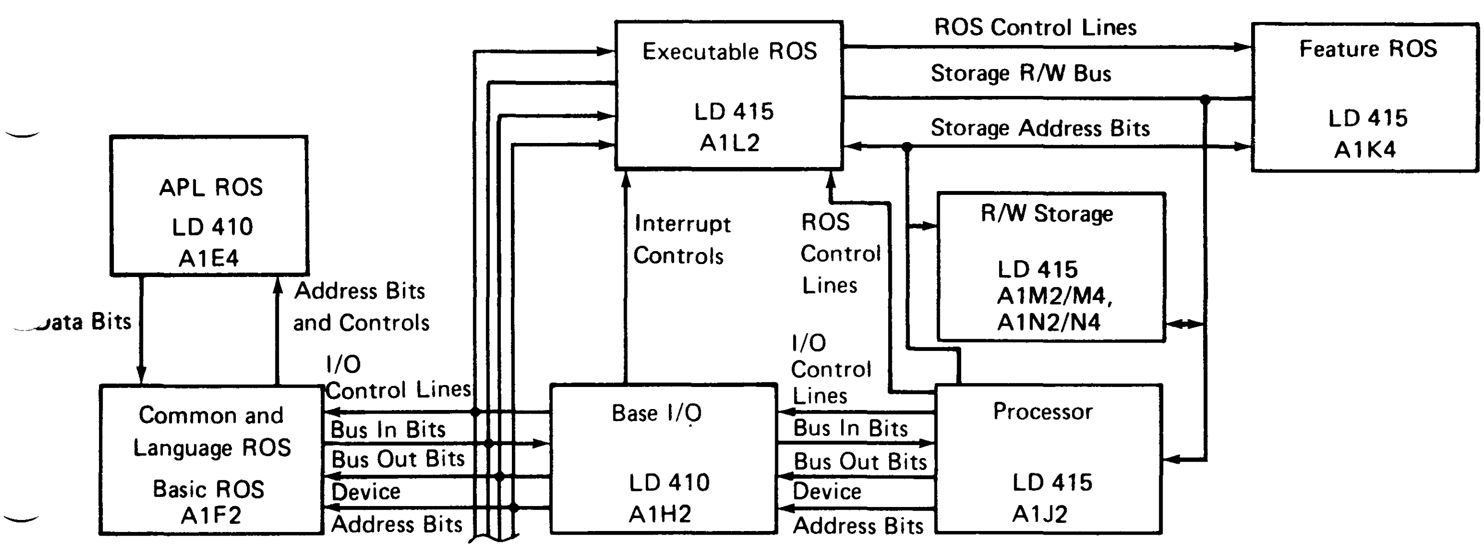
Executable ROS is divided into ROS 1 and ROS 2. During the power up sequence, the power on reset (POR) activates ROS 1 mode, and the processor begins executing instructions from executable ROS. The processor begins executing the bring up diagnostic at the address contained at location 000A, ending with the IPL routine. POR also latches the '+ APL switch' line to select the language in which the 5110 will operate. The selection of ROS 1 or ROS 2 is controlled by bus out bits 0 or 1 and a control strobe (microprogram instruction).

Executable ROS is activated by the '-select ROS' line. When the ROS control signals 'MCC4' and 'memory select' are active, executable ROS transfers a microinstruction from ROS at the address on the storage address bus to the storage read/write bus.

Processor clock signal 'MCC4' is used to reset the ROS array. The ROS 'memory select' line is the product of clocks 'MCC2' and 'MCC3', that are gated to access the data in the ROS array.

A three byte status word is available from the executable ROS card. It is gated to the 'bus in' line by the 'op code E' line and the 'device address 02' line. Bus out bits 0, 1, and 2 determine which status byte is to be sent back to the microprogram.

Feature ROS is an extension of Executable ROS. To select feature ROS, storage address bit 0 must be active; it gates the '-select ROS' line with either the '+memory select 5' line or the '+memory select 6' line.



Common ROS and Language ROS

Common ROS contains tables used in all system configurations; it also contains the disk read diagnostic microprograms. Diagnostic microprograms are loaded into read/write storage for execution by the processor when they are selected by the diagnostic control program (DCP).

Language ROS (APL or BASIC) interpreter functions are accessed and placed into R/W storage when they are needed to control the APL or the BASIC microprogram executed by the processor.

BASIC and common ROS are located on the F2 card and APL ROS is located on both the F2 and E4 cards. APL, BASIC and common ROS share a common address bus. To select one of the three ROS spaces, the processor must execute a control instruction using device address 01. The data byte of the control instruction is put on the bus out and stored in the bus out register on the F2 card. During control strobe, device address 01 and active data bit 4, 5, or 6 will select BASIC, APL, or common ROS respectively.

Next the microprogram must develop the 16-bit address from which data is requested in ROS. This is accomplished by two put instructions that are sent to device address 01. The high order address byte is provided by the first put instruction, and the low order address byte is provided by the second put instruction. The 16-bit ROS address register must be loaded a byte at a time. This loading is accomplished by two load lines. One load line is pulsed during the first put strobe, and the second load line is pulsed during the second put strobe. The highest six bits (bits 0–5) of the address are used to decode an address range line (30K bytes per range).

At the end of the second put strobe, the entire address is defined, and the 'C1 powered' line increments a three bit counter. The three outputs of this counter are decoded to make up the three ROS access control lines. The three ROS access control lines are '-restart', '-set', and '-sample and reset'. The 'restart' line initializes the ROS array, the 'set' line accesses the data within the ROS array, and the 'sample and reset' line gates the data onto the data bus lines.

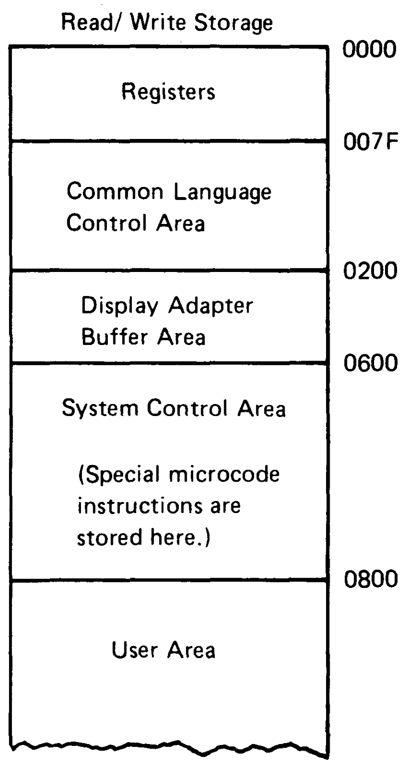
The 16 ROS bits are transferred 8 bits at a time to the 'bus in' line. This transfer is accomplished by two get instructions. The first get instruction transfers the high order byte, and the second get instruction transfers the low order byte. The second strobe signal caused by the get instruction also increments the address register by 1 and restarts the address control sequence. This is done to eliminate the need for reloading the address register if sequential addresses in ROS are to be accessed.

Read/Write Storage

Read/write storage is located on four cards: M2, M4, N2, and N4. The following configurations are available:

Storage	Cards
16K	M2
32K	M2, M4
48K	M2, M4, N2
64K	M2, M4, N2, N4

Data is not reset or changed when it is read out of read/write storage. When the power is turned on, the storage contents will be invalid and may have incorrect parity. However, the bring up diagnostic writes valid data into every read/write storage location.



Note: The first 128 bytes (0000 through 007F) of storage are located on the processor card. These bytes are used as registers.

Storage Data Flow

During the cycle steal time, storage read data is made available to the display card (G2) via the Storage R/W Bus. Data is also available to the processor card (J2) where the microprogram examines the data or instructions and controls the system operation.

During input operations, I/O data is sent to the base I/O card. This data is then transferred to the processor via the Bus In Bits and then to R/W storage via the Storage R/W Bus.

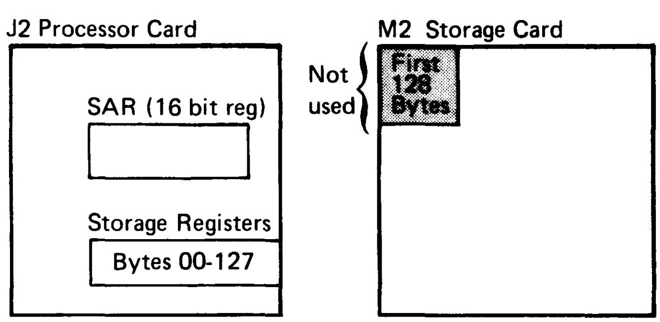
Card Layout

Each R/W storage card consists of eighteen 8K bytes storage modules. These 8K bytes modules are further broken down into eight 1K bytes storage chips.

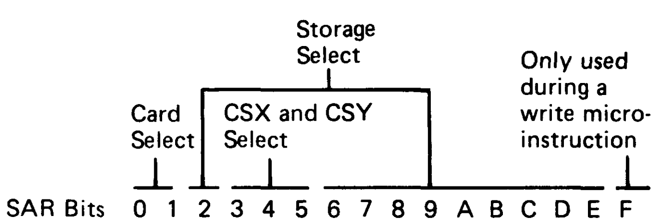
Storage Address Register (SAR)

The storage address register (SAR) is a 16-bit register used to address storage. It is located on the processor card (J2). The microprogram selects executable ROS, control ROS, or R/W storage addresses to be read into SAR. The 16 bits in SAR are labeled 0 through F. If the first nine SAR bits (0-8) contain logical zeros, an address of 0000-0127 is decoded from the remaining six SAR bits (9-E). SAR bit F is used only during a write microinstruction.

If SAR bits 0-8 are not active (each bit contains a 0), the SAR will use the remaining SAR bits (9 through E) to address the 128-bytes of storage located on the J2 processor card.



Functions of Address Lines



Example: The SAR contains an address of X'004A'.

SAR Bits	0	1	2	3	4	5	6	7	8	9	A	B	C	D	E	F
	0	0	0	0	0	0	0	0	0	1	0	0	1	0	1	0
	0				0				4				A			

This SAR will address storage position X'004A' in the storage on the processor card.

We do not address the first 128 bytes of R/W storage on the M2 card. These 128 bytes of read/write storage are located on the processor card (J2) and are used as registers.

Card Select

SAR bits 0 and 1 are used to select a specific storage card as follows:

SAR Bit 0 1	Card Select Line	Storage Card
0 0	0	M2
0 1	1	M4
1 0	2	N2
1 1	3	N4

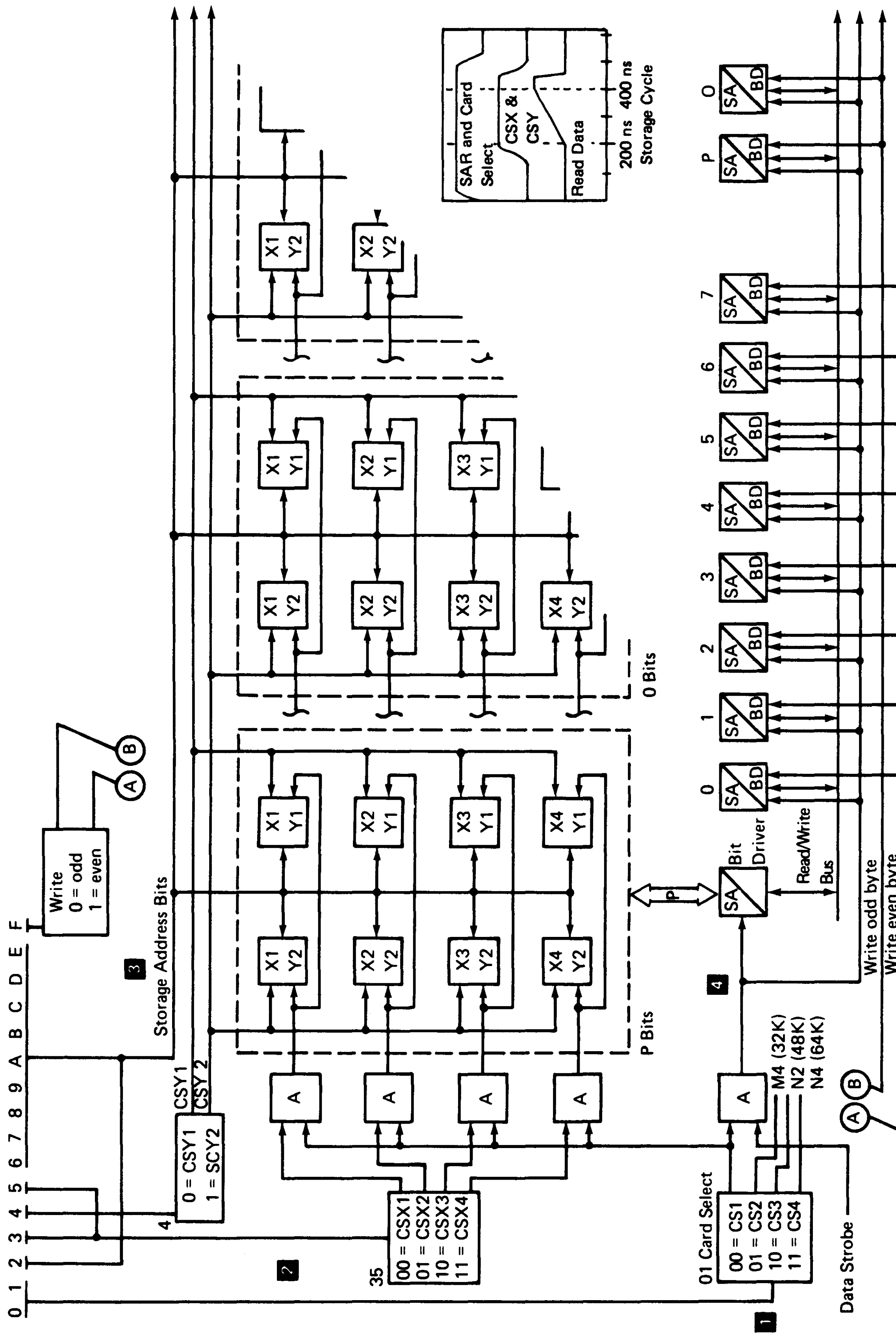
Chip Select

SAR bits 3, 4, and 5 are used to select a specific chip on the addressed storage card as follows:

SAR Bit 3 4 5	CSX/CSY Line (Chip Select)
0 0 0	CSX 1/CSY 1
0 0 1	CSX 2/CSY 1
0 1 0	CSX 1/CSY 2
0 1 1	CSX 2/CSY 2
1 0 0	CSX 3/CSY 1
1 1 0	CSX 3/CSY 2
1 0 1	CSX 4/CSY 1
1 1 1	CSX 4/CSY 2

Bit Select

SAR bits 2, 6, 7, 8, 9, A, B, C, D, and E are used to select an individual bit in each of the 1K bytes chips selected by the CSX and CSY lines.



1 'Card select' line selects 1 of 4 possible storage cards.

2 CSX and CSY select 1 of 8 groups of 1024-byte chips on a card.

3 Storage address bits select 1 9-bit byte of 1024 bytes in a group.

4 Bit driver drives the selected byte on the R/W bus.

Note: The dotted lines enclose an 8K bytes module

Storage Read

The Storage R/W Bus is a bidirectional bus that uses common lines to read from or write to storage. The bus is under the control of the '+data strobe' line when reading from R/W storage. During a read operation (the 'write even' or 'write odd' lines are inactive), the two bytes (18 bits) of data addressed by the microinstruction are transferred to the processor card (J2) or the display card (G2).

Storage Write

During a write operation, the 'write even' and 'write odd' lines are controlled by the microinstructions. All 18 bits of R/W storage (even byte) can be written by activating the 'write even' line, or the second 9 bits (odd byte) can be written by activating the 'write odd' line.

Storage Error Checking

The processor card checks the parity of the Storage R/W Bus. If the parity is not odd, the '-RDR check' line is activated. This line activates the 'machine check' line and the PROCESS CHECK light on the display panel.

BASE I/O CARD

The base I/O card contains drivers and receivers; it acts as a distributor of data, control information, and device addresses for the 5120 computing system. The power on reset signal is generated on the base I/O card and is distributed to all devices.

The keyboard adapter is located on the base I/O card (H2). Keyboard data and control information is sent through the adapter to the processor, where microprograms act on the data.

I/O CABLE DRIVER CARD

The I/O cable driver card (A1A2) supplies line receivers and line drivers for the internal diskette units and the various attached I/O devices. The Device Address Bus and the Bus Out Bits are repowered and sent to the devices. The Bus In Bits from devices are received, repowered, and sent to the H2 card. The control and clock lines to the devices are also repowered. The interrupt request line is received and repowered by the cable driver card while the machine check line merely passes through the H2 card to the L2 card.

Diskette Unit

The internal diskette drives are input/output (I/O) devices that connect to the 5110 with attachment cables. The diskette drives store and retrieve data by writing data on diskettes for later use and by reading data from diskettes for immediate use. The data rate in a write operation is 24K bytes per second. The data rate in a read operation is 48K bytes per second. The write operation is only half the speed of the read operation because of the verify read that occurs on the write operation. The data capacity of each diskette is a maximum of 1.2 megabytes.

The commands and controls for operating the internal diskette drives are provided by the system on the I/O data bus cables.

The diskette drives use three types of diskettes: diskette 1, diskette 2 and diskette 2D. The diskette drives can write on and read from all three types of diskettes.

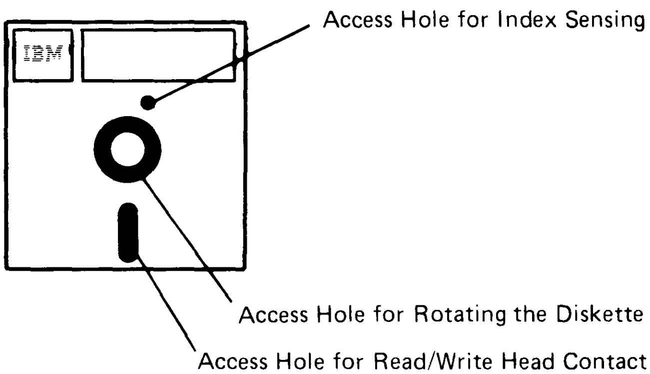
The diskette drives use both the frequency modulated (FM) and the modified frequency modulated (MFM) method of recording data on the diskette.

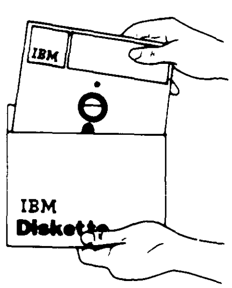
The diskette attachment board (B1) is mounted on a hinged bracket in the 5110. The adapter card and converter cards are plugged into the diskette attachment board. The diskette attachment cables are plugged into the converter cards.

The 5110 power supply provides AC and DC power to the diskette drives. Power to the diskette drives is turned on and off with the 5110 power switch.

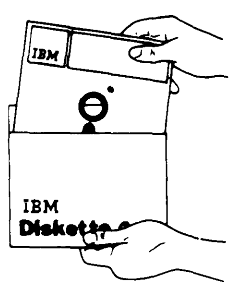
Diskette Description

The IBM diskette is a thin, flexible disk housed in a protective envelope. Information is stored magnetically on the diskette surface, which is coated with magnetic oxide. The diskette is free to rotate inside the envelope. As the diskette rotates, the inner surface of the envelope cleans the diskette. The envelope has access holes for rotating the diskette, for read/write (R/W) head contact, and for indexing hole sensing. There are two arrangements for recording data on a diskette. Diskette 1 permits the recording of data on only one side of the diskette; diskette 2 and diskette 2D permit the recording of data on both sides of the diskette.





Diskette 1



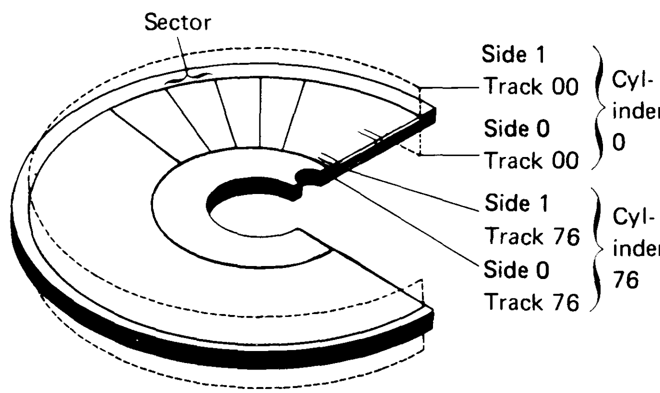
Diskette 2

The location of the access hole for index sensing on diskette 1 differs from that on diskette 2 and diskette 2D. When a diskette 1 is inserted on the diskette drive, index sensing circuits sense that a diskette 1 is being used, and the use of the blank side is prevented.

Information is written on the diskette in tracks. A track is a circular path on the diskette surface. A sector is a division of each track of the diskette that was determined during diskette initialization. Each sector is used to write one record. Information is magnetically written to and read from a track by a read/write head as the diskette rotates.

There are 77 tracks on each side of a diskette. Track 00, which is the outside track, is reserved as a label track and can not be used for data. Tracks 75 and 76, which are the two innermost tracks, are reserved as replacement tracks and can only be used for data if another track becomes damaged.

Diskette 1 has 74 tracks available for recording data. Diskette 2 or diskette 2D has 74 tracks available on each side of the diskette, resulting in a total of 148 tracks of data. When data is recorded on only one side of a diskette, it is practical to refer to each addressed circle of data as a track. When data is recorded on both sides of a diskette, however, each pair of tracks (one upper and one lower) is referred to as a cylinder. For example, cylinder 0, the outside cylinder, is made up of upper and lower track 00.



When one-sided diskettes (diskette 1's) are used, the most data that can be read or written on a track without moving the R/W head is that track over which the R/W head is positioned. When two-sided diskettes (diskette 2's or 2D's) are used, the most data that can be read or written on 2 tracks (one on each side of the diskette), without moving the R/W head assembly is the 2 tracks over which the R/W head is positioned. When 2 tracks are used, the total amount of area that can be accessed is referred to as a cylinder.

Diskette Safety

LONG TERM STORAGE

Place diskettes in their envelopes and store them in the following environment:

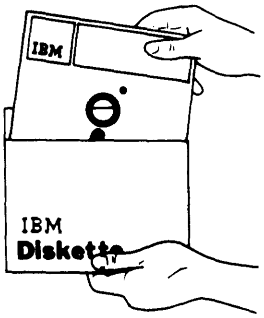
- Temperature 50°F to 125°F (10.0° to 51.5°C)
- Relative humidity 8% to 80%
- Maximum wet bulb 185°F (29.4°C)

If a diskette has been exposed to temperatures outside the indicated range, allow 5 minutes acclimation time before use. You should remove the diskette from its plastic shipping container during this time.

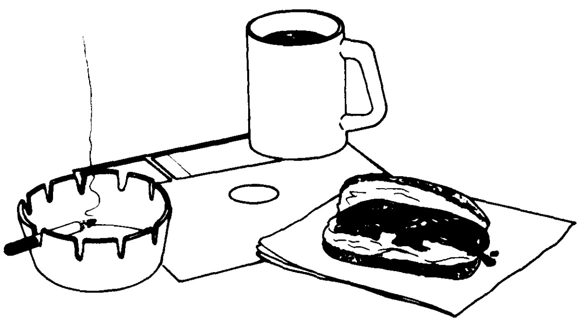
SHIPPING AND RECEIVING

Use only shipping cartons to ship diskettes. Additional shipping cartons are available at IBM branch offices. With the diskette in place, the package weighs 10 ounces (280 grams). Be sure to label the package: DO NOT EXPOSE TO HEAT OR SUNLIGHT. Save the carton for diskette storage and/or for later shipment.

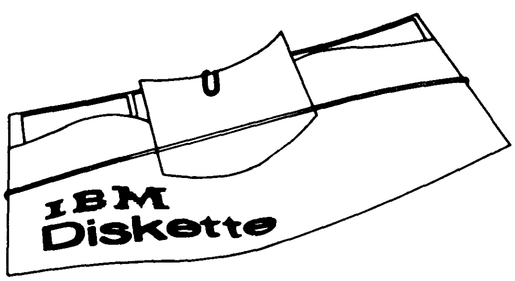
Return a diskette to its envelope whenever it is removed from the diskette drive.



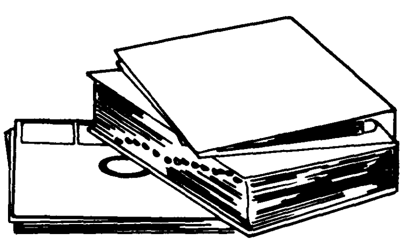
Do not lay diskettes near food, drink, or ashtrays.



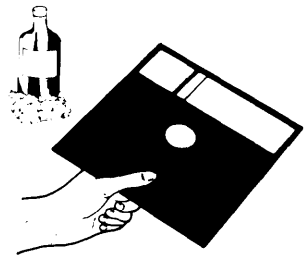
Do not use clips or rubber bands on a diskette.



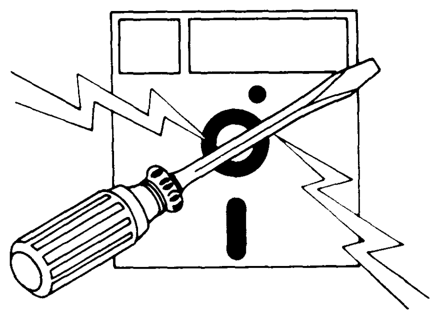
Do not place heavy objects on diskettes. The weight can cause serious damage.



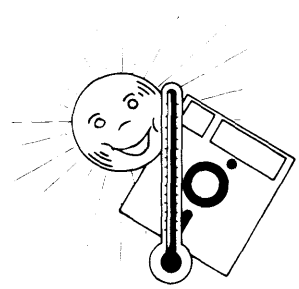
Do not touch or attempt to clean diskette surfaces. Contaminated diskettes must be discarded.



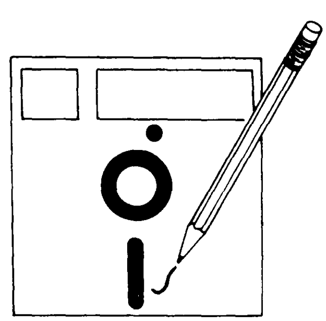
Do not place diskettes near materials that might be magnetized. Data can be lost from a diskette exposed to a magnetic field.



Do not expose diskettes to heat greater than 51.5°C (125°F) or direct sunlight.



Do not write on diskettes outside label area.



Diskette Handling

DISKETTE INSERTION

1. Open the diskette latch.

2. Remove the diskette from its protective envelope.

3. Place the diskette squarely into the diskette drive (with the label facing the latch).

4. Close the diskette latch.

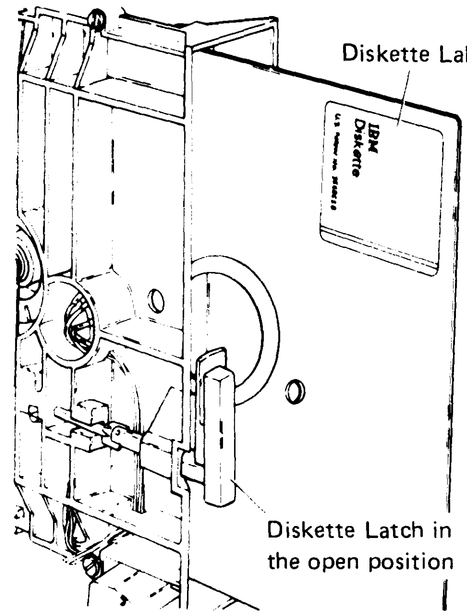
DISKETTE REMOVAL

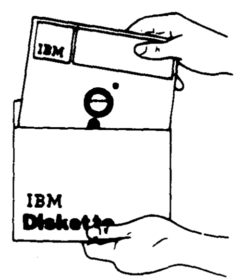
1. Open the diskette latch.

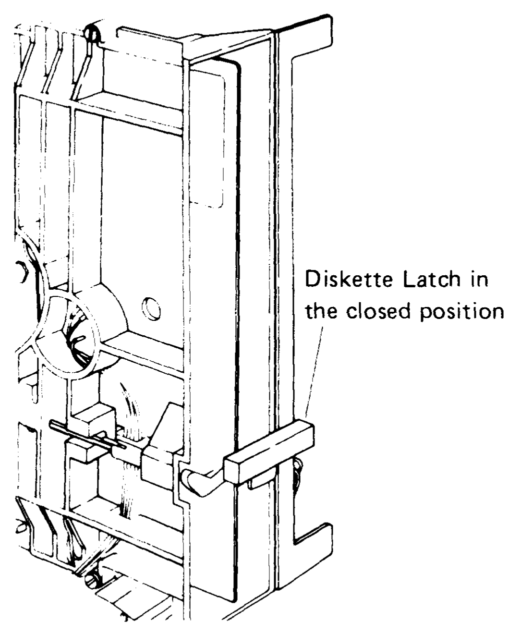
2. Remove the diskette.

3. Insert the diskette into a protective envelope.

4. Close the diskette latch.







Stepper Motor

Stepper Motor Description

The dc stepper motor consists of a permanent magnet rotor (armature) and pairs of two-phase stator windings. The motor is a sealed unit having no gears or commutators and requiring no maintenance.

Notes:

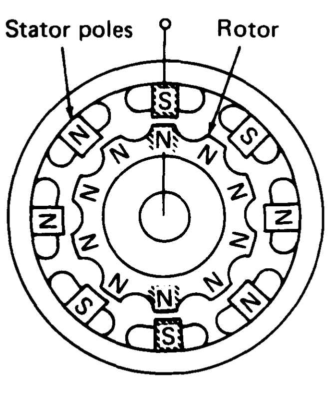
1. The rotor is magnetized after assembly at the plant of motor manufacture. Disassembly of the motor reduces the magnetic flux of the rotor. This causes a reduction in the torque produced by the motor. For this reason, you should not disassemble the motor.

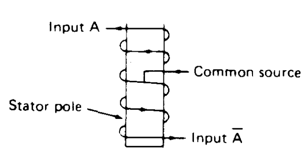
   When current flows through a pair of stator windings, a magnetic field set up in the stator poles acts on the rotor to provide torque to the rotor shaft. This torque turns the rotor shaft only a part of a revolution; then it holds the shaft in an electrically detented position. The electrical detent is due to the direct current in the stator windings acting on the permanent magnet rotor. Shaft rotation is not continuous unless the stepper motor is continually pulsed.
2. The rotor cannot be easily turned by hand with the power on. When power is off, any residual detenting is felt as a drag or roughness, and it may cause a clicking sound as the shaft is turned.

Stepper Motor Operation

For ease of understanding, the motor used in this example turns 9° per step; the actual motor turns 1.8° per step.

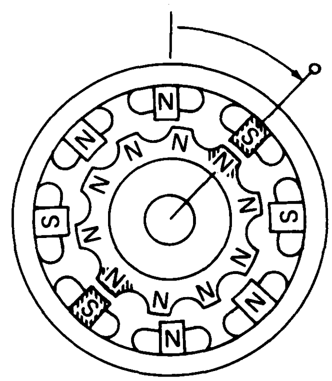
This simplified stepper motor consists of eight coil wound stator poles and a ten-pole permanent magnet rotor.





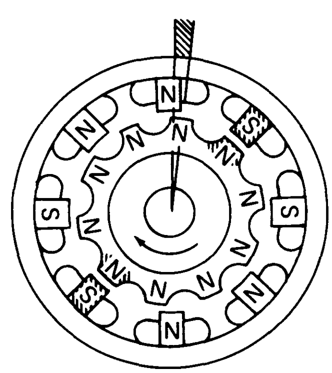
Stator-pole winding

If you could rotate the stator in either direction, the rotor would maintain its detented position and follow the stator as shown. Both the stator poles and the rotor are shown rotated 45° clockwise.



Note: Current flows only in one-half of the winding at a time. Polarity of the stator poles is determined by which half of the winding has the current flow.

If, instead of physically rotating the stator, you electrically rotate its magnetic field by switching the current to the next stator winding, the rotor turns until the closest opposite-polarity magnetic poles are attracted into alignment. Note that the polarity of the poles has rotated one position clockwise from that shown in the first illustration. The sequence of the phase pulses from the logic circuits determines the direction of rotation.



In the diskette unit, the stepper motor drive band is attached to the head/carriage assembly. As the motor turns, the band moves the assembly. A 90° rotation of the motor moves the assembly across the diskette the distance of one track. A clockwise movement of the rotor moves the assembly toward the hub of the diskette. The stepper motor moves the assembly one track in 5 milliseconds. It requires 35 milliseconds to stop the moving assembly. Total seek time is 5 milliseconds times the number of tracks traveled plus 35 milliseconds.

FM (Frequency Modulated) Format Principles

FM format is a method of recording data on a diskette surface. The frequency of pulses is changed (modulated) to represent data.

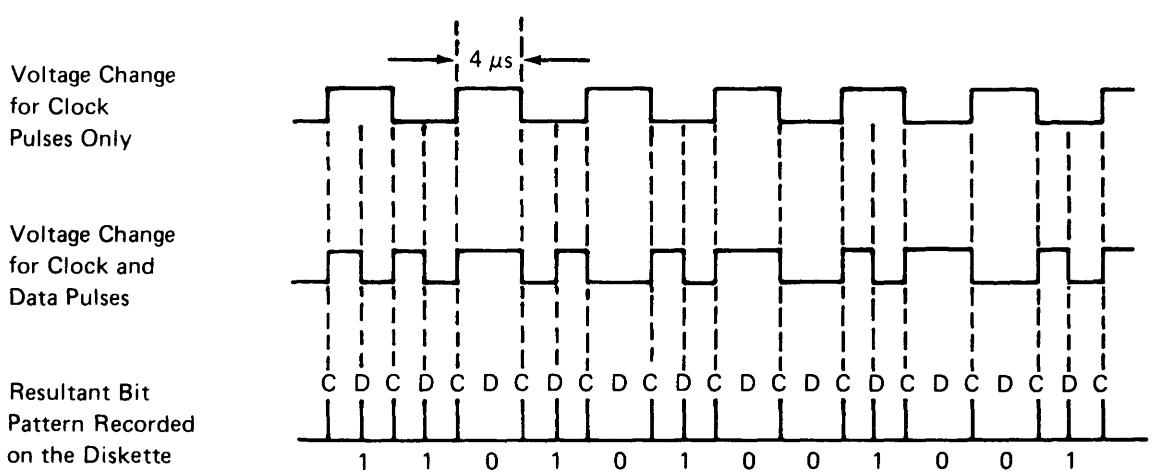
When no data is present (all 0 bits), only clock pulses are present. These pulses occur at a frequency of every 4 μs.

When data is present, the pulse frequency changes. Each 1 bit pulse is inserted halfway between adjacent clock pulses so there is double the pulse frequency. If a 0 bit is recorded, no pulse is between the clock pulses, so the pulse frequency is not changed.

The raw data rate in FM format is 250,000 bits (31,250 bytes) per second.

READ DATA

Each clock pulse or 1-bit pulse is recorded on the diskette surface as a change in magnetic direction (flux) from the bit immediately preceding it. As this change in flux passes the read/write heads, it causes the current in the read/write heads to change direction. This change in current direction is recognized by the adapter as either a clock pulse or a 1-bit pulse. If there is no change in the direction of the current between two adjacent clock pulses, the adapter recognizes that a 0 bit is present.



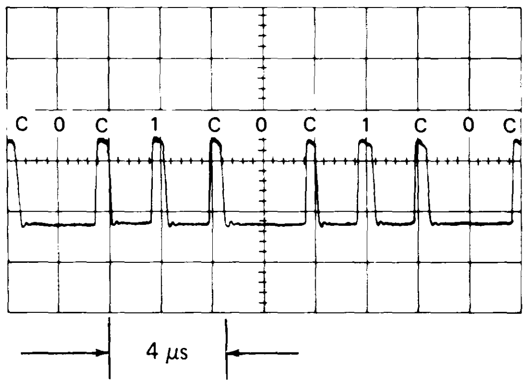
The C and D above the line show the clock and data bit times.

The numbers under the line show whether a 1 bit or a 0 bit is recorded.

See logic 440A in the *5120 System Logic Manual* for circuit description and MIM 237 for the test points.

File Data
Example: 01010

2.0 V/cm



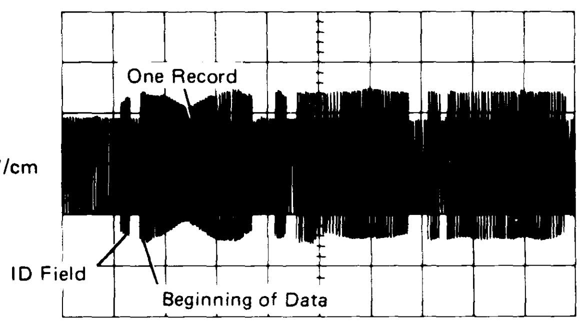
2.0 µs/cm

Note: Use Tektronix 453, 454, or similar oscilloscope with x10 probes.

Channel A sweep mode	Normal
Channel A level	+
Channel A coupling	DC
Channel A slope	+
Channel A source	External
Trigger	Normal
Mode	Channel 1
Channel 1 volts/division	2.0 V/cm
Channel 1 input	DC
Times per division	2 µs/cm
Connect channel 1 to	+File data
Connect trigger to	+Index test pin
Observe:	Clock pulses every 4 µs. Pulse duration should be between 100 and 500 ns. Pulse amplitude should be between 2.4 and 4.2 volts.

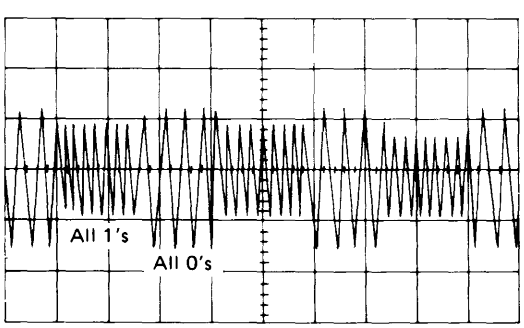
Read Head Signal at TP1 and TP2

0.05 V/cm



2 ms/cm

0.05 V/cm



10 µs/cm

Note: Use Tektronix 453, 454, or similar oscilloscope with x10 probes.

Channel A sweep mode	Normal
Channel A level	+
Channel A coupling	DC
Channel A slope	+
Channel A source	External
Trigger	Normal
Mode	Add
Channel 1 volts/division	0.05 mV/cm
Channel 2 volts/division	0.05 mV/cm
Channel 1 input	AC
Channel 2 input	AC
Invert	Pull out
Times per division	2 ms/cm
Connect channel 1 to	Preamp TP1
Connect channel 2 to	Preamp TP2
Connect trigger to	+Index test pin
Observe:	The amplitude of the read signal should be between 6.5 to 560 mV.

MFM (Modified Frequency Modulated) Format Principles

MFM format is a method of recording data on a diskette surface. The frequency of pulses is changed (modulated) to represent data.

With no data present (all 0 bits) the only pulses present are clock pulses. These pulses occur at a frequency of every 2 μs.

When data is present, the pulse frequency changes. Each 1-bit pulse is inserted halfway between adjacent clock times. The clock pulses are suppressed however, so the frequency remains the same. All clock pulses will be suppressed unless two 0 bits (no pulse) occurs next to each other. When this happens, the clock pulse that would normally occur at the clock time between the 0 bits is not suppressed. Therefore, for that particular time, the pulse frequency changes.

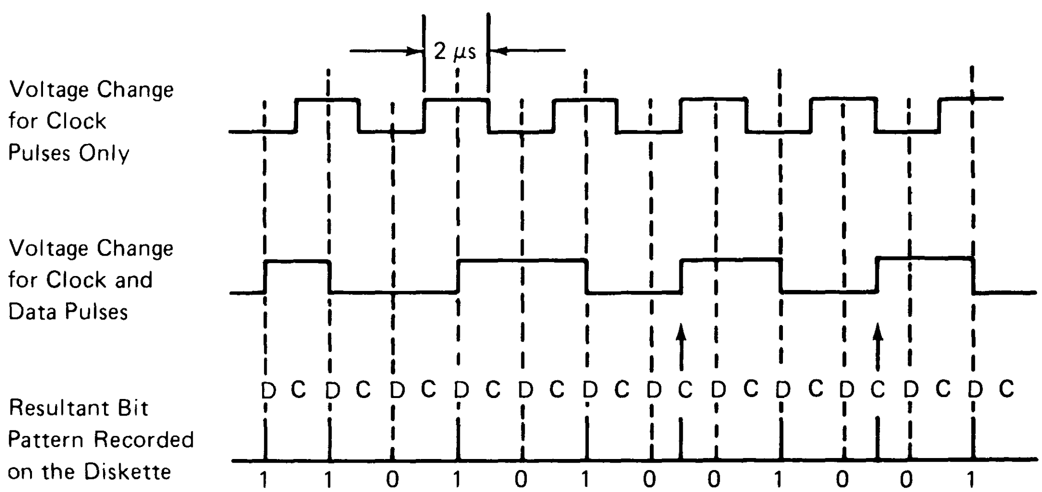
Therefore, a pulse appears *between* any consecutive 0 bits (the clock pulses) and *for* each 1 bit.

READ DATA

Each clock pulse or 1 bit is recorded on the diskette surface as a change in magnetic direction (flux) from the bit immediately preceding it. As this change in flux passes the read/write heads, it causes the current in the read/write heads to change direction. This change in current direction is recognized by the adapter as either a clock pulse or a 1-bit pulse. If there is no change in the direction of current at data time, the adapter recognizes that a 0 bit is present.

The raw data rate in MFM format is 500,000 bits (62,500 bytes) per second.

MFM format, when compared to FM format, can record twice the amount of data on a diskette surface.



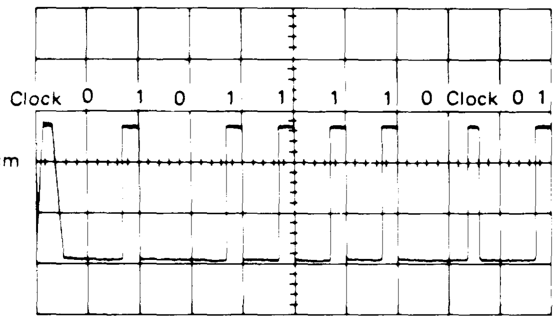
The C and D above the line show the clock and data bit times.

The numbers under the line show whether a 1 bit or a 0 bit is recorded.

See Logic 440A in the *5120 System Logic Manual* for circuit description and MIM 237 for the test points.

File Data
Bit Pattern: Hex 'E5E5'
Example: 0101111001

1.0 V/cm



2.0 μs/cm

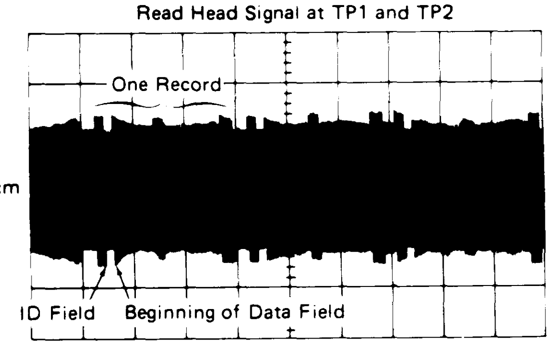
Note: Use Tektronix 453, 454, or similar oscilloscope with x10 probes.

Channel A sweep mode	Normal
Channel A level	+
Channel A coupling	DC
Channel A slope	+
Channel A source	External
Trigger	Normal
Mode	Channel 1
Channel 1 volts/division	1.0 V/cm
Channel 1 input	DC
Times per division	2μs/cm
Connect channel 1 to	+File data
Connect trigger to	+Index test pin
Observe:	Clock or data pulses every 2 to 4 μs. Pulse duration should be between 100 and 500 ns. Pulse amplitude should be between 2.4 and 4.2 volts.

Theory

Read Head Signal at TP1 and TP2

0.05 V/cm



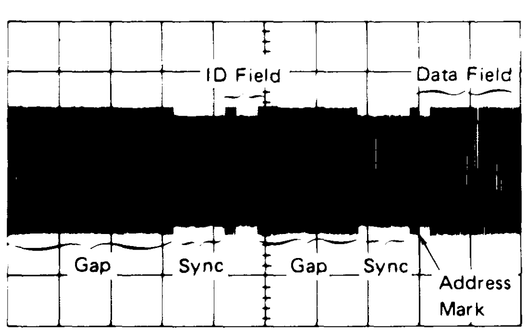
2.0 ms/cm

Note: Use Tektronix 453, 454, or similar oscilloscope with x10 probes.

Channel A sweep mode	Normal
Channel A level	+
Channel A coupling	DC
Channel A slope	+
Channel A source	External
Trigger	Normal
Mode	Add
Channel 1 volts/division	0.05 V/cm
Channel 2 volts/division	0.05 V/cm
Channel 1 input	AC
Channel 2 input	AC
Invert	Pull out
Times per division	2 ms/cm
Connect channel 1 to	Preamp TP1
Connect channel 2 to	Preamp TP2
Connect trigger to	+Index test pin
Observe:	The amplitude of the read signal should be between 6.5 and 560 mV.

One Record

0.05 V/cm



200.0 μs/cm

Volume Label

VOLUME LABEL LAYOUT

Track 00 Head 0 Record 7

Byte	
0–3	Volume Label Identifier and Number
4–9	Volume Identifier as Specified by the User
10	Accessibility
11–15	Reserved
16–23	Reserved

Byte	
24–36	System Identification
37–50	Owner Identification

Byte	
51–63	Reserved
64	Extended Label Area
65–70	Reserved
71	Volume Surface Indicator
72	Extent Arrangement Indicator
73	Special Requirements Indicator
74	Reserved

Byte	
75	Physical Sector Length
76	Physical Record
77	Sequence Code
78	Reserved
79	Label Standard Version
80–127	Pad

VOLUME LABEL FORMAT

The volume label is located at track 00 head 0 record 7 on all diskettes. It identifies the diskette and indicates to the adapter how the information on the diskette is arranged. The volume label is encoded on the diskette every time the diskette is initialized using the initialization utility program. The volume label is always encoded in FM format. This label is read and verified each time a sense command is issued to the diskette drive.

Volume Label Fields

Volume Label Identifier and Number (0-3): Identifies this particular portion of the diskette as a volume label (for example: VOL1).

Volume Identifier As Specified By User (4-9): Identifies this diskette. This identifier contains up to 6 alphameric characters. The identifier is specified during diskette initialization.

Accessibility (10): Indicates if the diskette can be read from or written to. If this bit is on, the diskette cannot be read from or written to. This bit can be turned on or off using the)VOLID command in APL or the UTIL command in BASIC.

System Identification (24-36): Identifies the system or system group on which the diskette was initialized (for example: IBM 5100).

Owner Identification (37-50): This field contains 14 alphameric characters. Identifies the owner of the diskette or the owner of the information written on the diskette.

Extended Label Area (64): Indicates how many, if any additional tracks have been allocated as header label tracks. Up to 9 additional tracks on each side of a diskette 2D can be set aside for header labels (for example: 0 = no additional tracks, 1 = one additional track).

track 00, side 0 = 19 labels
track 00, side 1 = 52 labels (2 labels per sector)
9 additional tracks, both sides = 936 labels

Volume Surface Indicator (71): Identifies the diskette as a diskette 1 diskette 2 or a diskette 2D. Set to space for a diskette 1, 2 for a diskette 2, or M for a diskette 2D.

Extent Arrangement Indicator (72): Indicates if there are any constraints on the arrangement of extents, data set labels, or unallocated space on this diskette. A 'P' indicates the extents must be adjacent and must begin at cylinder 1, head 0, sector 1. 'P' also indicates that the data set labels must begin at cylinder 0, head 0, sector 8 and must be in the same sequence as the extents they describe and that all unallocated space must follow the last data set extent on the volume. A 'blank' indicates that there are no special constraints on the arrangement of the extents, data set labels, or the unallocated space on the diskette.

Special Requirements Indicator (73): Indicates if there are any special requirements for accessing data on this volume. A 'blank' indicates that there are no special requirements. An 'R' indicates that some of the data sets were recorded in logically nonsequential manner.

Physical Sector Length (75): Specifies the sector length as 128 bytes, 256 bytes or 512 bytes. Set to space for 128 bytes, 1 for 256 bytes, 2 for 512 bytes, or 3 for 1024 bytes.

Physical Record Sequence Code (76-77): Indicates how the physical records are sequenced on this diskette. This field will contain either a blank or the characters 01 through 13. A blank or a 1 indicates the sectors are physically sequential. Otherwise, this field is used as an increment to determine the next physical sector.

26 Sectors Per Track

When this field contains:

The sequencing will be:

Blank	01	02	03	04	05	06	07	08	09	10	11	12	13
1	1	1	1	1	1	1	1	1	1	1	1	1	1
2	2	3	4	5	6	7	8	9	10	11	12	13	14
3	3	5	7	9	11	13	15	17	19	21	23	25	2
4	4	7	10	13	16	19	22	25	2	2	2	2	15
5	5	9	13	17	21	25	2	2	11	12	13	14	3
6	6	11	16	21	26	2	9	10	20	22	24	26	16
7	7	13	19	25	2	8	16	18	3	3	3	3	4
8	8	15	22	2	7	14	23	26	12	13	14	15	17
9	9	17	25	6	12	20	3	3	21	23	25	4	5
10	10	19	2	10	17	26	10	11	4	4	4	16	18
11	11	21	5	14	22	3	17	19	13	14	15	5	6
12	12	23	8	18	3	9	24	4	22	24	26	17	19
13	13	25	11	22	8	15	4	12	5	5	5	6	7
14	14	2	14	26	13	21	11	20	14	15	16	18	20
15	15	4	17	3	18	4	18	5	23	25	6	7	8
16	16	6	20	7	23	10	25	13	6	6	17	19	21
17	17	8	23	11	4	16	5	21	15	16	7	8	9
18	18	10	26	15	9	22	12	6	24	26	18	20	22
19	19	12	3	19	14	5	19	14	7	7	8	9	10
20	20	14	6	23	19	11	26	22	16	17	19	21	23
21	21	16	9	4	24	17	6	7	25	8	9	10	11
22	22	18	12	8	5	23	13	15	8	18	20	22	24
23	23	20	15	12	10	6	20	23	17	9	10	11	12
24	24	22	18	16	15	12	7	8	26	19	21	23	25
25	25	24	21	20	20	18	14	16	9	10	11	12	13
26	26	26	24	24	25	24	21	24	18	20	22	24	26

15 Sectors Per Track

When this field contains:

The sequencing will be:

Blank	01	02	03	04	05	06	07
1	1	1	1	1	1	1	1
2	2	3	4	5	6	7	8
3	3	5	7	9	11	13	15
4	4	7	10	13	2	4	7
5	5	9	13	2	7	10	14
6	6	11	2	6	12	2	6
7	7	13	5	10	3	8	13
8	8	15	8	14	8	14	5
9	9	2	11	3	13	5	12
10	10	4	14	7	4	11	4
11	11	6	3	11	9	3	11
12	12	8	6	15	14	9	3
13	13	10	9	4	5	15	10
14	14	12	12	8	10	6	2
15	15	14	15	12	15	12	9

8 Sectors Per Track

When this field contains:

The sequencing will be:

Blank	01	02	03	04
1	1	1	1	1
2	2	3	4	5
3	3	5	7	2
4	4	7	2	6
5	5	2	5	3
6	6	4	8	7
7	7	6	3	4
8	8	8	6	8

Label Standard Version (79): Indicates what kind of labels are on the diskette. A blank indicates other than IBM standard labels. A W indicates that IBM standard labels are on the diskette.

Pad (80-127): Indicates the end of the volume label. The pad extends to the end of the sector.

Header Label

HEADER LABEL LAYOUT

Byte — Track 00 — Head 0 — Records 8 through 26

0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21
Header Label Identifier and Number				Reserved	Data Set Identifier																

22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43
Block Length					Record Attribute	Beginning of Extent					Physical Record Length	End of Extent					Record Block Format	Bypass Indicator	Data Set Security	Write Protect Indicator	Exchange Type Indicator

44	45	46	47	48	48	50	51	52	53	54	55	56	57	58	59	60	61	62	63	64	65
Multivolume Indicator	Volume Sequence Indicator		Creation Date						Record Length				Offset to Next Record Space					Reserved			

66	67	68	69	70	71	72	73	74	75	76	77	78	79	80	81	82	83	84	85	86	87
Expiration Date						Verify/Copy Indicator	Data Set Organization	End of Data Address					Reserved								

88	89	90	91	92	93	94	95	96	97	98	99	100	101	102	103	104	105	106	107	108	109	110	111	…	126	127
Reserved							Pad																			

HEADER LABEL FORMAT

The header labels are located on track 00, head 0, records 8 through 26 on all diskettes. In addition, on a diskette 2 or diskette 2D, the header labels are also located at track 00, head 1, records 8 through 26. On a diskette 2D, additional header labels can be set aside for all record lengths. Up to 9 additional tracks on each side of the diskette 2D can be allocated for header labels. The header labels are used to reserve a block of record space for a particular use. They also contain controls, status information, and the record name for that block of records.

Header Label Fields

Header Label Identifier and Number (0-3): Identifies this particular record as a header and denotes which header it is (for example: HDR1).

Data Set Identifier (5-21): Establishes a name for this particular block of records. This field is user optional.

Block Length (22-26): Specifies the number of characters per block. It must be in the range of 00001 to 08192. For a basic exchange data set, this field must be set to the range of 00001 to 00256.

Record Attribute (27): Indicates the blocking and spanning attributes of the data set as follows:

'space'=Records Unblocked, Unspanned
'B'=Records Blocked, Unspanned
'R'=Records Blocked, Spanned

Beginning of Extent (28-32): Identifies the position of the first record of the data set. The first two bytes are the cylinder number, the next byte is the head number, and the last two bytes are the sector number.

Physical Record Length (33): Determines the size of the physical record. If blank, the record length is 128 bytes; if 1, the record length is 256 bytes; if 2, the record length is 512 bytes; if 3, the record length is 1024 bytes. The physical record length indicator must be identical to the physical sector length indicated by the volume label.

End of Extent (34-38): Identifies the address of the last position on the diskette reserved for the data set identified by this label. The first two bytes are the cylinder number, the next byte is the head number, and the last two bytes are the sector number.

Record Block Format (39): Indicates the type of blocking used by the data set as follows:

'F'=Fixed length records in fixed blocks
'blank'=Record length not fixed

Bypass Indicator (40): Indicates if this data set should be read. This field may serve many purposes and is especially useful when program files are stored on the same diskette as data files. This field is set as follows:

'space'=Data set can be read
'B'=Data set can not be read

Data Set Security (41): Indicates whether this data set can be processed or not. If this field is blank, normal processing can take place. If any other code is present in this field, the data set cannot be processed.

Write Protect Indicator (42): Indicates if this is a protected data set.

'space'=No protection. Can read or write this data set
'P'=Protected. Can read only

Exchange Type Indicator (43): Indicates that the data set has certain specified attributes. It is used as a summary indicator for certain other fields in this label as follows:

'H'=Basic exchange data set for the 5110 internal diskette drive
'E'=No summation of the attributes exists

The 'space' and the 'H' indicate the following attributes:

- Physical record size is 256 bytes
- Unblocked, unspanned records
- Record length maximum is 256 bytes
- Sequentially organized

- Data set identifier is a single name of up to eight characters
- Data in the data set must be recorded in EBCDIC, ASCII, or user, and must be in the same code as the data set label describing it.
- The data set label must reside on cylinder 0.

Multivolume Data Set Indicator (44): Indicates if the data set is complete on this diskette or is continued on another diskette: This field will contain one of the following:

'C'=Data set continued on another diskette
'L'=This is the last volume of a multivolume data set
'space'=The data set is completely contained on this diskette

Volume Sequence Indicator (45-46): Indicates the volume number of this diskette in a multivolume data set.

Creation Date (47-52): Indicates the date this data set was created. This field is coded YYMMDD or all space characters.

Record Length (53-56): Indicates the length of a stored logical record to be transferred to an application program. This field will contain the numeric value of the length of the logical record or will contain spaces. A space in this field means that the record length equals the block length.

Offset to Next Record Space (57-61): Indicates the starting position of the next sequential record relative to the end of the last block preceding the EOD address. This field will contain either spaces or a decimal value to be used as a negative displacement value.

Expiration Date (66-71): Indicates the date on which this data set can be destroyed. This field is coded YYMMDD for data sets that can be destroyed or 999999 for data sets which can not be destroyed.

Verify/Copy Indicator (72): Indicates if the data set has been verified. This field will contain a 'V' when the last non-deleted record in the data set has been processed in verify mode.

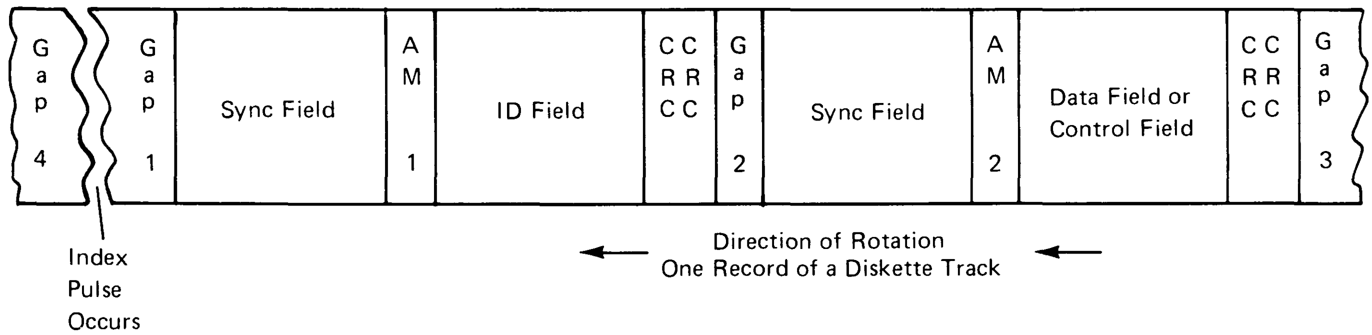
Data Set Organization (73): Indicates how the data set is organized. If SEQ is specified, the field is set to D, otherwise, it is set to space.

End of Data Address (74-78): Indicates the address of the next available unused block in the extent. The first two bytes are the cylinder number, the next byte is the head number, and the last two bytes are the sector number.

Pad (110-127): Indicates the end of this data set header label. The pad extends to the end of the sector. Each position of this field contains hex FF.

Note: On the diskette 2D, the tracks that are set aside for additional header labels contain two header labels per sector. Starting at byte 128, the label sequence shown in the Header Label Format is repeated. That is, the header label is contained in bytes 128 through 256.

Data Recording Format



GAP 1

This gap separates the index pulse from the sync field of the first record. Gap 1 consists of 40 bytes of Hex FF in FM mode and 80 bytes of hex 4E in MFM mode.

Sync Field

This field is required to synchronize the adapter circuitry to the information being read from the diskette. Each sync field contains a set number of bytes of hex 00. In FM format, the sync field contains 6 bytes. In MFM format, the sync field contains 12 bytes.

AM 1

AM 1 is the address mark that identifies the following field as an ID field. In FM format, this field contains 1 byte that is always hex FE. In MFM format, this field contains 4 bytes that are always hex A1A1A1FE.

ID Field

The ID (identification) field is made up of the track address, record address, head address, and record length.

The *track address* contains a hex number from hex 00 through hex 4A (hex 00 = track 00, hex 01 = track 01, hex 02 = track 02, and so on).

The *record address* contains a hex number from hex 01 through hex 1A (hex 01 = sector 1, hex 02 = sector 2, and so on).

The *head address* for a diskette 1 is always hex 00. For a diskette 2 and diskette 2D, the head address contains either hex 00 or hex 01 depending on which side of the diskette is being read or written.

The *record length* contains a number from 0 through 3, depending on the number of sectors the track is divided into.

Number	Record Format	Sectors Per Track	Record Length
0	FM	26	128 bytes
1	FM	15	256 bytes
2	FM	8	512 bytes
1	MFM	26	256 bytes
2	MFM	15	512 bytes
3	MFM	8	1024 bytes

Note: All records on a track will have hex FF recorded as record length if any record on that track is damaged.

CRC

Two CRC (cyclic redundancy check) bytes are generated in the CRC register during a write operation for an ID field or a data field. The bit structure of the CRC bytes is determined by an algebraic formula applied to the bit structure of the field being written. These 2 CRC bytes are written on the diskette immediately following the field. The data written on the diskette during a write operation is retained in a buffer for use during the verify read operation. During the verify read operation, the data is compared bit for bit with the data in the buffer, as it is read from the diskette. If any bit read from the diskette does not compare with the corresponding bit in the buffer, a data check error occurs. Also, as the data is read from the diskette, 2 CRC bytes are built in the CRC register. When the 2 CRC bytes (written on the diskette during the write operation) are read, they are subtracted from the 2 CRC bytes that were built in the CRC register during the verify read operation. The CRC register is then tested for a content of 0. If the CRC register equals 0, the field was written correctly. If the CRC register does not equal 0, a CRC error occurs.

During a read operation, 2 CRC bytes are again generated in the CRC register for ID fields and data fields. The bit structure of the CRC bytes is determined by an algebraic formula applied to the bit structure of the field being read. After the complete field is read, the 2 CRC bytes on the diskette are read and compared to the 2 CRC bytes from the CRC register. If the CRC bytes are exactly the same, the field has been read correctly. If they are not exactly the same, a CRC error occurs.

GAP 2

This Gap is used to separate the ID field from the data field. Gap 2 consists of 11 bytes of hex FF in FM format and 22 bytes of hex FF in MFM format.

AM 2

AM 2 is the address mark that identifies the following field as either a data field or a control field. If the following field is a data field, AM 2 (in FM format) contains hex FB. In MFM format, it contains hex A1A1A1FB. If the following field is a control field, AM 2 (in FM format) contains hex F8. In MFM format, it contains hex A1A1A1F8.

Data Field

The data field contains the data record.

Control Field

The control field contains data to control the reading of that particular record.

GAP 3

Gap 3 separates one sector from another. This gap contains 27 bytes of hex FF in FM format. In MFM format, it contains 84 bytes of hex 4E.

Record Format	Gap Size	Record Length
FM	27 bytes	128 bytes
FM	42 bytes	256 bytes
FM	58 bytes	512 bytes
MFM	54 bytes	256 bytes
MFM	84 bytes	512 bytes
MFM	116 bytes	1024 bytes

GAP 4

Gap 4 occurs after the last record of the last sector of a track and separates that record from the index pulse. This gap contains a variable number of bytes of hex FF in FM format and a variable number of bytes of hex 4E in MFM format. The actual number of bytes depends on the speed of the diskette. The length of this field is variable to allow interchangeability of diskettes between diskette drives.

Index

An index pulse occurs each time the index hole in the diskette passes the light emitting diode/phototransistor (LED/PTX) of the diskette drive. The index pulse indicates to the adapter that sector 1 of that particular track will be the next sector to reach the read/write heads.

Typical Operation

Operating the internal diskette drive is simply a matter of inserting a diskette into the diskette drive and closing the diskette latch. With the system power on, the following occurs: (See *Typical Timing Sequence*.)

1. The diskette starts turning. It takes approximately 10 seconds for the diskette to reach operating speed (360 rpm).

2. Index pulses are sensed every revolution (166.7 ms) by the LED/PTX. The type of diskette inserted is identified on the diskette sense line. An UP level on the diskette sense line indicates a diskette 2 or a diskette 2D is inserted.

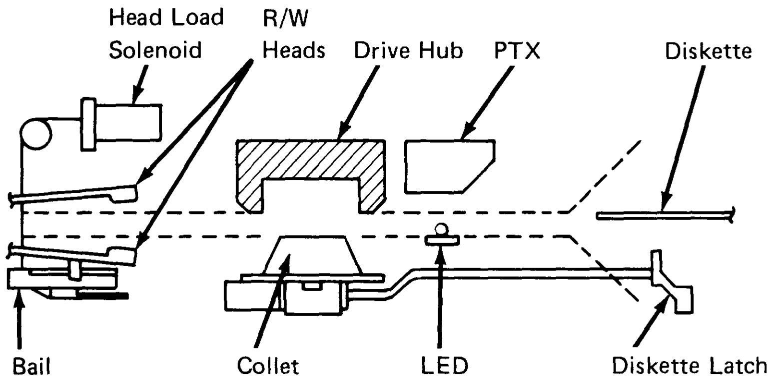
3. Seeking to the selected track is accomplished by alternately activating access line 0 and access line 1. This turns the stepper motor, which moves the read/write heads across the diskette surface a distance equal to one track. The access line activated at the time the read/write heads reach the desired track, remains activated as long as the heads remain at that track. It takes 40 ms for the heads to settle to a complete stop after a seek operation. Because of this, data is not valid for a minimum of 40 ms after a seek operation.

4. A head load command can be issued before or during a seek operation to activate the head load solenoid. Because of head settling time, the read or write operation cannot begin until 80 ms after a head load operation, or until 40 ms after a seek operation.

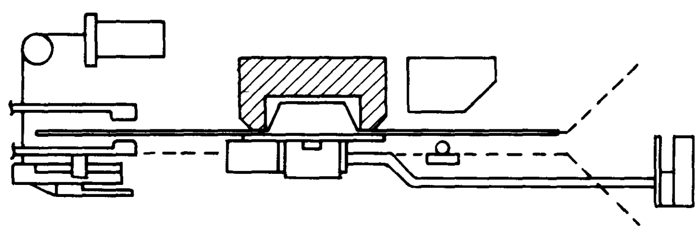
5. In order to reduce the wear on the diskette and the read/write heads, the heads are unloaded after the read/write operation if another command is not issued by the system within two revolutions of the diskette.

The mechanical sequence is as follows:

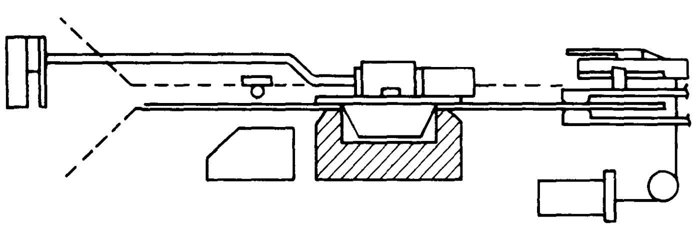
- The diskette is ready to be inserted.



- The diskette is inserted into the diskette guide, the diskette latch is closed and the collet is clamped (R/W heads are much closer to the diskette).

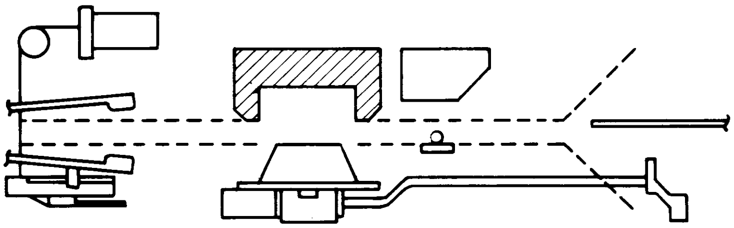


- The heads are loaded (touching the diskette): the solenoid is activated and the cable pulls the bail, which allows the heads to contact the diskette.

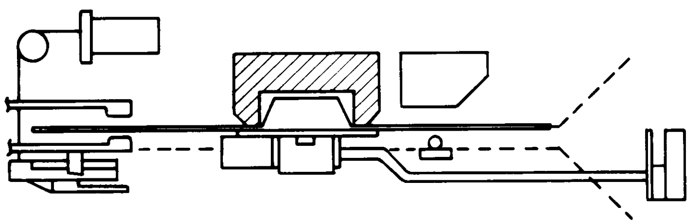


- Read/Write operation takes place. The heads are moved to the desired cylinder on the diskette by activating the two stepper motor access lines in a specific sequence.

- The heads are released (the solenoid is deactivated).



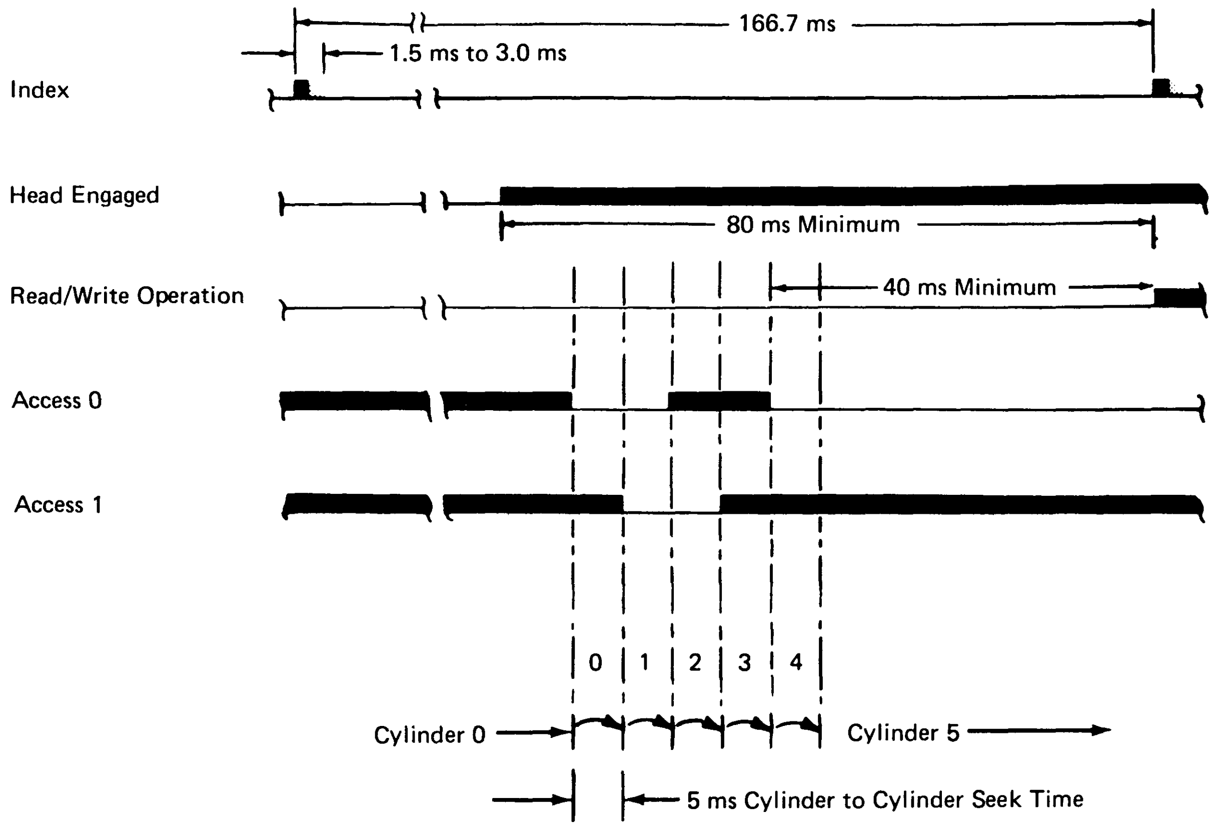
- The diskette latch is opened; the diskette is released and then removed from the drive.



Theory

Typical Timing Sequence

This timing sequence shows a seek operation from cylinder 00 to cylinder 05. Cylinder 05 is the cylinder that is to be read from or written to.



Note: Seeking and head loading are not timed to the index.

Diskette Adapter Card

DISKETTE ADAPTER

The diskette adapter is packaged on one card. This card plugs into socket B1C1.

The diskette adapter provides an interface between the system and the diskette drives. The adapter accepts access, read, and write commands from the system and activates the proper control lines to the diskette drive. The adapter assembles the sense information and data and passes them back to the system.

The adapter function is divided into four modes of operation. These modes are: initialization, access, read, and write.

Initialization mode is a type of power on reset for the diskette dirve. Initialization mode occurs each time the system is powered on or the diskette latch is opened and then closed while the power is on. In this mode, the adapter controls are reset, the 'new media' latch is set, and commands from the system are monitored for a diskette drive address. This reset condition can also be caused by an I/O reset command; however, the 'new media' latch is not set.

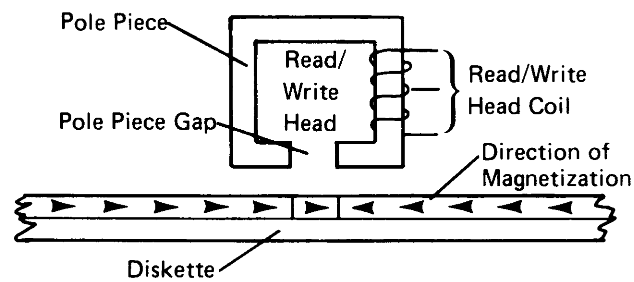
Access mode is determined by the absence of read or write mode with a diskette drive selected. Access mode is the mode of operation in which the heads can be moved to the selected track, the heads can be loaded or unloaded, and the proper head can be selected.

Read mode is determined by issuing the START READ command. The VFO circuitry, in read mode, receives data from the system diskette and passes it through the adapter to the system.

During a read operation, with the recording surface of the diskette magnetized in one horizontal direction, constant flux flows and the coil registers no output voltage. However, when a recorded bit (180 degrees horizontal flux reversal) passes the pole piece gap, the flux flowing through the ring and coil also reverses and produces a voltage output pulse. This output pulse represents a clock pulse or 1 bit.

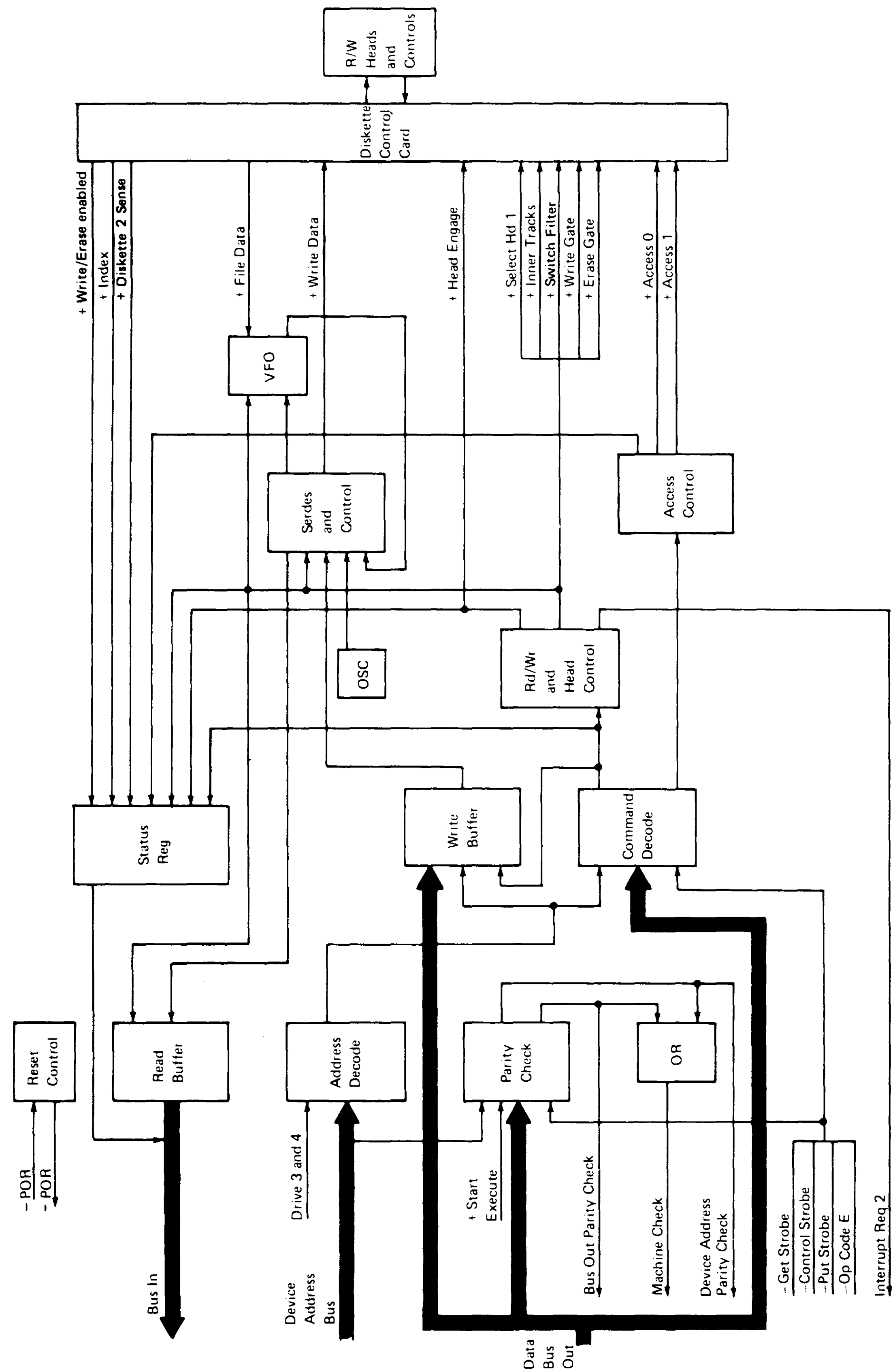
Write mode is determined by issuing the START WRITE command. The adapter, in write mode, receives data from the system, writes it onto the diskette, and erases the edges of the data track just written. This erasing process prevents crosstalk between tracks during later read operations (tunnel erase).

During a write operation, a clock pulse or 1 bit is recorded by reversing the direction of the current in the read/write head coil. This reverses the flux direction in the pole piece and the pole piece gap. When the flux in the pole piece gap reverses, either a clock pulse or a 1 bit pulse is recorded on the diskette surface. Each reversal represents a clock pulse or 1 bit pulse.

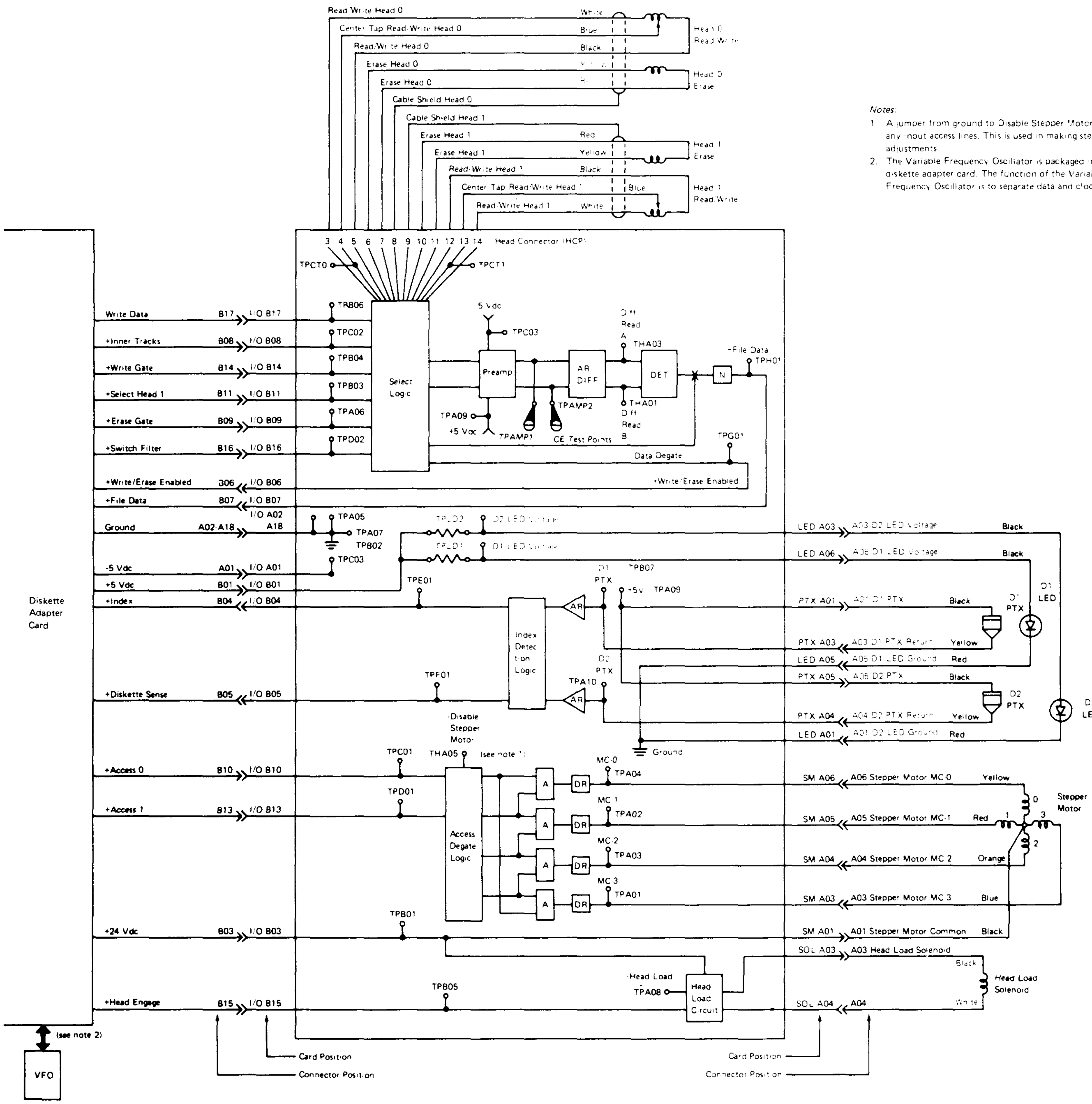


Theory

DISKETTE ADAPTER CARD DATA FLOW



DISKETTE CONTROL CARD CIRCUITRY



Notes:

1. A jumper from ground to Disable Stepper Motor overrides any input access lines. This is used in making stepper motor adjustments.
2. The Variable Frequency Oscillator is packaged in the diskette adapter card. The function of the Variable Frequency Oscillator is to separate data and clock pulses.

Theory

DATA FLOW FUNCTIONAL COMPONENTS

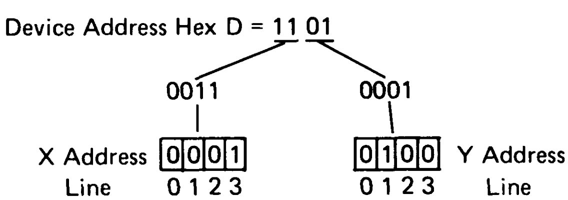
Parity Check

This block is used in all modes of operation. It checks for odd parity on the 'data bus out' line. The parity bits are generated in the system. If an odd parity exists, the bytes are passed to the appropriate circuits. If an even parity exists, the 'machine check' line to the system is activated, and the remaining bytes coming in are ignored. This block also checks the X and Y device address lines. Only one X line and only one Y line must be active. If any other condition exists, the 'machine check' line is activated.

Address Decode

This block reads all address bytes coming to the adapter for hex D. Hex D is the address byte for a diskette drive. Any other address will be ignored. When an address of hex D is decoded, the commands that follow the address are passed to the appropriate circuits.

The hex D is converted to a binary number to activate the X and Y device address lines.



Diskette Control Card Controls

This block is used in all modes of operation. There are several lines to this block that perform the tasks necessary to read, write, and load the heads. These lines are as follows:

+Write Data: For each change of the write data signal, the current switches in the read/write head. This process records the data on the diskette surfaces. (See Logic 440A.)

+Select Head 1: When active, this line selects head 1. (See Logic 440A.)

+Inner Tracks: On a write operation, this line is used to reduce the amount of recording current beyond the middle cylinders. On a read operation, this line is used to compensate for bit shifting beyond the middle cylinders. The '+inner tracks' line is active from track 43 through track 76.

+Write Gate: Write gate activates the write circuits and deactivates the read circuits for a write operation. (See Logic 440A.)

+Erase Gate: Erase gate activates the erase circuits for a write operation. (See Logic 440A.)

+Switch Filter: This line is used with the inner tracks line to further compensate for bit shifting beyond cylinder 60 for MFM encoding. This line is only used on a read operation.

+Write/Erase Enabled: When this line is active, either write or erase current has been enabled on the card.

+File Data: File data is a series of clock and data pulses that represent the data read from the diskette surface. The VFO circuits separate the clock pulses from the data pulses.

+Index: This line indicates the beginning of a track. This 1.5 to 3.0 ms pulse occurs every 166.7 ms.

+Diskette 2 Sense: When active, this line indicates that a diskette 2 or 2D is being used. This line is not activated by a diskette 1.

+Head Engage: When active, this line loads the read/write heads.

+Access Lines 0 and 1: The read/write heads are moved from one cylinder to the next by sequentially activating the access lines.

As shown, the sequence for activating the access lines is repeated every four cylinders. The drive control card decodes 'access 0' and 'access 1' into four motor control (MC) pulses (MC-0 through MC-3) for the four stepper motor poles. Refer also to the control card circuitry for the representation of MC-0 through MC-3.

Cylinder Location	In → 0	1	2	3	4	5	-- 40 --	74	75	← Out 76
Access 0	1	0	0	1	1	0	1	0	1	1
Access 1	1	1	0	0	1	1	1	0	0	1
MC-0	1	0	0	1	1	0	1	0	1	1
MC-1	1	1	0	0	1	1	1	0	0	1
MC-2	0	1	1	0	0	1	0	1	0	0
MC-3	0	0	1	1	0	0	0	1	1	0

The four MC pulses are sequenced to move the heads in (toward the drive hub) or out (away from the drive hub).

Status Register

This block provides sense information to the system. It senses the condition of the latches and several lines in the adapter. This block turns on associated bits in the diskette sense and access sense bytes of the 'bus in' line.

Latch	Bit
Write Mode	Diskette Sense Bit 0
Read Mode	Diskette Sense Bit 1
Diag 1 or 2	Diskette Sense Bit 2
Index	Diskette Sense Bit 3
Erase Gate	Diskette Sense Bit 4
Diskette 1 or Diskette 2	Diskette Sense Bit 5
CRC Error	Diskette Sense Bit 6
Read/Write Overrun	Diskette Sense Bit 7
New Media	Access Sense Bit 0
MFM	Access Sense Bit 1
Switch Filter	Access Sense Bit 2
Inner Tracks	Access Sense Bit 3
Head Engage	Access Sense Bit 4
Head Selected	Access Sense Bit 5
Access Lines	Access Sense Bits 6 and 7

Read and Write Data Buffers

These buffers provide a temporary storage for data as it travels to and from the adapter.

Access Control (Register)

This register takes the output of the access control byte, bits 6 and 7, to activate the access lines. The access lines cause the stepper motor to rotate moving the read/write heads across the recording surface of the diskette. (See *Stepper Motor* in this section.)

R/W & Head

This register controls the condition of the write gate. When the 'write gate' line is active, the read circuitry is degated. When the 'write gate' line is inactive, the read circuitry is active.

Serdes and Control

This block is made up of the write serializer, the read deserializer, and the controls necessary to count the bits.

On a write operation, this block receives bytes of data and sends them to the write circuitry serially bit by bit. On a read operation, this block receives data from the diskette serially bit by bit, builds bytes of data, and sends the data to the system byte by byte.

Oscillator

The oscillator is only used in a write operation. It is used to insert clock bits in the write data at the correct times. These clock bits are used on a read operation for synchronization of the VFO circuitry. The VFO circuitry deletes the clock bits from the data before sending the data to the Serdes register.

VFO

This block is physically a part of the VFO circuitry. It is only used in a read operation. This block provides clocking for the raw data and subdevice selection.

Operations

INITIALIZATION

Diskette drive initialization, which is a type of power on reset, occurs each time the diskette drive is turned on, or a new diskette is inserted in the drive. During the initialization phase of operation, all controls on the adapter are reset, and system commands are monitored for a diskette drive address.

After the diskette drive is selected, the system looks at the sense byte of the 'bus in' line to determine the condition of the drive. If the sense byte indicates that the 'new media' latch is set, the diskette drive is forced to access mode and the access sense lines are sensed to determine their condition. The correct number of reverse seek commands are issued to move the read/write heads to track 00.

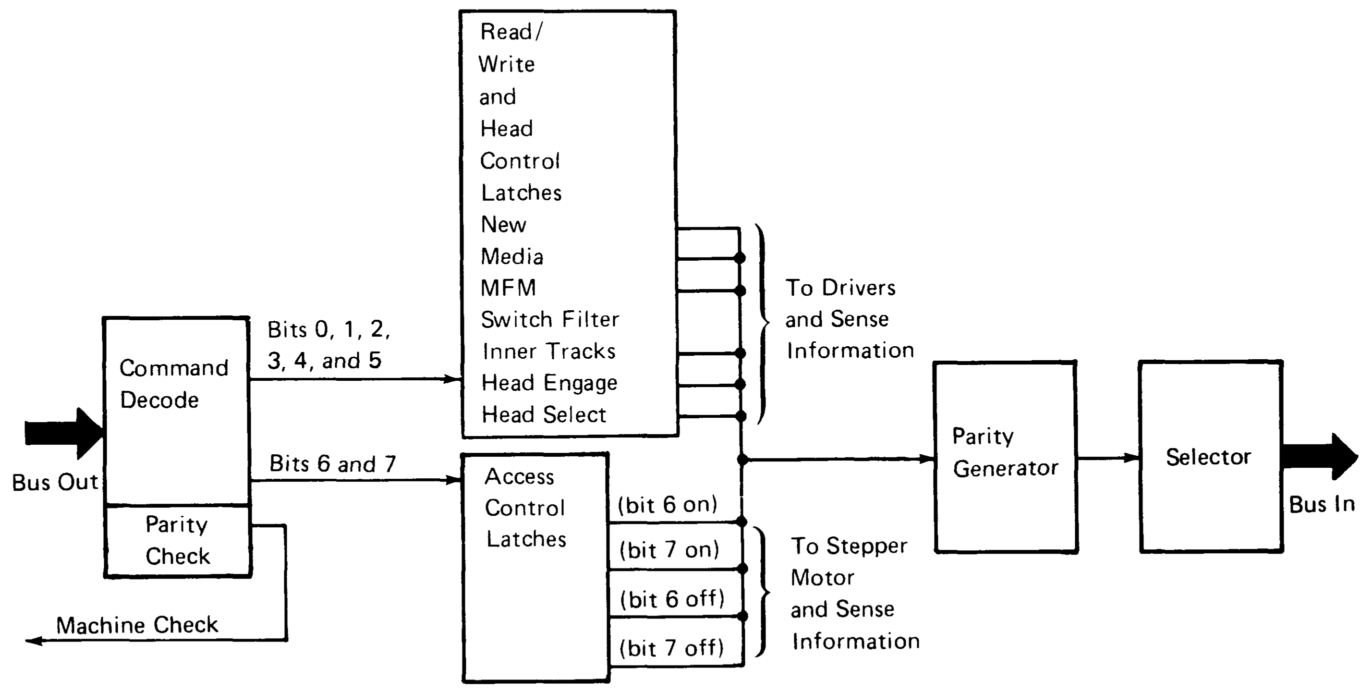
If the 'access 0' and 'access 1' lines are active, 76 reverse seek commands are issued.

If the 'access 0' line is inactive and 'access 1' line is active, 77 reverse seek commands are issued.

If the 'access 0' and 'access 1' lines are inactive, 78 reverse seek commands are issued.

If 'access 0' is active and 'access 1' is inactive, 79 reverse seek commands are issued.

ACCESS MODE



In access mode, the system can check the status of the drive and diskette, move the heads, select the correct side and current, and load or unload the heads. The adapter is in access mode when no read, write, or diagnostic operation is in progress, and a diskette drive has been selected.

After an initialization sequence, the adapter is set to access mode.

The commands for the adapter in access mode are sent by the system over the 'bus out' line, access control byte. As the access control byte enters the adapter, it is checked for odd parity. This parity is generated by the system. If an even parity is detected, the machine check line is activated and the commands are ignored.

Bit 0 of the 'bus out' line is turned on to reset the 'new media' latch in case it has been set. The 'new media' latch is set anytime an index pulse is not sensed for 200 ms or the index pulse duration exceeds 16 ms. If a diskette is not inserted in the drive, the diskette latch is open, or the diskette has stopped turning or slowed down with the index sensing mechanism covered, the index pulse sensing time will exceed 200 ms. If the diskette has stopped turning or slowed down with the index hole over the index sensing mechanism, the index pulse duration will exceed 16 ms.

The 'MFM control' latch is set or reset depending on the format to be used in the operation following the access operation. If the following operation is in the MFM format, bit 1 of the 'bus out' line is set on and the 'MFM control' latch set. If the following operation is to be in the FM format, bit 1 of the 'bus out' is turned off and the 'MFM control' latch is reset.

As the read/write heads move toward track 76 of the diskette, the density of the recorded information increases. This happens because the physical length of the track is smaller on the inside tracks. Since the same amount of information is recorded on each track, the information on the inner tracks is more compact than the information on the outer tracks. When the heads reach track 60 accessing toward track 76, bit 2 of the 'bus out' line is turned on. This sets the switch filter latch which filters out the clock pulses. When the heads are accessing toward the track 00 and the head location is between track 00 and track 59, this bit is turned off and the switch filter latch is reset.

A lower current is required at the inner tracks for write operations. The inner tracks latch is used to provide a lower current at the inner tracks. Any time the heads are located at track 42 or greater, bit 3 of the 'bus out' line is turned on. This sets the inner tracks latch. Bit 3 of the 'bus out' line is turned off, and the inner tracks latch is reset any time the head location is track 41 or less.

The loading or unloading of the read/write heads is controlled by bit 4 of the 'bus out' line. When this bit turns on, the heads are loaded. In the loaded position, the heads can read or write information on the diskette surface. If two index pulses are detected and a command was not issued to the adapter, this bit is turned off and the heads are unloaded.

There are two read/write heads on the diskette drive. In order to read or write the correct side of the diskette, one and only one head must be selected. Bit 5 of the 'bus out' line determines which head is used in the read or write operation. If this bit is off, head 0 is selected. If this bit is on, head 1 is selected.

Four motor control lines are used to move the heads from track to track. When the adapter first entered access mode, the heads were located at track 00. This was accomplished in the initialization phase of the operation. In track 00, bits 6 and 7 of the 'bus out' line are both on. With these bits on, MC-0 and MC-1 are active. These MC lines remain active as long as the heads stay at track 00 and no access command is issued by the system to change the status of bits 6 and 7. Access commands move the read/write heads sequentially from track to track in both forward and reverse directions.

	Track									
	00	01	02	03	04	05	06	07	08	09
Bus Out Bit 6	1	0	0	1	1	0	0	1	1	0
Bus Out Bit 7	1	1	0	0	1	1	0	0	1	1
MC-0	1	0	0	1	1	0	0	1	1	0
MC-1	1	1	0	0	1	1	0	0	1	1
MC-2	0	1	1	0	0	1	1	0	0	1
MC-3	0	0	1	1	0	0	1	1	0	0

To move the heads from track 00 to track 01, bit 6 of the 'bus out' line turns off and bit 7 remains on. This pulses the stepper motor and turns it just enough to move the heads to track 01. Bit 6 turning off with bit 7 remaining on deactivates the 'MC-0' line and activates the 'MC-2' line. The 'MC-1' line remains active. These two MC lines (1 and 2) remain active as long as the heads are located at track 01 and no access commands have changed the status of bits 6 and 7. To move the heads from track 01 to track 00, bit 6 is turned on and bit 7 remains on. This turns off the 'MC-2' line and turns on the 'MC-0' line. The 'MC-1' line remains active. The stepper motor now turns in a reverse direction to move the heads back to track 00.

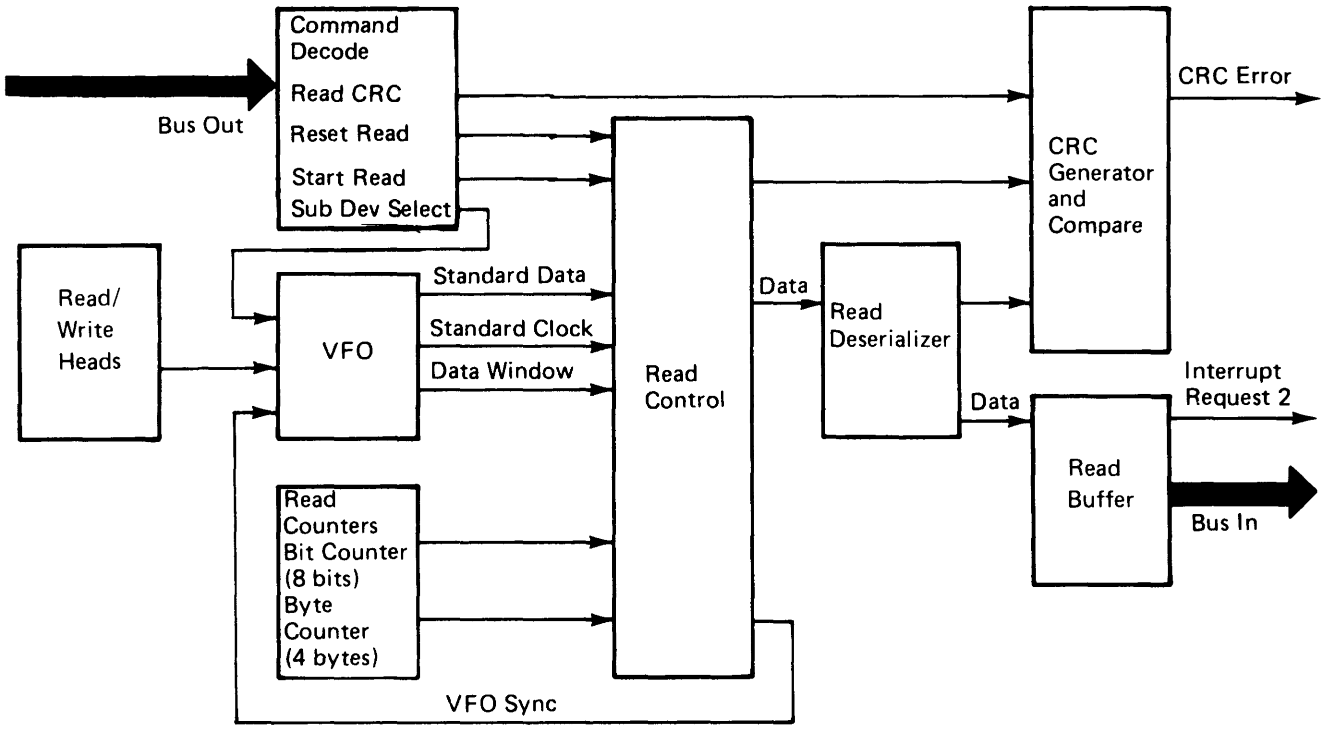
ACCESS MODE SENSING

In access mode, sense information is sent to the system by the adapter. This information is in the access sense byte of the 'bus in' line. The bits in the access sense byte represent the condition of the different control latches in the adapter. Bits 6 and 7 are set according to the condition of the access lines.

This byte of information tells the system the operational state of the diskette drive. (See *Access Sense,* under *Adapter Commands* in this section.)

The system has sent commands to the adapter over the 'bus out' line. After these commands were sent, the system sensed the condition of the adapter by analyzing the access sense byte of the 'bus in' line to ensure that all of the commands were operated on and the diskette drive is in the exact operational status as demanded by the commands.

READ MODE



The correct drive, head, and track for a read operation is selected during access mode. A read operation senses data that has been recorded on a diskette and sends this data to the system. The data rate for read operation is 48K bytes/second.

The read operation starts when the system sends the START READ command to the adapter. This command comes on the 'bus out' line, diskette control byte, bit 1. When the adapter senses that this bit is turned on, it sends a signal to the read control block to raise the 'VFO Sync' line. The 'VFO Sync' line causes the VFO to sync on all data transitions. The VFO syncs on the raw data coming from the VFO control block.

The adapter now starts looking for a sync field of all 0's (6 in FM, 12 in MFM). Once the correct number of 0's have been detected, the adapter drops the 'VFO sync' line.

The presence of a bit after the sync field signals the start of an address mark. The read control block checks for the correct clock pattern of the address mark and passes the data portion through the read deserializer block to the buffer and on to the system. The data portion of the address mark is also sent to the CRC generator. The address mark has clock pulses 2, 3, and 4 suppressed to ensure its validity and to ensure that it is not mistaken for data. In FM, 1 byte is needed for the address mark. In MFM, 4 bytes are required. A byte counter frames these bytes and keeps track of how many bytes have been processed.

In MFM, the first 3 bytes of the address mark are checked for correct clock and data. The 4th byte is passed back to the system.

If the address mark is correct, the read operation continues. If the address mark is not correct, a resync is issued by the system. A resync command consists of two separate commands. First the system sends the RESET READ command over the 'bus out' line, diskette control byte, bit 7. Then it sends the START READ command over the 'bus out' line, diskette control byte, bit 1. This causes the adapter to start looking for a sync field again.

The presence of a 1 bit after the sync field starts a bit and byte counter and the CRC generator.

The bit counter counts to 8 and is used to frame the data into bytes. The data is blocked into bytes in the read deserializer. As soon as 8 bits have been counted, they are passed to the buffer. When the buffer receives a byte of data, the 'interrupt request 2' line is raised. When the system receives the interrupt request, it takes the data from the buffer over the 'bus in' line and resets the interrupt request. This transfer of data to the buffer and interrupt sequence is repeated every 8 bits. (32 microseconds in FM; 16 microseconds in MFM). This sequence continues until reset by the system.

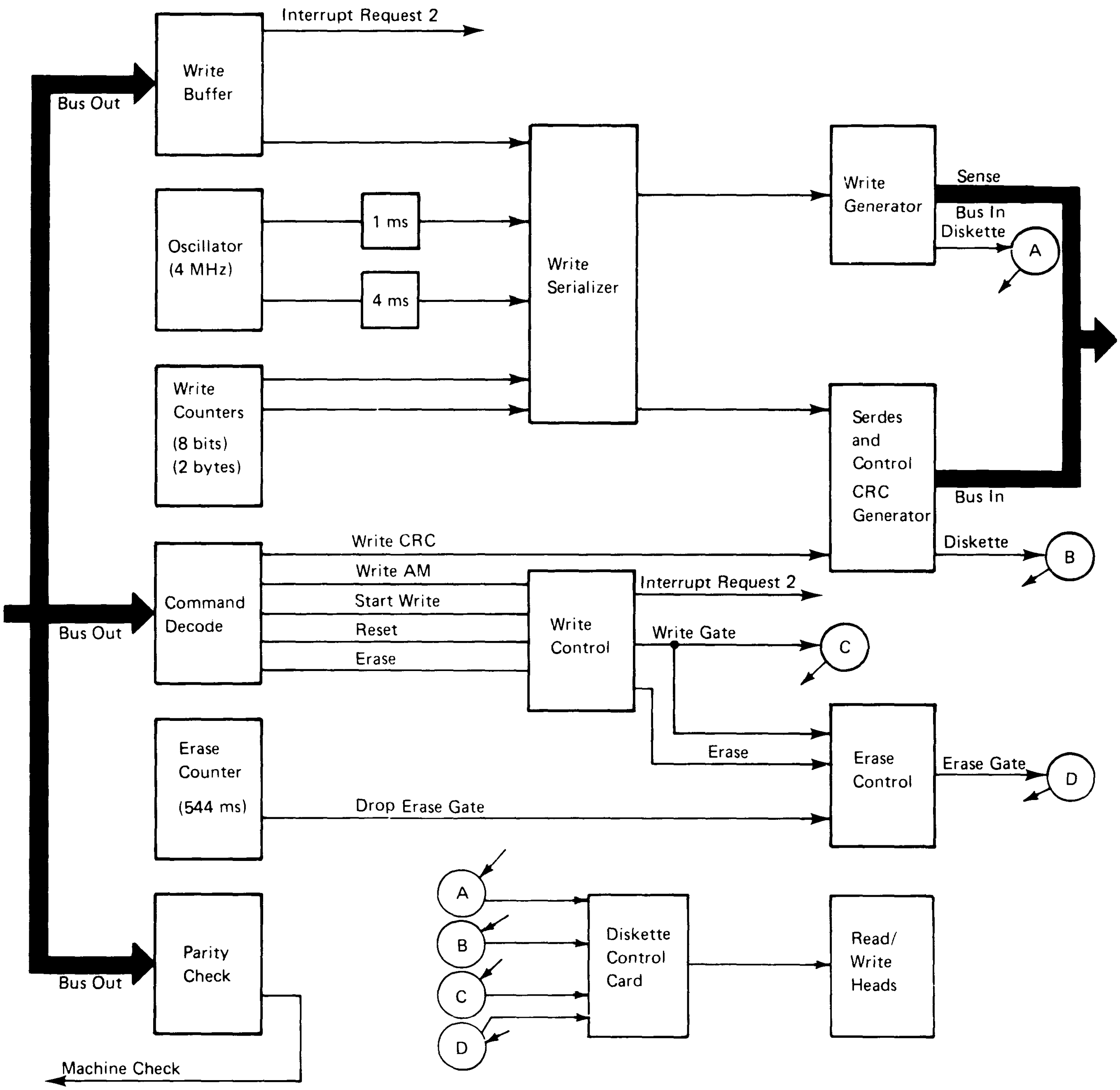
The data bits that are sent to the buffer are also sent to the CRC generator. This generator builds 2 bytes of CRC information. The command to read the CRC information comes from the system over the 'bus out' line, diskette control byte, bit 5. For a read operation, this command causes the adapter to compare the CRC generated during the read operation with the CRC read from the diskette.

The read operation is terminated when the system sends the RESET READ command over the 'bus out' line, diskette control byte, bit 7.

READ MODE SENSING

During a read operation, the system is sensing the condition of the adapter over the 'bus in' line by sampling the diskette sense byte. For an explanation of the different bits of the diskette sense byte, see *Diskette Sense* under *Adapter Commands* in this section.

WRITE MODE



Theory

The data rate in a write operation is 24K bytes/second.

The write operation starts when the system sends the START WRITE command to the adapter. This command comes on the 'bus out' line, diskette control byte, bit 0. When the adapter senses that this bit is turned on, it sends a signal to the write control block. This block raises the 'interrupt request 2' line. This causes the system to send the first byte of data to the buffer and reset the interrupt request.

Now the buffer transfers the byte of data to the write serializer and raises the 'interrupt request 2' line to obtain the next byte of data.

The first bytes (6 in FM, 12 in MFM) are all 0's. This is the sync field. After the sync field is written, the system sends the WRITE AM command on the 'bus out' line, diskette control byte, bit 6. This sets the 'write AM' the latch in the write control block which brings up the 'write gate' line and turns on the 'erase gate' latch. Turning on the 'erase gate' with the WRITE AM command provides the necessary delay at the beginning of the write operation before the tunnel erase operation begins (544 microseconds). The oscillator provides the correct clock pulses for the address mark and the data.

When the address mark is written, the system resets the 'write AM' latch and starts sending data. The write serializer takes a byte of data and sends it to the write generator a bit at a time. It also sends the data a bit at a time to the CRC generator.

After all the data is written, the system issues, a WRITE CRC command over the 'bus out' line, diskette control byte, bit 5. This command is decoded and the 'write CRC' line causes the 2 CRC bytes to be written serially from the CRC generator to the diskette.

While writing the CRC, the adapter still interrupts the system. The system has to service these interrupts by sending dummy data.

When the CRC information is written, the system issues a RESET WRITE command over the 'bus out' line, diskette control byte, bit 7. This stops the write operation.

Because the erase heads are physically located behind the read/write heads, the tunnel erase operation has not been completed at this time. An erase counter provides a drop out delay to the erase heads of 544 microseconds after the RESET WRITE command has been received.

The system now issues a START READ command over the 'bus out' line, diskette control byte, bit 1. This puts the adapter in read mode. The adapter now reads and sends all of the data just written to the system. The data is compared bit for bit in the system for validity. This is the verify read operation.

WRITE MODE SENSING

During a write operation, the system is sensing the condition of the adapter over the 'bus in' line by sampling the diskette sense byte. The bits of the diskette sense byte are used to inform the system of the condition of several latches during the write operation. (See *Diskette Sense* under *Adapter Commands* in this section.)

Adapter Commands

DISKETTE CONTROL

Bus Out Bit 0 — Start Write

Start write causes the adapter to raise the 'interrupt request 2' line and set the 'write mode' latch. The adapter starts writing data to the diskette and interrupts the system after each byte has been written.

Bus Out Bit 1 — Start Read

Start read causes the adapter to search for a sync field and detect an address mark. As soon as the 8-bit address mark has been shifted into the serdes, the adapter raises the 'interrupt request 2' line for the system to read the data. The adapter keeps interrupting every 8 bits until the RESET READ command is given.

Bus Out Bits 2 and 3 — Diag 1 and Diag 2

The combination of these 2 bits determines the diagnostic state of the adapter.

Bit 2	Bit 3	Diagnostic Mode
0	0	Normal read or write operation
1	0	Loop write read with VFO and read CRC
0	1	Loop write read without VFO and read CRC
1	1	Loop write read without VFO and write CRC

Bus Out Bit 4 — Erase Gate

This bit controls the turn on and turn off of the 'erase gate' latch. This bit is turned on when the 'write AM' latch is set.

Bus Out Bit 5 — Read/Write CRC

When writing to the diskette, this bit turning on causes the contents of the CRC register to be written on the diskette. During a read operation, this bit causes the adapter to compare the CRC read from the diskette with the contents of the CRC register.

Bus Out Bit 6 — Write AM

This bit causes the adapter to write an address mark by dropping clock pulses 2, 3, and 4. It also turns on bit 4 of the 'bus out' line.

Bus Out Bit 7 — Reset Read/Write/Diagnostic

When the system has completed reading, writing, or diagnostics, this bit causes the system to issue the RESET command, which sets the adapter into access mode.

DISKETTE SENSE

Bus In Bit 0 — Write Mode

This bit is turned on when the 'write' latch is set.

Bus In Bit 1 — Read Mode

This bit is turned on when the 'read' latch is set.

Bus In Bit 2 — Diag 1 or Diag 2

This bit is turned on when either the 'diag 1' or the 'diag 2' latch is set.

Bus In Bit 3 — Index

This bit is turned on when the index hole in the diskette passes by the index phototransistor.

Bus In Bit 4 — Erase Gate Sense

This bit indicates the status of the 'erase gate' latch.

Bus In Bit 5 — Diskette 1, Diskette 2

This bit is turned off when a diskette 1 is located in the diskette drive. This bit is turned on when a diskette 2 is located in the diskette drive. This bit must be tested after the index pulse has been checked.

Bus In Bit 6 — CRC Error

This bit is turned on when the CRC read from the diskette does not agree with the generated CRC.

Bus In Bit 7 — Read/Write Overrun

This bit is turned on when the system does not service an interrupt before the next interrupt occurs. Detection of an overrun causes the adapter to reset to access mode.

ACCESS CONTROL

Bus Out Bit 0 — Reset New Media

This bit resets the 'new media' latch. The latch is set when the diskette drive cover is opened.

Bus Out Bit 1 — MFM

This bit sets the adapter to the desired recording mode. If the bit is off, the adapter is in FM mode. If the bit is on, the adapter is in MFM mode.

Bus Out Bit 2 — Switch Filter

This bit sets the switch filter latch. The bit is turned on and the switch filter latch is set when the read/write head location is equal to or greater than track 60. This bit is turned off, and the switch filter latch is reset when the read/write head location is less than track 60.

Bus Out Bit 3 — Inner Tracks

This bit sets the inner tracks latch. This bit is turned on and the inner tracks latch is set when the read/write head location is equal to or greater than track 42. This bit is turned off, and the Inner tracks latch is reset when the read/write head location is less than track 42.

Bus Out Bit 4 — Engage Head

This bit controls the loading and unloading of the read/write heads. This bit is turned on to load the heads. This bit is turned off to unload the heads. If two index pulses are detected and no commands have been issued to the adapter, the heads are unloaded.

Bus Out Bit 5 — Head Select

This bit selects the appropriate head for the read/write operation. This bit is turned on to select head 1. This bit is turned off to select head 0.

Bus Out Bits 6 and 7 — Access Lines

These 2 bits together control the movement of the heads from track to track.

	Tracks				
	00	01	02	03	04
Bus out Bit 6	1	0	0	1	1
Bus out Bit 7	1	1	0	0	1
Access Line 0	1	0	0	1	1
Access Line 1	1	1	0	0	1

Setting in track 00, both bits 6 and 7 are on. This makes access lines 0 and 1 active. To move the read/write heads to track 01, bit 6 must be turned off. This deactivates access line 0 while leaving access line 1 active. With access line 1 active, the stepper motor moves the read/write heads to track 01.

ACCESS SENSE

Bus In Bit 0 — New Media

If no index pulse is sensed for 200 ms or an index pulse duration exceeded 16 ms, this bit turns on indicating the 'new media' latch is set.

Bus In Bit 1 — MFM

If this bit is on the diskette adapter is in MFM mode. If this bit is off the diskette adapter is in FM mode.

Bus In Bit 2 — Switch Filter

This bit indicates the status of the switch filter latch.

Bus In Bit 3 — Inner Tracks

This bit indicates the status of the inner tracks latch.

Bus In Bit 4 — Head Engage

This bit indicates whether the heads are loaded or unloaded.

Bus In Bit 5 — Head Selected

This bit indicates which side of the diskette is being used.

Bus in Bits 6 and 7 — Access Lines

These bits indicate the status of the access lines.

DISPLAY

All data entered through the keyboard is displayed on the 5110 9-inch screen and is shown on a TV monitor if one is attached. The display can show as many as 1,024 characters. There are 16 lines per display and 64 characters per line. Each line is made up of 12 rows; 8 rows contain the characters and 4 rows contain blanks between the characters. (See the display screen example in this section.)

The display unit can only present the characters represented in the 2048 x 16 display ROS. These characters include alphabetic, numeric, World Trade, and special characters. When the DISPLAY REGISTERS switch is active, the display is limited to the 16 hexadecimal characters.

Display Adapter

The display adapter is on card G2. Signals generated by the display adapter are sent to the display unit and TV monitor.

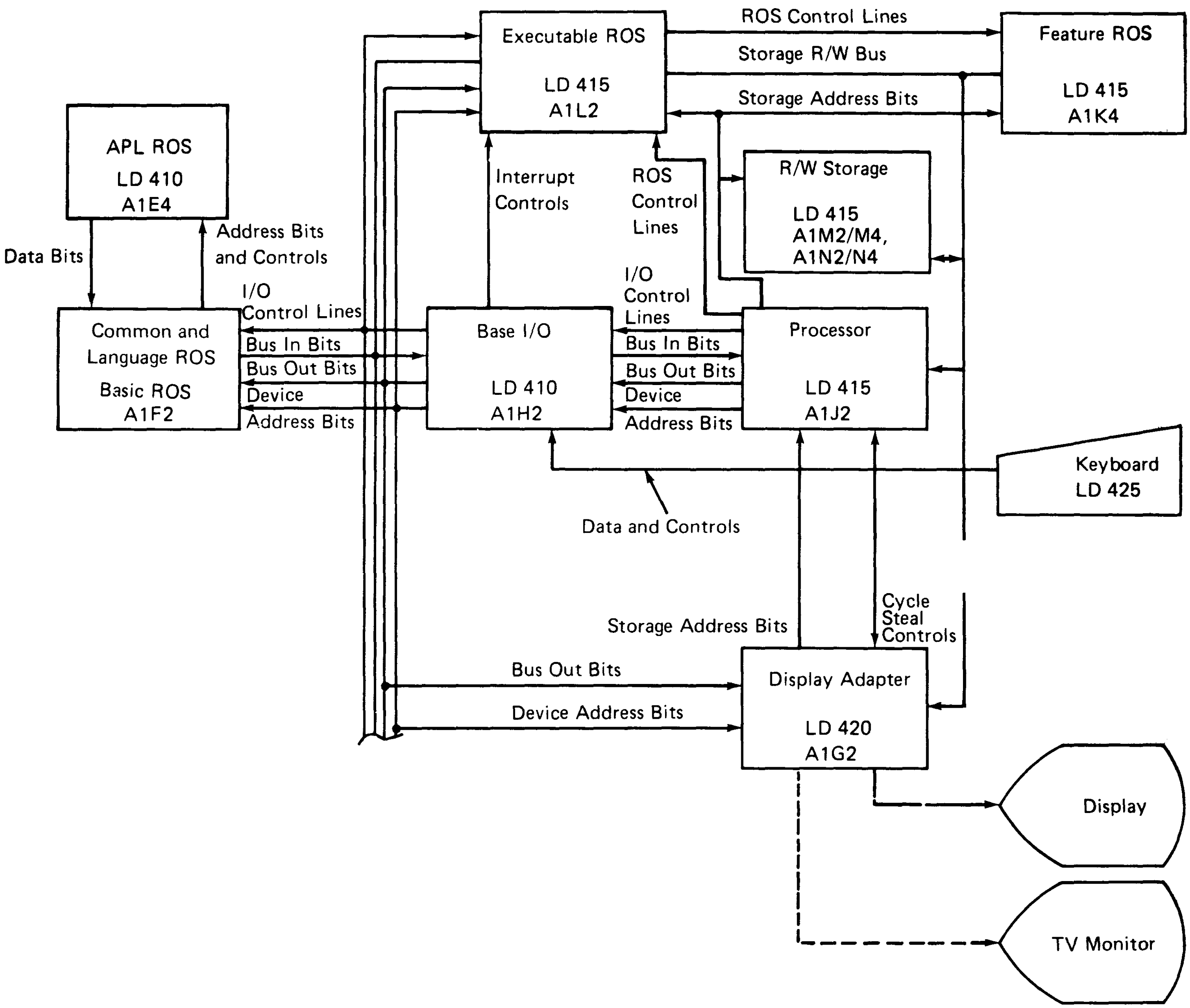
Addressing

The display and audible alarm are addressed by the Device Address Bus and controlled by the processor through the bus out and the following control lines: '+start execute', '-control strobe', and '-put strobe'. The '-control strobe' line and the '-put strobe' line indicate when information on the device address bus is valid.

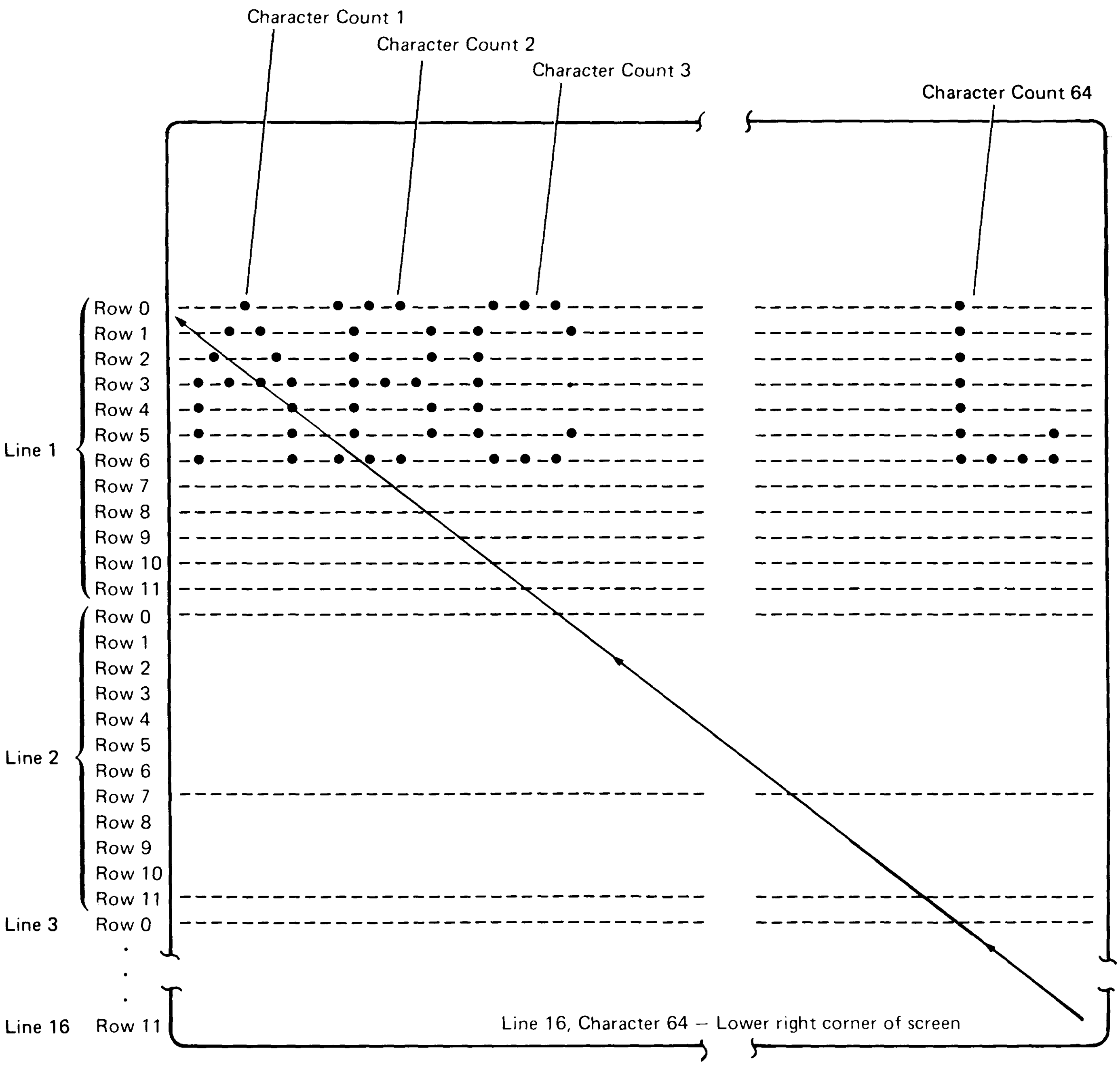
The display adapter responds to device addresses 0 and F. The device address bus and bus out bits are parity checked. Incorrect parity will cause a machine check. The World Trade latch and selector jumper information is loaded when the computer is turned on and when the RESTART switch is operated. The jumper information is used by the ROS address generator to allow the 12 unique World Trade characters to be displayed.

Adapter Controls

The display adapter receives data from the 'read data bus' lines through cycle steal controls. Signals generated by the display adapter are sent to the display unit and TV monitor to form characters. The adapter supplies three signals to the display unit and one signal ('+monitor composite video' line) to the TV monitor jack.



Display Counters



Note: The line counter is 0 on line 1, 1 on line 2, . . . , and 15 on line 16.

Theory

The video pattern of 7 possible data bits followed by a 0-bit is stored in the 2048 x 16 display ROS as 8-bit horizontal rows of the characters to be displayed. The 8-bit rows are read (along with two 0-bit spacer bits) into the 10-bit shift register each time the character counter is advanced. The address of each 8-bit horizontal row is derived from the data in the display data register, which selects the character pattern, and from the row counter, which selects the horizontal row of the character pattern.

When the electron beam begins to scan the upper left corner of the display screen, the character, line, and row counters are all set to zero. The storage address bus contains information from the character counter, the line counter, and the DISPLAY REGISTERS switch.

The first two bytes of data are read from read/write storage into the display data register. Because the two counters are 0, the even byte in the display data register is used to read the first 8-bit horizontal row from the 2048 x 16 display ROS into the 10-bit register. The 10 bits from the register are shifted out serially as video pulses, and the character counter is advanced.

The odd byte in the display data register is used to address the next character pattern. The top row of this pattern is put into the 10-bit shift register and shifted out. The character counter is advanced again; because it now contains an even number, the next two bytes in read/write storage are read into the display data register. This process continues until all 64 characters in the top row are accessed. Then the character counter returns to 0, the address bus returns to the base address, and the row counter becomes 1. The entire process is repeated for the first line of characters in the second row.

After the row counter reaches 12, it is reset to 0, and the line counter is advanced. The line counter increment adds 64 to the base address so that the next 64 characters in read/write storage are accessed.

The preceding process continues for each line. One is added to the row counter each time the character counter reaches 64, and one is added to the line counter each time the row counter reaches 12. When the line counter reaches 16, and the row counter reaches 12, and the character counter reaches 64, the frame is completed. The counters continue advancing to maintain synchronization while the beam retraces from the lower right to the upper left of the display screen. The counters are then reset to zero, and the next frame begins.

When the DISPLAY REGISTERS switch is set to the DISPLAY REGISTERS position, the first hexadecimal digit of the byte is shown on line 1, and the second hexadecimal digit is shown on line 2. Therefore, the base address is advanced only on even lines.

The first 4 bits of each byte in the display data register are used to address the character pattern on the odd numbered lines; the second 4 bits of each byte are used to address the character pattern on the even numbered lines.

Display Unit I/O Lines

When the reverse display switch on the CE panel is set to display black characters on a white background, the character video signal is sent to the cathode of the CRT. This signal blanks the beam everywhere character information appears on the display screen. Therefore, if no video signal is sent to the display unit, the display is completely white.

When the reverse display switch on the CE panel is set to display white characters on a black background, the '+machine video' line blanks the beam everywhere except where a character appears. Therefore, if no video signal is sent to the display unit, the display is completely dark.

The '-external vertical sync' line goes directly to the display PC board; this signal keeps the video signal synchronized with the vertical and horizontal signals. If the '-external vertical sync' signal is missing, the video information rolls vertically.

The '+external horizontal sync' line controls the beam sweeping horizontally across the display. If the '+external horizontal sync' is missing, the display is black.

Cycle Steal Control Lines

The display adapter and the processor access read/write storage through the Storage Read/Write Bus. The cycle steal control lines control the way in which the adapter and the processor use the Storage Read/Write Bus and the storage access cycles.

The '-display request' line is used by the display adapter to request a storage cycle steal when the adapter is ready to receive the next two bytes of data in the display data register. The processor activates the '-stolen cycle next' line during the storage cycle that precedes the requested stolen cycle. The '-stolen cycle next' signal deactivates the '-display request' line and limits the display adapter to alternating the cycle steal activity with a processor storage cycle.

During the stolen storage cycle, the processor activates the '-stolen cycle' line and puts the two bytes of data addressed by the storage address bus onto the storage read/write bus. The '-stolen cycle' line also gates the data from the storage read bus into the display register on the display card.

Microinstructions are processed faster when no storage cycles are stolen. The I/O display offline is set or reset by a microinstruction to prevent cycle steal activity by the display. When cycle steal activity is prevented, the display is blank and the IN PROCESS light is on.

Read/Write Storage I/O Lines

The I/O lines from the display card to read/write storage consist of the Storage Read/Write Bus (input lines) and the Storage Address Bus (output lines). See the *Processor Data Flow* diagram in this section.

The Storage Address Bus on the display card is sent a base address (CRT buffer address); this address is determined by the position of the DISPLAY REGISTERS switch (DISPLAY REGISTERS or NORMAL). When the switch is in the DISPLAY REGISTERS position, the base address is 0000, and the contents of addresses 0000-01FF are displayed. (See *Display Registers* in the *Diagnostic Aids* section and *Control Unit* in this section for the contents of these addresses.) When the switch is in the NORMAL position, the base address is 0200, and the contents of addresses 0200-05FF in read/write storage are displayed.

After the base address is set, the character counter updates the addresses by two (the low order bit is always logical 0) every other character count (CC1 time). For each address received from the display card, two bytes of data are transferred from the storage read/write bus to the display card.

The data is transferred to the display adapter through the Storage Read/Write Bus. This data is double buffered by the display data register and the character register. The data is gated into the display data register when clock times 'MCC3', 'MCC4', and the '-stolen cycle' line are active. The '+C4 powered' and '+C5 powered' lines are used to synchronize the data into the character register.

The data in the character register is decoded to select the correct character dot pattern from the 2048 x 16K bytes ROS on the display card. These dot patterns are serialized by the 10-bit shift register and placed on the '-machine video' line to the display unit. The '-machine video' line is controlled by the brightness potentiometer. Also, the output of the 10-bit shift register is put on the '+monitor video' line to the TV monitor.

TV Monitor

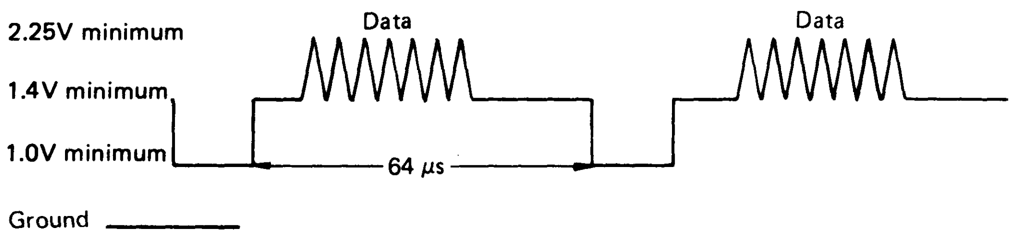
A separate display unit (TV monitor) can be attached to the 5110 through a connector on the back of the 5110. Identical information is shown simultaneously on the nine-inch display screen and on the TV monitor.

When connected, the TV monitor should provide a 75 ohm termination load to the source ground. When several monitors are connected, they should be connected in parallel fashion, and the last monitor in the string should be terminated with 75 ohms. In some cases, the 5110 might overdrive the TV monitor. Therefore, the customer might have to add a 75 ohm attenuator to the rear of the 5110.

A composite video/sync signal ('+monitor video') is sent to the TV monitor through a coaxial cable connected to the 5110.

The TV monitor has its own AC power source and develops its own DC voltages.

The following illustration shows the '+monitor video' signal as it appears on an oscilloscope when the 5110 power is on and the DISPLAY REGISTERS switch is set to the DISPLAY REGISTERS position.



Scope Set-up:

Sync trigger	int (-) DC
Sweep	Auto
Sweep speed	10 μs
Vertical amp	0.1 V/div
Probe point	A1-K6B04 (+monitor video)
(Use a grounded 10X probe.)	

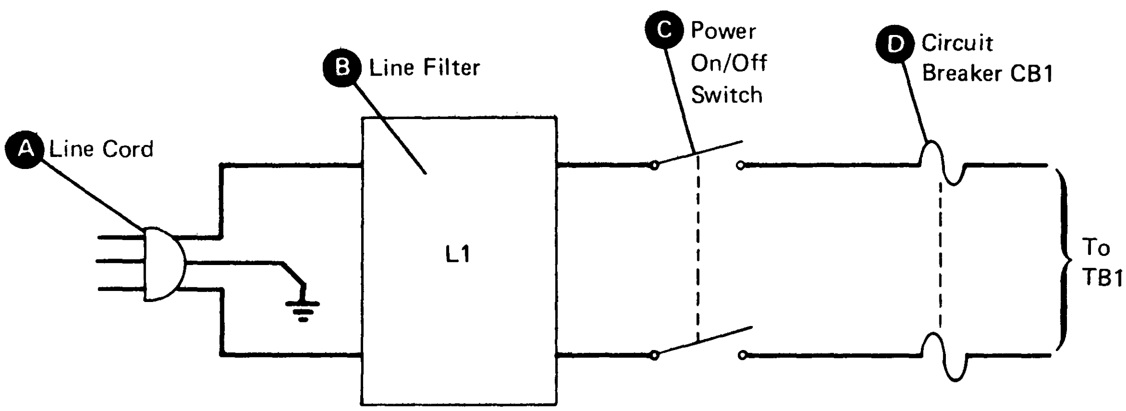
POWER

The 5110 operates with any of the following single-phase AC power sources:

- 60 Hz
  - 100, 110, 120, 127 Vac
- 50 Hz
  - 100, 110 Vac
  - 200, 220, 230, 240 Vac

AC Power Box

AC power enters the 5110 through a line cord A that attaches to the line filter B in the AC power box. The AC power box also contains the power on/off switch C and circuit breaker CB1 D. The power on/off switch controls the distribution of AC power to the 5110.



Theory

5110-3 Power Supply

The 5110-3 power supply contains two printed-circuit (PC) boards. The larger of the two PC boards uses a small, high power, high frequency transistor switching regulator (TSR) supply to develop five DC voltages for the 5110, as follows:

+5 Vdc	Basic logic voltage
-5 Vdc	Storage cards, BSCA cards, and common ROS
+8.5 Vdc	Storage cards, keyboard, display adapter, printer adapter, BSCA cards, and all ROS cards
+12 Vdc	BSCA cards, load resistor RL1 and 5114 R1 relay
-12 Vdc	5114 R1 relay, BSCA cards, and asynchronous communications/serial I/O card

This PC board has built-in overvoltage, undervoltage, and overcurrent protection. The overvoltage protection shuts down the power supply when the +12 Vdc output exceeds +16 Vdc. The undervoltage protection shuts down the power supply when the -5 Vdc is less than -3 Vdc. The overcurrent protection automatically shuts down the power supply when the current in the primary of the transformer is excessive. Any time that the power supply automatically shuts down the 5110, the computing system should be powered down with the on/off switch for at least 60 seconds before it is powered up again.

The smaller PC board uses a ferroresonant supply to develop three DC voltages for the internal diskette units, as follows:

+5 Vdc

-5 Vdc

+24 Vdc

This PC board is protected against excessive overcurrent by a fuse on each of the three dc voltage outputs.

DC Power Distribution

The voltages supplied to the attached I/O devices are distributed through the interface port of the 5110 through the power cable of the attached device. The 5114 and the 5103 each have an I/O cable assembly that includes a power connector plug (A1). The voltage ground is distributed through the I/O cable signal connectors (A2, A3) of the I/O cable.

The +5 Vdc supplied to the 5114 is not used by the 5114 nor is it distributed to any devices attached to the 5114. The 5114 develops its own +5 Vdc and supplies this voltage through the A1 connector to any devices that are attached.

DC Voltage Tolerance

The DC outputs may vary from +10% to -9% of the rated voltage before they affect the operation of the system.

Reference Voltage

A +6 Vdc controlled voltage is provided on the display card (G2) as a reference in critical voltage measurements.

5110 Operations

POWER ON PROCEDURE, INITIALIZATION, AND BRING-UP DIAGNOSTIC

When the 5110 is powered up or when the restart switch is pressed, executable ROS provides the processor with the instructions of the bring-up diagnostic. Before the user enters any programs or data, the processor executes these instructions to determine if the 5110 is operating correctly. If a failure is detected during the bring-up diagnostic, the 5110 will stop with a bring-up halt or a process check. If LOAD0 or CLEAR WS appears on the bottom line of the display, the bring-up routine and the IPL have run successfully.

Upon completion of the bring-up diagnostic, the processor starts to execute the initial program load (IPL) routine, beginning at address 000A in executable ROS. The language in which the 5110 will be operated is selected when the routine examines the status of the APL/BASIC switch on the console.

The processor next executes an I/O microprogram that flashes the cursor on the display screen. The program then waits for a keyboard interrupt indicating the entry of a program or instruction.

I/O OPERATION AND DATA TRANSFER FROM KEYBOARD TO DISPLAY AND PRINTER

The following program illustrates how the processor interprets input through the execution of microprograms and controls the execution of a BASIC program.

```
0010   A=2
0020   B=2
0030   C=A+B
0040   PRINT FLP,C
RUN
```

When the 5110 is not processing any statements or programs and the user is not entering data from the keyboard, the processor executes an I/O microprogram that flashes the cursor and waits for a keyboard interrupt.

When the first key (0) of the program data is pressed, the following takes place:

1. The 0 key code is placed in the character register on the keyboard PC board and is sent to the keyboard data latch in the keyboard adapter on the base I/O card.

2. A program level 3 interrupt is generated, and the processor begins operating at level 3.

3. The interrupt causes the I/O microprogram to stop the flashing of the cursor and to pass control to the keyboard I/O microprogram.

4. The level 3 microprogram transfers the key code to a register in the processor through the 'data bus in' line.

The keyboard I/O microprogram converts the key code to 5110 internal code by using the translation table in common ROS. The microprogram transfers the translated characters to hex 00B0 in read/write storage, the interrupt is reset, and control is returned to the I/O microprogram.

The I/O microprogram checks the internal code to determine if the key that was pressed was a data key or a function key. If a data key was pressed, the internal code is moved to the read/write storage buffer area. The display adapter then transfers the internal code for the key from the buffer area to the display adapter through the 'read data bus' line, using the cycle steal data transfer controls. The data is decoded, using the ROS on the display card to select the correct character dot pattern. The selected dot pattern is put on the 'machine video' line to the display unit and the I/O microprogram resumes flashing the cursor and waits for the next keyboard interrupt.

When the EXECUTE key is pressed at the end of a statement, the key code for the key is transferred to read/write storage by the I/O microprogram in the same way that the key code for the data key was transferred. The EXECUTE key is a function key that causes the I/O microprogram to pass control to the BASIC microprogram in executable ROS.

The processor begins to execute the BASIC microprograms and calls out microprograms that are located in BASIC ROS. The BASIC ROS microprogram checks the statement in the display screen buffer and stores the statement in the user area of read/write storage. Each statement is stored in the same manner until a RUN statement is encountered by the BASIC interpreter; at this time, all of the statements are interpreted and executed. (If this had been a calculator statement, each statement would have been interpreted and executed as it was entered.)

When the PRINT FLP,C statement is interpreted, the interpreter places information in the input/output control block (IOCB) of read/write storage for the print operation and passes control to the I/O microprogram. The I/O supervisor microprogram checks the device address and passes control to the printer I/O microprogram.

The printer I/O microprogram transfers the data to the printer, which prints the data, places a return code in the IOCB, and returns control to the I/O microprogram. (The data flow is from the print buffer in read/write storage to the printer through the processor, the base I/O adapter, the I/O cable driver, and the printer adapter.)

The BASIC microprogram determines that there are no more statements to be interpreted and returns control to the I/O microprogram. The I/O microprogram flashes the cursor and waits for a keyboard interrupt.

Contents

Diagnostic Aids

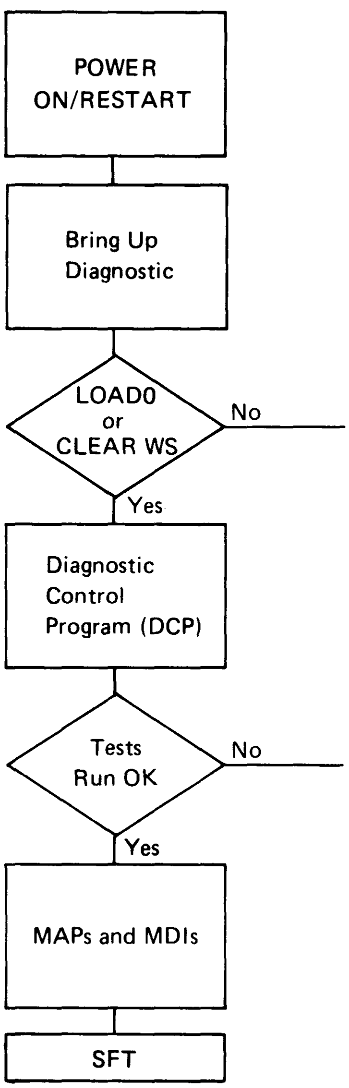
Diagnostic Aids

5120 SYSTEM DIAGNOSTICS OVERVIEW

The 5120 system diagnostics start testing a small area of the machine and gradually expand to test the complete system. Each diagnostic tests a specific area and overlaps other tests. For example, the ROS diagnostic tests ROS, but, because ROS contains the printer microinstructions, some printer operations are indirectly tested. Normally, the tests should be run in the sequence shown on the 5120 *System Diagnostics Overview Chart*. However, in the case of intermittent failures, this sequence can be altered depending on:

- The information you have concerning the failure
- Whether or not this is the first call
- How frequent the failure occurs

The following chart shows the order and the concepts used in diagnosing 5120 system problems:



Bring Up Diagnostic:
- Runs automatically with POWER ON or RESTART
- Located in ROS
- Tests 5110 internal machine functions

LOAD0 or CLEAR WS — No:
- Displays bring up halt codes (A through Q)
- Go to MAP 0200

Diagnostic Control Program (DCP):
- Selected from the keyboard
- Located in ROS
- Tests and loops bring up diagnostic tests

Tests Run OK — No:
- Error displayed for MAP entry

MAPs and MDIs:
- Selected from the Start MAP
- MDI programs stored on diskette
- MAPs are stored in the (MLM) binder

5120 SYSTEM DIAGNOSTICS OVERVIEW CHART

The *5120 System Diagnostics Overview Chart* and the *Diagnostic Run Summary Chart* provide a quick reference to aid you in selecting and running the 5120 system diagnostics.

The first group of diagnostics in the overview chart is the bring up diagnostic. The tests associated with bring up diagnostic reside in ROS and run automatically after power up or RESTART. The bring up diagnostic is used to verify that enough of the 5110 Model 3 functions are operable to allow the running of additional diagnostic programs. If the bring up diagnostic does not run to completion, a halt code appears on the display (see *Error Codes* in this section).

The next group of diagnostics is also located in ROS and is shown under Diagnostic Control Program (DCP) in the overview chart. DCP controls the loading of the remaining diagnostics and MDIs. DCP also allows selection of the individual diagnostics and the various options associated with them.

Because the tests in the bring up diagnostic do not loop, some of them are repeated in DCP. They are the call tests:

2 – Op code test
3 – Read/write storage test
4 – ROS CRC test

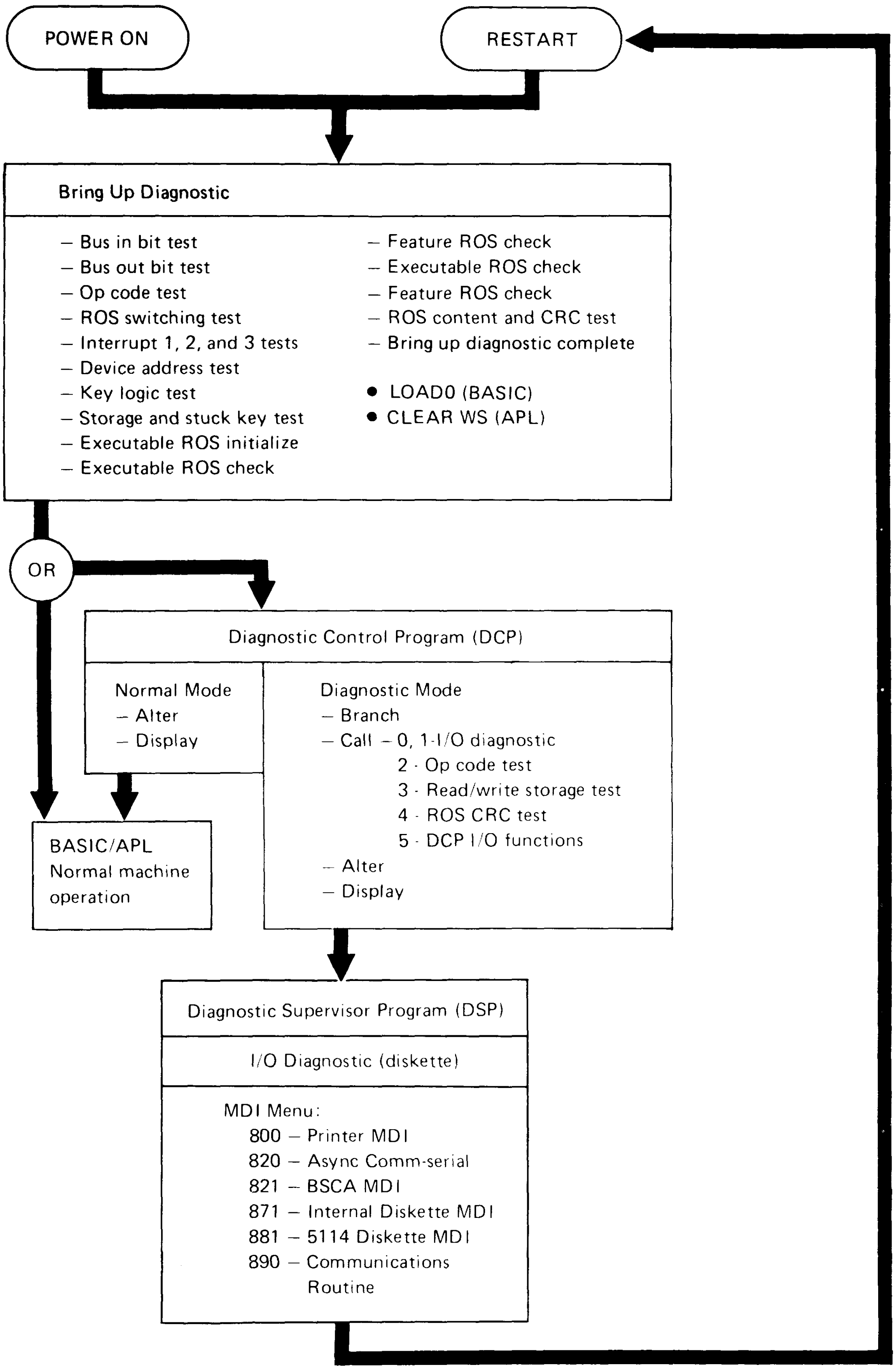
When controlled by DCP, each of these tests loops continuously until an error occurs or the test is stopped by the operator. Call tests 0 and 1 (I/O diagnostics) verify the read operation of the loading device (diskette) circuitry. DCP contains some optional functions that allow you to alter, display, or branch to data in storage.

The DCP also controls loading of the diagnostics supervisor program (DSP). The DSP is loaded from the diagnostic diskette. The DSP controls and allows selection of the MDIs. MDI is the integration of MAPs and diagnostics. The diagnostics are selected and run at the appropriate time and their results are sampled automatically.

The DSP provides for tracing and looping the MDIs. Tracing allows you to see which path was used in the MDIs.

Looping on an MDI allows repetitive testing of a complete device. Failures during looping cause a branch to a subsection of the MDI that checks a smaller area of the device. You can loop on subsections of the MDI to further isolate the failure. However, it is important to start with one of the display DSP menu options because these tests are sequence sensitive.

5120 System Diagnostics Overview Chart



Diagnostic Run Summary Chart

POWER ON → or ← RESTART

Bring Up Diagnostics		
Tests	**Halt Indicator**	**Area Tested**
	Blank	G2, Power, Display
Bus In Bit Test	A	L2, H2, J2
Bus Out Test	A B	A2, B2, D2, F2, H2, J2, All I/O
Op Code Test	A B C	J2
R/W Storage and ROS Switching Test	A B C D	H2, J2, L2
Interrupt 1, 2, 3 Tests	A B C D E	A2, B2, D2, H2, AI
Device Address Test	A B C D E F	B2, D2, F2, H2, J2, All I/O
Keyboard Test	A B C D E F G	H2
Storage Test (05FF to end) and Stuck Key Test	A B C D E F G H	M2 through N4, H2, Keyboard
Executable ROS Initialize	A B C D E F G H J	L2
Executable ROS Check	A B C D E F G H J K	L2
Feature ROS Check	A B C D E F G H J K L	K4
Executable ROS Check	A B C D E F G H J K L M	L2
Feature ROS Check	A B C D E F G H J K L M N	K4
ROS Content and CRC Test	A B C D E F G H J K L M N P	E4, F2
Bring Up Complete	A B C D E F G H J K L M N P Q	L2

OR

DCP Diagnostic Mode

Load DCP Diagnostic Mode:

- Hold CDM and press HOLD
- Hold CMD and press - (minus on numeric key pad)
- Hold CMD and press * or X (multiply on numeric key pad)

To run call 0, 1, 2, 3, 4, or 5:

- Press C
- Press the appropriate test number (0, 1, 2, 3, 4, or 5)
- Press EXECUTE

Test	Area Tested
0 – I/O Diagnostic	Diskette Read
1 – I/O Diagnostic	Diskette Read
2 – Op Code Test	H2, J2
3 – R/W Storage Test	M2, M4, N2, N4
4 – ROS CRC Test	E4, F2
5 – DCP I/O Functions	A2, H2, J2, All I/O

APL/BASIC

Normal machine operation

OR

DSP

Load DCP Diagnostic Mode as described above.
Run 0 or 1 as described above.

DSP is now loaded. Select DMI from the menu via the instructions on the display.

- MDI – 800, Printer – See MDI 800 in this section.
- MDI – 820, Async Comm-Serial I/O – See MDI 820 in this section.
- MDI – 821, BSCA – See MDI 821 in this section.
- MDI – 871, Internal Diskette – See MDI 871 in this section.
- MDI – 881, 5114 Diskette – See MDI 881 in this section.
- MDI – 890, Communications, Routines – See MDI 890 in this section.

Miscellaneous Instructions:

Press ATTN (1 time) = MDI Options
Press ATTN (2 times) = DSP Menu
Press ATTN (3 times) = DCP Diagnostic Mode
Loop On MDI Instructions = Refer to Loop On MDI in this section

BRING UP DIAGNOSTIC

This is the first diagnostic run by the 5110, and it runs each time the machine power is turned on or when the RESTART switch is pressed. The bring up diagnostic exercises and tests the internal machine functions, such as microinstruction processing, data transfer, and display controls. It also tests all the base machine logic cards, the keyboard, and the display unit. The executable ROS card (L2) contains the bring up diagnostic.

The purpose of the bring up diagnostic is to ensure that the 5110 is capable of processing data. The bring up diagnostic does not test all functions of the 5120 system.

If the bring up diagnostic runs to completion, either LOAD0 (BASIC language) or CLEAR WS (APL language) will appear on the display after 25 seconds. Failures occurring during this program are flagged by the PROCESS CHECK light or by bring up halt codes on the display.

Test	Area Tested	Halt Indicator
	G2, Power, Display	none
Bus In Bit Test	L2, H2, J2	A
Bus Out Test	A2, B2, D2, F2, H2, J2, All I/O	A B
Op Code Test	J2	A B C
R/W Storage and ROS Switching Test	H2, J2, L2	A B C D
Interrupt 1, 2, 3 Tests	A2, B2, D2, H2, A1	A B C D E
Device Address Test	B2, D2, F2, H2, J2, All I/O	A B C D E F
Keyboard Test	H2	A B C D E F G
Storage Test (05FF to end) and Stuck Key Test	M2 through N4, H2, Keyboard	A B C D E F G H
Executable ROS Initialize	L2	A B C D E F G H J
Executable ROS Check	L2	A B C D E F G H J K
Feature ROS Check	K4	A B C D E F G H J K L
Executable ROS Check	L2	A B C D E F G H J K L M
Feature ROS Check	K4	A B C D E F G H J K L M N
ROS Content and CRC Test	E4, F2	A B C D E F G H J K L M N P
Bring Up Complete	L2	A B C D E F G H J K L M N P Q

BRING UP DIAGNOSTIC CHART

Error halts can occur before the bring up diagnostic clears the display. In this case, an unpredictable jumble of characters is displayed as is shown in the following illustration. This situation indicates that the machine did not reach halt A.

See the bring up diagnostic halt codes in this section.

```
AFDURBJFDKIFJG&LPFD# AAAAAAAAAJ   R   YRTTYYAAAAHAHAJAJAAAJAHAGAJJA
KDJKPHKJFIRJGUTOEPFKGJJGOROYUJEOFJRMIRLG   LROGIR LIGJGIUUJOOEK875
```

The halts occur in alphabetical order. For example, if the machine stops at halt F, it did not reach halt G.

Examples:

The bring up diagnostic program is at halt B if line 1 of the display is blank except for an A in position 2 and a B in position 3; that is, an AB on line 1:

```
AB
```

The bring up diagnostic program is at halt E if ABCDE is displayed on line 1:

```
ABCDE
```

DIAGNOSTIC CONTROL PROGRAM (DCP)

DCP controls access to most of the diagnostic programs residing in ROS. Only the bring up program is not under the control of DCP. DCP allows you to alter or display any location in read/write storage. The two operating modes of DCP are normal and diagnostic. The following charts show the loading of and the options for DCP normal mode.

POWER ON or RESTART

Bring Up Diag Complete

Customer Job

To Load DCP Normal Mode:

1. Press and hold the CMD key.
2. Press the HOLD key.
3. Press the - (minus) key on the numeric keyboard.
4. Release the CMD key. (DCP is now loaded)

Options: Display and Alter

Display:

1. Press the D key.
2. Enter the address you want to display.
3. Scroll the address up or down as required.
4. Press the ATTN key to clear the display.

Alter:

1. Press the A key.
2. Enter the address you want to alter.
3. Enter the new data.*
4. Press the EXECUTE key to enter data.

**Note:* A data error can be cleared by pressing the ATTN key and then reentering the Alter mode.

To continue in DCP diagnostic mode:

1. Press the ATTN key.
2. Press and hold the CMD key.
3. Press the x (multiply) key on the numeric keyboard. See *DCP Diagnostic Mode* in this section.

To return to the customers job:

1. Press the ATTN key.
2. Press and hold the CMD key.
3. Press the + (plus) key on the numeric keyboard.

DCP NORMAL MODE

DCP normal mode can be entered during a customer job in order to display and alter data. Control of the 5110 can then be returned to the customer program and execution of the job can continue.

You can return to the customer job after displaying or altering data, or you can continue from normal mode to diagnostic mode. Once the DCP diagnostic mode is initiated on the keyboard, you cannot return to the customer job. You can, however, choose to go from the DCP diagnostic mode to DSP or do a RESTART.

To load the DCP normal mode:

1. Press the HOLD key.

2. Press and hold the CMD key and press the – (minus) key on the numeric keyboard.

To exit[1] from the DCP normal mode:

1. Press and hold the CMD key; then press the + (plus) key on the numeric keyboard.

When DCP is loaded, the top eight lines on the display are cleared, and the header DCP is placed in the middle of both halves of the top line. The cursor flashes (or blinks) whenever the keyboard is operational.

[1] When the DCP normal mode is exited, the only change in the display is the repositioning of the cursor to the bottom of the display screen.

Display

Display is a DCP normal mode function. To use this function, you must load DCP and then press the D key and enter the starting address of the location of the read/write storage that you want to display.

The display now shows 32 sequential locations of read/write storage starting with the input address. Scroll up (↑) displays the next 16 bytes, and scroll down (↓) displays the previous 16 bytes. The ATTN key returns control to DCP. To exit from DCP, press and hold the CMD key; then press the + (plus) key on the numeric keyboard.

To display storage locations using a different starting address, enter D and the new starting address.

Entry Format

D xxxx

Example:

```
                       DCP                                  DCP
 D  0120
    ADDR
    0120     0000   01B2   019C   001D   01A0   01A1   0000   0000

    0130     0B56   0018   001A   0272   0276   027A   027E   0282
```

Valid Input Keys	
D	Calls the display function to display read/write storage.
↑	Scrolls forward; displays the next 32 bytes.
↓	Scrolls backward; displays the previous 32 bytes.
0-9, A-F	Enters hex characters.

Valid Input Keys	
ATTN	Cancels the requested function. To turn off the PROCESS CHECK light, press the RESTART key.
CMD and * or x (multiply on the numeric keyboard)	Calls the DCP diagnostic mode.
CMD and + (plus on the numeric keyboard)	Returns to the customer program if the DCP diagnostic mode has not been called.

Alter

Alter is a DCP normal mode function. In order to use this function, you must first load DCP by holding the CMD key and pressing the HOLD key; then hold the CMD key and press the - (minus) key. To select the alter function, press A; then enter the starting address of the location of the read/write storage you want to alter.

After you enter a starting address, the existing contents of 32 bytes of read/write storage are displayed on two lines of 16 bytes each. New data can be entered on the top line only. The display is altered with each keystroke.

New data is entered into read/write storage in two ways:

- Press the EXECUTE key.
- Enter the 16th byte.

In both cases, the top line is entered into read/write storage and the display is advanced one to allow additional entries. This option allows you to enter a program that can be executed immediately. Pressing the ATTN key terminates the alter function and returns control to DCP. To exit from DCP, hold the CMD key and press the + (plus) key on the numeric keyboard.

Entry Format

A xxxx

Example:

```
                   DCP                                        DCP
   A 4000
     ADDR
     4000      0000   0000   0000   0000   0000   0000   0000   0000

     4010      0000   0000   0000   0000   0000   0000   0000   0000
```

Valid Input Keys

A	Calls the alter function to alter read/write storage.
↑	Scroll forward and displays the next 16 bytes.
↓	Scroll backward and displays the previous 16 bytes.
0-9, A-F	Enters hex characters.
→	Spaces forward.
←	Backspaces.

Valid Input Keys

EXECUTE	Enters the altered hex data into read/write storage.
ATTN	Cancels the requested function.
CMD and * or x (multiply on the numeric keyboard)	Calls the DCP diagnostic mode.
CMD and + (plus on the numeric keyboard)	Returns to the customer program if the DCP diagnostic mode has not been called.

DCP DIAGNOSTIC MODE

The DCP diagnostic mode allows you to branch to addresses in executable ROS or read/write storage. DCP also allows you to use the alter or display functions. The call function is also active which allows you to call in specific tests.

Entry From DCP Normal Mode

To load DCP Diagnostic Mode:

1. Press the ATTN key.
2. Press and hold the CMD key.
3. Press the x (multiply) key (on the numeric keyboard).
4. Release the CMD key (DCP diagnostic mode is now loaded).

Options: Branch and call functions (display and alter active also)

Branch functions:

BE	Branch to executable ROS.	If an error occurs, the entry can be cleared by pressing the ATTN key.
BX	Branch to extended ROS address.	
BR	Branch to read/write storage.	

To branch:

1. Enter one of the above selections.
   That is, press B and R to branch to read/write storage.
2. Enter the branch to address.

Call functions:

0, 1 – I/O diagnostics.
2 – Op code test.
3 – Read/write storage test.
4 – ROS CRC test.
5 – DCP I/O functions.

To load a call function:

1. Press the C key.
2. Enter a call function (0-5).
3. Press the EXECUTE key.

To load DSP:

1. Press the C key.
2. Enter 0 or 1.
3. Press the EXECUTE key.
4. Follow the prompts on the display.

Press the RESTART switch to return to BASIC or APL.

To enter the DCP diagnostic mode, use the numeric keyboard as follows:

1. Press the HOLD key.

2. Press and hold the CMD key and press the – (minus) key on the numeric keyboard.

3. Press and hold the CMD key and press the * key or the x (multiply) key on the numeric keyboard.

Recovery from an error is accomplished by pressing the ATTN key and requesting the function again. Exit from the DCP diagnostic mode by pressing the RESTART key.

Branch Function

The branch function is a DCP diagnostic mode function. To use this function, you must load DCP by holding the CMD key and pressing the HOLD key; then hold the CMD key and press the – (minus) key and the * or x (multiply) key on the numeric keyboard. To select the branch function, enter one of the following and then press the EXECUTE key:

Branch Display Formats

xxxx = Branch address in hex.
yyyy = (optional) Halt address in hex.

Branch in executable ROS:

```
              DIAG DCP                                DIAG DCP

     XXXX YYYY - BRANCH @; HALT @ (OPTIONAL) PRESS EXECUTE
 BE
```

Branch in read/write storage:

```
              DIAG DCP                                DIAG DCP

     XXXX YYYY - BRANCH @; HALT @ (OPTIONAL) PRESS EXECUTE
 BR
```

Branch to feature ROS:

```
              DIAG DCP                                DIAG DCP

     XXXX YYYY - BRANCH @; HALT @ (OPTIONAL) PRESS EXECUTE
 BX  _
```

Valid Input Keys

BE	Branches to the executable ROS address.
BX	Branches to the extended ROS address.
BR	Branches to the read/write storage address with the option of entering a halt address.
EXECUTE	Executes the preceding branch instructions and exits from the branch routine; it remains in the DCP diagnostic mode.

DCP normal mode keys are also valid in the DCP diagnostic mode.

The branch function exits from the DCP diagnostic mode to execute microinstructions located in executable ROS or in read/write storage.

When you exit from the diagnostic mode, the keyboard is activated to accept the CMD and ATTN key combination. Pressing this key combination cancels any operation and returns control to the DCP diagnostic mode (unless the branch went to another keyboard control routine). Therefore, when the program branches to DSP, any of the branch operations can be canceled.

Entering the halt option halts processing when the halt address is reached in the instruction address register of level 0 (R0L0). Pressing the shift key and ATTN key together restores the microinstruction at the halted address and forces level 0 to a halt.

At this time, the 5110 should be placed in the step mode (see the *CE Switches* in the *Service Aids* section of this manual). Pressing the ATTN key again resumes processing in level 0 following completion of the step mode in level 3. The spacebar returns control to the DCP diagnostic mode. The RESTART switch resets a process check.

Call Function

The call function allows you to load the diskette read test into read/write storage for execution, and allows you to execute the op code, read/write storage, and ROS test routines from executable ROS. The call function also provides special DCP I/O functions.

Once the DCP diagnostic mode is entered, use the following keying sequence to use the call function:

1. Press the C key.

2. Select and enter the option number from the menu on the display. The menu consists of the following:

   0, 1 I/O diagnostic
   2 Op code tests
   3 R/W storage test
   4 ROS CRC test
   5 DCP I/O functions

```
              DIAG DCP                                   DIAG DCP

 0     PRESS EXECUTE
 0,1  I/O DIAGNOSTIC
 2     OP CODE TEST
 3     R/W STORAGE TEST
 4     ROS CRC TEST
 5     DCP I/O FUNCTIONS
```

The I/O diagnostic 0 and 1 routines test the read functions of diskette drive 1.

If a failure is detected during I/O diagnostic 0 or 1, the display will guide you to a specific MAP or MDI to isolate the failing field replaceable unit. If the I/O diagnostic runs OK, the DSP menu will be displayed.

Loading the I/O Diagnostic

See *DCP Diagnostic Mode* in this section.

To load the I/O diagnostic:

1. Press and hold the CMD key and press the HOLD key.
2. Press and hold the CMD key and press the – (minus) key on the numeric keyboard.
3. Press and hold the CMD key and press the * or x (multiply) key on the numeric keyboard.
4. Press the C key.
5. Press the 1 key.
6. Press the EXECUTE key.

You can return to the DCP diagnostic mode from the diskette read test by holding down the CMD key and pressing the ATTN key.

Pressing the EXECUTE key calls the diskette read program into read/write storage and starts the test.

The CRC is checked when the diskette read test located in ROS is called into read/write storage. If the CRC is bad, an error is displayed and control returns to the diagnostic mode.

Do NOT press the EXECUTE, R, or L keys until directed to do so by the instructions.

The characters DSP MENU appear on the display when the diskette read test is finished.

The program can be rerun by pressing the ATTN key, entering BR 2A00, and pressing the EXECUTE key. *However, once another program is selected from the DSP MENU, the diskette read test cannot be run unless it is recalled from ROS via DCP.*

Retry Test

Pressing the R key retries the present test once. If an error exists after pressing the R key, the following error message appears on the display screen:

```
ERROR   XXX D 80    GO TO MAP 0310
```

Rerun Test

To run the diskette read test again (because it is still in read/write storage), do the following:

1. Remove the CE diagnostic diskette.
2. Press the ATTN key.
3. Enter BR (branch to read/write storage).
4. Enter 2A00 (starting address of the read test).
5. Press the EXECUTE key.

Follow the instructions on the display (some loops will not have instructions).

The CE diagnostic diskette must be removed before you retry the diskette read test.

Note that once another program has been selected from the DSP menu, the test cannot be run unless it is recalled.

Diskette Read Test Error Chart

Error Code	Meaning	Area Tested
001	Subdevice select	LED, PTX, diskette control card
002	Set write, diskette 1 erase	LED, PTX, diskette control card, diskette adapter card
003	Set read, diskette 2	Diskette adapter card, I/O cables
004	Set MFM	Diskette adapter card, I/O cables
005	Set FM	Diskette adapter card, I/O cables
006	Test current select and status	Diskette adapter card, I/O cables
008	Test head 1 and head 0 select	Diskette adapter card, I/O cables
009	Test access lines	Diskette adapter card, I/O cables
010	Test overrun status	Diskette adapter card
011	Test loop write/read	Diskette adapter card, executable ROS (L2) card
012	Test loop write/read	Diskette adapter card
013	Test loop write/read	Diskette adapter card
014	New media	Diskette drive, diskette
015	Index pulse timing	Diskette drive, diskette
016	Index pulse width	Diskette drive, diskette
017	Head access test	Diskette adapter card, diskette control card, stepper motor
018	Auto head engage/disengage test	Power supply, head load assembly, diskette control card
019	Head initialize	Stepper motor
020	Sense side 0, cylinder 0	Head carriage assembly, stepper motor, diskette control card, power supply
021	Sense side 1, cylinder 0	Head carriage assembly, stepper motor, diskette control card, diskette adapter card, diskette
022	Random access test	Diskette adapter card, diskette control card, stepper motor
023	Load DSP	Bad diskette

```
              DIAG DCP                          DIAG DCP
OC   W
2    PRESS EXECUTE
0,1  I/O DIAGNOSTIC
2    OP CODE TEST
3    R/W STORAGE TEST
4    ROS CRC TEST
5    DCP I/O FUNCTIONS
```

This routine tests all controller microinstructions. Numerous IAR (instruction address register) hang points localize specific failing processor operations and monitor storage addresses at the RDR (read data register) for improper parity.

If accessed through DCP, this test loops until halted by the operator. When accessed by the bring up diagnostic, it is not repeated.

```
              DIAG DCP                                 DIAG DCP

 3     PRESS EXECUTE
 0,1   I/O DIAGNOSTIC
 2     OP CODE TEST
 3     R/W STORAGE TEST
 4     ROS CRC TEST
 5     DCP I/O FUNCTIONS
```

This routine stores data in all locations of the read/write storage above location 00FF and then reads it all out and compares it one address at a time. The routine then shifts the data one position and loops on the test. If allowed to run, all read/write storage addresses above location 00FF are tested for each possible data combination. The test runs until the operator stops it by using the RESTART switch. Either a process check or a customer halt condition can occur.

RFLO (register F in level 0) contains the storage location that was being addressed at the time of the failure. The suspected read/write storage card that caused the failure can be identified by using the following table:

Storage Location	**Storage Capacity**	**Card Location**
0000 to 3FFF	16K	M2
4000 to 7FFF	32K	M4
8000 to BFFF	48K	N2
C000 to FFFF	64K	N4

```
              DIAG DCP                                DIAG DCP

4    PRESS EXECUTE
0,1  I/O DIAGNOSTIC
2    OP CODE TEST
3    R/W STORAGE TEST
4    ROS CRC TEST
5    DCP I/O FUNCTIONS
881    DISKETTE MDI

890    DIAGNOSTIC ROUTINE CHART
```

The ROS test checks to see if the machine can address and fetch data from each ROS module relating to the language (APL or BASIC) of the machine. While the test runs, each byte of data in each ROS module is read, and CRC sums are generated and compared. The test runs until the operator stops it by pressing the CMD and ATTN keys or until an error is detected. Compare failures end the test and post an error on the display.

Parity errors from the ROS adapter are detected on the bus in to the controller and cause a process check.

```
                 DIAG DCP                               DIAG DCP
                    5   DCP I/O
DV@   _
```

This function allows you to dump read/write storage to a diskette. It also allows you to dump a diskette to storage.

The DCP I/O function is a ROS resident program that is called via the DCP diagnostic mode. To use this function you must load DCP as follows:

1. Press and hold the CMD key and press the HOLD key.
2. Press and hold the CMD key and press the – (minus) key on the numeric keyboard.
3. Press the * or x (multiply) key on the numeric keyboard.
4. Press the C key.
5. Press the 5 key.

This function requires input to define the function desired. The parameters available are:

MK XXX YY ZZ – Selects the mark function (diskette).
XXX = file size in K bytes.
YY = number of files.
ZZ = starting file.

RD	– Selects the read function (from diskette).
WT	– Selects the write function (to diskette).
WTP	– Selects the write function with file protect (diskette).
A XXXX	– Defines the starting storage address.
S XXXX	– Defines the stop address in read/write storage (required on write functions).
F #	– Defines the file number (#).
N name	– Defines a file name for all write commands (17 characters maximum; blanks are not allowed).
T YY	– Defines the file type which can be optional for write functions.
C Y	– Defines the diskette cylinder number and forces a single selected sector.
H Y	– Defines the diskette head (optional) for use with the C function.
DV@ XXX	– Defines the device address.

Diskette Read Format:

DV@ XXX
Device Address

RDƀAƀXXXXƀFƀ#
File number
Address
Read Function

(ƀ = blank space)

Example:

DV@ D20

RD A 0228 S 0328 F 2

This example shows the format for reading a diskette on diskette drive 3 starting at address '0228' and ending at address '0328'.

To display the volume label (cylinder 0, head 0, record 7), do the following:

1. Insert the diskette in the drive unit.
2. Press the HOLD key.
3. Press and hold the CMD key and press the – (minus) key on the numeric keyboard.
4. Press and hold the CMD key and press the * or x (multiply) key on the numeric keyboard.
5. Press the C key.
6. Press the 5 key on the numeric keyboard.
7. Enter D80 (if you are using drive 1).

The volume label will now be displayed.

To display any other sector of the diskette after the volume label has been displayed, enter the desired cylinder, head and sector. For example, RD A 0400 C 2 H 1 R 8, EXECUTE will place the contents of cylinder 2, head 1, record 8, into storage starting at location 0400. Record 8 (sector 8) can be 128, 256, 512, or 1024 bytes of data, depending on the diskette type and initialization format. The record will be displayed in alphanumeric format on the lower half of the display screen. The data may also be displayed in hexadecimal format by displaying storage at address 0400.

To write the data to storage:

1. Press the HOLD key.
2. Press and hold the CMD key and press the – (minus) on the numeric keyboard.
3. Press and hold the CMD key and press the * or x (multiply) key on the numeric keyboard.
4. Enter: A 0800 *data in hexadecimal* EXECUTE.

To write the data on a diskette:

1. Press the ATTN key.
2. Press the C key and the 5 key.
3. Enter D80 (if you are using drive 1).

Example:

WT A 0800 C 4 H 0 R 3 EXECUTE

This example will write at cylinder 4, head 0, sector 3, the data contained in storage starting at storage address 0800 and ending at the storage address that fills the sector. The sector may be 128, 256, 512, or 1024 bytes in length, depending on the diskette type and the initialization format.

Diskette Write Format:

DV@ XXX

Device Address

W T b̸ A b̸ X X X X b̸ S b̸ X X X X b̸ F b̸ # b̸ N b̸ (17 characters) b̸ T b̸ #

File Type

File Name

File Number

Stopping Address

Starting Address

Write Function
(b̸ = blank space)

Example:

DV@ D80

WT A 0335 S 04FF F 3 N PAYROLL1

This example shows the format for writing a diskette on diskette drive 1 starting at address '0335' and stopping at address '04FF'. The file number is 3 and the file name is PAYROLL1.

Diagnostic Diskette Volume Label

The diagnostic diskette (part 6842932) is initialized to 512 bytes. The VOL I D is displayed using DCP option 5 as:

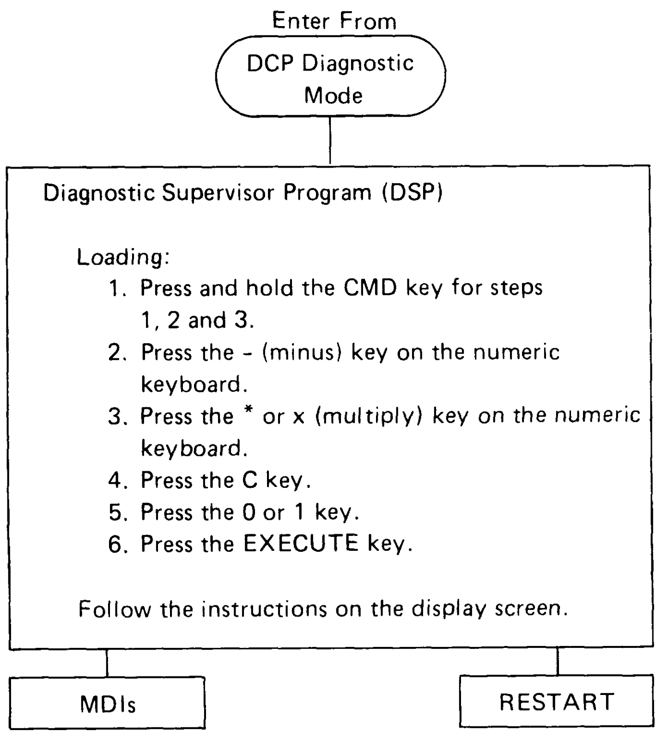
```
                DIAG DCP                               DIAG DCP
                   5   DCP I/O
DV@   D40   RD    WT    MK




VOL1DIAG01                                   ECXXXXXX
            M   2    W***************************************
                      **************************************
```

M = MFM mode   2 = initialized to 512 bytes   XXXXXX = EC level of diagnostic

The diskette can be copied by using the customer's disk to disk copy program that is located on the customer support diskette.

CAUTION
The volume label (VOL1DIAG01) is not copied by the disk to disk copy program and the diagnostics will not execute properly unless the volume label is VOL1DIAG01.

Diagnostic Supervisor Program (DSP)



The DSP controls loading and execution of programs residing on diskette. DSP is located on file one of the diskette and is loaded automatically after call functions 0 or 1. After DSP is loaded into read/write storage, the display screen shows the DSP menu and the instructions for loading the programs.

The leftmost dash before the words ENTER THE MDI NUMBER TO BE RUN flashes to indicate the position of the next character to be entered on the keyboard. To move from one entry area to another, press the # key. The procedure for entering the MDI number is found under *Map Diagnostic Integration (MDI)* in this section.

```
                                                 MENU    EC   XXXXXX
    DSP
    800 PRINTER MDI
    820 ASYNCHRONOUS COMM. AND SERIAL I/O MDI
    821 BSCA MDI
    871 INTERNAL DISKETTE MDI
    881 5114 DISKETTE MDI
    890 COMMUNICATIONS ROUTINES


  #--ENTER THE MDI NUMBER TO BE RUN
  #--ENTER  'O' IF THE OPTIONS ARE TO BE DISPLAYED
```

Diagnostic Diskette

XXXXXX is the current EC number of this diskette.

MAP Diagnostic Integration (MDI)

MDI is MAPs and diagnostic programs integrated into a single maintenance approach. MDI, with the display and the keyboard, allows you to isolate machine failures by responding to information on the display screen. Questions on the display screen require a response through the keyboard. The MDI goes to the next question or section indicated by the keyboard input. The MDI proceeds automatically through the steps that do not require a response if the MDI is in the run mode.

The MDIs are used to diagnose I/O problems other than read failures in the loading device.

The MDIs for the 5120 system are contained on the diagnostic diskette. This diskette contains *all* MDIs for the 5110, the 5114, the 5103 Printer, communications features, and serial I/O.

Note: The maintenance package for the 5114 Diskette Unit also contains a diagnostic diskette. *Do not* use the 5114 diagnostic diskette with the 5120 system.

DSP Menu

MDI (MAP Diagnostic Integration)

Loading:

1. Select the MDI section number from the DSP menu.
2. Enter the MDI section number.
3. Press the EXECUTE key.

This procedure loads and automatically runs the MDI.

To stop the MDI and return to the MDI options, press the ATTN key.

The following message might appear if the MDI halts:

ENTER Y OR N (B, O, T)

Y = Yes N = No	Refers to an answer to a specific question on the display screen. Enter the appropriate answer and press the EXECUTE key.
B = Back:	You can enter B or BXX and press the EXECUTE key. XX is the number of steps you want to back up in the trace table.
O = Option:	You can enter O and press the EXECUTE key to display the MDI options.
T = Trace:	You can enter T and press the EXECUTE key to display the steps that were executed along with the decision (Y or N) that was displayed. To obtain a copy of the trace table, press the HOLD key, press and hold the CMD key, and press the x key.

MDI ran OK. Return to MAP or press ATTN key twice and select the next MDI.

Intervention required. Read the display and take the appropriate action.

RESTART

DSP

MDI Options

Loading:

1. Select the MDI section from the DSP menu.
2. Enter the MDI section number.
3. Press the # key.
4. Enter the letter O (option).
5. Press the EXECUTE key.

The MDI option table is now on the display screen.

Note: The # key will tab to the next entry instruction.

MODE:

STEP	Halts at each step and waits until the EXECUTE key is pressed to continue. You can change the decision of a step by keying in Y, N, B, O, or T.
RUN	(default selection) Runs MDI automatically and halts when a question must be answered.

NEXT STEP NO: Enter the next step number to be executed. (If you are using the loop on path option, you must enter the stop number here.)

LOOP ON:

STEP	Allows looping on a specified next step number.
PATH	Allows looping on a path specified by the path start number and path stop number. The last step in the trace must be answered yes.
MDI	Allows looping a complete MDI section in step and run mode.

UNTIL: (Use with loop on option)

Blank	Loops until the CMD and ATTN keys are pressed (used with loop on step).
YES	Loops until a yes decision is obtained (used with loop on step).
NO	Loops until a no decision is obtained (used with loop on step).
DIFFERENT	Loops until a decision different from the decision established by the trace is obtained (used with loop on path or MDI).

PATH START NO: Defines the path start number when loop on path is selected.

PATH STOP NO: Defines the path stop number when loop on path is selected.

```
                MDI OPTIONS

MODE=#RUN_      NEXT STEP NO.=#001
    *-STEP-*
    *-RUN -*

LOOP ON -#____   - UNTIL - #_________   -   PATH START NO.=#000
       *-STEP-*         *-YES        -*
       *-PATH-*         *-NO         -*   PATH STOP  NO.=#000
       *-MDI -*         *-DIFFERENT-*

PRESS -(CMD)ATTN- TO STOP LOOPING
PRESS -ATTN- TO RETURN TO DSP
PRESS -EXECUTE- TO CONTINUE WITH THIS MDI
```

Loading the MDI Sections

To load MDI sections, select the section from the DSP menu, enter the section number, and press the EXECUTE key.

An O (letter) can be entered along with the MDI section number (but on the next line) to select a special option or to alter a previously selected special option. To move from one entry area to another, press the # key. Pressing the EXECUTE key loads the selected MDI and displays the MDI options.

It is possible to enter and run MDI numbers not appearing on the menu because the listed MDI sections are divided into subdivisions with their own individual numbers. These MDI subsections are discussed in greater detail later. MDI sections and subsections can be used with some of the options mentioned in the previous paragraph.

CAUTION
When you enter these sub-MDI numbers, the MDI runs out of its normal sequence and, therefore, might give false results. You should be familiar with the MDI options before using this technique.

After you select the MDI number from the menu and press the EXECUTE key, the 5110 automatically loads the MDI from the diagnostic diskette and begins running it. As the MDI runs, the steps of the MDI appear on the display screen.

The MDI either runs to completion with no errors detected and with no intervention required or it stops to allow action. If it stops, read the display to determine the appropriate action to use. Possible actions include the following:

- Replace FRUs.
- Make an adjustment.
- Probe a logical level.
- Meter voltages.
- Exchange FRUs.
- Make an observation.

If a question is asked, answer it before pressing the EXECUTE key to continue. The format of the display and an explanation of the line numbers follows.

MDI Display Format

```
 0  MDI ID           STEP NO XXX   |
 1                                 |  XXXX
 2    COMMAND TEXT AREA            |
 3    QUESTION TEXT AREA           |
 4    FIX TEXT AREA                |
 5                                 |
 6                                 |        SUPPLEMENTARY TEXT AREA
 7                                 |
 8                                 |
 9                                 |
10                                 |
11                                 |  TEST  – BITS ON
12                                 |  MASK – 0300
13    INSTRUCTION AREA             |  RCVD – 0700
14    REPLY AREA                   |  NEXT STEP NO. – 037
15    STATUS AREA                  |
```

Command Text Area

Line 0	The name of the MDI and the step number that is currently running.
Lines 1-12	The command text from the MAP.
Lines 13, 14	Instructions usually tell you to press the EXECUTE key after entering the reply (Y, N, B, O, or T). Y means yes; N means no. The meanings of B-back, O-option, T-trace are explained later under *MDI Display Replies* in this section.

Supplementary Text Area

Line 1 (XXXX)	The diagnostic routine number (described under *Diagnostic Program Routines* in this section).
Lines 2-10	Supplemental information
Lines 11, 12, 13, 14	The bottom right of the display screen shows the data used to make the decision. TEST defines the type of comparison used for the decision. The comparison is made between the data defined by MASK and RCVD. MASK is used to refer to either expected data or a MASK for bit comparisons. RCVD refers to the data that is returned from the section and can be data, status, or timing information. MASK and RCVD refer to data strings between 1 and 24 characters.

The three classes of test are:

1. Bit comparisons (bits on, bits not on, bits not off) compare the RCVD data against the bits that are on in the MASK. Zero bits in the MASK are do-not-care bits.

2. Magnitude comparisons (low, high, equal, not equal, less than or equal, greater than or equal) compare the RCVD data aginst the MASK.

3. Limit comparisons verify that the RCVD data is within the upper and lower limits specified by the MASK.

A yes or no decision is made based on these results.

MDI Message Displays

The following message is displayed when a section is run in step mode, the results of the section are tested, and a decision is made by the program based on the results. (In this case, the decision is yes.) You can override this decision by entering an N, or you can also select one of the other specified options. When you press the EXECUTE key, DSP interrogates the reply and proceeds accordingly.

```
                                  TEST- EQUAL
                                  MASK- 15
DECISION IS (Y,N,B,O,T)           RCVC- 15
#Y__                              NEXT STEP NO.-009
```

The following message is displayed when you must manually answer the MDI question. You can answer yes or no or select one of the other specified options. When you press the EXECUTE key, DSP interrogates the reply and proceeds accordingly.

```
ENTER Y OR N (B, O, T)
#___
```

The following message is displayed when a remove, replace, or adjust action (RRA) is required to correct the failing FRU or when a no-trouble-found (NTF) step is reached. The reply defaults to an O, but one of the other options can be selected. When you press the EXECUTE key, MDI interrogates the reply and proceeds accordingly.

```
ENTER B, O, OR T
#O__
```

Diagnostic Aids

If you press and hold the CMD key and press the ATTN key while the MDI is running, the MDI option display returns. If you press the ATTN key a second time, the DSP menu returns, and if you press the ATTN key a third time, the DCP diagnostic mode returns.

The following message is displayed when the MDI requires a set up, when additional displays of command text are required, when a GOTO STEP or GOTO MAP is specified, or when a trace is displayed. If you press the EXECUTE key, the MDI continues; however, if one of the options is entered before pressing the EXECUTE key, that option is taken.

```
PRESS EXECUTE(B,O,T) TO CONTINUE
#___
```

The following message is displayed when additional displays are needed to show the entire trace table (256 steps maximum).

While in trace mode, 80 steps can be displayed on one display screen at a time. If the trace contains more than 80 steps, it is displayed on multiple display screens, and the EXECUTE key must be pressed to page through multiple displays.

The reply defaults to a T, but one of the other specified options can be selected. When you press the EXECUTE key, DSP interrogates the reply and proceeds accordingly.

The following message is displayed when a test is looping. You are instructed to probe pins or observe an operation. The diagnostic test runs until the ATTN key is pressed, then the MDI question message appears.

```
PRESS -ATTN- TO REPLY
STATUS: RUNNING
HOLD
```

MDI Display Replies

T = Trace: Displays the trace of the steps that were executed and the decision, yes (Y) or no (N), associated with each step. (A GO TO STEP is designated by a G; the G means go to a step within the same MDI.)

```
ENTER B, O, OR T
#T
HOLD
```

The trace is erased when an MDI subsection is called. For example, the MDI subsection 801 is called automatically as MDI 800 is executed. But, as you step through the MDI 800, you can see the display message that indicates the MDI subsection that will be called if you press the EXECUTE key. This is the last time you can call the trace for MDI 800 before it is erased.

If trace is called for after you have entered the MDI subsection, the trace table shows the entry and exit steps from the previous MDI and the steps for the MDI subsection.

```
MDI 804              STEP NO. 003 --->

001,0800,080          002-N    003-
```

B = Back: Backs up one step in the MDI. A decimal number between 2 and 99 can be entered following the B to back up more than one step at a time. Execution begins at the step number you backed up to. If the number that is entered is greater than the number of steps that were executed, the first step in the trace is selected.

You cannot back out of an MDI program (only one MDI is in read/write storage). If you are in an MDI subsection, then you must return to the DSP menu to load the previous MDI. The previous MDI is called from the DSP menu by entering the MDI number and pressing the EXECUTE key.

O = Option: Returns to the MDI options display so you can enter new options. Pressing the ATTN key returns the DSP menu.

MDI Options

The MDI options are accessed through the MDI options display. Instructions on how to run the MDI options are provided on the display. To move from one entry area to another, press the # key.

To call the MDI options display, enter O (option) in the reply area of the display. There is one exception: if you are in an MDI section that does not have the MDI options as one of the display replies. Press the ATTN key, or hold down the CMD key and press the ATTN key, to get to the MDI options display. An illustration of the MDI options display follows.

CAUTION
If you are using MDI options on MDI 871 or MDI 881, remove the diagnostic diskette and do not insert it until instructed to do so on the display.

Note: If you enter the first letter of a reply in the area, the complete reply is entered.

```
                  MDI OPTIONS

MODE=#RUN_        NEXT STEP NO.=#001
    I-STEP-I
    I-RUN -I

LOOP ON -#____   - UNTIL - #__________   -   PATH START NO.=#000
        I-STEP-I          I-YES       -I
        I-PATH-I          I-NO        -I     PATH STOP  NO.=#000
        I-MDI -I          I-DIFFERENT-I

PRESS -(CMD)ATTN- TO STOP LOOPING
PRESS -ATTN- TO RETURN TO DSP
PRESS -EXECUTE- TO CONTINUE WITH THIS MDI
```

Diagnostic Aids

MODE: Defaults to RUN if STEP is not entered.

STEP—Displays the results of each test and waits until the EXECUTE key is pressed before continuing to the next test. STEP is used to step through each step in the MDI. You can alter each decision in the step mode. The MDI remains in the STEP mode until it is manually changed to the RUN mode.

RUN—Proceeds automatically through the MDI; it performs the designated test and displays the results. The RUN mode stops and waits for the EXECUTE key to be pressed only when a question must be answered or when a fix is displayed.

NEXT STEP NO.: Selects the MDI step number to be executed next. You have the option of selecting any step within the MDI (001-nnn). If an invalid step number is entered, an error message is displayed.

LOOP ON: Loop on options are intended to help you diagnose intermittent problems. (If you press the HOLD key when the option is looping, the PROCESS CHECK light might come on.)

STEP—Loops on the step are specified by the NEXT STEP NO. until you press the CMD key and the ATTN key or until one of the selected termination options of the until option is met.

PATH—Loops on the path are specified by the PATH START NO. and PATH STOP NO. when the DIFFERENT option is selected (see *Loop On Path* for information on how to establish a path).

MID—Loops on the entire MDI when the DIFFERENT option is selected.

UNTIL: Looping termination options. Blank, YES, and NO should be used with LOOP ON STEP. DIFFERENT should be used with LOOP ON PATH or LOOP ON MDI.

These options are recognized only when one of the LOOP ON options is selected.

Blank (option field left blank)—Loops until the CMD key and ATTN key are pressed, then returns the MDI options to the display screen.

YES—Loops until a yes decision for a diagnostic test is obtained (the screen describing the current MDI step is then displayed), or until the CMD key and ATTN key are pressed (this gives the same results as blank).

NO—Operates the same as YES except it loops until it obtains a no decision for a diagnostic test.

DIFFERENT—First, a trace must be defined by proceeding through the desired sequence of steps in the MDI or PATH. Then the program loops on the predetermined sequence of steps until the current sequence varies from the predetermined sequence. When the loop terminates, the last valid step of the sequence is displayed along with the decision that varied. Question steps are assumed to have the same response each time they pass through the loop as they had when the initial trace was defined; therefore, they do not have to be answered each time.

PATH START NO: Defines the beginning step of the path.

PATH STOP NO: Defines the ending step of the path.

Stepping and Looping

Step Through MDI:

MODE = STEP

NEXT STEP NO. = XXX

STEP—Displays the results of each test and waits until the EXECUTE key is pressed before continuing to the next test. STEP is used to step through each step in the MDI. You can alter each decision in the step mode. The MDI remains in the step mode until it is manually changed to the run mode or until a different MDI is loaded.

Loop On Step:

MODE = STEP

NEXT STEP NO. = XXXX

LOOP ON – STEP—Loops on the step specified by the NEXT STEP NO. until the CMD key and ATTN key are pressed or until one of the selected termination options of the UNTIL option is met.

UNTIL – blank, YES, NO, DIFFERENT

Loop On Path:

PATH—Loops on the path specified by the PATH START NO. and the PATH STOP NO. when the DIFFERENT option is selected.

You must answer the questions exactly as they were answered on the initial pass through the path.

No intervention is required for the program to loop continuously. However, before you can use the DIFFERENT option correctly, you must create a trace of the desired step sequence by proceeding through the path. The DIFFERENT option uses the trace table as a guide.

To use the LOOP ON PATH until DIFFERENT option:

1. With the DSP loaded and the menu displayed, enter the selected MDI number along with O for options, and press the EXECUTE key. This initializes the trace.

2. Enter the STEP mode, then enter the path starting step number into NEXT STEP NO.

3. Press the EXECUTE key. This begins execution of the step selected by NEXT STEP NO.

4. Proceed through the path steps and answer those steps that require intervention until you reach the desired path stopping step. This builds the trace of the steps in the path. The last step must be answered YES.

5. Press the ATTN key to return to the MDI options.

6. Enter:

   MODE = RUN
   NEXT STEP NO. (use PATH STOP NO.)
   LOOP ON PATH UNTIL DIFFERENT
   PATH START NO.
   PATH STOP NO.

7. Press the EXECUTE key to begin looping.

8. Press the CMD key and ATTN key to stop looping. This returns you to the MDI OPTIONS display so you can select new options. To resume looping, press the EXECUTE key without changing the options.

9. Looping stops if the sequence of step execution deviates from the initial sequence. The last executed step is displayed along with the decision that varied. The looping options are cleared automatically so that when you press the EXECUTE key, the MDI proceeds to diagnose the error that occurred.

Loop On MDI:

MDI—Loops on the entire MDI when the DIFFERENT option is selected.

You must answer the questions exactly as they were answered on the initial pass through the MDI.

No intervention is required for the program to loop continuously. However, before you can use the DIFFERENT option correctly, you must create a trace of the desired step sequence by proceeding through the path. The DIFFERENT option uses the trace table as a guide.

To use the LOOP ON MDI until DIFFERENT option:

1. With the DSP loaded and the menu displayed, enter the selected MDI number, and press the EXECUTE key to initialize the trace and begin running the MDI.

2. Proceed through the MDI by answering the steps that require intervention; continue until the last step in the MDI is reached. This builds the trace of the sequence of steps that were executed. The question in the last step must be answered YES.

3. Press the T key and the EXECUTE key to display the trace table. Record the first and last steps of the trace table for the MDI being run.

4. Press the ATTN key to return to the MDI options.

5. Enter:

```
              MDI OPTIONS

MODE=#____      NEXT STEP NO.=#
   *-STEP-*
   *-RUN -*

LOOP ON -#____    - UNTIL - #_________
        *-STEP-*          *-YES
        *-PATH-*          *-NO
        *-MDI -*          *-DIFFERENT-
```

6. Press the EXECUTE key to begin looping.

7. If looping does not start, repeat steps 2 through 6.

8. Press the CMD key and ATTN key to stop looping. This returns you to a display of the MDI options so you can select new options. To resume looping, press the EXECUTE key without changing the options.

9. Looping stops if the sequence of step execution deviates from the initial sequence. The last executed step is displayed along with the decision that varied. The looping options are cleared automatically so that when you press the EXECUTE key, the MDI proceeds to diagnose the error that occurred.

MDI Subsections

The printer MDI, diskette MDI, and the communications MDIs on the DSP menu, are subdivided into individually numbered subsections. In addition, they can be entered directly when the DSP menu is displayed.

CAUTION
If you enter the MDI subsection numbers directly into the DSP menu, the MDI runs out of its normal sequence; this can cause erroneous results.

A list of the MDIs and their subsections are as follows:

- 800 5103 Printer MDI Exerciser
  - 801
  - 802
  - 803
  - 804
  - 805
- 820 Asynchronous Communications/Serial I/O MDI
- 821 BSC MDI
- 822 Reserved
- 871 Internal Diskette MDI
- 881 5114 Diskette MDI
  - 882
  - 883
  - 884
  - 885
  - 886
  - 887
  - 888
- 890 Communications Routines
  - 894
  - 895
  - 896
  - 897
  - 898
  - 899

5103 PRINTER DIAGNOSTIC ROUTINES

These routines are used in MDIs 800-805. The expected information column in the chart contains the following types of information:

SA = Status byte A
SB = Status byte B

Device Address	Device Name	Bits 8-15	Definition
5	Printer		If Ry is even, status byte A:
		8	Print emitter latch 3
		9	Print emitter latch 2
		10	Print emitter latch 1
		11	Wire check or not ready
		12	Forms emitter B
		13	Forms emitter A
		14	Not end of forms
		15	Left margin switch or not ready
			If Ry is odd, status byte B:
		8	Print motor latch B (0 = not B)
		9	Print motor latch A (0 = not A)
		10	Print emitter interrupt
		11	Not ready interrupt
		12	Forms motor latch B (0 = not B)
		13	Forms motor latch A (0 = not A)
		14	80 cps = 0, 120 cps = 1
		15	Timer interrupt

Ry is the third hex digit in the microinstruction.

EC = Error Code

An error code is a 2-digit decimal number described under *Error Codes* in this section.

PLFP = Print Line Failure Position

The print line failure position is a 4-digit decimal number between 0001 and 0132.

TS = Test Status

Test status is either 00 or FF. 00 indicates a test failure, and FF indicates a pass.

Diagnostic Aids

Routine Number	Description	Expected Information	Error Code	Meaning
PT02	Forms emitter balance. Increments the platen forward and reverse for the same specified time. Counts the number of emitter pulses and displays the forward and reverse pulses as up arrows and down arrows.		–	If the arrows are not within ±3 of the same count, up and down, move the forms emitter in the direction of the greater number of arrows. Printers used for plot output should be adjusted to ±1 count difference.
PT03	Turns off (resets) the forms motor latch A and B in the printer adapter card (B1A2).	XX XX SA SB	–	Returns status bytes A and B.
PT04	Turns on the forms motor latch A.	XX XX SA SB	–	Returns status bytes A and B.
PT05	Turns on the forms motor latch B.	XX XX SA SB	–	Returns status bytes A and B.
PT06	Turns on the forms motor latch A and B.	XX XX SA SB	–	Returns status bytes A and B.
PT07	Gets status.	XX XX SA SB		MDI 892 returns status bytes A and B.
PT08	Spaces forms in increments of 1/16 of a line. Sixteen increments are spaced (one line); detects open forms predriver lines or an open forms stepper motor winding.	XX XX XX SA SB EC	50-59	Returns status bytes A and B, and an error code.
PT09	Checks the ability of the timer in the printer adapter card to count down to zero and cause an interrupt. A variety of values are used.	00	–	Returns a two-digit number indicating the timers performance.
PT10	Checks the ability of the timer to automatically reload itself when an interrupt occurs.	00	–	Returns a two-digit number indicating the timers performance.
PT11	Turns on the print motor latches A and B.	XX XX SA SB	–	Returns status bytes A and B.
PT12	Turns on the print motor latch B.	XX XX SA SB	–	Returns status bytes A and B.
PT13	Turns on the print motor latch A.	XX XX SA SB	–	Returns status bytes A and B.

Routine Number	Description	Expected Information	Error Code	Meaning
PT14	Turns off the print motor latches A and B.	XX XX SA SB	–	Returns status bytes A and B.
PT15	Turns off the forms go and the print go latches that disable the two printer motors.	XX XX SA SB	–	Returns status bytes A and B.
PT15A	Same as PT15 except status is returned after 300 ms delay.	XX XX SA SB	–	Returns status bytes A and B.
PT16	Gets and saves status bytes A and B the first time it is called and returns that status on all subsequent calls.	XX XX SA SB	–	Returns saved status bytes A and B.
PT20	Prints four lines of alternating Hs and blanks. Terminates early if an error code occurs.	XX EC	50-59	Returns an error code.
PT21	Ripple Print with Underscore – Prints one line of all characters without underscore and one line of all characters with underscore. Terminates early if an error occurs.	XX EC	50-59	Returns an error code.
PT26	Gets the last error code value.	XX EC	50-59	Returns an error code.
PT01V6	Spaces forms six lines and repeats this sequence six times (36 lines).	XX EC	50-59	Returns an error code.
PT01V15	Spaces forms 15 lines and repeats the sequence six times (90 lines).	XX EC	50-59	Returns an error code.
PT17V1	Drives the print head carrier to the right margin, then ramps. If an error occurs, the routine gets the status, issues a ramp command, and terminates.	XX XXXX EC PLFP	50-59	Returns EC and PLFP.
PT17V10	Same as PT17V1 except it repeats this sequence 10 times.	XX XXXX EC PLFP	50-59	Returns EC and PLFP.
PT25V1	Left Margin Timing Test – Moves carrier to the right 3.3 inches (83.8 mm), then ramps. Checks to determine if left margin drops between print emitters 1 and 2. Terminates the routine and causes TS (test status) to be 20 if an error occurs.	XX XX XX XX SA SB EC TS	50-59	Returns status bytes A and B, an error code, and test status.

Diagnostic Aids

Routine Number	Description	Expected Information				Error Code	Meaning
PT25V5	Same as PT25V1 except it repeats this sequence five times if there are no errors.	XX SA	XX SB	XX EC	XX TS	50-59	Returns status bytes A and B, an error code, and test status.
PT25V10	Same as PT25V1 except it repeats this sequence 10 times if there are no errors.	XX SA	XX SB	XX EC	XX TS	50-59	Returns status bytes A and B, an error code, and test status.

DISKETTE DIAGNOSTIC ROUTINES

These routines are used in MDIs 871 and 881 through 888.

Routine Number	Description	Status	Meaning
DT01	Displays 'ENTER SUBDEVICE ADDRESS'. Tests all I/O resets, the status, and the select and access status of the devices and subdevices selected.	801	Failed to reset to FF.
		803	Subdevice did not respond.
		806	Wrong initial status.
		0000	Good test.
DT14	Tests the current select bit by setting and resetting the bit and returning the status for each condition.	9080	Good test.
DT16	Issues access commands for each combination of lines 6 and 7 and returns the status.	83818082	Good test.
DT17	Tests the head engage/disengage bit. The heads do not load.	8880	Good test.
DT20	Tests the head selection (0 or 1) and returns the status.	8480	Good test.
DT24	Tests the MFM bit (without the heads engaged) and returns the status.	C0	Good test.
DT25	Tests the FM bit (without the heads engaged) and returns the status.	40	Good test.
DT31	Tests the write, diagnostic 1, and erase bits and returns the status.	A400	Good test.
DT32	Tests the read and diagnostic 2 bits and returns the status.	6400	Good test.
DT42	Tests the overrun error checking ability of the adapter.	0000	Good test.
DT40	ALL LWR Tests—Performs all loop-write-read tests on both FM and MFM mode. An error code of 01 indicates a bad adapter card. An error code of 02 indicates a bad VFO card.[1] The test stops on the first error and returns the error code.	00	Good test.
DT98	Returns the error code from the DT40ALL tests.	01	Bad adapter card.[1]
		02	Bad VFO card.[1]

[1] Some 5114 diskette adapter cards have the VFO circuitry on them. See MAP 050.

Diagnostic Aids

Routine Number	Description	Status	Error Code	Meaning
The following tests must be run with the diagnostic diskette inserted.				
DT12	Returns the status, resets the new media bit, and returns the status.	8000		Good test.
DT27A	Tests index pulses for timing (162.5 to 170.9 ms).	1625–1709	0827	Returned timing must be between these numbers.
DT27B	Tests index pulses for duration (1.5 to 3.0 ms).	15–30		Returned timing must be between these numbers.
DT17A	Tests the loading and unloading of the heads and returns the status.	0800		Good test.
DW05	Reads the header label, side 0, track 0, and record 7. Compares the data and returns the status.	0000		Good test.
DW07	Reads the volume label, side 1, track 0, and record 20. Compares the data and returns the status (must be DIAG01).	41 or 00		Good test.
DW26	Tests the seek function by seeking randomly 100 times. Flags any hardware errors and returns the status.	00		Good test.
DW03	Returns the heads to zero and returns the status.	0000		Good test.
DW33	Write/Read Test. Data patterns of 4C4C and 0000 are used to write on record 1 of cylinders 7 and 54 using both heads. CRC checking is done and any errors are returned.	0000		Good test.
The following tests are loop diagnostics. These tests are terminated by pressing the ATTN key.				
DT13	Seeks forward and reverse 80 cylinders.			
DW29	Writes on track 7, record 1 using both heads.			
DW28	Reads track 7, record 1 using both heads.			
DT18	Head Engage Test—Loads and unloads the heads. A diskette must be in the drive.			
DT33	Write/Read Test—Writes and reads cylinders 7 and 54 using both heads.			

Routine Number	Description	Status	Meaning

The following test uses the 3742 Alignment Diskette, part 2455026.

DW38	Head Alignment Diagnostic (5114 only)—This diagnostic reads tracks 7 and 8 of the alignment diskette looking for a data compare on any two successive pairs of records. It uses only head 0. Head 1 is factory aligned with head 0.		

ASYNCHRONOUS COMMUNICATIONS ADAPTER/ SERIAL I/O ADAPTER PROGRAM AND DIAGNOSTIC ROUTINES

When the Asynchronous Communications Adapter/Serial I/O Adapter features are installed, the diagnostic program provides:

- A test of all the status and control circuitry on the expansion feature card. The test further isolates problems to either the 5110 or the customer provided data set/ communications facility.
- A test of the long space interrupt and the timer interrupt of the Asynchronous Communications Adapter feature. The long space interrupt detects an end of transmission request from the remote facility. The timer interrupt controls the data sampling and the data transmission rates.
- A test of the timer interrupt of the Serial I/O Adapter feature. The timer interrupt controls the data sampling and the data transmission rates.
- A test for each of the interrupt sources. It tests both for the ability to set the interrupt through the hardware and the ability to reset the interrupt through the microcode.
- Data tests of various bit combinations that isolate problems between the 5110 and the customer provided modem/communications facility. The test uses a manually attached wrap connector to further isolate problems to the defective FRU in the 5110.

The diagnostic routines are used in MDI 820.

Routine Number	Description	Returned Information Status	Data	Meaning

Routines COM00 through COM25 test the asynchronous communications feature. Neither the data set nor the wrap connector needs to be attached for routines COM00 through COM05.

COM00	Resets the asynchronous communications/ Serial I/O card.	–	–	
COM01	Returns asynchronous communications status.	XX	–	One byte of sense status.
COM02	Tests for timer interrupt in transmit mode.	96	–	Good test.
COM03	Tests 134.5 bps timer interrupt[1] rate.	96	0733 through 0748	Good test.
		00	2000	No interrupt occurred for 20 milliseconds.
COM04	Tests 300 bps timer interrupt[1] rate.	96	0327 through 0334	Good test.
		00	2000	No interrupt occurred for 20 milliseconds.
COM05	Tests 110 bps timer interrupt[1] rate.	96	0897 through 0921	Good test.
		00	2000	No interrupt occurred for 20 milliseconds.

The asynchronous communications wrap connector must be attached for routines COM06 through COM19.

COM06	Tests for long space interrupt when long space received with terminal ready set.	EF	6326 through 6366	Good test.
		00	9999	No interrupt occurred for 250 milliseconds.
COM07	Tests for inactive long space interrupt when continuous mark received with terminal ready set.	00	–	Good test.
COM08	Tests for inactive long space interrupt when short space received with terminal ready set.	00	–	Good test.
COM09	Tests that long space interrupt reset command resets the interrupt level and long space interrupt status.	96	–	Good test.

[1] Interrupt frequency is in milliseconds with a decimal implied between the second and third digits from the right.

Routine Number	Description	Returned Information Status	Data	Meaning
COM10	Tests that the asynchronous communications feature reset command resets the interrupt level and long space interrupt status.	96	–	Good test.
COM11	Tests that alternating bit patterns can be transmitted and wrapped back correctly.	–	10 bytes of AA	Good test.
			10 bytes of E1	Long space interrupt detected.
			10 bytes of E2	Interrupts too frequent.
			10 bytes of E3	No interrupt occurred.
COM12	Tests that all 0's pattern can be transmitted and wrapped back correctly.	–	10 bytes of 00	Good test.
			10 bytes of E1	Long space interrupt detected.
			10 bytes of E2	Interrupts too frequent.
			10 bytes of E3	No interrupt occurred.
COM13	Tests that all 1's pattern can be transmitted and wrapped back correctly.	–	10 bytes of FF	Good test.
			10 bytes of E1	Long space interrupt detected.
			10 bytes of E2	Interrupts too frequent.
			10 bytes of E3	No interrupt occurred.
COM14	Tests for timer interrupt when start bit received while in receive mode.	97	–	Good test.
COM15	Tests for inactive timer interrupt when no start bit received while in receive mode.	00	–	Good test.
COM16	Tests that dropping out of receive mode after a start bit is received prevents a timer interrupt.	00	–	Good test.
COM17	Tests for an inactive timer interrupt when a short start bit is received while in receive mode with the start bit check enabled.	00	–	Good test.
COM18	Tests that a receive data bit can be set and that the adapter reset command resets it.		–	Good test.
		96	–	Good test.
		03	–	Bit cannot be set.
COM19	Tests that data set ready and clear to send status bits can be set.		–	Good test.
		F6	–	Good test.

The data set must be attached for routines COM20 through COM25. These routines test the communications network. The status is displayed on the bottom line. COM20 through COM25 and EIA01 routines are used in MDI 895 only.

Routine Number	Description	Meaning
COM20	Transmits solid mark.	
COM21	Transmits solid space.	Causes line to disconnect if either the transmitting or the receiving data set is strapped for a long space disconnect.
COM22	Transmits 300 bps alternating bit pattern.	
COM23	Transmits 134.5 bps alternating bit pattern.	
COM24	Receives and analyzes 134.5 bps alternating bit pattern.	Results of the analysis are displayed in a graph with a 4-digit decimal number computed to two decimal places.
COM25	Receives and analyzes 300 bps alternating bit pattern.	Results of the analysis are displayed in a graph with a 4-digit decimal number computed to two decimal places.
EIA01	Activates 'data terminal ready', 'transmit data', and 'request to send' lines for measuring the voltage levels.	Turn the power off and remove the machine cover to allow installation of a jumper during the test.

Routine Number	Description	Returned Information Status	Data	Meaning
Routines SIO01 through SIO15 test the Serial I/O Adapter feature. Neither the I/O device nor the wrap connector needs to be attached for routines SIO01 through SIO06.				
SIO01	Returns Serial I/O Adapter status.	XX	–	One byte of sense status.
SIO02	Tests for timer interrupt in transmit mode.	96	–	Good test.
SIO03	Tests FFFF timer interrupt[1] rate constant.	96	8650 through 8680	Good test.
		00	9999	No interrupt occurred within 100 milliseconds.
SIO04	Tests AAAA timer interrupt[1] rate constant.	96	5761 through 5791	Good test.

[1] Interrupt frequency is in milliseconds with a decimal implied between the second and third digits from the right.

Routine Number	Description	Returned Information Status	Data (hex)	Meaning
SIO05	Tests 5555 timer interrupt[1] rate constant.	96	2872 through 2902	Good test.
		00	9999	No interrupt occurred within 100 milliseconds.
SIO06	Tests 004F timer interrupt[1] rate constant.	96	0009	Good test.
		00	9999	No interrupt occurred within 100 milliseconds.

The Serial I/O Adapter feature wrap connector must be attached for routines SIO07 through SIO14.

Routine Number	Description	Status	Data (hex)	Meaning
SIO07	Tests that data set ready and clear to send status bits can be set.	F6	–	Good test.
SIO08	Tests that alternating bit patterns can be transmitted and wrapped back correctly.	–	10 bytes of AA	Good test.
			10 bytes of E1	Long space interrupt detected.
			10 bytes of E2	Interrupts too frequent.
			10 bytes of E3	No interrupt occurred within 100 ms.
SIO09	Tests that all 0's pattern can be transmitted and wrapped back correctly.	–	10 bytes of 00	Good test.
			10 bytes of E1	Long space interrupt detected.
			10 bytes of E2	Interrupts too frequent.
			10 bytes of E3	No interrupt occurred within 100 ms.
SIO10	Tests that all 1's pattern can be transmitted and wrapped back correctly.	–	10 bytes of FF	Good test.
			10 bytes of E1	Long space interrupt detected.
			10 bytes of E2	Interrupts too frequent.
			10 bytes of E3	No interrupt occurred within 100 ms.
SIO11	Tests for timer interrupt when start bit received while in receive mode.	97	–	Good test.
SIO12	Tests for inactive timer interrupt when no start bit received while in receive mode.	00	–	Good test.
SIO13	Tests that dropping out of receive mode after a start bit is received prevents a timer interrupt.	00	–	Good test.

[1] Interrupt frequency is in milliseconds with a decimal implied between the second and third digits from the right.

Diagnostic Aids

Routine Number	Description	Returned Information Status	Data (hex)	Meaning
SIO14	Tests for an inactive timer interrupt when a short start bit is received while in receive mode with the start bit check enabled.	00	–	Good test.

The Serial I/O Adapter feature wrap connector should not be attached for routine SIO15. Probe pin 8 on the serial I/O connector.

Routine Number	Description	Returned Information Status	Data (hex)	Meaning
SIO15	Tests the '+receive line signal detector' signal line.	–	–	Both CE probe lights should be on.

BSC DIAGNOSTIC ROUTINES

The BSC diagnostic routines are used in MDI 821. This MDI and its use is described in the *IBM 5110 Binary Synchronous Communications Feature Maintenance Information Manual,* SY31-0558.

Service Aids

ERROR INDICATORS

There are two error indicators on the 5110—the control panel PROCESS CHECK light and messages on the display. The PROCESS CHECK light is activated by parity errors detected in any of several functional units. (See *Control Unit* in Section 3.) When the PROCESS CHECK light is activated, the machine stops immediately with the error latched. This allows you to identify the type of error by means of the logic probe.

Error messages are displayed only when enough of the 5110 internal functions are operating to ensure that the display message is accurate. Error messages appear whenever the customer programs sense an error condition or when the CE diagnostic programs are run and an error occurs. The errors that occur when the diagnostic programs run are coded to provide entry points to the MAPs.

Halt codes are displayed when a failure occurs during the bring up program. When the bring up program is run, a sequence of letters (A through Q) is displayed; each letter indicates the completion of a portion of the bring up program. If a failure occurs during bring up, the last letter of the sequence indicates the failure that occurred. This information is used in the MAPs to determine the cause of the failure.

CE Switches

Three CE switches, run, step, and reverse display, are located inside the 5110 next to the display assembly. Removing the top cover allows access to these switches. The run switch and the reverse display switch are two position toggle switches, and the step switch is a small momentary switch.

Run Switch

The run switch controls the operational state of the 5110. To execute programs, the run switch must be in the RUN position. This is the processing state and the switch must be in this position when the 5110 is returned to the customer.

Moving the switch from the RUN position stops program processing upon completion of the E cycles of the current microinstruction.

To see the effect of the run switch when the 5110 is processing, set the DISPLAY REGISTERS switch to the DISPLAY REGISTERS position. Register 0 of one of the program levels changes rapidly unless the 5110 is halted by a halt microinstruction. Moving the run switch from the RUN position stops register 0 and allows you to read the hex numbers on the display. The 5110 remains stopped until the run switch is returned to the RUN position or until the step switch is pressed.

Step Switch

The step switch has no effect on the operation of the 5110 unless the run switch is moved from the RUN position. When the step switch is pressed, the 5110 executes one microinstruction and then stops. The step switch must be pressed and then released in order to execute each microinstruction. Pressing the step switch moves the number in register 0 of the current program level to the next microinstruction address as each microinstruction is processed.

Reverse Display Switch

The reverse display switch is used by the CE to perform certain MAP procedures. When this switch is active, it causes black characters to be displayed on a white background. This switch must be in the normal (RUN) position for customer operations.

JUMPERS

Machine Check Jumper

This jumper connects pin J2-S07 to J2-S09 on the 5110 A1 board. Removing this jumper allows the controller to continue functioning when an error occurs on the machine check line. Misleading results can be received by running with the jumper removed.

Basic Language Jumper

This jumper connects pin H2-S04 to H2-U08 on the A1 board. The jumper ties the '+APL switch' line to ground.

Katakana Check Jumper

This jumper connects pin H2-S12 to G2-P13 on the A1 board. This jumper is used with the Katakana display card to instruct the microcode to handle the country select keycode properly.

Logic Card Jumpers

See MAP 050 for the jumper locations on the following cards:

- Processor card (J2)
- Display card (G2)
- Feature ROS card (K4)
- Executable ROS card (L2)
- Internal diskette adapter card
- Printer adapter card
- 5114 Diskette Unit adapter card

The BSCA jumpering information is found in the *IBM 5110 Binary Synchronous Communications Feature Maintenance Information Manual,* SY31-0558.

DISPLAY REGISTERS

To display the hex registers and the read/write storage size, the DISPLAY REGISTERS switch must be in the DISPLAY REGISTERS position. This displays the first 512 bytes or 256 halfwords of storage. The first 64 halfwords are the registers.

The 64 registers (halfwords) are divided into 4 levels (0, 1, 2, and 3) consisting of 16 registers each (0-F). The MAPs refer to the registers and levels in an abbreviated manner; for example, R1L2 means register 1, level 2.

The following examples and the illustration show how to locate certain registers within the various levels. Note that the bytes are displayed vertically. Use the numbers in lines 5 and 6 to help you locate the registers in each level.

R0L0	=	hex 1234	2
R1L0	=	hex 5786	3
RFL0	=	hex 0000	4

The remaining level 0 registers contain hex EEEE.

R0L1	=	hex 2345	5
RFL1	=	hex FEDC	7

The remaining level 1 registers contain hex DDDD.

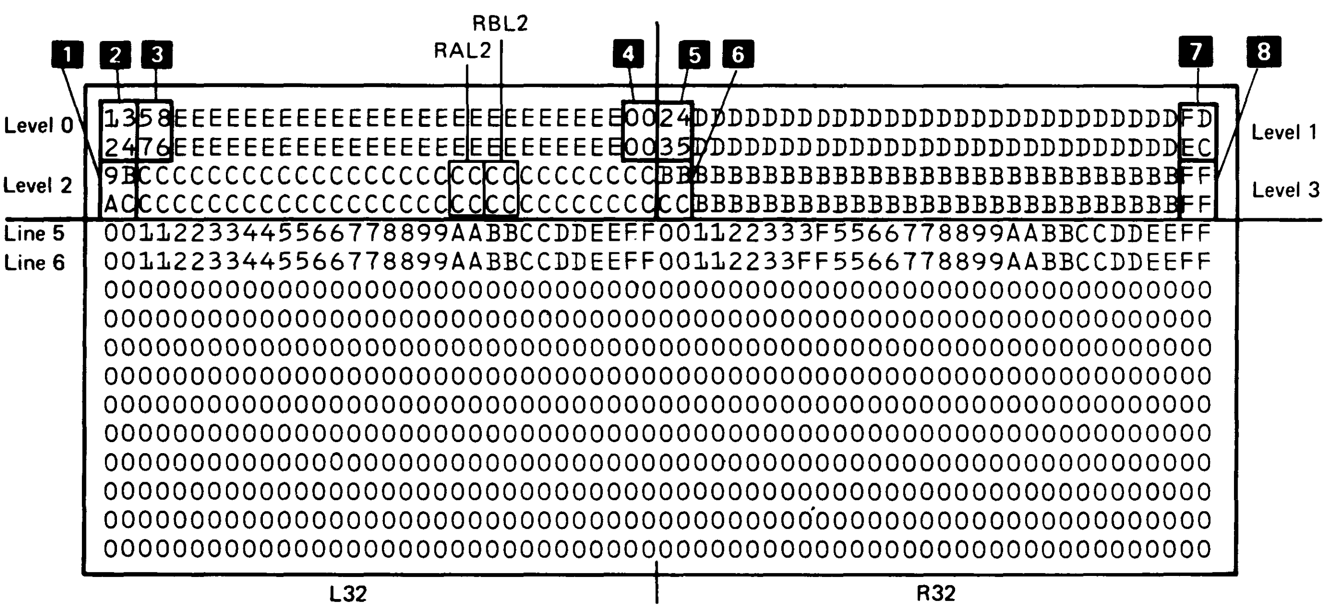
R0L2	=	hex 9ABC	1

The remaining level 2 registers contain hex CCCC.

R0L3	=	hex BCBC	6
RFL3	=	hex FFFF	8

The remaining level 3 registers contain hex BBBB.

Register Level	Use
0	Normal machine operation.
1	Asynchronous Communications.
2	Printer, diskette, and serial I/O
3	Keyboard.



Read/Write Storage Size

In this example, the read/write storage size = hex 3FFF **4**

The address of the last byte of installed read/write storage is stored in read/write storage halfword hex 00AA **3**. Read/write storage size is measured each time the bring up diagnostic is run and the storage size is not valid at hex 00AA until checkpoint I is displayed.

The hexadecimal number read/write storage size indicates the amount of read/write storage installed.

Read/write storage size = hex 3FFF – 16K (M2)
Read/write storage size = hex 7FFF – 32K (M4)
Read/write storage size = hex BFFF – 48K (N2)
Read/write storage size = hex FFFF – 64K (N4)

All other values for read/write storage size are invalid.

Storage location hex 00A8 **7** contains a value that indicates the read/write storage available to the user. If the PATCH program or the Serial I/O microprogram is loaded in read/write storage, the value in hex 00A8 will be substantially smaller than the value in hex 00AA.

```
                                         1     2              7     3     4
                                       0055  0057           00A8  00AA
        0000              0010              0020              0030
      1358EEEEEEEEEEEE EEEEEEEEEEEEEE00 24DDDDDDDDDDDDDD DDDDDDDDDDDDDDFD
      2476EEEEEEEEEEEE EEEEEEEEEEEEEE00 35DDDDDDDDDDDDDD DDDDDDDDDDDDDDEC
0040  9BCCCCCCCCCCCCCC CCCCCCCCCCCCCCCC BBBBBBBBBBBBBBBB BBBBBBBBBBBBBBFF
      ACCCCCCCCCCCCCCC CCCCCCCCCCCCCCCC CBBBBBBBBBBBBBBB BBBBBBBBBBBBBBFF
0080  0011223344556677 8899AABBCCDDEEFF 001122333F3F6677 8899AABBCCDDEEFF
      0011223344556677 8899AABBCCDDEEFF 00112233FFFF6677 8899AABBCCDDEEFF
00C0  0000000000000000 0000000000000000 0000000000000000 0000000000000000
      0000000000000000 0000000000000000 0000000000000000 0000000000000000
0100  0000000000000000 0000000000000000 0000000000000000 0000000000000000
      0000000000000000 0000000000000000 0000000000000000 0000000000000000
0140  0000000000000000 0000000000000000 0000000000000000 0000000000000000
      0000000000000000 0000000000000000 0000000000000000 0000000000000000
0180  0000000000000000 0000000000000000 0000000000000000 0000000000000000
      0000000000000000 0000000000000000 0000000000000000 0000000000000000
      0000000000000000 0000000000000000 0000000000000000 0000000000000000
      0000000000000000 0000000000000000 0000000000000000 0000000000000000
        01C0         L32  01D0              01E0         R32  01F0
                                                00E8  00E9
                                                  5     6
```

1 Printer status byte A
2 Printer status byte B
5 Diskette status byte A
6 Diskette status byte B

Diagnostic Aids

STATUS BYTES

The status bytes and their storage addresses for the various I/O devices follow. If any operation is performed after the error halt has occurred, the information contained in any of these addresses might not be valid. All of the storage addresses used can be viewed by switching to the DISPLAY REGISTERS position.

Printer Status Bytes

Note: The status bytes displayed are not the ones that caused the error halt; they result from a sense command that followed the error condition.

Status Byte A—Storage Address 0055

Bus in bit	0	1	2	3	4	5	6	7	
	1								Print emitter latch 3.
		1							Print emitter latch 2.
			1						Print emitter latch 1.
				1					Wire check or not ready.
					1				Forms emitter B.
						1			Forms emitter A.
							1		Not end of forms.
								1	Left margin signal.

Status Byte B—Storage Address 0057

Bus in bit	0	1	2	3	4	5	6	7	
	1								Print motor latch B (0 = not B).
		1							Print motor latch A (0 = not A).
			1						Print emitter interrupt.
				1					Not ready interrupt.
					1				Forms motor latch B (0 = not B).
						1			Forms motor latch A (0 = not A).
							1		Forms control interrupt.
								1	Timer interrupt.

Diskette Status Byte

Note: These status bytes are available only with error code 35.

Status Byte A—Storage Address 00E8

Bus in bit	0	1	2	3	4	5	6	7	
	1								Write mode.
		1							Read mode.
			1						Diagnostic mode.
				1					Index.
					1				Erase gate.
						1			Diskette 2.
							1		CRC error.
								1	Read/write overrun.

Status Byte B—Storage Address 00E9

Bus in bit	0	1	2	3	4	5	6	7	
	1								New media.
		1							MFM mode.
			1						Filter control.
				1					Current select.
					1				Head engaged.
						1			Head selected (0 = head 0).
							1		Access line.
								1	Access line.

STATUS BYTE BIT DESCRIPTIONS

Printer Status Bytes

Status Byte A

Bit 0—Print Emitter Latch 3: Monitors the printer error conditions and times the print wire firing.

Bit 1—Print Emitter Latch 2: Monitors the printer error condition and times the print wire firing.

Bit 2—Print Emitter Latch 1: Monitors the printer error condition and times the print wire firing.

Bit 3—Wire Check or Not Ready: Signals the adapter that a print wire magnet was energized for more than 1.6 ms when printing or 3.0 ms when not printing.

Bit 4—Forms Emitter B: Determines when to stop.

Bit 5—Forms Emitter A: Forms movement.

Bit 6—Not End of Forms: Indicates the presence of forms. This signal is active when forms are within two inches (50.8 mm) of the print line.

Bit 7—Left Margin: Used as a reference to position the print head.

Status Byte B

Bit 0—Print Motor Latch B (0 = not B): Provides controls for the print head stepper motor.

Bit 1—Print Motor Latch A (0 = not A): Provides controls for the print head stepper motor.

Bit 2—Print Emitter Interrupt: Generates an 'interrupt request 2' when print emitters are activated by the microprogram.

Bit 3—Not Ready Interrupt: Is caused by the printer adapter sensing a not ready condition from the printer.

Bit 4—Forms Motor Latch B (0 = not B): Provides controls for the forms feed stepper motor.

Bit 5—Forms Motor Latch A (0 = not A): Provides controls for the forms feed stepper motor.

Bit 6—Forms Control Interrupt: Generates an 'interrupt request 2' by changing conditions from the forms control emitter.

Bit 7—Timer Interrupt: Indicates that the timer interrupt controls the speed of the print head stepper motor.

Diskette Status Bytes

Status Byte A

Bit 0—Write Mode: Indicates that the write latch is set.

Bit 1—Read Mode: Indicates that the read latch is set.

Bit 2—Diagnostic Mode: Indicates that the diagnostic latch is set.

Bit 3—Index: Indicates that the index hole on the diskette is passing by the index phototransistor.

Bit 4—Erase Gate: Indicates the status of the erase gate from the diskette drive.

Bit 5—Diskette 2: Indicates that a diskette 2 is located in the diskette drive. This line is tested after the index pulse has been checked.

Bit 6—CRC Error: Indicates that the CRC read from the diskette did not agree with the generated CRC.

Bit 7—Read/Write Overrun: Indicates that the processor did not service an interrupt. Detection of an overrun causes the adapter to reset to the access mode.

Status Byte B

Bit 0—New Media: Indicates that the diskette drive cover is open.

Bit 1—MFM Mode: Sets the adapter to the desired recording mode.

1 = MFM
0 = FM

Bit 2—Inner Track Select (filter control): Sets the inner track select (filter control) latch. 1=on (> track 60), 0=off (< track 60). This latch is used with the inner tracks bit to further compensate for bit shifting beyond cylinder 60. The latch is only used during a read operation.

Bit 3—Inner Tracks: Sets the inner tracks latch. 1=on (> track 42), 0=off (< track 42). This bit is used on a write operation to reduce the amount of recording current beyond track 42. On a read operation this bit is used to compensate for bit shifting beyond track 42.

Bit 4—Head Engage: Indicates if the heads are loaded. (1=Lower heads; 0=Raise heads).

Bit 5—Head Selected: Indicates which side of the diskette is being used. (1=side 1; 0=side 0).

Bit 6—Access Lines: Controls the movement of the heads from track to track.

Bit 7—Access Lines: Controls the movement of the heads from track to track.

BINARY SYNCHRONOUS COMMUNICATIONS (BSC) ERROR LOG AND HISTORY TABLE

Errors

Errors are recorded in an error log to assist you in determining the cause of intermittent BSC problems.

See *Diagnostic Aids* section of the *IBM 5110 Binary Synchronous Communications Feature Maintenance Information Manual,* SY31-0558.

Diagnostic Aids

PRINT PLOT FORMS MOVEMENT EXERCISER PROGRAM

The print plot forms movement exercise program is used to check the 5103 Printer for forms movement problems. This program is contained on the print plot/BASIC or the print plot/APL diskette. The printout of the program follows:

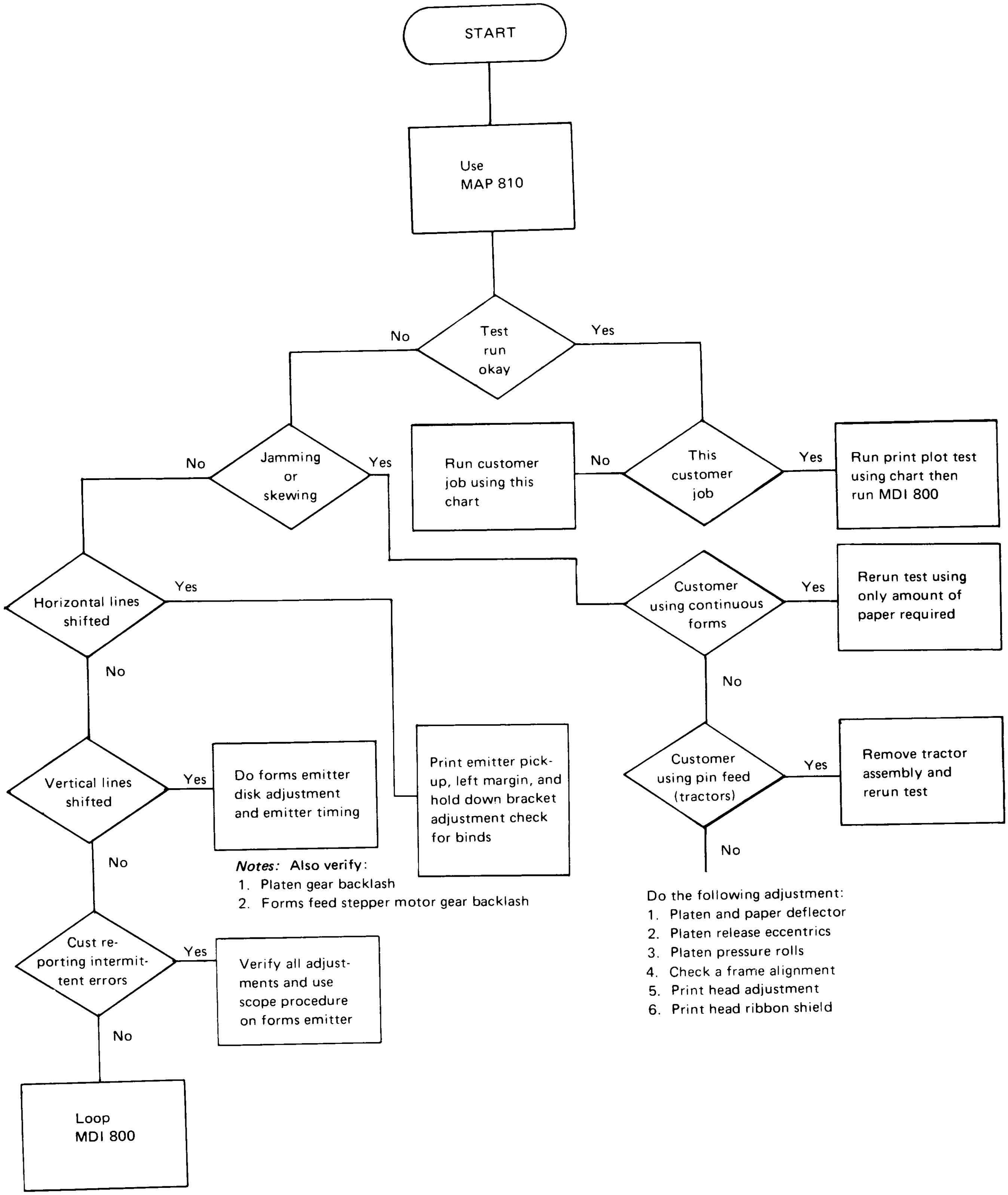
The program plots two sets of parallel horizontal lines. These lines are tolerance lines. The program then alternately plots one dot at a time within each set of tolerance lines. If the forms movement is working correctly, the dots should be plotted within the tolerance lines. After plotting all of the dots, the program then plots the parallel vertical lines. If the forms movement is working correctly, these lines should be the same length as the distance between the top and bottom horizontal lines; the density of the vertical lines should be consistent.

Use the following procedure to run the print plot/BASIC exerciser program:

1. Load the print plot/BASIC forms movement exerciser program. See *Appendix A. Print Plot/BASIC Forms Movement Exerciser Program* of the *IBM 5110 Print Plot/BASIC User's Manual,* SA21-9310 or load the print plot/APL program. See *Appendix A. Print Plot/APL Forms Movement Exerciser Program* of the *IBM 5110 Print Plot/APL User's Manual,* SA21-9305. The file name is PLOTDIAG.

   Watch the results on the 5103 Printer. If the dots are not within the tolerance lines or the vertical lines are not the correct length or density, use the *Print Plot Error Chart* in this section.

Print Plot Error Chart



Diagnostic Aids

Teleprocessing Diagnostic Analyzer Tester

The teleprocessing diagnostic analyzer tester (1200 TDAT) is a branch office tool. The TDAT is capable of substituting for the data set, an under the cover modem, or the data terminal equipment (DTE). The TDAT is useful as a substitute for a data set when the 5110 is used on a leased line. Using the TDAT in this manner allows you to dial another station to test the 5110 when trouble is experienced on the leased line network. For a complete description of the procedures see: *Appendix C, Tools and Test Equipment,* of the *IBM 5110 Binary Synchronous Communications Feature Maintenance Information Manual,* SY31-0558.

Free Lance Troubleshooting Guide

This guide is a summary of the 5120 system diagnostics and a guide for troubleshooting intermittent failures.

HOW TO USE THIS GUIDE

Because this is a guide instead of a MAP, you must make many decisions based on the information available and the frequency of the failure. The OR circles on the *Failure Isolation Chart* indicate that type of situation.

RECOMMENDATIONS ON FAILURE INFORMATION

The following recommendations are given to assist you in obtaining failure information. The order of presentation has no significance.

- Determine the customer error code if possible. An error code is normally more factual than the operator's failure description. The descriptions of the customer error codes are found in the *BASIC Reference Manual,* SA21-9308, Appendix D, and in the *APL Reference Manual,* SA21-9303, *Appendix F.* See *Error Codes* in this section for the hardware error codes descriptions. Use these error code descriptions to aid you in deciding which diagnostics or MDIs to run.

- If the failure appears to be a printer or diskette problem, record the status byte information. This information will help you to isolate the failure and to determine which MDI to run. See *Status Bytes* in this section.

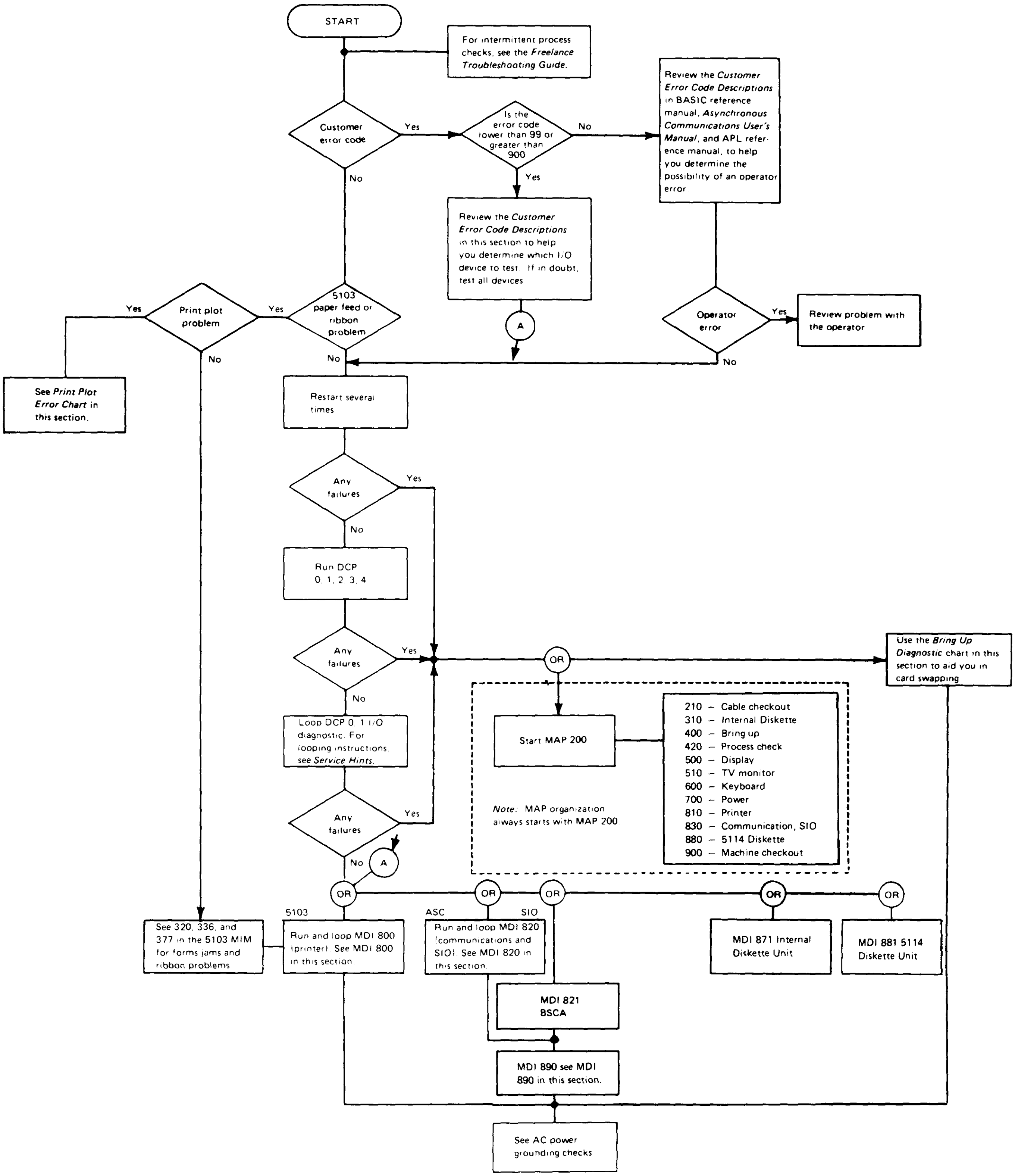
- Have the customer record as much information as possible when the failure occurs.
  - How often does the machine fail?
  - Does the failure occur during one job or during many jobs or programs?
  - Does the failure occur in BASIC, APL, or both?
  - Does the failure occur at a particular time, such as when the machine is first powered up or after it is warmed up?
  - Is the system configuration always the same; are other devices attached when the failure occurs?

- Record any information on the previous items and any information on fixes in the space provided.

- If the failure cannot be fixed by card/FRU replacement, consider replacing board(s).

Diagnostic Aids

Failure Isolation Chart



Intermittent Process Check

Use the following procedure to help you find the cause of intermittent process checks:

1. Do not disconnect the cable from the 5110 I/O interface port and do not press the RESTART switch.

2. With the PROCESS CHECK light on, probe the following pins to determine the cause of the process check:

Error (active level)	Pin	FRU
-RDR	J2S08	G2, J2, L2, M2, M4, N2, N4, A2
-Bus in	J2U09	A2, B2, D2, F2, H2, J2
+DA error base I/O	H2M02	H2, J2
+DA error common and language ROS	F2U13	F2
+DA error display	G2M09	G2
+DA error internal diskette	B1-C1D11	B1-C1
+DA error 5114	A1-C1D11	5114 A1-C1
+DA error 5103	B1-A2P12	5103 B1-A2
+DA error asynchronous communications – serial I/O	D2J13	D2
+DA error BSCA	B2J04	B2
+DA error executable ROS	L2P06	L2
+Bus out error base I/O	H2P07	H2, J2, L2, A2, M2, M4, N2, N4
+Bus out error BSCA	B2J05	B2
+Bus out error asynchronous communications – serial I/O	D2M02	D2, A2, M2, M4, N2, N4
+Bus out error internal diskette	B1-C1D10	B1-C1
+Bus out error common and language ROS	F2U11	F2, A2, M2, M4, N2, N4
+Bus out error display	G2M05	G2, A2, M2, M4, N2, N4
+Bus out error executable ROS	L2P05	L2
+Bus out error 5103	B1-A2P11	5103 B1-A2
+Bus out error 5114	A1-C1D10	5114 A1-C1
+Keyboard parity error	H2U13	H2

3. Reseat all cards and cables.

4. Check voltages.

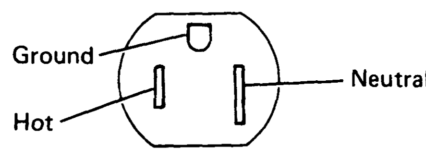
5. Check the customers AC ground.

6. Check the fan(s).

7. Replace the board(s).

AC Power Grounding Checks

To check for proper AC power receptacle grounding, measure the AC voltages at the locations shown in the following figure. This check does not detect a poor quality ground (high resistance to earth).



Front View

If you suspect a line problem you can:

1. Place an isolation transformer between the line and the 5110 computer.

2. Inspect the AC box to be sure the wires do not cross. The line side and load side wires should not cross as this can induce line spikes in the load side wires.

3. Check for a machine or a device in the same room, on the same line, or near by that can induce conductive or inductive noise.

The voltage between neutral and ground should be less than 2 volts AC.

The voltage between neutral and hot should be approximately 110 Vac to 120 Vac. Also, the voltage between ground and hot should be approximately 110 Vac to 120 Vac.

Check that all frame ground connections are clean and tight in all devices on the system. Frame grounding is indicated by either a braided cable or a green and yellow wire.

5110 ground locations:
- Main base plate (left rear)
- Fan bracket to base plate
- Power supply
- Logic box
- Power switch
- AC power box (3)
- Diskette unit motor
- TV monitor plug

5103 ground locations:
- Left front corner
- Right front corner
- AC line cord
- Flat cable shield clamp
- Left rear of forms tractor

5114 ground locations:
- Back panel (yellow/green wire)
- Hinges (2)
- Power supply chassis
- AC capacitor
- Line filter
- Relay chassis
- AC motor, AC connector to ground
- DC power supply AC ground
- Line cord
- Diskette drive motor cable
- Frame to frame ground
- AC switch box, through cable
- Fan bracket (thread forming screw)
- Fan frame through star washer

AC Power Considerations

Checking for proper AC line voltage is a task that you are familiar with. However, other aspects of the AC power source are also very important. The AC line voltage should not vary by more than ± 10% except for 500 ms transients of +15% to −18%.

A type of AC power disturbance becoming more frequent is fractional phase loss. This is a result of phase controlled triacs or SCRs controlling motors, ovens, or other loads. These devices turn on their loads during each phase and deplete the sine wave of energy.

AC Power Terms

Current Carrying Ground: This is the neutral line that is connected to the neutral bus.

Neutral Bus: This bus bar is inside the power panel. The neutral line should be tied to this bus. The neutral bus should be tied to the ground bus only at the main distribution panel.

Main Distribution Panel: This is the first power panel inside of the customer's building. This panel is fed directly from the power company lines. The ground bus in this panel is serviced by the service entrance ground.

Ground Bus: This bus bar is in the power panel. The ground wire for the power source of the 5110 should connect to this bar, along with a wire into the panel from an approved earth ground source.

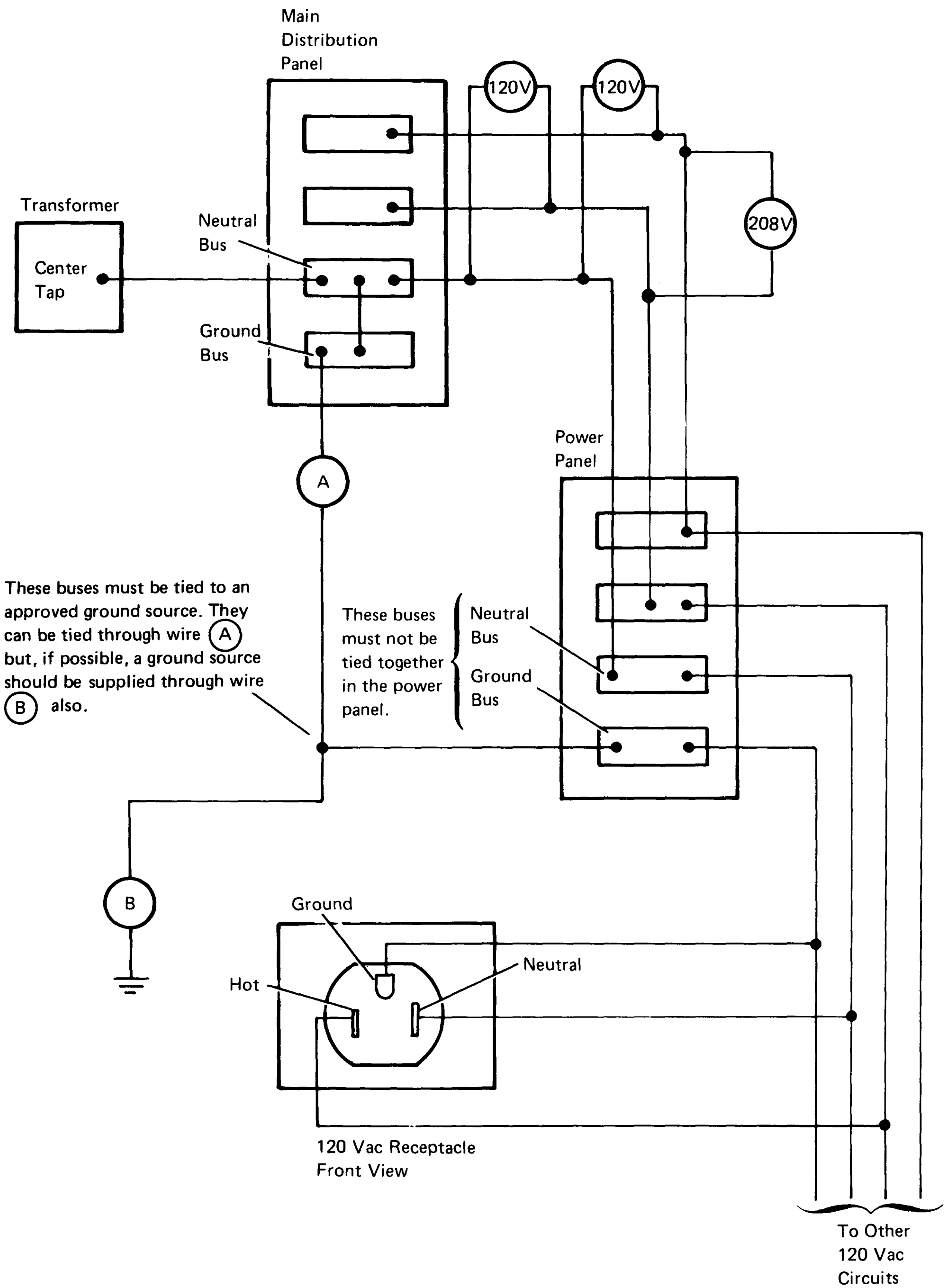
Earth Ground: The definition depends upon local electrical building codes. Usually, an earth ground is supplied in two forms:

1. A metal pipe running into the earth and containing running water. Stagnant water or sump lines are not good earth ground sources. Lines broken by nonmetal connections do not supply a good earth ground.

2. A metal stake driven into the ground. The length of the stake and the depth to which it must be driven into the ground depends on local codes.

Noncurrent Carrying Ground: This is the line from the ground in the receptacle to the ground bus.

AC Power Distribution in a Typical Commercial Building



5120 System Function Test

The system function test consists of three tests that exercise different I/O devices. The tests are:

- System test
- Diskette exerciser
- 5103 Printer exerciser

Note: Tape exerciser test options appear on the screen, but are not used with the 5120 system.

The purpose of the system function test is to exercise the 5110 Computer internal diskette unit, the 5114 Diskette Unit, and the 5103 Printer. Any or all of these devices can be exercised if they are in the ready state.

The system function test should be run during the installation of the system, after feature additions/deletions and installation of ECs, and when you are troubleshooting problems that the MDIs/MAPs cannot find.

When you have identified the failing device, the next step is to select the I/O exerciser for that device and run the test. These tests loop automatically, thus enabling you to probe/scope various control lines while trying to locate the problem.

A typical sequence for finding problems using the 5120 system function test is:

Symptom: A customer reports that the time required to run his programs has doubled, and he does not get any errors while the programs are running.

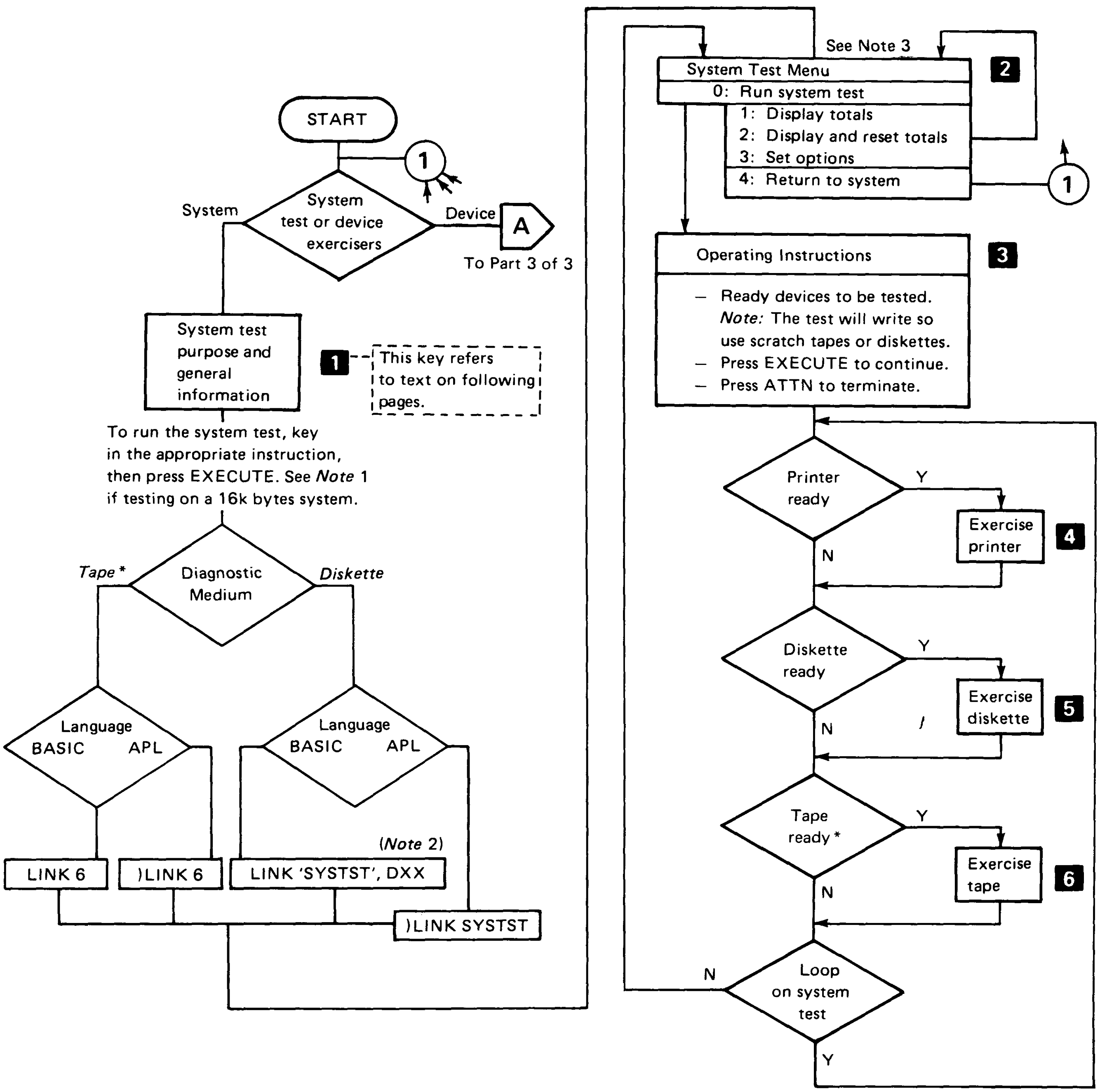
This symptom could indicate that a diskette unit is failing but because of the error retry capabilities of the 5110, the program eventually runs.

Step 1: Run the 5120 system function test and use the loop on system test option. Let the test loop for some time while the 5110 is logging the errors.

Step 2: Use the display totals option to help you identify the device and failing I/O command. Then use the device exerciser test to further isolate the problem.

For example, if the problem occurs during a write operation, use the diskette exerciser in write mode. Do not use the stop-on-error option, and probe/scope the signal lines while referring to the *IBM 5120 System Logic Manual,* SY34-0193.

SYSTEM FUNCTION TEST OVERVIEW
(PART 1 OF 3)



*Tape unit load and test options appear on the screen, but are not used with the 5120 system.

SYSTEM FUNCTION TEST OVERVIEW (PART 2 OF 3)

Notes:

1. The system test or device exercisers cannot be loaded as shown in this flowchart if your 5110 is limited to 16K bytes of read/write storage. To load these tests and exercisers you must first load the DCP I/O function as follows:
   a. Press HOLD and release.
   b. Hold CMD and press – (minus) and then press * or x (multiply).
   c. Press C.
   d. Press 5.
   e. Next, enter the device address of the loading device in the space following DV@ on the display. The following information contains the data and format for loading the system test or device exercisers either from the internal tape unit or from diskette drive 1-4.

      *Internal or 5106 Tape Unit**

      - System test:
        DV@ E80 or E40 (note 2)
        RD A 0B00 F 6
        (EXECUTE)
      - Tape/printer exerciser:
        DV@ E80 or E40 (note 2)
        RD A 0B00 F 11
        (EXECUTE)

      Diskette Drive 1-4

      - System test:
        DV@ DXX (note 2)
        RD A 0B00 F 21
        (EXECUTE)
      - Tape/printer exerciser:
        DV@ DXX (note 2)
        RD A 0B00 F22
        (EXECUTE)
      - Diskette exerciser:
        DV@ DXX (note 2)
        RD A 0B00 F 23
        (EXECUTE)

   f. To run the system function test that was loaded via the DCP I/O function, do the following:
      1. Press ATTN.
      2. Enter BR 0B00.
      3. Press EXECUTE.

2.

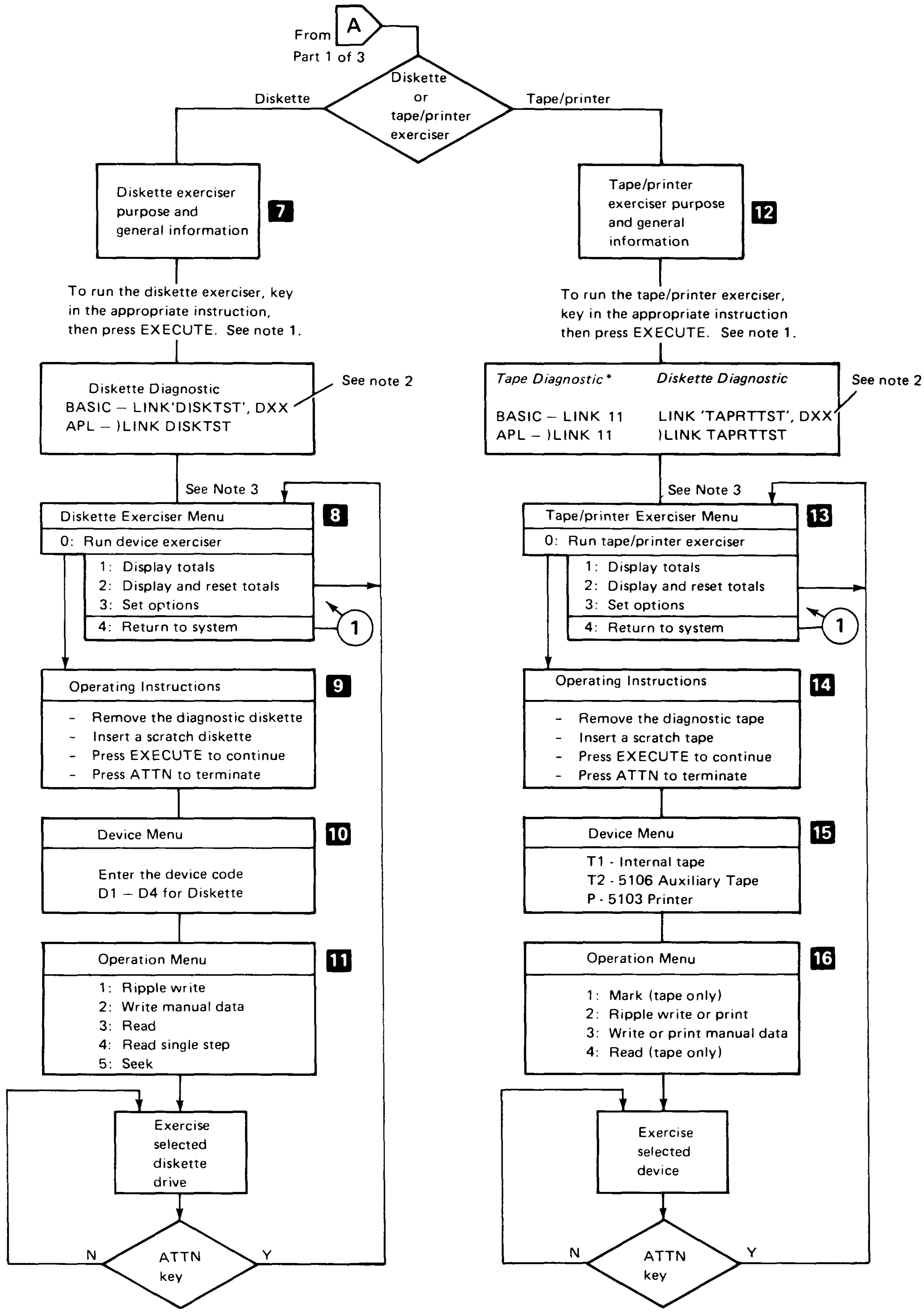
DXX	EXX*
D80 = Diskette drive 1 D40 = Diskette drive 2 D20 = Diskette drive 3 D10 = Diskette drive 4	E80 = Internal tape unit E40 = 5106 auxiliary tape unit

3. Menu description
   0: Pressing 0 (zero) and EXECUTE runs the test with the following options on:
      – Stop on error (Y)
      – Print IOC on error (Y)
      – Loop on system test (N)
      Note: Device exercisers loop automatically.
   1: This menu selection displays a test summary table that contains all I/O operations executed and the errors that occurred.
   2: This selection is identical to 1 above except that the totals are reset when the display changes.
   3: This selection enables the following options to be set:
      – Stop on error (y/n)
      – Print IOC on error (y/n)
      – Loop on system test (y/n)
      Note: Device exercisers loop automatically.
   4: Pressing the 4 key and EXECUTE key returns the 5110 to normal operation.

*Tape unit load and test options appear on the screen, but are not used with the 5120 system.

Diagnostic Aids

SYSTEM FUNCTION TEST OVERVIEW (PART 3 OF 3)



*Tape unit load and test options appear on the screen, but are not used with the 5120 system.

1 SYSTEM TEST

The system test briefly exercises all I/O devices attached to the system that are in a ready state. The test pattern used for each device appears on the top half of the display screen while the test is being executed. This test would normally be run when you are trying to determine which I/O device is causing the problem. Once a problem is detected, an attempt should be made to complete exercising all remaining devices. This will indicate whether the problem affects only one device or is common to all.

2 *System Test Menu:*

0: RUN SYSTEM TEST
1: DISPLAY TOTALS
2: DISPLAY AND RESET TOTALS
3: SET OPTIONS
4: RETURN TO SYSTEM

0: Run System Test

Pressing the 0 (zero) key and the EXECUTE key runs the system test with the following preset options:
- Enable Stop on Error (set to yes)
- Print IOC on Error (set to yes)
- Loop on System Test (set to no)

Note: To alter any of these preset options, press the 3 key (set options) and change the options as indicated.

1: Display Totals

The display totals option indicates the device, subdevice, and command that is causing the problem. Pressing the 1 key and then the EXECUTE key displays the following summary table after the test has been run. The table can occupy more space than can be displayed on one display screen. Press EXECUTE to display the balance of the table.

This table displays the number of times a device/subdevice has been exercised by a given I/O command. The count column displays the number of times the device has been exercised correctly only if there is no error code appearing in that row. If an error code is shown, it describes the type of error that occurred; the count column indicates the number of times that particular error occurred.

For example, device 05 subdevice 00 was exercised correctly eight times by I/O command 02. However, the other three times this same I/O command exercised this device and subdevice it failed one time with a 56 error code and two times with a 72 error code.

Note: See *Error Codes* in this section for definitions of the error codes. The DC (data compare) error can only appear during system test. The data that was read back did not compare with the data that was written and no CRC error occurred. See *I/O Control Information* for definitions of the device, subdevice, and command codes.

DEVICE	SUBDEVICE	COMMAND	ERROR CODE	COUNT
05	00	00	--	3
05	00	02	--	8
05	00	02	56	1
05	00	02	72	2
0D	40	00	--	2
0D	40	01	--	66

Diagnostic Aids

2: Display and Reset Totals

This option is identical to option 1 (display totals) except that all accumulated totals are reset at the end of the display.

3: Set Options

The following options control the system test.

OPTIONS:

ENABLE STOP ON ERROR(Y/N)?

PRINT IOC ON ERROR(Y/N)?

LOOP ON SYSTEM TEST(Y/N)?

Enable Stop on Error (Y/N)?

Setting this option to (Y) halts the program when an error occurs. The error code and failing IOC are displayed (see description of IOCs for further information).

Print IOC on Error

This option prints the failing IOC. See description of IOCs for further information.

Loop on System Test

This option when set to (Y) repeats the system test until the ATTN key is pressed or an error occurs. If the 0 option (run system test) was made at the beginning of the system test menu, this loop function is not active.

4: Return To System

This option enables you to return to system control and either terminate the system function test or select another exerciser within the test.

3 *Operating Instructions:*

– READY DEVICES TO BE TESTED
– PRESS EXECUTE TO CONTINUE
– PRESS ATTENTION TO TERMINATE

4 **System Test Printer Routine**

The printer exerciser prints a five-line rolling pattern that contains all possible characters.

```
ENTER PRINT POSITIONS(1-132),(10/INCH)


                                                                       001
ABCDEFGHI¢.<(+|&JKLMNOPQR!$*);¬-/STUVWXYZ¦,%_>?&^¨Δ±⍞⊢⊣∨`:#@'= ~abcdefghi↑↓≤⌈⌊→⎕
jklmnopqr⊃⊂⊓⍝⍲←¯⍨stuvwxyz∩∪⊥[≥∘α∊⍳ρω⋄×\÷´∇Δ⊤]≠|⍃ABCDEFGHI⍱⍒⌽⍉⍋⍕⊦JKLMNOPQR⌶!⍫⍎⍞⍺\
ΣSTUVWXYZ⍁⍀⍟⊖⌹⍑0123456789|⍒⌿⍟⍎ ABCDEFGHI¢.<(+|&JKLMNOPQR!$*);¬-/STUVWXYZ¦,%_>?&^
¨Δ±⍞⊢⊣∨`:#@'="~abcdefghi↑↓≤⌈⌊→⎕jklmnopqr⊃⊂⊓⍝⍲←¯⍨stuvwxyz∩∪⊥[≥∘α∊⍳ρω⋄×\÷´∇Δ⊤]≠|⍃A
BCDEFGHI⍱⍒⌽⍉⍋⍕⊦JKLMNOPQR⌶!⍫⍎⍞⍺\ΣSTUVWXYZ⍁⍀⍟⊖⌹⍑0123456789|⍒⌿⍟⍎ ABCDEFGHI¢.<(+|&JK
```

5 System Test Diskette Routine

The first part of this routine marks three 3K byte files on cylinders 69, 70, and 71. The routine then writes a ripple pattern a sector at a time until the 3K byte files have been completely written.

The second part of this routine reads the 3K files and compares them byte by byte for proper read/write operation.

This routine sequentially exercises all diskette drives (1–4) that are in the ready state.

6 System Test Tape Routine

The system test tape routines are not used with the 5120 system.

DEVICE EXERCISERS

7 Diskette Exerciser

The diskette exerciser is more flexible than the system test because the exerciser allows you to tailor the program to suit your needs. If a particular command is causing intermittent problems, it can be run continuously while you probe/scope various functions. While the program is running, the correct operation is still being monitored, and all errors that occur are logged with the failing IOC and error code shown.

You can select a read or write command using either head 0 or head 1. You can also select the cylinder to be exercised and the data to be written. The diskette unit can be directed to seek between any two cylinders on the diskette and run continuously.

8 *Diskette Exerciser Menu:*

0: RUN DEVICE EXERCISER
1: DISPLAY TOTALS
2: DISPLAY AND RESET TOTALS
3: SET OPTIONS
4: RETURN TO SYSTEM

0: Run Device Exerciser

Pressing the 0 (zero) key and then the EXECUTE key starts the diskette exerciser with the following options set on:

- Enable stop on error
- Print IOC on errors

Note: The loop function is always on when the device exercisers are used.

Diagnostic Aids

1: Display Totals

The display totals option indicates the device, subdevice, and command that is causing the problem. Pressing the 1 key and then the EXECUTE key displays the following summary table after the test has been run:

DEVICE	SUBDEVICE	COMMAND	ERROR CODE	COUNT
05	00	00	--	3
05	00	02	--	8
05	00	02	56	1
05	00	02	72	2
0D	40	00	--	2
0D	40	01	--	66

This table displays the number of times a device/sub-device has been exercised by a given I/O command. The count column displays the number of times the device has been exercised correctly only if there is no error code appearing in that row. If an error code is shown, it describes the type of error that occurred; the count column indicates the number of times that particular error occurred.

For example, device 05 subdevice 00 was exercised correctly eight times by I/O command 02. However, the other three times this same I/O command exercised this device and subdevice, it failed one time with a 56 error code and two times with a 72 error code.

Note: See *Error Codes* in this section for definitions of the error codes. See *I/O Control Information* for definitions of the device, subdevice, and command codes.

2: Display and Reset Totals

This option is identical to option 1 (display totals) except that all accumulated totals are reset at the end of the display.

3: Set Options

The following options control the device test.

OPTIONS:

ENABLE STOP ON ERROR(Y/N)?

PRINT IOC ON ERROR(Y/N)?

Note: The loop function is always on when the device exercisers are used.

Enable Stop on Error (Y/N)?

Setting this option to (Y) halts the program when an error occurs. The error code and failing IOC are displayed (see description of IOCs for further information).

Print IOC on Error

This option prints the failing IOC. See description of IOCs for further information.

4: Return To System

This option enables you to return to system control and either terminate the system function test or select another exerciser within the test.

9 *Operation Instructions:*

After entering the selected options and pressing EXECUTE key, the next display shows the operating instructions for the diskette exerciser.

1. REMOVE DIAGNOSTIC DISKETTE
2. INSERT SCRATCH DISKETTE
3. PRESS ATTENTION TO TERMINATE

10 *Device Menu:*

Enter the corresponding device code of D1 – D4 for the diskette drive to be exercised. Only one unit can be exercised at a time.

ENTER DEVICE CODE
D1-D4 FOR DISKETTE

11 *Operation Menu:*

1: RIPPLE WRITE
2: WRITE MANUAL DATA
3: READ
4: READ SINGLE STEP
5: SEEK

1: Ripple Write

This routine writes a ripple pattern on each sector of the cylinder and head specified. The routine continues under control of the stop-on-error options.

2: Write Manual Data

This routine is the same as routine 1 except that manual data, up to 128 bytes, can be entered and will be written on each sector of the cylinder head specified. This pattern will be repeated as needed to fill the sector.

3: Read

This routine reads the data written on each sector of the cylinder and head specified. The system continues reading until the ATTN key is pressed or an error occurs.

4: Read Single Step

This routine is the same as routine 3 except that the program stops at the end of each sector. Pressing the EXECUTE key increments the sector location by one until all sectors have been read for that head. The program starts reading head 0, regardless of which head is selected. Normal progression of the program is head 0, cylinder 0, sector 1; head 0, cylinder 0, sector 2; etc until all sectors have been read for that track. Then the program switches to head 1, cylinder 0, sector 1.

5: Seek

This routine seeks continuously between any two cylinders specified on the diskette. The first display is given to input the *seek from* cylinder. The second display enables the input of the *seek to* cylinder. The device now seeks between these two addresses until the ATTN key is pressed or a seek error occurs.

12 **Print Exerciser**

The print exerciser is used to exercise the 5103 Printer. Any I/O command will be looped continuously utilizing any data pattern desired. The program is under control of the options set in the print exerciser menu, and all errors will be logged with the failing IOC and error code. This exerciser is usually run while you are checking out a unit or troubleshooting an intermittent problem.

13 *Print Exerciser Menu:*

0: RUN EXERCISER
1: DISPLAY TOTALS
2: DISPLAY & RESET TOTALS
3: SET OPTIONS
4: RETURN TO SYSTEM

0: Run Device Exerciser

Pressing the 0 (zero) key and the EXECUTE key starts the printer exerciser with the following options set to on:

- Enable stop on error
- Print IOC on error

Note: The loop function is always on when the device exercisers are used.

1: Display Totals

The display totals option indicates the device, subdevice, and command that is causing the problem. Pressing the 1 key and then the EXECUTE key displays the following summary table after the test has been run.

DEVICE	SUBDEVICE	COMMAND	ERROR CODE	COUNT
05	00	00	--	3
05	00	02	--	8
05	00	02	56	1
05	00	02	72	2
0D	40	00	--	2
0D	40	01	--	66

This table displays the number of times a device/subdevice has been exercised by a given I/O command. The count column displays the number of times the device has been exercised correctly only if there is no error code appearing in that row. If an error code is shown, it describes the type of error that occurred; the count column indicates the number of times that particular error occurred.

For example, device 05 subdevice 00 was exercised correctly eight times by I/O command 02. However, the other three times this same I/O command exercised this device and subdevice it failed one time with a 56 error code and two times with a 72 error code.

Note: See *Error Codes* in this section for definitions of the error codes. See *I/O Control Information* for definitions of the device, subdevice, and command codes.

2: Display and Reset Totals

This option is identical to option 1 (display totals) except that all accumulated totals are reset at the end of the display.

3: Set Options

The following options control the device test.

OPTIONS:

ENABLE STOP ON ERROR(Y/N)?

PRINT IOC ON ERROR(Y/N)?

Note: The loop function is always set to on when the device exercisers are running.

4: Return To System

This option enables you to return to system control and either terminate the system function test or select another exerciser within the test.

14 *Operating Instructions:*

- PRESS EXECUTE TO CONTINUE
- PRESS ATTENTION TO TERMINATE

15 *Device Menu:*

T1 – Internal tape
T2 – 5106 Auxiliary Tape } Tape routines are not used with the 5120 system
P – Printer

Select the proper device code for the unit to be exercised. You can exercise only one unit at a time.

16 *Operation Menu:*

1: MARK (TAPE ONLY)
2: RIPPLE WRITE OR PRINT
3: WRITE OR PRINT MANUAL DATA
4: READ (TAPE ONLY)

1: Mark (tape only)

This option is not used with the 5120 system.

2: Ripple Write or Print

Ripple Write (internal tape or 5106 Auxiliary Tape)

This routine is not used with the 5120 system.

Ripple Print (5103)

This routine will print a continuous ripple pattern as shown while under control of the options set in the test menu.

```
CLEAR WS
      )LINK TAPRTTST
ABCDEFGHI¢.<(+‡&JKLMNOPQR!$*);¬−/STUVWXYZ¦,%_>?&∧¨Δ±⍉⊢⊣∨`:#@'="~abcdefghi↑↓≤⌈⌊→⎕
BCDEFGHI¢.<(+‡&JKLMNOPQR!$*);¬−/STUVWXYZ¦,%_>?&∧¨Δ±⍉⊢⊣∨`:#@'="~abcdefghi↑↓≤⌈⌊→⎕j
CDEFGHI¢.<(+‡&JKLMNOPQR!$*);¬−/STUVWXYZ¦,%_>?&∧¨Δ±⍉⊢⊣∨`:#@'="~abcdefghi↑↓≤⌈⌊→⎕jk
DEFGHI¢.<(+‡&JKLMNOPQR!$*);¬−/STUVWXYZ¦,%_>?&∧¨Δ±⍉⊢⊣∨`:#@'="~abcdefghi↑↓≤⌈⌊→⎕jkl
EFGHI¢.<(+‡&JKLMNOPQR!$*);¬−/STUVWXYZ¦,%_>?&∧¨Δ±⍉⊢⊣∨`:#@'="~abcdefghi↑↓≤⌈⌊→⎕jklm
FGHI¢.<(+‡&JKLMNOPQR!$*);¬−/STUVWXYZ¦,%_>?&∧¨Δ±⍉⊢⊣∨`:#@'="~abcdefghi↑↓≤⌈⌊→⎕jklmn
GHI¢.<(+‡&JKLMNOPQR!$*);¬−/STUVWXYZ¦,%_>?&∧¨Δ±⍉⊢⊣∨`:#@'="~abcdefghi↑↓≤⌈⌊→⎕jklmno
HI¢.<(+‡&JKLMNOPQR!$*);¬−/STUVWXYZ¦,%_>?&∧¨Δ±⍉⊢⊣∨`:#@'="~abcdefghi↑↓≤⌈⌊→⎕jklmnop
I¢.<(+‡&JKLMNOPQR!$*);¬−/STUVWXYZ¦,%_>?&∧¨Δ±⍉⊢⊣∨`:#@'="~abcdefghi↑↓≤⌈⌊→⎕jklmnopq
¢.<(+‡&JKLMNOPQR!$*);¬−/STUVWXYZ¦,%_>?&∧¨Δ±⍉⊢⊣∨`:#@'="~abcdefghi↑↓≤⌈⌊→⎕jklmnopqr
.<(+‡&JKLMNOPQR!$*);¬−/STUVWXYZ¦,%_>?&∧¨Δ±⍉⊢⊣∨`:#@'="~abcdefghi↑↓≤⌈⌊→⎕jklmnopqr⊃
<(+‡&JKLMNOPQR!$*);¬−/STUVWXYZ¦,%_>?&∧¨Δ±⍉⊢⊣∨`:#@'="~abcdefghi↑↓≤⌈⌊→⎕jklmnopqr⊃⊂
(+‡&JKLMNOPQR!$*);¬−/STUVWXYZ¦,%_>?&∧¨Δ±⍉⊢⊣∨`:#@'="~abcdefghi↑↓≤⌈⌊→⎕jklmnopqr⊃⊂⊓
+‡&JKLMNOPQR!$*);¬−/STUVWXYZ¦,%_>?&∧¨Δ±⍉⊢⊣∨`:#@'="~abcdefghi↑↓≤⌈⌊→⎕jklmnopqr⊃⊂⊓○
‡&JKLMNOPQR!$*);¬−/STUVWXYZ¦,%_>?&∧¨Δ±⍉⊢⊣∨`:#@'="~abcdefghi↑↓≤⌈⌊→⎕jklmnopqr⊃⊂⊓○⍀
&JKLMNOPQR!$*);¬−/STUVWXYZ¦,%_>?&∧¨Δ±⍉⊢⊣∨`:#@'="~abcdefghi↑↓≤⌈⌊→⎕jklmnopqr⊃⊂⊓○⍀←
JKLMNOPQR!$*);¬−/STUVWXYZ¦,%_>?&∧¨Δ±⍉⊢⊣∨`:#@'="~abcdefghi↑↓≤⌈⌊→⎕jklmnopqr⊃⊂⊓○⍀←¯
KLMNOPQR!$*);¬−/STUVWXYZ¦,%_>?&∧¨Δ±⍉⊢⊣∨`:#@'="~abcdefghi↑↓≤⌈⌊→⎕jklmnopqr⊃⊂⊓○⍀←¯≁
LMNOPQR!$*);¬−/STUVWXYZ¦,%_>?&∧¨Δ±⍉⊢⊣∨`:#@'="~abcdefghi↑↓≤⌈⌊→⎕jklmnopqr⊃⊂⊓○⍀←¯≁s
MNOPQR!$*);¬−/STUVWXYZ¦,%_>?&∧¨Δ±⍉⊢⊣∨`:#@'="~abcdefghi↑↓≤⌈⌊→⎕jklmnopqr⊃⊂⊓○⍀←¯≁st
NOPQR!$*);¬−/STUVWXYZ¦,%_>?&∧¨Δ±⍉⊢⊣∨`:#@'="~abcdefghi↑↓≤⌈⌊→⎕jklmnopqr⊃⊂⊓○⍀←¯≁stu
OPQR!$*);¬−/STUVWXYZ¦,%_>?&∧¨Δ±⍉⊢⊣∨`:#@'="~abcdefghi↑↓≤⌈⌊→⎕jklmnopqr⊃⊂⊓○⍀←¯≁stuv
PQR!$*);¬−/STUVWXYZ¦,%_>?&∧¨Δ±⍉⊢⊣∨`:#@'="~abcdefghi↑↓≤⌈⌊→⎕jklmnopqr⊃⊂⊓○⍀←¯≁stuvw
QR!$*);¬−/STUVWXYZ¦,%_>?&∧¨Δ±⍉⊢⊣∨`:#@'="~abcdefghi↑↓≤⌈⌊→⎕jklmnopqr⊃⊂⊓○⍀←¯≁stuvwx
R!$*);¬−/STUVWXYZ¦,%_>?&∧¨Δ±⍉⊢⊣∨`:#@'="~abcdefghi↑↓≤⌈⌊→⎕jklmnopqr⊃⊂⊓○⍀←¯≁stuvwxy
!$*);¬−/STUVWXYZ¦,%_>?&∧¨Δ±⍉⊢⊣∨`:#@'="~abcdefghi↑↓≤⌈⌊→⎕jklmnopqr⊃⊂⊓○⍀←¯≁stuvwxyz
$*);¬−/STUVWXYZ¦,%_>?&∧¨Δ±⍉⊢⊣∨`:#@'="~abcdefghi↑↓≤⌈⌊→⎕jklmnopqr⊃⊂⊓○⍀←¯≁stuvwxyz∩
*);¬−/STUVWXYZ¦,%_>?&∧¨Δ±⍉⊢⊣∨`:#@'="~abcdefghi↑↓≤⌈⌊→⎕jklmnopqr⊃⊂⊓○⍀←¯≁stuvwxyz∩∪
);¬−/STUVWXYZ¦,%_>?&∧¨Δ±⍉⊢⊣∨`:#@'="~abcdefghi↑↓≤⌈⌊→⎕jklmnopqr⊃⊂⊓○⍀←¯≁stuvwxyz∩∪⊥
```

3: Print or Write Manual Data

Print Manual Data (5103 Printer)

This test provides you with a 128-character print field that can be filled or partially filled with any keyboard character you wish to be printed. If only 10 characters are filled into the print field, only 10 characters will be printed.

Write Manual Data (internal tape or 5106 Auxiliary Tape)

This routine is not used with the 5120 system.

4: Read (tape only)

This test is not used with the 5120 system.

I/O Control Information (IOC)

The IOC information is prepared by the language microprogram when a statement that requires an I/O operation is executed. The IOC identifies the device to be used, the function to be performed, and the address and the length of the data buffer, as well as other information required by the microprogram routines.

The following is an example of the IOC information as it is printed when you select the print-IOC-on-error option in the system function test. The example shows the error code, the device and subdevice addresses, the I/O command, and the control information at the time that the error occurred. The remaining IOC bytes do not contain any useful information for the system function test.

```
ERR/DEV SUB/I/O CMD/CTL
72     0500     02       0001 00020000009000100000F7F2000048240000
```


Device Address

Address in Hexadecimal	Device
05	Printer
0D	Diskette unit

Subdevice Address

Address in Hexadecimal	Subdevice	
80	Diskette drive 1	Internal diskette units
40	Diskette drive 2	
20	Diskette drive 3	5114 diskette units
10	Diskette drive 4	

I/O Command

Code in Hexadecimal	Diskette	Printer
00	Sense	Sense
01	Read	
02	Write	Write (output to printer)
03	Write Last	Same as Write
04	Find	
05	Mark	
08	Forward Space	
0B	Write Header	
0C	Scan	
0D		Plot Function
10	Find ID (diagnostic only)	
11	Initialize Head (diagnostic only)	

Invalid I/O command will cause command errors.

Error Codes

The CE diagnostic error codes are 800 through 999. See *Diagnostic Program Routines* in this section for the diagnostic error codes and their meanings.

The error codes in the following list are hardware related only. The BASIC or APL language error codes are in the APL or BASIC reference manuals.

The display format for the hardware error codes is ERROR xxx yzz and is displayed on the bottom line of the display. The xxx represents the error code, y represents the failing device, and zz representa the subdevice address.

The subdevice address allows the 5110 to distinguish between I/O devices using the same device address, as in the case of the diskette drives 1-4.

The subdevice address can be one of many addresses depending on the number and type of subdevices attached.

ERROR CODES AND DEVICE ADDRESS SUMMARY

Device	Language	Error Code XXX	Device Address Y	Subdevice Address ZZ
Printer	APL/BASIC	050-059	5	00
Print/Plot	APL	BPXXX	0	51
Print/Plot	BASIC	BPXXX	C	01
Async comm/BSC	APL/BASIC	081-099	8	00
Serial I/O	BASIC	002-014	A	02-40
Serial I/O	APL	002-014	0	30-34
Diskette	BASIC	001-045	D	80—Drive 1 40—Drive 2 20—Drive 3 10—Drive 4
Diskette	APL	001-045	0	11—Drive 1 12—Drive 2 13—Drive 3 14—Drive 4
BSC	BASIC	002-014, 080-099	6	80 Data file 40 Data file 08 Command file 04 Command file
BSC	APL	002-014, 080-099	6	1 Data file 2 Data file 5 Command file 6 Command file

DISKETTE ERROR CODES

Device	Error xxx	Device Address y	Subdevice Address zz	Description
Diskette	001	D	zz	Diskette Timing Error—This error occurs when a sense command follows the detection of a diskette in the diskette drive. The index pulse must be 166.7 ± 4.2 ms to be within specifications. The diskette timing is rechecked if time-out errors occur when a diskette is being read or written.
	002	D	zz	Command Reject—This error occurs when: • The diskette code receives an IOCB without the proper device address. • The diskette code receives an IOCB with an invalid command. • The diskette code receives an IOCB with a subdevice address of hex 08, hex 04, hex 02, or hex 01, and the initial selection sequence is successful. • A mark command is given and one of the following conditions existed: – The number of files to mark is set to zero. – The beginning file plus the number of files to mark exceeds the maximum number of labels for the diskette mounted. – The beginning file number (determined by the prior find command) is equal to zero. • A write header command is given with an EOD greater than 1 plus EOE or with an EOD that is different than the EOE set up on the find command for that file. • A physical read or write operation is given with an invalid cylinder or sector number. • A relative read or write command is given with a buffer size of zero.
	009	D	zz	End of Data—EOD is returned on read operations if the relative physical sequence number in the control field is between the EOD and the EOE numbers inclusive for the opened file.
	010	D	zz	End of File—EOF is returned on read operations if the relative physical sequence number is greater than the EOF for the file. EOF is also returned if the relative physical sequence number is greater than the current EOD for the file.

Device	Error xxx	Error Code: Device Address y	Subdevice Address zz	Description
Diskette (continued)	013	D	zz	5114 Diskette Unit Not Present—Response was hex FF. The 5114 IPO switch can be in the down (off) position.
	014	D	zz	Subdevice Select Failure—The subdevice selection was unsuccessful because the response to the microinstruction did not fit the subdevice address that was sent.
	015	D	zz	CRC Error When Reading or Writing a System Sector—This error occurs: • On a mark command when a header cannot be written and verified or logically deleted and verified. • On a write header command when a header cannot be successfully read. • On a sense command when the volume label cannot be successfully read. • On a find or mark command when a header cannot be read.
	016	D	zz	CRC Error on Matched ID—An ID field with cylinder, head, and record numbers equal to the sector being searched was found, but the CRC was incorrect.
	017	D	zz	CRC Error on a Data Read—A data sector was reread ten times; a CRC error occurred each time. A CRC error on any physical read returns this error regardless of the cylinder specified.
	018	D	zz	CRC Error on All IDs of a Track—All IDs of a track were read with a CRC error.
	019	D	zz	CRC Error or Data Miscompare on Data Write—A data miscompare, a CRC error on the read-back-check operation, or a data write causes this error. All CRC errors on physical writes return this error regardless of the cylinder specified.

Device	Error Code			Description
	Error xxx	Device Address y	Subdevice Address zz	
Diskette (continued)	020	D	zz	ID Search Failure—An access to the correct track was successful, but after all of the IDs on that track were read, a match with the one being searched was unsuccessful.
	021	D	zz	Time-Out on ID Read—The adapter failed to detect an address mark in one complete revolution of the disk, or a time-out occurred when counting down the gap between the ID field and the data field on a read or write operation.
	022	D	zz	Time-Out on Data Read Operation—A read operation exceeded its allotted time.
	023	D	zz	Time-Out on Data Write Operation—A write operation exceeded its allotted time (no data was found following an ID field).
	024	D	zz	No Volume 1 Label on the Diskette—The sector located at cylinder 0, head 0, sector 7 was read as a result of a sense command but: • The first four bytes did not contain volume 1. • The sector was marked as a control record.
	025	D	zz	Invalid Media (improper volume 1 parameters)—One of the following conditions was encountered while the volume 1 label was being verified: • The volume surface indicator indicated a diskette 1, and the diskette sense bit indicated a diskette 2 or diskette 2D. • The volume surface indicator was not a diskette 1 (hex 40), diskette 2 (hex F2), or diskette 2D (hex D4). • The volume surface indicator indicated a diskette 2D, but the record length indicator was a space (hex 40). • The record length indicator was not a space (hex 40), 1 (hex F1), 2 (hex F2), or 3 (hex 2).

Diagnostic Aids

Device	Error xxx	Error Code: Device Address y	Subdevice Address zz	Description
Diskette (continued)	025	D	zz	• The extent arrangement volume 1 (72) was not blank. • The special requirements indicator volume 1 (73) was not blank. • The label standard version volume 1 (79) was not a W. • The volume surface indicator indicated a diskette 1 or a diskette 2, but the record length indicator was hex F3. • The extended label area on a diskette 2D was not a space (hex 40), and the value was not between 1 (hex F1) and 9 (hex F9).
	026	D	zz	Head Select Failure—An attempt was made to read an ID from one side of a diskette, but the head number from the ID field of the diskette indicated that the other side was selected.
	027	D	zz	Access Failure—The head was repositioned ten times without the correct cylinder being found. This can also occur when the head is initialized to cylinder zero and when the access lines do not initialize to B'1100'.
	028	D	zz	Attempt to Select the Nonencoded Side of Diskette 1—A physical read or write operation was requested with a head number of 1, and a diskette 1 was loaded.
	029	D	zz	Key Search Failure—When the scan command was executed, the first sector read was greater than the search argument.
	030	D	zz	New Diskette on Command Other than Sense—The diskette drive cover was opened after the last command was issued to the diskette drive. This could mean that a new diskette was inserted, and a sense command must be issued to verify the volume label before any other kind of operation can be allowed.
	031	D	zz	Failure to Write a Surface Defect Control RCD—A write command was issued to the disk unit with sequential relocate valid. When a data sector could not be written and verified, a sequential relocate control record (control flag F) failed to be written in this location. When this occurs, the diskette should be considered defective until a reformatting operation is possible.

Device		Error Code		Description
	Error xxx	Device Address y	Subdevice Address zz	
Diskette (continued)	032	D	zz	Overrun Occurred on Either Read or Write—In either a read ID, read data, or write data operation, the diskette adapter posted an overrun condition. This means that the diskette microprogram did not service a level 2 interrupt fast enough and terminated the operation.
	033	D	zz	Head Engage Failure—The diskette microprogram issued a head engage command, but the diskette sense information indicated that the head did not engage.
	034	D	zz	Erase Gate Failure—Tunnel erase failed to turn on properly during a write operation, or it failed to turn off properly after completing the write operation.
	035	D	zz	Sense Error in Interrupt Routine—A sense error occurred during a read interrupt routine.
	036	D	zz	Invalid File Number on a Find—On a find number operation, the file number in the IOCB was zero or greater than the number of files possible for this diskette.
	037	D	zz	Invalid Control Flag—This can occur on: • A find or mark command when there is a sequential relocate (control flag F) or alternate sector relocate (control flag) control record written in a header area. • A read command when an alternate sector relocate (control flag) control record is encountered.
	038	D	zz	Invalid Header Parameters—This can occur on a mark command if: • Any header on the diskette has an EOE past cylinder 741. • Any header on the diskette has a BOE greater than the EOE. • Any header on the diskette has nondecimal extents.

Diagnostic Aids

Device	Error Code			Description
	Error xxx	Device Address y	Subdevice Address zz	
Diskette (continued)	038	D	zz	This error can occur on a find command if: • Any of the above conditions is true for the found file. • The first four bytes of the found file do not contain HDR1. • The record length indicator in the header does not match the record length indicator in the volume label. • A diskette 2D is sensed with a diskette 1 or diskette 2 basic exchange type indicator (hex 40). • The EOD field is greater than 1 plus the EOE.
	039	D	zz	Attempted to Delete a Protected Header—This error can occur if the user attempts to remark or delete a file that contain an expiration date or a write protect indicator.
	040	D	zz	Duplicate File Names—Whenever a find-by-name occurs, all nondeleted headers on the diskette are searched and compared against the argument name. If more than one file generates a match, the error is posted.
	041	D	zz	File Not Found—This error is posted on a find-by-number if that header has been logically deleted. On a find-by-name, file not found is posted if no match against the argument name is made on any of the marked files for this diskette.
	042	D	zz	Diskette Full—This error occurs on a mark command when the number of sectors required to mark a file exceeds the number of continuous unallocated sectors available.
	043	D	zz	Access Protect Code On in Volume Label—This error occurs as a result of a sense operation when the volume label is being verified and the access protect indicator (VOL1-10) is found.
	044	D	zz	Control Record Read—This error occurs under the following conditions: • A control record is encountered during a physical read. • A sequential relocate or a logical delete control record is encountered on relative read when the sequential relocate is prohibited.
	045	D	zz	No Index—The diskette was being timed and no index pulse was sensed for 333 msec. Either no diskette was mounted or the diskette was mounted backwards.

5103 PRINTER ERROR CODES

Device	Error Code			Description
	Error xxx	Device Address y	Subdevice Address zz	
5103 Printer	013	5	00	Printer Not Attached—An incorrect device address was specified by the user for the printer, or the returned status on bus in was hex FF.
	047	5	00	Print Position Error—The print head was not in the position indicated by the microprogram.
	048	5	00	Undetermined nonrecoverable error on a sense command.
	049	5	00	Two or more underscores with a delete (program error).
	050	5	00	End of Forms—'+End of forms' line is shown. This was caused by a defective switch and associated circuits, a maladjusted switch, or the absence of forms.
	051	5	00	Printer Not Ready—Printer voltages (+24 Vdc or 10.8 Vdc) were out of tolerance or a wire check occurred with the print head at the left margin.
	052	5	00	Forms Step Time-Out—A forms emitter pulse did not occur within approximately two seconds from the time of the previous forms emitter pulse. This timing does not apply during the forms movement stopping sequence.
	053	5	00	Line length too long (program error).
	054	5	00	Wire check or power off while printer is operating—A print wire driver was on too long. If the print head is in the left margin and '-wire on' line is down, a 051 error occurs. If the print head is not in the left margin and '-wire on' line is down, an 054 error occurs.
	055	5	00	Undefined Interrupt—'-Interrupt request 2' line was down, but none of the three interrupt bits from the printer adapter were on: • Printer emitter interrupt — Status byte B bit 2 • Not ready — Status byte B bit 3 • Timer interrupt — Status byte B bit 7 • Forms interrupt — Status byte B bit 6

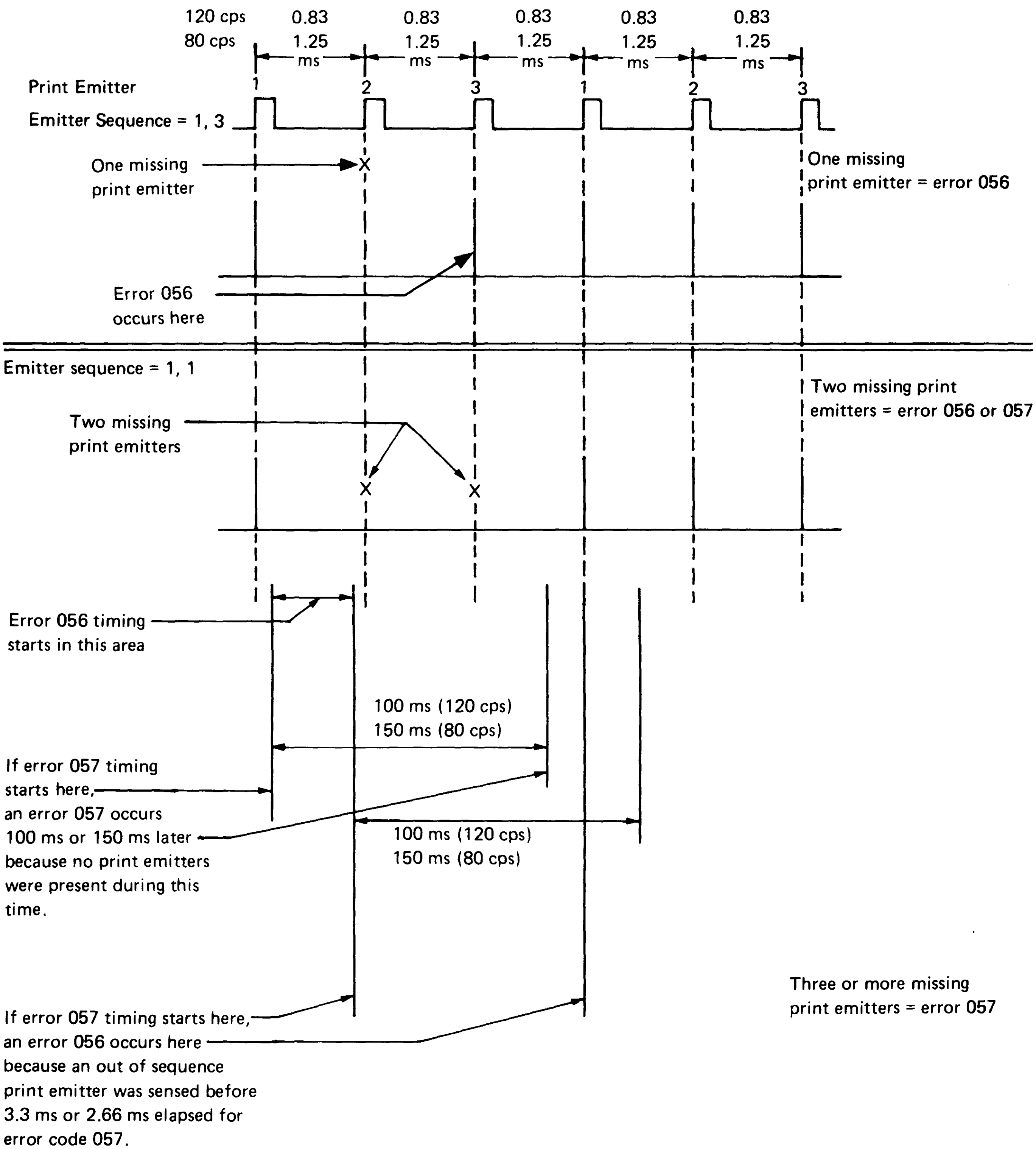
Diagnostic Aids

Device	Error xxx	Error Code: Device Address y	Subdevice Address zz	Description
5103 Printer (continued)	056	5	00	Incorrect Print Emitter Sequence—The current print emitter and previous print emitter were out of sequence. Print emitter sequence when printing is: Right is 1, 2, 3, 1, 2, 3, 1 Left is 3, 2, 1, 3, 2, 1, 3 Light mechanical binds or print emitter failures usually cause a 056 error.
	057	5	00	Missing Print Emitter Pulses—A print emitter pulse was not found during the specified time 150 ms (80 cps) or 100 ms (120 cps). The print head stepper motor begins turning when it receives pulses from the printer adapter. Error checking begins when the print head stepper motor is up to speed. If a print emitter pulse does not occur during the 100 ms or 150 ms timing, a 057 error occurs. If a print emitter pulse does not occur but is not the expected pulse, a 056 occurs. (See *Print Emitter Error Timing* following these error codes.) Failures that prevent the carrier from moving such as a broken belt can cause a 057 error.
	058	5	00	Timer Interrupt Time-Out—Defective 1.1 ms or 2.66 ms (120 cps) timer, or 1.1 ms or 3.3 ms (80 cps) timer. Timer accuracy is checked by running the printer diagnostic program (MDI 800).
	059	5	00	Overspeed Error—Five or six print emitters occurred during one print head stepper motor step. The normal number of print emitters is 2 to 4 per motor step.
	070	5	00	System error—Level 2 busy and the microcode timer timed out. • IOB status required use of level 2. • Level 2 busy flag is on in the IOB flags (HOLD will reset level 2 busy flags).

Device		Error Code		Description
	Error xxx	Device Address y	Subdevice Address zz	
5103 Printer (continued)	071	5	00	This error code is posted on a sense command after a 070 error is posted. Error code 071 indicates the printer is clear and the sense command indicates ramp is satisfactory.
	072	5	00	An error was posted in a previous print operation, but no Sense command was issued prior to the current printer operation to clear the error. Probable cause–Operator was changing the paper when the system was trying to use the printer. The hold key was not pressed before the printer was made inoperative.

Note: Error code 06X is reserved for the print plot function.

Print Emitter Error Timing (Nominal Timings)



SERIAL I/O ERROR CODES

The display format for serial I/O error codes is:

ERROR xxx yyy

where xxx is the error code and yyy is the device address of the failing device.

Device	Error xxx	Device Address yyy	Description
SIO	002	yyy	An invalid command was sent to an I/O device. For example: • A REWIND (BASIC) or)REWIND (APL) command was issued to an I/O device. • An invalid device characteristic was specified to the command device. • The input buffer size was increased after the input device was opened. • An invalid parameter was specified when the command device or the I/O device was opened.
	003	yyy	With the 5110 in modem mode, data terminal ready from the I/O device is off during a transmit operation. With the 5110 in terminal mode, data set ready from the I/O device is off during a transmit operation. These conditions can be caused when: • The I/O device does not conform to the EIA RS232C standard interface. • The serial I/O cable is defective. • The I/O device power is not on. • The I/O device is attached with the wrong cable. With the 5110 in modem mode, request to send (RTS) from the I/O device is dropped during a 5110 receive operation. With the 5110 in terminal mode, clear to send (CTS) from the I/O device is dropped during a 5110 transmit operation. These conditions can be caused when: • The I/O device does not conform to the EIA RS232C standard interface. • The serial I/O cable is defective.

Diagnostic Aids

Device		Error Codes	Description
	Error xxx	**Device Address yyy**	
SIO (continued)	003	yyy	• The I/O device is attached with the wrong cable. • The I/O device power is not on. • The wrong mode (modem, ignore, terminal, or set is specified). • The I/O device hardware fails.
	004	yyy	The I/O device hardware fails.
	010	yyy	The 5110 recognized an end-of-file condition. This condition can be caused when: • Both the CMD key and 0 key are pressed. • With the 5110 in modem mode, data terminal ready from the I/O device is off during a receive operation. • With the 5110 in terminal mode, data set ready from the I/O device is off during a receive operation.
	013	yyy	The Serial I/O Adapter feature hardware was not installed or it is defective. The Serial I/O Adapter program was not loaded in user storage.
	014	yyy	An invalid device address was specified.

Bring-Up Diagnostic Halt Codes

The following chart shows the individual tests within the bring-up diagnostic. It also shows the halt codes, the area tested, and the service aids to use in helping to determine the cause of intermittent failures. (Use MAP 200 to diagnose solid failures during bring up.)

- Use the bring up diagnostic chart as a guide for replacing cards on intermittent problems.
- Reseat all the cards and cables in the 5110.
- Determine if the problem exists with the I/O devices attached to the 5110 I/O interface port. If it does, reseat all the cards and cables in the I/O devices.

Halt Code	Test	Area Tested	Service Aids
Undefinable	Resets control logic with the Power On Switch through a 350 ms single shot on the H2 card or directly with the Restart switch.	A2, B2, C2, D2, F2, H2, J2	Probe—POR on the H2 card while activating bring up.
	Puts FFFF in R7L0. This halt code remains in R7L0 to the end of the bring up diagnostic.	L2, J2	Use the Display Registers switch to check R7L0.
	Tests read/write storage locations 0020 through 05FF.	J2, M2	Use the Display Registers switch to check RFL0. If RFL0 is less than 0080, replace J2.
Blank	Resets the CRT buffer on G2 card to all blanks.	G2	Use the Display Registers switch to check for a blank display. The display screen should be blank in normal mode only.
A	Turns all bus in bits on.	A2*, H2, J2, L2	Probe the 'bus in' lines on the H2 card. All bus in bits should be up or pulsing.
AB	Tests bus out parity.	A2, C2, D2, F2, H2, J2, all I/O	Remove A2, C2, D2, and F2. Reinstall them one at a time. The card that causes AB on Power On should be replaced. If this does not fix the problem, the cause might be H2 or J2.

*Not tested by the bring up diagnostic but can cause bring up halts.

Halt Code	Test	Area Tested	Service Aids
ABC	Tests processor microinstructions.	J2	Probe the 'RDR error' line on the J2 card. Loop on the op code test in DCP if the problem is intermittent.
ABCD	Tests the ability to switch to read/write storage and back to ROS.	H2, J2, L2	None
ABCDE	Activates program interrupt levels 1, 2, and 3.	A2, C2, D2, H2, all I/O	Level 1 – C2 or D2 Level 2 – A2, H2, internal diskettes, 5103, and 5114 Level 3 – H2 or keyboard
ABCDEF[1]	Tests all device addresses.	0 – J2, 1 – F2, 4 – H2, Kybd 5 – 5103, 6 – C2, 8 – D2, D – Internal diskettes, 5114 E – H2	Probe the device address error on the device.
ABCDEFG[1]	Tests the keyboard.	H2	None
ABCDEFGH[1]	Tests the keyboard for stuck flyplates and displays the key symbol and its key code (hex). Also tests all read/write storage locations above 05FF. The read/write storage test writes shifting data, then reads it. Before the test is complete, all read/write storage locations above 05FF are set to 0.	M2, M4, N2, N4, key module (see 250), keyboard PC board, keyboard cable, H2	Loop on the read/write storage test in DCP if the problem is intermittent.
ABCDEFGHJ[1]	Initializes executable ROS.	L2	None
ABCDEFGHJK	Tests the first half of the executable ROS card.	L2	None
ABCDEFGHJKL	Tests the feature ROS card if the K4 card is installed.	K4	Remove the K4 card and press the Restart switch.
ABCDEFGHJKLM	Tests the second half of the executable ROS card.	L2	None

[1] Interrupt errors can occur during bring-up diagnostics ABCDEF through ABCDEFGHJ (see ABCDE for levels).

Halt Code	Test	Area Tested	Service Aids
ABCDEFGHJKLMN	Tests the SORT utility on the feature ROS card if the K4 card is installed.	K4	Remove the K4 card and press the Restart switch.
ABCDEFGHJKLMNP ROS XX YY ERROR ---	Tests the content of nonexecutable ROS and does a CRC check on each ROS module. The display shows ROS XX YY, where XX identifies the card. (See *ROS Content* and *CRC Errors*.)	1X = F2. 2X, 31, 32 = E4. 33 or 4X = F2.	Loop on the ROS CRC test in DCP if the problem is intermittent.
ABCDEFGHJKLMNPQ	Bring up is complete. Control passes to the BASIC or APL microprogram subroutine that displays LOAD0 or CLEAR WS.	L2	The bring up diagnostic can be looped once by pressing the Restart switch.

Note: On an APL/BASIC machine, the bring up diagnostic tests only the nonexecutable ROS that you select with the APL/BASIC switch on the control panel. For example, with the APL/BASIC switch set to APL, the APL ROS on the E4 and F2 card is tested; BASIC ROS on the F2 card is not tested. To test the BASIC ROS, set the APL/BASIC switch from APL to BASIC and restart the bring up diagnostic.

Diagnostic Aids

ROS Content and CRC Errors

ABCDEFGHJKLMNP

ROS XX YY

ERROR ZZZ

XX = Module ID being tested.
- 1X = BASIC ROS on the Common and language ROS card (F2).
- 2X series or 31 or 32 = APL ROS card (E4).
- 33 or 4X series = Common and language ROS card (F2).

Note: If a failure on 2X, 31, or 32 is not corrected by replacing the APL card, replace the Common and language ROS card (could be an addressing problem).

YY = Module ID read.

ERROR ZZZ 001 – Common and language ROS card (F2).
002 and 014 – Executable ROS (L2) processor (J2) or read/write storage card (M2).
005 – Common and language ROS card (F2).
007 – CRC error.
008 – Module ID error.

Cause: Addressing problem. Common and language ROS card (F2), or APL ROS card (E4).

BINARY SYNCHRONOUS COMMUNICATIONS (BSC) ERROR LOG AND HISTORY TABLE

Errors are recorded in an error log and an error history table to assist you in determining the cause of intermittent BSC problems.

To use diagnostic aids to determine the cause of a problem see the *IBM 5110 Binary Synchronous Communications Feature Maintenance Information Manual,* SY31-0558.

5110 SYMPTOM INDEX

Symptom	Isolation Aid	Fix
Intermittent process checks with all I/O devices attached.	Remove all the I/O devices to see if the problem still occurs.	Replace the printer adapter card.
Intermittent process checks and bring up failures.	Check the power cable plug (Y1) on the A1 board. The clamp might be formed wrong; this allows the plug to fall out.	Reform the clamp holding Y1.
Process check on power up.	Suspect the M2 storage card. Swap the M2 card with another storage card to verify this.	Replace the M2 card.
Bring up failure on power up.	Go to Display Registers. If R0L0 is 0006, the failure is in the bring up diagnostic.	Replace the J2 card.
Fails to power up intermittently. Fans run but there is no voltage to A1 board.	None	Replace the Power On/Power Off switch.
Fails to power up within five seconds after power down (30 to 90 seconds).	Remove the AC fan motor plugs and the AC diskette motor plugs at the diskette units. Then power up.	If the machine powers up, suspect the wiring of the AC box.
Blows card and land patterns on A1 board after installing a TV monitor.	Check the TV monitor line cord wiring for an error causing chassis to be hot (110 AC).	The customer must have the TV monitor wiring corrected.
Keyboard locks with flashing cursor.	Check the last key pressed and verify that it operates. Press the Restart key to isolate the failing key.	Clean or replace the failing flyplate and/or key module.
Key pressed and wrong character is displayed.	None.	Replace the ROS card, storage card, or display card.
Unsteady display.	Switch to Display Registers. Check the connections on the brightness control.	Repair the connections on the brightness control.
No display and registers are not running.	Remove the printer from the system.	Replace the printer adapter card.

Diagnostic Aids

Symptom	Isolation Aid	Fix
Unable to clear messages from display line 15 when errors occur during an input statement.	None (operator error).	Do not use undefined function keys or copy display without a printer attached to the system.
Display character distortion.	Adjusting the CRT has little or no effect.	Replace the G2 card.
TV monitor has wavy or distorted characters.	5110 display is OK.	Uncrimp the cable connection to the TV monitor.
SIO fails to run the I/O device.	Check for proper wiring of the I/O device.	Wire the I/O device to provide 'data terminal ready' if the 5110 is acting as a modem. If the device is acting as a terminal, wire the I/O device to provide 'data set ready'.

5120 SYSTEM SERVICE TIPS

DANGER
Do not touch or attempt to remove the coax cable while the TV monitor is plugged into an AC outlet. There is the possibility of 110 volts being carried on the coax BNC connector and the cable shield, if the TV monitor has not been properly modified by the user. This voltage could also appear on the frame of the 5110.

General Tips

- Try to force the failure when running diagnostic by:
  - Vibrating the machine/cards/connections.
  - Raising the machine temperature (unplug the blower).

    CAUTION
    Do not exceed 20 minutes.

  - Lowering the machine temperature (use a circuit coolant).
- Machine power switch must be down (off) when you remove the read/write storage cards (M2, M4, N2, N4). All other cards can be removed with power switch up (on).
- You can remove the following cards/devices if they are not part of the failing operation or when you are trying to isolate to a failing operation:
  - A2—I/O cable driver card
  - B2—BSCA 1 card
  - D2—Asynchronous communication/serial I/O card
  - APL card E4 if the failure is in BASIC
  - Read/Write storage cards M4, N2, and N4
  - 5103 Printer
  - Internal diskette adapter card
  - A4—BSCA 2 card
  - 5114 Diskette Unit
  - BSCA attachment cards A4 and C2
  - EIA communications facility interface card C2
  - Feature ROS card K4
- You can swap either the parts of the internal diskette units or the complete diskette units (physically or electrically). To swap electrically, interchange the two cable ends that are plugged into B4 and D4 of the B1 board.
- To loop the diskette read diagnostic (call 0).
  1—Load and run call 0 until the first stop occurs.
  2—Insert the diagnostic diskette.
  3—Hold the CMD key and press the ATTN key.
  4—Press the A key.
  5—Enter: 35BA2A1E.
  6—Press the EXECUTE key.
  7—Press the ATTN key.
  8—Press the A key.
  9—Enter: 2A6830BA.
  10—Press the EXECUTE key.
  11—Press the ATTN key.
  12—Enter: BR2A1E.
  13—Press the EXECUTE key.
- To stop looping:
  - Hold the CMD key and press the ATTN key.

Error Retry Bypass

The 5110 has the capability of retrying an operation up to ten times before it displays the error and stops. These retries can cause the processing time to increase for diskette or communications operations. If this occurs, you can inhibit the retries by changing the read/write storage location 00A2 through 00A5 from xxxx to 8xxx.

Freelance Aids

Isolation aids that can be used when freelancing:

1. Disconnect one or both external I/O devices.

   CAUTION
   The last cabled I/O device must have a terminator or you will get process checks and bring-up diagnostic errors. The 5103 has its own internal terminator.

2. Remove all but 16K bytes of storage and use extra cards to isolate the problem.

3. Remove the A2 card to isolate the 5110 from the external I/O.

4. Remove the B2 and D2 cards to isolate the 5110 from the communications and/or SIO.

5. Remove internal diskette adapter card.

6. Disconnect the CRT connector if a display is not needed.

7. All 5110 cards except read/write storage can be pulled with power on.

8. All pins except voltage pins can be tied down.

9. Check all voltages.

10. Disconnect the fan motors to heat the machine and aggravate the failure.

    CAUTION
    Do not exceed 20 minutes of machine operation without fans running and covers installed.

Card and Board Jumpers

Hard to analyze failures on the 5110 might be associated with the jumper installed on the A1 board, the H2 card, the J2 card, the G2 card, the L2 card, or the I/O adapter cards. In several cases, the jumpers have been missing or loose.

When working with the A1 board or its cards, be sure that the jumpers are installed correctly. If you are experiencing any of the following symptoms, check the jumpers: (See MAP 050 for the correct jumpering of the logic cards.)

1. Process check on power up, but restart works properly.
2. No display; will not restart; meaningless data on the display.
3. Single row of digits across the bottom of the display or blank display.
4. Unable to analyze process checks or more than one type of process check at the same time.
5. Wrong characters printed on the printer or displayed on the display.

Intermittent Process Checks

If you are experiencing intermittent process checks on the 5110 and cannot determine the type or the cause, see *Error Checking* in the *Theory* section. When an error occurs, do not reset the machine. This will allow you to probe the failing line.

Dropping Records

If you are experiencing dropping records from files or you are getting 009 or 152 errors, check the file to see which recent changes were made and check to see if the file is larger than the available workspace. If you load a data file into storage, get a 152 error, make changes or corrections to that file, and then save the file, all data beyond the available storage will be lost. To eliminate losing these files, change or update the files under program control.

Attachment of a TV Monitor

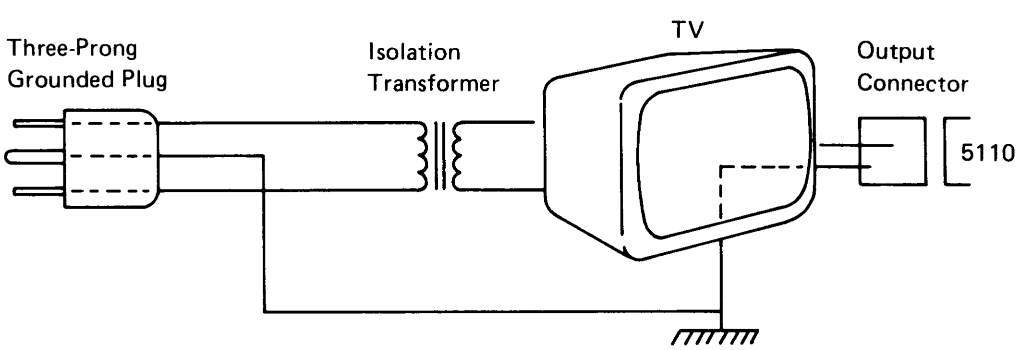
Generally, modifying a standard TV set and using it as a video monitor yields less satisfactory results than a regular video monitor. This is because the same level of quality is not built into TV receivers as is found in monitor class units. For example, the contrast and resolution are not as good on a modified TV receiver; thus the image is not as sharp and usually more difficult to read.

However, if a TV receiver is modified and used as a video monitor, the following procedure must be observed, or exposure to a severe electric shock or damage to the 5110 may occur when the TV set is connected to the IBM 5110.

A modified TV set *must* have isolation between the primary line voltage and the frame and circuitry of the set. This can be accomplished by using an isolation transformer between your outlet line voltage and the voltage input to the TV set. This transformer should be permanently wired into the circuit. The new input power plug must be a three-prong grounded plug with the ground connected to the chassis of the TV set. This grounding circuit must be electrically connected to the 5110 grounding circuit.

Before the video input is connected to anything, it should be tested to verify that the connector's external shell is at ground potential and that no line voltage is present on either the external shell or the center conductor.

It is the responsibility of the TV modifier to ensure that the input circuit meets the requirements of the 5110 output and will not damage the 5110. IBM will not modify the TV receiver.

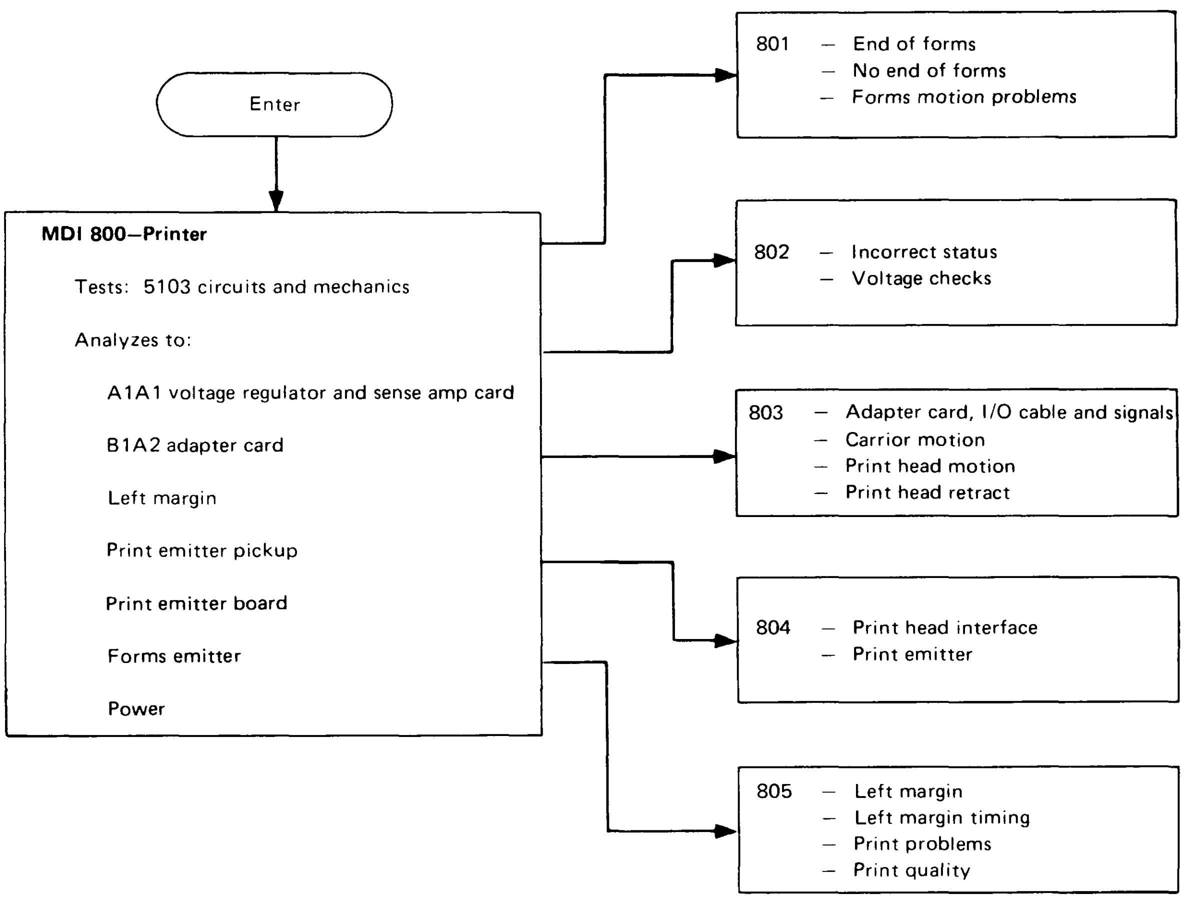


Note: If a TV receiver is modified for use as a video monitor, IBM accepts no responsibility for safety precautions during conversion and hookup for damages incurred to the TV receiver or 5110 or for the quality of the TV receiver as a video monitor.

MDI FAILURE ISOLATION CHARTS

MDI 800—Printer

The following chart shows the relationship of MDI 800 and MDIs 801 through 805. MDI 800 tests the entire printer. When MDI 800 detects a failing condition, it halts and displays the test routine that failed. MDI 800 isolates certain failures as shown for further failure isolation. You can loop MDIs 801 through 805 by returning to the MDI option display and following the instructions.



MDI 820—Async Comm/Serial I/O

This MDI tests the Asynchronous Communications Serial I/O features that reside on the D2 card. When this MDI detects a failing condition, it halts and displays the routine that failed. For descriptions of these routines, see the *Async Comm Adapter/Serial I/O Adapter and Diagnostic Routines.*

MDI 820—Async Comm/Serial I/O

Tests: Async comm/serial I/O circuits

Analyzes to:

- Async comm
  - Timer interrupts
  - Data set ready
  - Clear to send
  - Data through the async comm circuits
  - Long space interrupts
- Serial I/O:
  - Timer interrupts
  - Data set ready
  - Clear to send
  - Data through the serial I/O circuits

MDI 821—Binary Synchronous Communications Adapter (BSCA)

This MDI tests the BSCA logic cards and the communication facility card in the C2 card socket. When the MDI detects a failing condition, it halts and displays the suspected FRU and the diagnostic routine number that detected the failing condition. For a description of these routines, see the *BSCA Diagnostic Routines* in this section.

MDI 821—BSCA

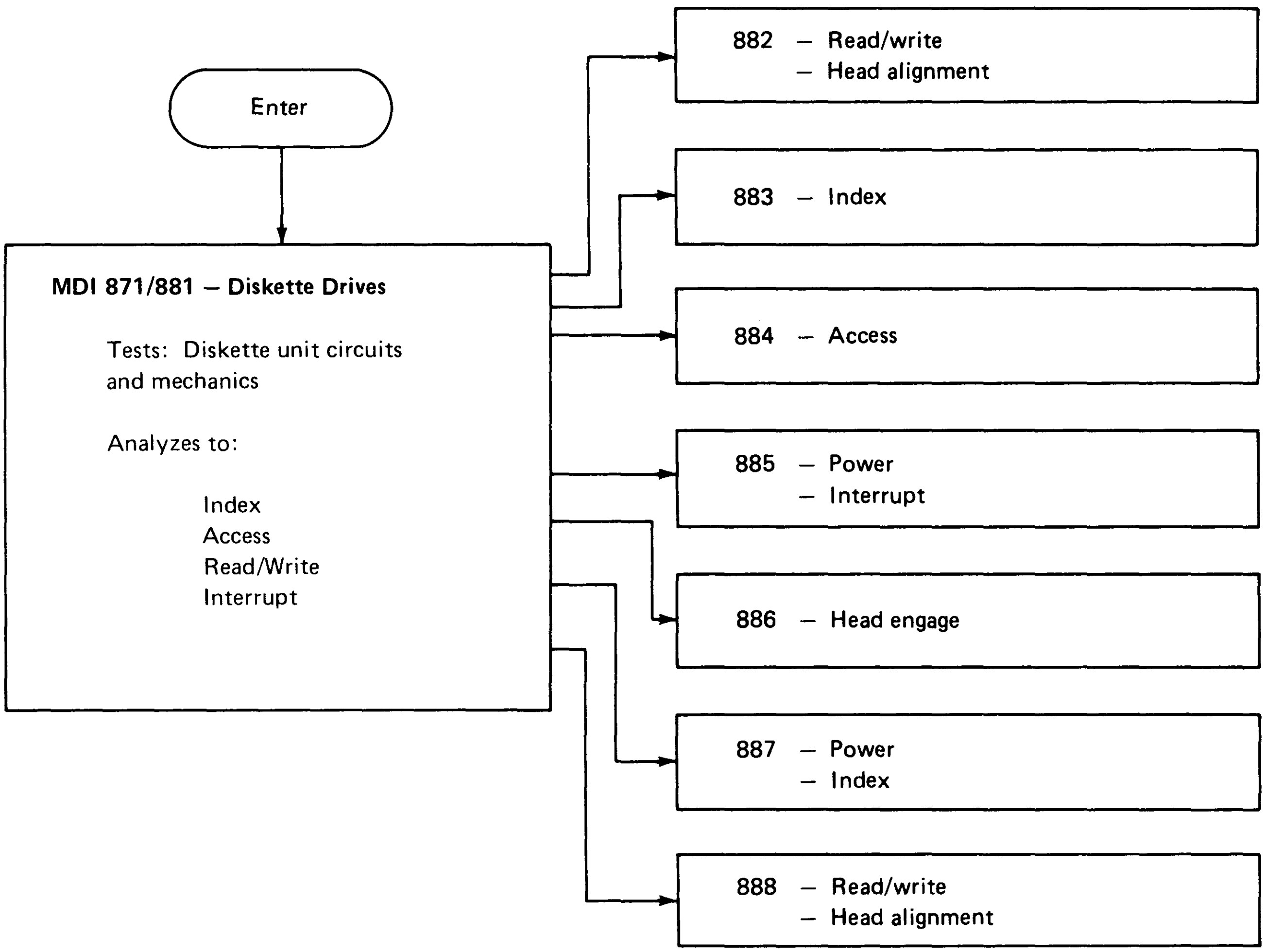
Tests: BSCA logic cards B2 and A4, and communication facility card C2.

Analyzes to:

- BSCA microproccssor and read/write storage
- Timer interrupts
- SYN character detection
- Data terminal ready
- High speed and low speed cperation
- Data path of the BSCA card and the communications facility logic card

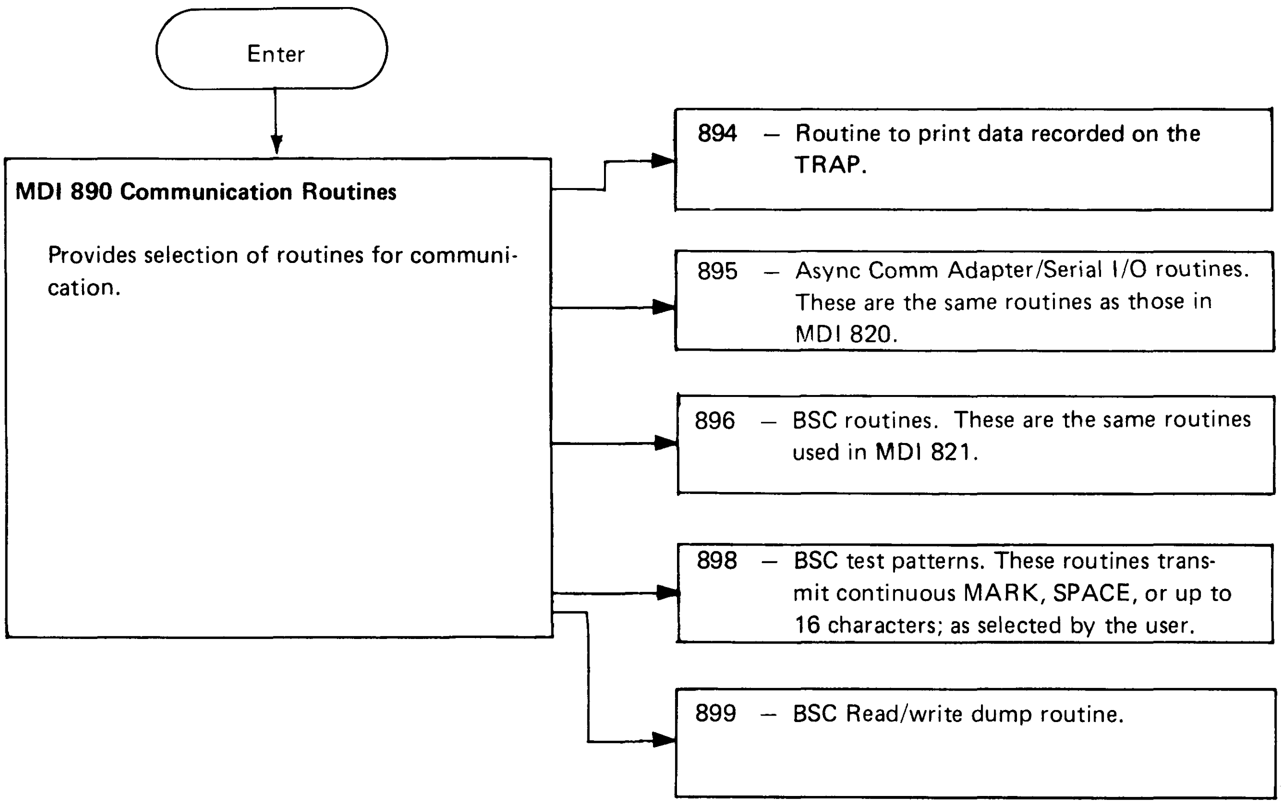
MDI 871/881 – Diskette Drive

These MDIs check all of the diskette functions. MDI 871 checks the internal diskette drives, and MDI 881 checks the 5114 diskette drives. If MDI 871/881 detects a failing condition, it halts and displays the number of the test routine that failed. MDI 881 can then branch to another MDI (882 through 888) for further tests to isolate the failure. MDI 871 contains all of the routines for the internal diskette drives, and does not branch.



MDI 890 — Communications Routines

This MDI is a MAP that prompts the user to select special communications routines.



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Installation Procedures

Prepower Check

Check with the customer to verify that the AC voltage outlet is grounded properly.

Power On Check

1. Make sure that the POWER switch is off.
2. Connect the mainline cord to the AC power outlet.
3. Turn the POWER switch on.
4. Observe the 5110 for signs of overheating or smoke. Turn off the POWER switch immediately if any abnormal conditions are noted.
5. Check that the fans are turning.
6. Use the MACHINE CHECKOUT, MAP 0900, to check the 5110 operation and performance.

Completion of Installation

The 5110 serial number is engraved on the rear of the base. Place the MAPs in the separate MAP binder provided. Insert the MAPs binder into the 5120 System MLM binder by inserting its back cover into the slot in the front cover of the MLM binder. Place the 5110 Model 3 Parts Catalog and the 5110 Model 3 Maintenance Information Manual into the 5120 System MLM binder.

Cover Cleaning

Use a mild soap or isopropyl alcohol (part 2200200). **DO NOT** use IBM cleaning fluid.

5110 Model 3 Specifications

Dimensions:

	Front	Side	Height
Millimeters	580	537	385
Inches	23.2	21.4	15.4

Weight: 48Kg (106 pounds)

Power Requirements and Heat Output/Hr.:

AC Voltage	Hertz	KVA	BTU/Hr.
120	60*	.52	1774
100/110/120/127	60**	.53	1808
200/220/230/240	50**	.57	1945
100/110	50**	.55	1877

*U.S. and Canada
**GBG/I

Power Cord Specifications (220, 235):

Cable OD—10.16 ± 0.38 mm (0.4 ± 0.015 inches)
Shields—none
Conductors—3
Conductor size—1.3 mm^2 (16 Awg)

IBM 5103 PRINTER

Refer to the *IBM 5103 Printer Maintenance Information Manual,* SY31-0414 for the 5103 installation procedures.

5114 DISKETTE UNIT

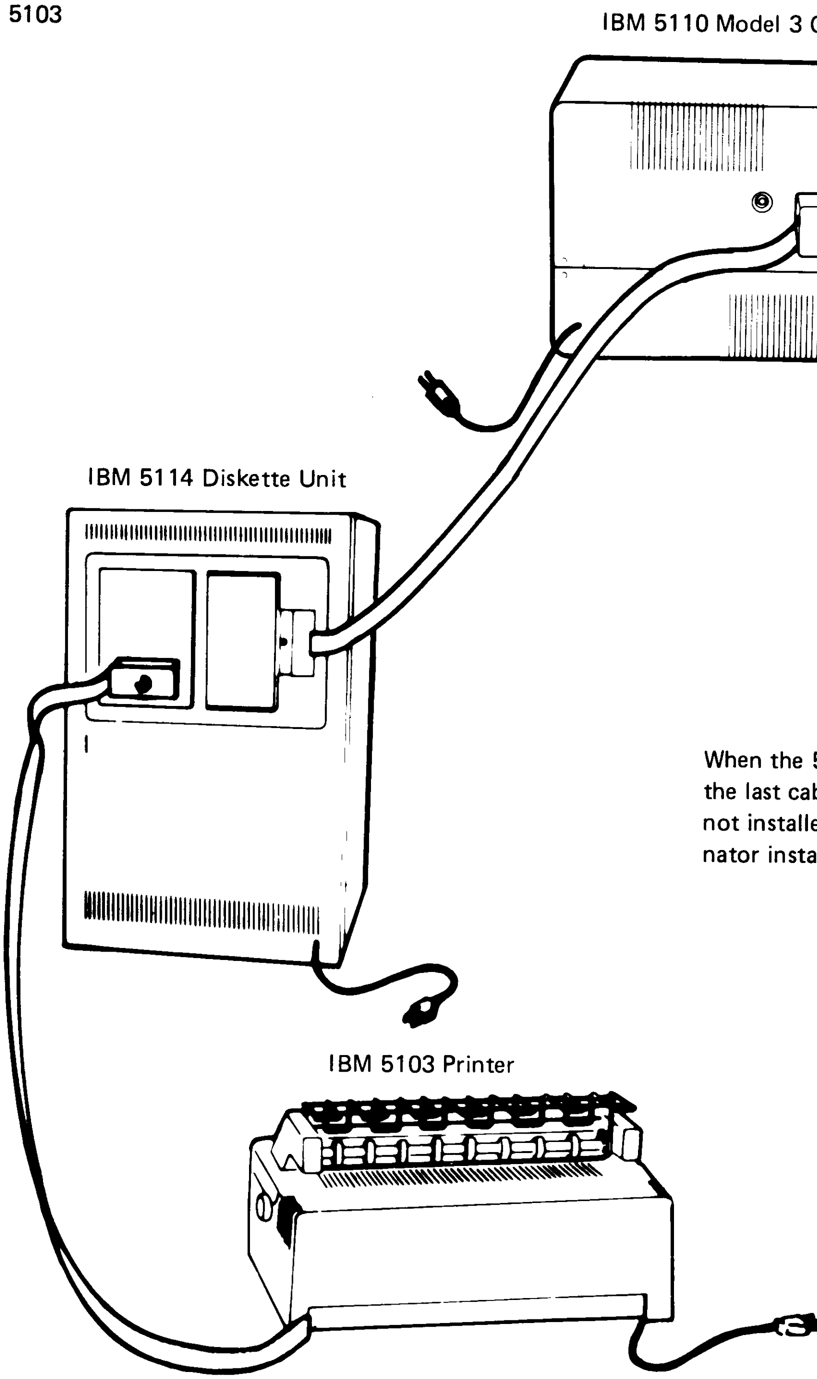
Refer to the *IBM 5114 Maintenance Information Manual,* SY31-0551 for the 5114 installation procedures.

5120 SYSTEM I/O DEVICE CONFIGURATIONS

IBM 5103 Printer and IBM 5114 Diskette Unit to the IBM 5110 Model 3 Computer

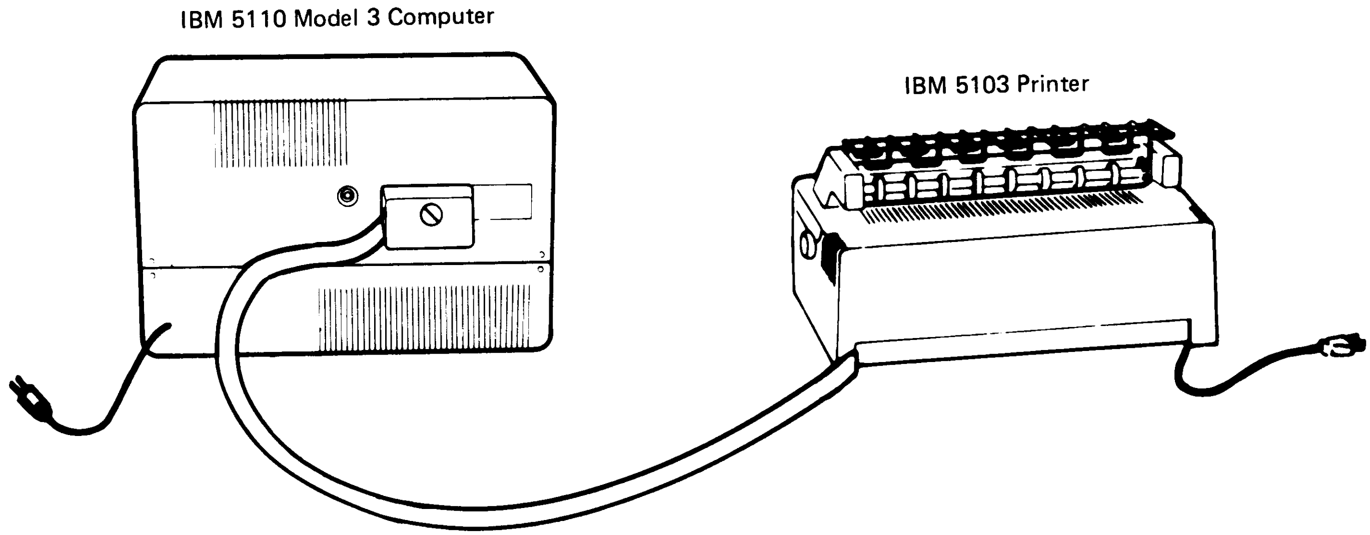
A maximum of two devices can be attached to a 5110 computer. The following specific arrangements are allowed as configurations:

5110 Model 3
5114
5114, 5103
5103

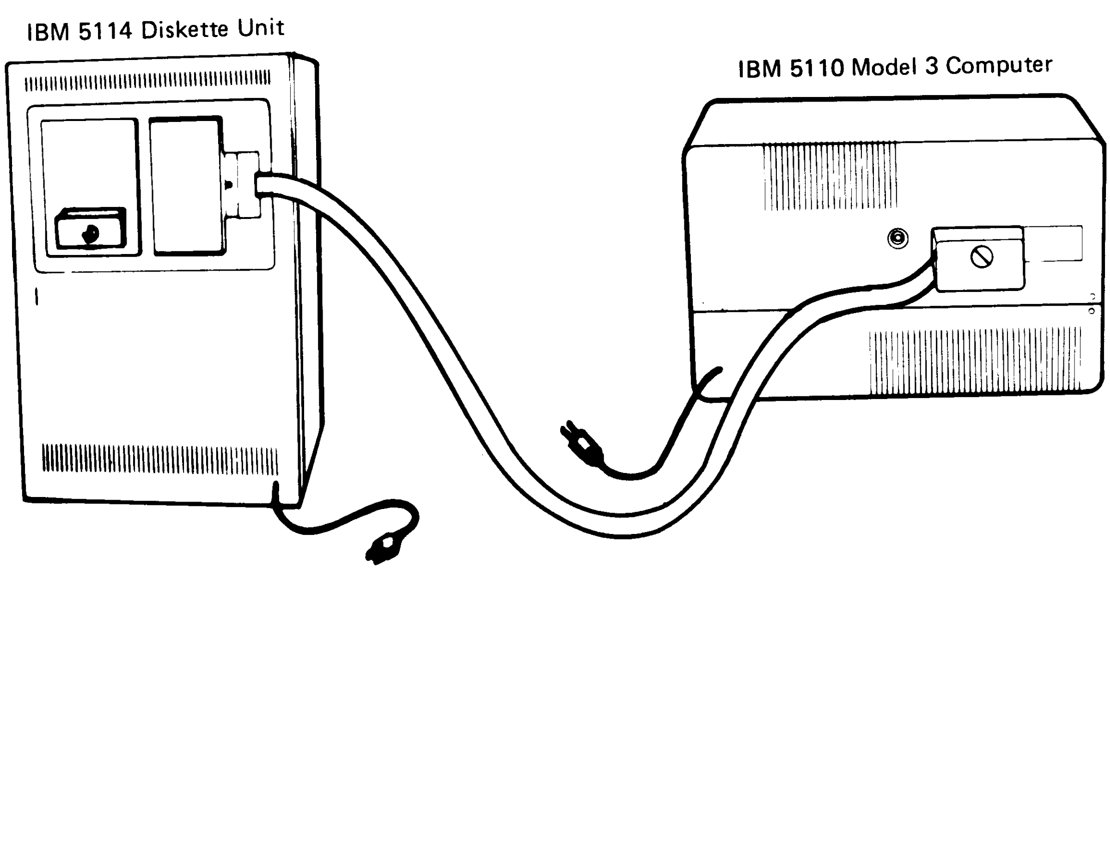


When the 5103 printer is installed, it must always be the last cabled device attached. If a 5103 printer is not installed, the last cabled device must have a terminator installed.

IBM 5103 Printer to the IBM 5110 Model 3 Computer



IBM 5114 Diskette Unit to the IBM 5110 Model 3 Computer



Appendix A

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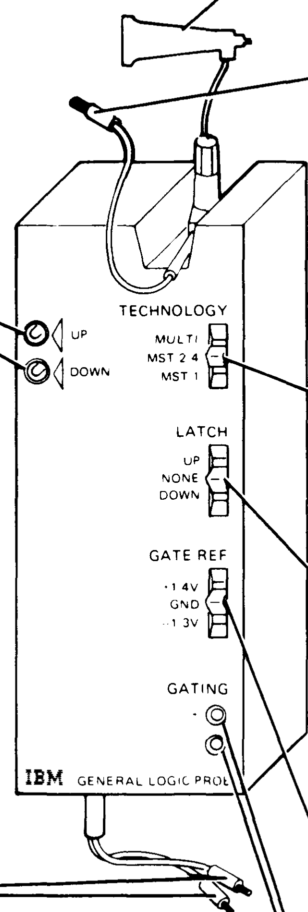
GENERAL LOGIC PROBE (part 453212)

The general logic probe provides a visual indication of a line level. The probe can also be used to detect pulses and to serve as a babysitter. (Refer to handbook that comes with probe.)

Probe UP and DOWN lights will momentarily flash on during power up if the probe is connected to its machine power source. Please ignore.



Indicator Lights

UP indicates an up level (+).
DOWN indicates a down level (–).

A pulsing line is indicated by both lights being on.

Both lights are off if the line level is from +1.0 Vdc to +2.0 Vdc for the MULTI logic setting.

Safe Operating Ranges:

	MULTI	+60.0V
Logic	MST 2/4	+14.0V
Selector	MST 1	+14.0V

Voltages greater than the above ranges will damage the probe.

Power Leads

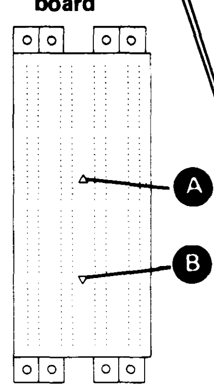
CAUTION
Improper connection of the power lead might cause the probe to malfunction.

Connect the probe power leads as follows:

	Black (-)	Other (+)
5110	A1 board M2D08 (Gnd)	M2D03 (+5V)
	B1 board, see insert A	See insert B
5103	TP-G6 (Gnd)	
5114	See insert A	See insert B

Note: Power for the probe can be obtained from any of the above devices when you are probing any other device.

5110 B1 board or 5114 A1 board



Test Terminal

The line being probed is connected to this terminal. (Various probes may be attached, other than the one shown, to aid in probing.) Do not use a tip longer than 3 inches (76.2 mm).

Ground Lead

Connect this lead to any signal ground near the probe point. Do not use frame ground.

CAUTION
Improper indications result if this lead is not connected to signal ground. A maximum length of 4 inches (101.6 mm) can be used.

Logic Selector (TECHNOLOGY)

- MULTI

Selects the type of logic to be probed. Circuits probed in the 5120 system require the MULTI setting.

LATCH Switch

- NONE

Allows the probe to be used as a babysitter. The up position allows latching the UP light on a positive pulse. The down position allows latching the DOWN light on a negative pulse. NONE position resets the lights and prevents any latching action. This position is used for most probing in the 5120 system.

GATE REF Volts Switch

- GND

This switch affects only the gating terminals and is not required for probing the 5120 system.

GATING Terminals

These terminals are not required for probing the 5120 system.

CE METER CALIBRATION CHECK

1. When measuring voltages, set the CE meter on the 15 Vdc scale and set the meter to zero.

2. Ground the CE meter at G2-D08 and measure the voltage at G2-S02. Your CE meter is measuring the reference voltage (ref vol). A zener diode provides a 6 Vdc reference (see Logic 420).

3. If your meter does not read exactly +6 Vdc, it is not calibrated, and you must use the following formula to determine the actual voltage (act vol):

$$\text{Act Vol} = \frac{6 \times \text{Mea Vol}}{\text{Ref Vol}}$$

Mea Vol = measured voltage (reading on CE meter of voltage being measured)

Example:

Ref Vol = 5.8 Vdc (value of reference voltage at G2-S02 as measured by the CE meter)

When you measure the +5 Vdc, your meter reads +4.8 Vdc.

$$\text{Act Vol} = \frac{6 \times 4.8}{5.8} = 4.97 \text{ Vdc}$$

3742 ALIGNMENT DISKETTE (part 2455026)

The 3742 alignment diskette is a branch office tool. The alignment diskette is used with the 5114 diagnostic MDIs to check the 5114 drive head alignment.

DISKETTE UNIT TOOLS

Force gauge (part 460870)—The force gauge is a branch office tool and is used to adjust the drive band tension of the diskette unit.

Thickness gauge clip (part 4240632)—The thickness gauge clip is shipped with the diskette unit and is located on the diskette guide. The clip is used to hold the thickness gauge during head alignment adjustments.

Tension spring (part 4240631)—The tension spring is shipped with the diskette unit and is located on the diskette guide. The tension spring is used during head alignment adjustments.

Timing pin (part 5562019)—The timing pin is shipped with the diskette unit and is located on the diskette unit casting. The timing pin is used during head alignment adjustments.

Numbering Systems

HEX NUMBERING SYSTEM

Binary numbers require about three times as many positions as decimal numbers to express the equivalent number. This is not much of a problem for the computer. However, binary numbers are bulky for humans when they are talking, writing, or communicating with a computer. A long string of 1's and 0's cannot be effectively transmitted from one individual to another. Some shorthand method is necessary. The hex numbering system fills this need.

Because of the simple relationship of hex to binary, numbers can be converted from one system to another by inspection. The base of the hex system is 16. This means there are 16 symbols: 0, 1, 2, 3, 4, 5, 6, 7, 8, 9, A, B, C, D, E, and F. The letters A, B, C, D, E, and F represent the decimal (base 10) values of 10, 11, 12, 13, 14, and 15, respectively.

Four binary positions are equivalent to one hex position. The following table shows the comparable values of the three numbering systems:

Decimal	Binary	Hex
0	0000	0
1	0001	1
2	0010	2
3	0011	3
4	0100	4
5	0101	5
6	0110	6
7	0111	7
8	1000	8
9	1001	9
10	1010	A
11	1011	B
12	1100	C
13	1101	D
14	1110	E
15	1111	F

At this point, all 16 hexadecimal symbols were used, and a carry to the next higher position of the number is necessary. For example:

Decimal	Binary	Hex
16	0001 0000	10
17	0001 0001	11
18	0001 0010	12
19	0001 0011	13
20	0001 0100	14
21	0001 0101	15

—and so on—

HEX AND DECIMAL CONVERSION

Hex Columns											
6		5		4		3		2		1	
Hex	= Dec	Hex	= Dec	Hex	= Dec	Hex	= Dec	Hex	= Dec	Hex	= Dec
0	0	0	0	0	0	0	0	0	0	0	0
1	1,048,576	1	65,536	1	4,096	1	256	1	16	1	1
2	2,097,152	2	131,072	2	8,192	2	512	2	32	2	2
3	3,145,728	3	196,608	3	12,288	3	768	3	48	3	3
4	4,194,304	4	262,144	4	16,384	4	1,024	4	64	4	4
5	5,242,880	5	327,680	5	20,480	5	1,280	5	80	5	5
6	6,291,456	6	393,216	6	24,576	6	1,536	6	96	6	6
7	7,340,032	7	458,752	7	28,672	7	1,792	7	112	7	7
8	8,388,608	8	524,288	8	32,768	8	2,048	8	128	8	8
9	9,437,184	9	589,824	9	36,864	9	2,304	9	144	9	9
A	10,485,760	A	655,360	A	40,960	A	2,560	A	160	A	10
B	11,534,336	B	720,896	B	45,056	B	2,816	B	176	B	11
C	12,582,912	C	786,432	C	49,152	C	3,072	C	192	C	12
D	13,631,488	D	851,968	D	53,248	D	3,328	D	208	D	13
E	14,680,064	E	917,504	E	57,344	E	3,584	E	224	E	14
F	15,728,640	F	983,040	F	61,440	F	3,840	F	240	F	15
0123		4567		0123		4567		0123		4567	
Byte				Byte				Byte			

From decimal to hex: (1) Locate the largest decimal value in the table that will fit into the decimal number to be converted, (2) note its hex equivalent and hex column position, and (3) find the decimal remainder. Repeat the process on this and subsequent remainders.

Example: **Decimal Value** **Hex Equivalent**

	Decimal Value		Columns 4	3	2	1
	19,367					
(1)	16,384	(2) →	4			
(3)	2,983					
	2,816	→		B		
	167					
	160	→			A	
	7	→				7
			4	B	A	7

From hex to decimal: Locate each hex digit in its corresponding column position and note the decimal equivalents. Add these to obtain the decimal value.

Example: **Hex Value** **Decimal Equivalent**

Columns
4 3 2 1

3 0 C F

Hex Value	Decimal Equivalent
F	15
C	192
0	0
3	12,288
	12,495

Glossary

adapter: A hardware device that connects two channels on the same computing system or on different systems

alphameric keys: That part of the keyboard that resembles a typewriter keyboard

ALU: Arithmetic and logic unit

APL: A Programming Language

Async Comm: Asynchronous Communications

ATTN: Attention

BASIC: Beginners all-purpose symbolic instruction code

BCD: Binary coded decimal

bits per second: Communications line transmission rate

BSC: Binary Synchronous Communications

BSCA: Binary Synchronous Communications Adapter

bps: Bits per second

CC1: Character count 1

CMD: Command key

control unit: That portion of the A1 board in the 5110 that contains the controller, portions of the base I/O card, and all storage. The control unit contains microinstructions and the logic necessary to execute them

controller: The microinstruction processor within the 5110

CRC: Cyclic redundancy check

CRT: Cathode ray tube

cyclic redundancy check: A system of error checking that is performed during transmission and reception of data by creating and checking a block check character.

DA: Device address

DCP: Diagnostic control program

DSP: Diagnostic supervisor program

EC: Error code

Emulator: Hardware, or a combination of hardware and software, that permits programs written for one computer to be run on another computer.

executable ROS: Contains microinstructions that can be executed directly by the controller

flyplate: The pad on the bottom of a keyboard key module. When a key is pressed, the flyplate raises and the capacitive change indicates to the keyboard printed circuit that the key is pressed

FRU: Field replaceable unit

header record: A record containing identifying information pertaining to a group of records that follow

hex: Hexadecimal

Hz: Primary unit of measure for alternating current frequency

I/O: Input/output

I/O interface port: A removable panel located on the back of the 5110 that contains the signal and power connectors for attaching I/O devices

IAR: Instruction address register

interpreter: A computer program stored in ROS that controls execution of BASIC and APL instructions

interval timer: Measures the time between clock pulses coming from the read head

IOCB: Input/output control block

Kbd: Keyboard

kVA: Kilovolt amperes

LED: Light emitting diode

logical record: A group of data independent of its physical location

loop: A group of instructions that are executed repeatedly

LWR: Loop write read

MAP: Maintenance analysis procedures

MCC: Multi clock cycle

MDI: MAP Diagnostic Integration

MHz: Megahertz

MIM: Maintenance information manual

mm: Millimeter

ms: Millisecond

N/C: Normally closed

N/O: Normally open

nonexecutable ROS: Contains microinstructions that are first loaded into read/write storage and executed from there

ns: Nanosecond

numeric keys: That portion of the keyboard that resembles a calculator keyboard

ohm: A primary unit of resistance

PC: Printed circuit

PC board: A printed circuit board consists of electrical circuits mounted on a board to distribute signals and voltages

PG: Parity generator

PH: Polarity hold

PLFP: Print line failure position

POR: Power on reset

power on reset: A signal occurring during power up, used to reset all circuits to an operational starting point

PTX: Phototransistor

RDDR: Read data deserializer register

RDR: Read data register

read only storage: A storage whose contents are not changed by computer instructions

record: A group of related data items

ROS: Read only storage

RRA: Remove, replace, adjust

SA: Status byte A

SAR: Storage address register

SB: Status byte B

scroll: Move data on the display screen up or down

SDR: Storage data register

sync: Synchronize or synchronous

TS: Test status

TSR: Transistor switching regulator

TTL: Transistor-transistor logic

TV monitor: An external display assembly that displays the same information as the 5110 9-inch display screen

typamatic: A keyboard signal generated by the repeat action keys when held down for more than 700 ms

Vac: Volts of alternating current

Vdc: Volts of direct current

video: Information relating to or used in receiving an image on the display screen

wrap connector: A communications adapter feature tool that allows testing of transmit and receive signals without attaching to a remote device

X: Hexadecimal

μs: Microsecond

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