



**IBM 5110  
Computer  
Maintenance Information Manual**

**5110**



*IBM 5110  
Computer  
Maintenance Information Manual*

## Preface

This maintenance information manual, SY31-0550 is intended to be used for servicing the 5110. Service personnel using this manual are assumed to have completed the 5110 training course.

To service the 5110, use this manual with the MAPs (maintenance analysis procedures), SY31-0553 and the 5110 Logic Manual, SY31-0552. It is important that you begin your call with the Start MAP that leads you to other MAPs and eventually to the failing FRU (field-replaceable unit).

## Third Edition (February 1979)

This is a major revision of, and obsoletes, SY31-0550-1. Changes or additions to the text and illustrations are indicated by a vertical line to the left of the change or addition.

Changes are periodically made to the information herein; changes will be reported in Technical Newsletters or in new editions of this publication.

Use this publication only as an aid in servicing the IBM 5110 system.

Publications are not stocked at the address below. Requests for copies of IBM publications and for technical information about the system should be made to your IBM representative or to the branch office serving your locality.

This publication could contain technical inaccuracies or typographical errors. Use the Reader's Comment Form at the back of this publication to make comments about this publication. If the form has been removed, address your comments to IBM Corporation, Publications, Department 245, Rochester, Minnesota 55901. IBM may use and distribute any of the information you supply in any way it believes appropriate without incurring any obligation whatever. You may, of course, continue to use the information you supply.

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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, 230 refers to the tape 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 functional units and features. These descriptions are preceded by a system overview that gives you a general picture of the 5110 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, communications, auxiliary tape, and tape write 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 and the 5106 Auxiliary Tape Unit. 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 are found in the following manuals:

*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 Parallel I/O Adapter Feature Maintenance Information Manual, SY31-0583*

*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 Computer, 5114 Diskette Unit, 5103 Printer, 5106 Auxiliary Tape Unit, and other attachable features are located in the *IBM 5110 Logic Manual, SY31-0552*.

## 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. Turn off all ac and dc power 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 you have turned off the wall box power 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). Use suitable rubber mats, purchased locally if necessary.
5. Wear safety glasses when:
  - a. Using a hammer to drive pins, riveting, staking.
  - b. Power or hand drilling, reaming, grinding.
  - c. Using spring hooks, attaching springs.
  - d. Soldering, wire cutting, removing steel bands.
  - e. Cleaning parts with solvents, sprays, cleaners, chemicals.
  - 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 for making sure 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.
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 the 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 the 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

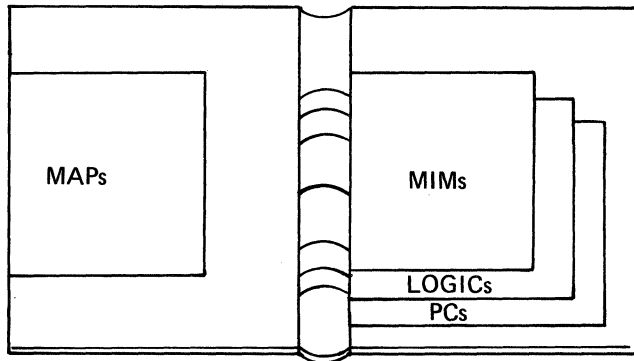




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## 5110 Maintenance Library

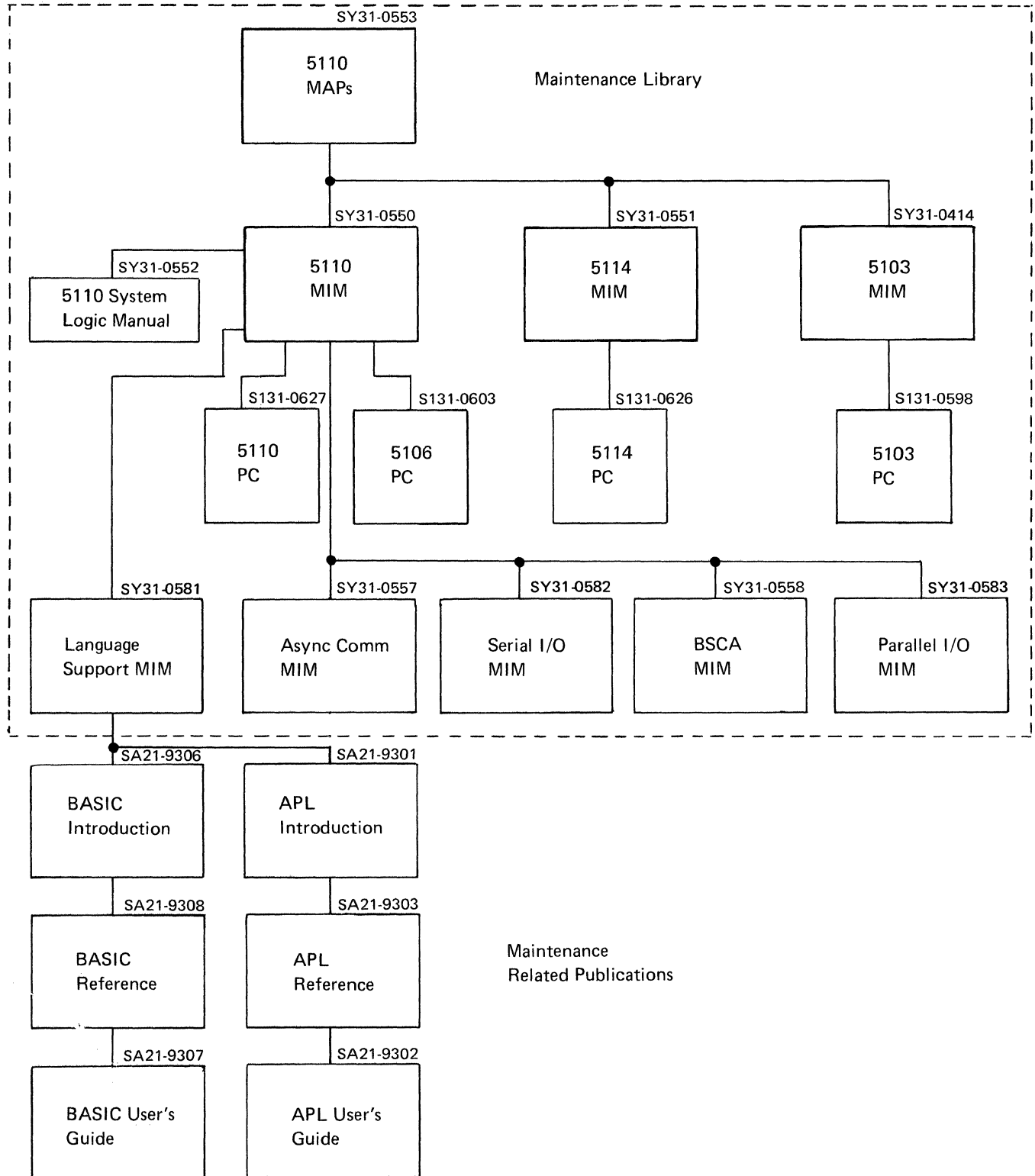
The 5110 maintenance library (MLM) consists of maintenance analysis procedures (MAPs), maintenance information manuals (MIMs), 5110 logic manual, parts catalogs (PCs), and diagnostic tools. These publications and diagnostic tools are all contained in a single binder.



The diagnostic tools contained in the 5110 MLM are:

- Diagnostic tape cartridge
- Diagnostic diskette
- Logic board jumpers
- Wrap connectors
- Cartridge stop gauge

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.



When necessary, MAPs and MIMs are updated to provide the latest information for diagnosing 5110 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 5110 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 SY31-0553	5110 SY31-0550	5114 SY31-0551	5103 Printer SY31-0414	Asynchronous Comm SY31-0557	Binary Synchronous SY31-0558	Serial I/O SY31-0582	Parallel I/O SY31-0583	Language Support SY31-0581	5110 Logic SY31-0552
Circuits										X	
Communications											
Asynchronous					X						
Binary Synchronous						X					
Character Code Chart									A		
Diagnostic Aids		4			X	X	X	X			
Glossary		D	C	D	X	X	X	X			
Installation Procedures		A	A	A							
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Communications	830										
Diskette Read	310										
Diskette Unit	880										
Display	500										
Keyboard	600										
Machine Checkout	900										
Parallel I/O	830										
Power	700										
Process Check	420										
Serial I/O	830										
Start	200										
Tape Read	300										
TV Monitor	510										
5103 Printer	810										
5106 Auxiliary Tape	850										
Numbering Systems		C									
Print Character Information				B							
Preventive Maintenance				C							
Theory		3	3	3	X	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 5110 that requires adjustment or replacement.

Two types of MAPs are used in the 5110 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 tape/diskette and are shown on the display screen. The system automatically pages through the MAPs when you respond to the questions on the display.

## MAP ORGANIZATION

START

Start MAP 200

Record the Error Code Displayed

For Intermittent Failures

Indicator Lights—Use MAP 200

Bring Up Diagnostic Failures

Process Checks

Display Failures

Other Reported Failures

No Symptoms

Diagnostic Aid Section

System Function Test

MAP 400—Bring Up

MAP 420—Process Check

MAP 500—Display

MAP 300—Tape Read

MAP 310—Diskette Read

MDI 860, 861

MAP 700—Power

MAP 510—TV Monitor

MAP 600—Keyboard

MAP 810—5103

MDI 800, 801, 802, 803, 804, 805

MAP 830—Communications, SIO, PIO

MDI 821—BSCA

MDI 820—Asynchronous Communications—  
Serial I/O

MDI 823—Parallel I/O

MDI 890—Communications Routines

MAP 850—5106

MDI 840 through 847 and 860, 861

MAP 880—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 failures 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 probe 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

## PROCESS CHECK MAP 0420

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
0850	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

2 2 2  
A B C

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.

MAP name and number

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

MAP EXAMPLE (continued)

**PROCESS CHECK MAP**

A B C  
1 1 1

PAGE 2 OF 75

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.

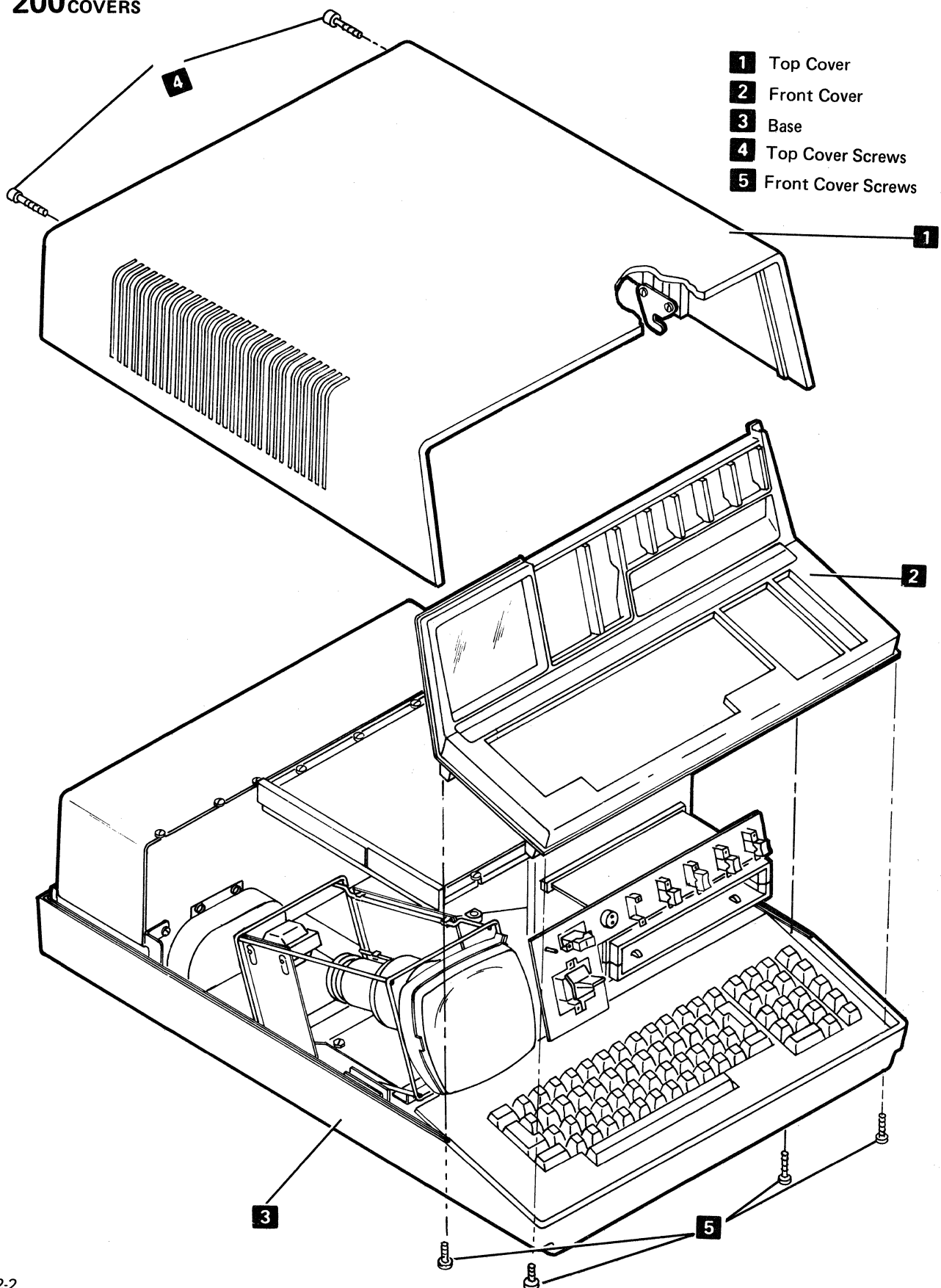
On-page reference—indicates the trace on this page from which this leg of the MAP continues.

7 7 1  
5 5 8  
D E F G

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# Locations

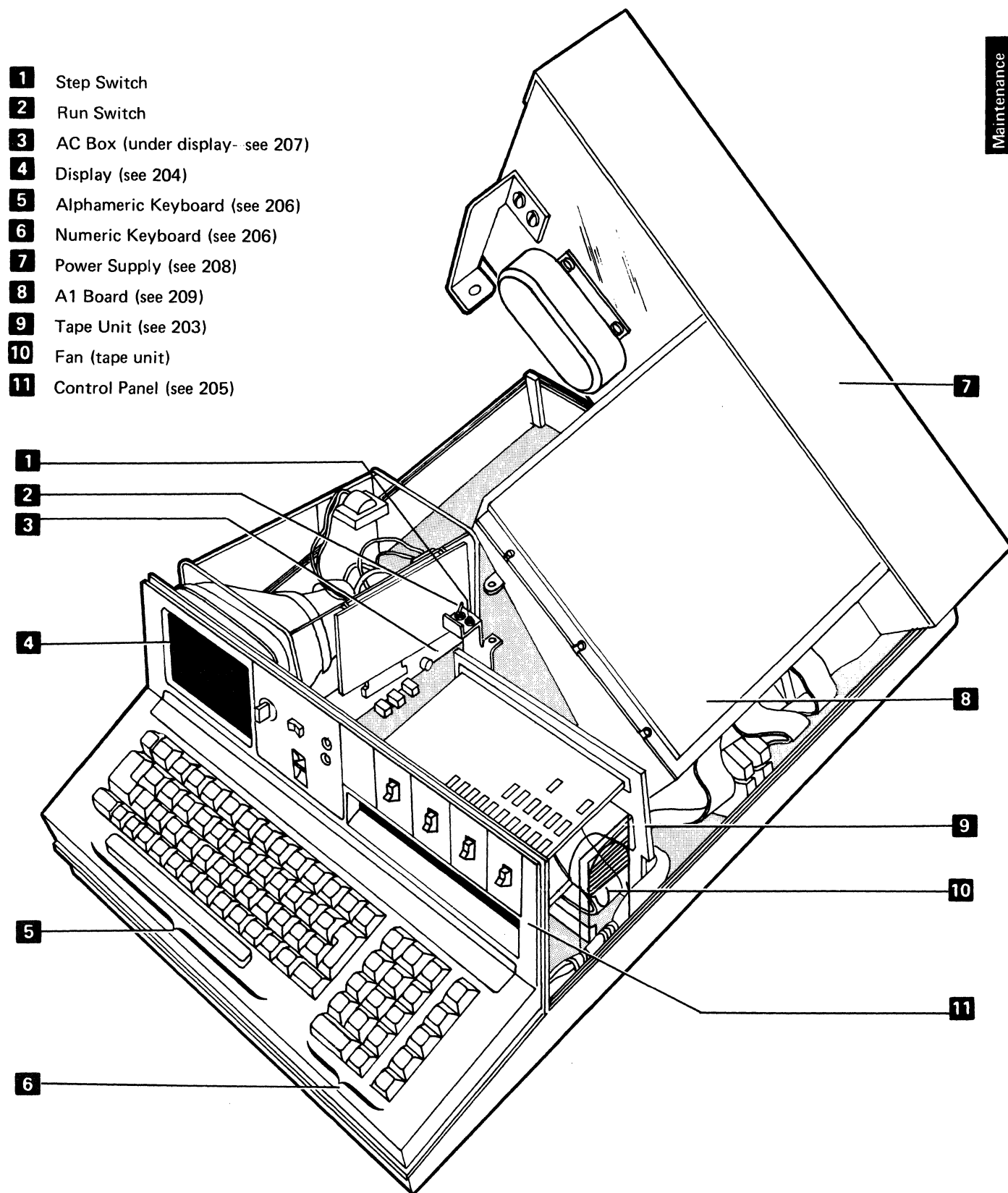
## 200 COVERS





# 201 5110 MODEL X1X, FUNCTIONAL UNITS (WITH TAPE UNIT) (Page 1 of 2)

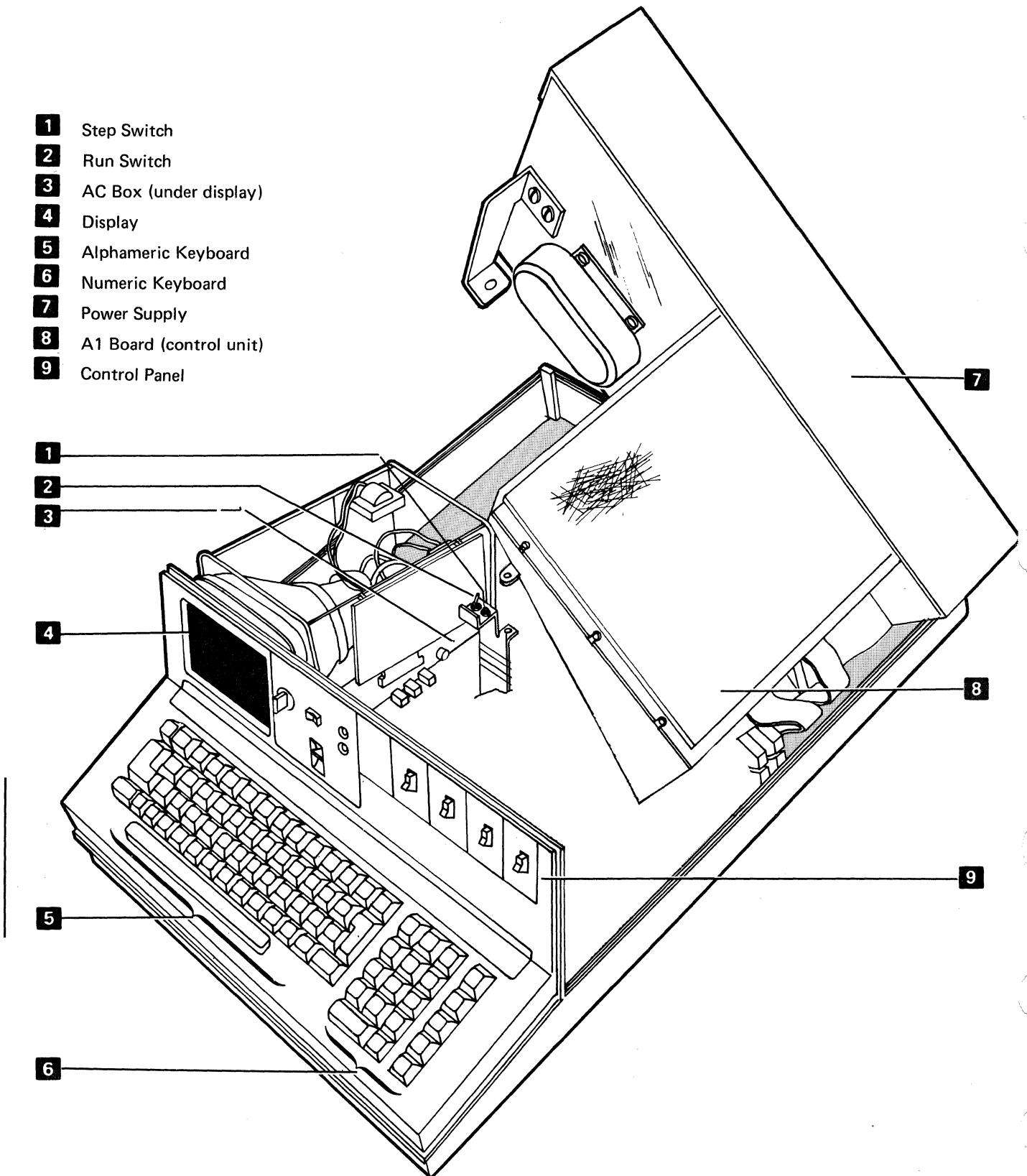
- 1 Step Switch
- 2 Run Switch
- 3 AC Box (under display- see 207)
- 4 Display (see 204)
- 5 Alphameric Keyboard (see 206)
- 6 Numeric Keyboard (see 206)
- 7 Power Supply (see 208)
- 8 A1 Board (see 209)
- 9 Tape Unit (see 203)
- 10 Fan (tape unit)
- 11 Control Panel (see 205)



Maintenance

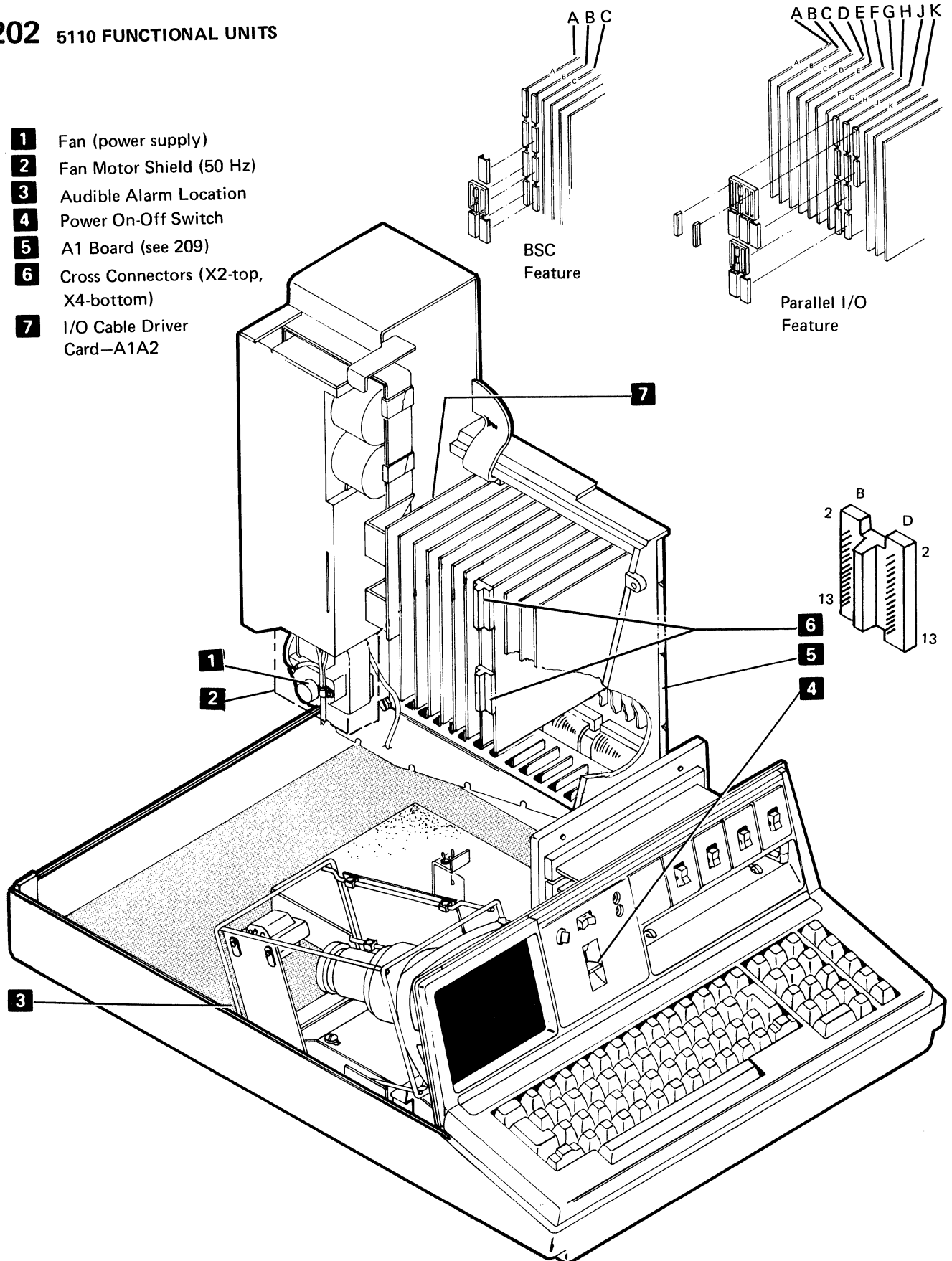
**| 201** 5110 MODEL X2X, FUNCTIONAL UNITS (WITHOUT  
TAPE UNIT) (Page 2 of 2)

- 1** Step Switch
- 2** Run Switch
- 3** AC Box (under display)
- 4** Display
- 5** Alphameric Keyboard
- 6** Numeric Keyboard
- 7** Power Supply
- 8** A1 Board (control unit)
- 9** Control Panel



## 202 5110 FUNCTIONAL UNITS

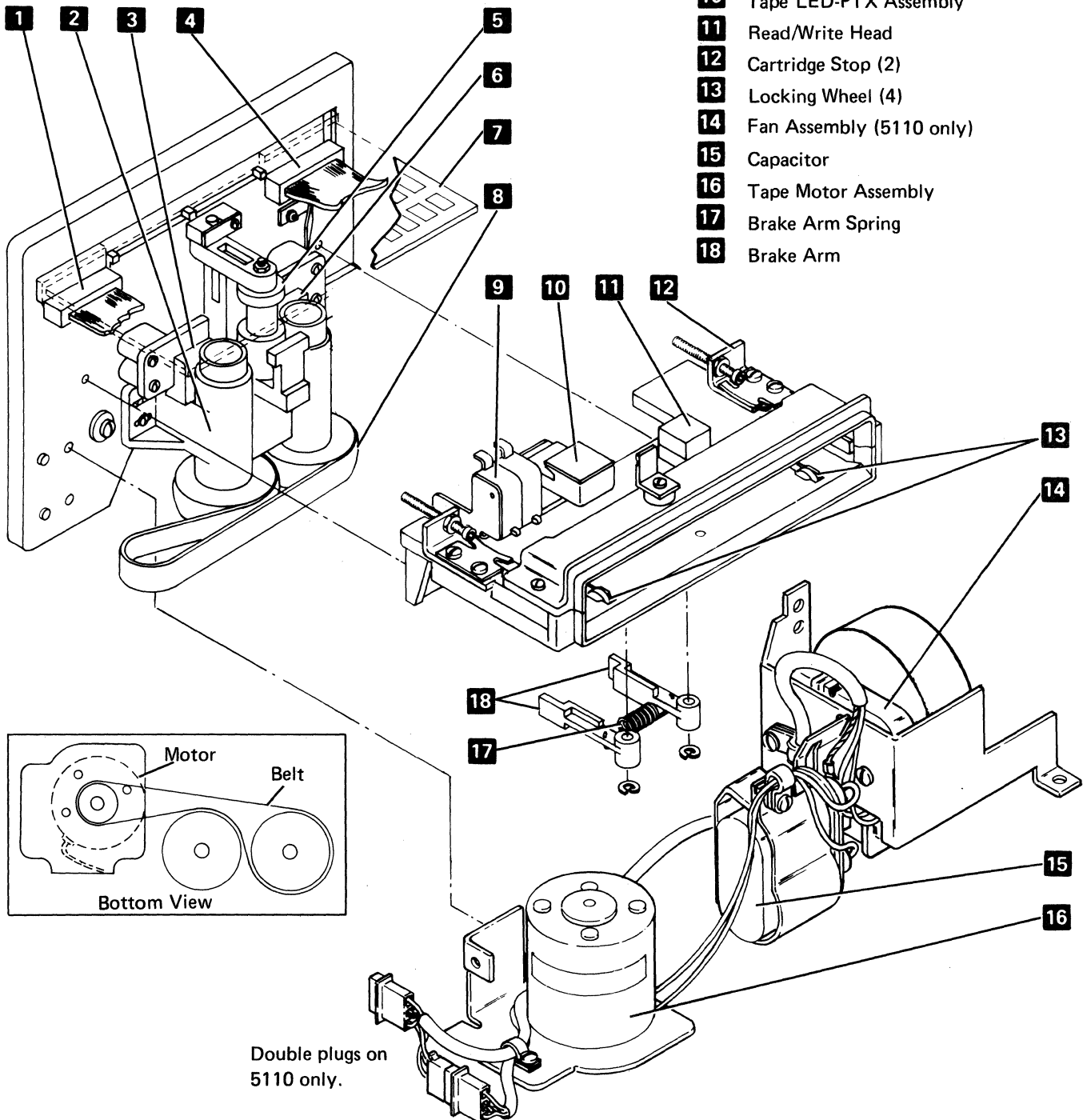
- 1** Fan (power supply)
- 2** Fan Motor Shield (50 Hz)
- 3** Audible Alarm Location
- 4** Power On-Off Switch
- 5** A1 Board (see 209)
- 6** Cross Connectors (X2-top, X4-bottom)
- 7** I/O Cable Driver Card—A1A2



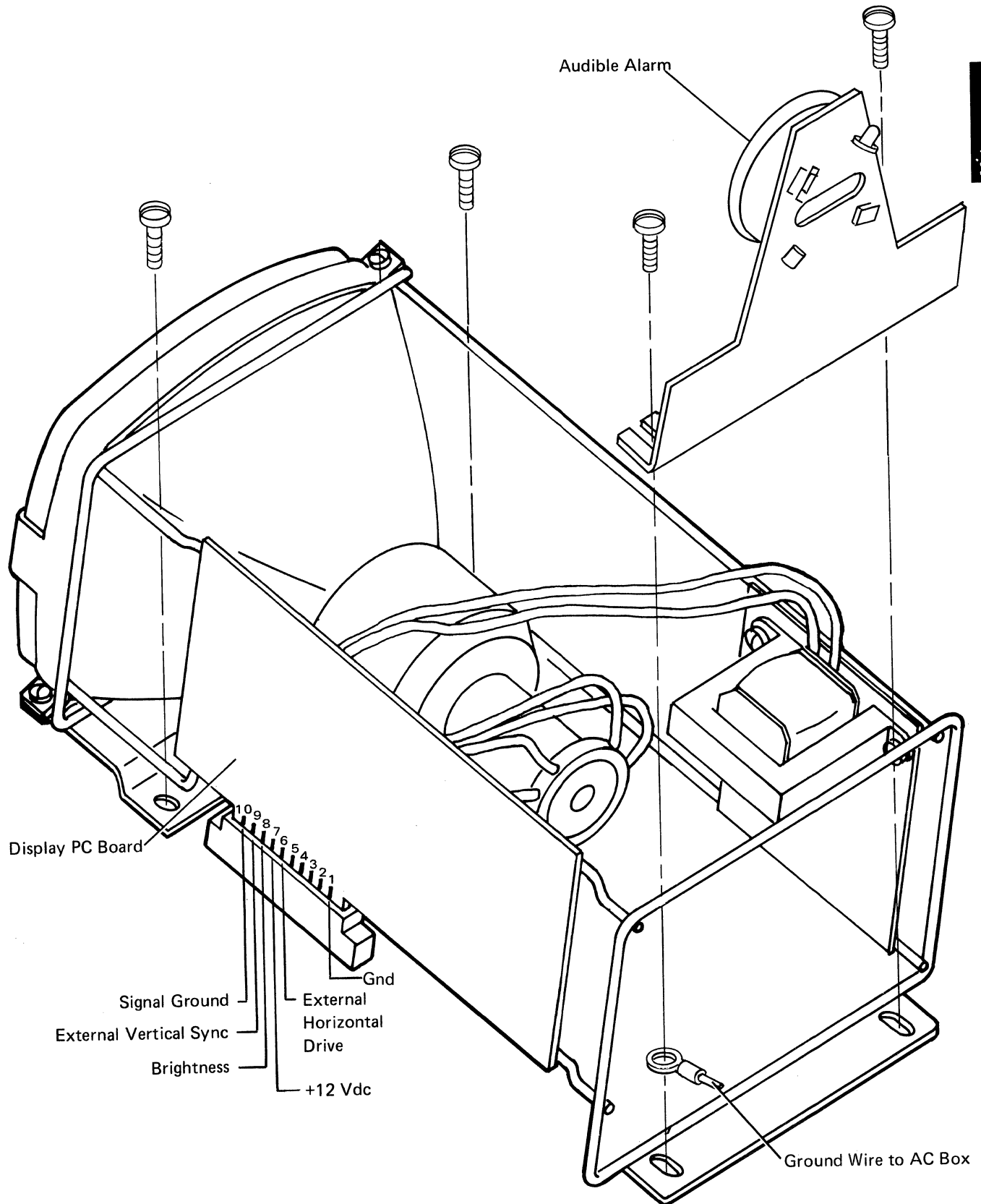
Maintenance

## 203 TAPE UNIT

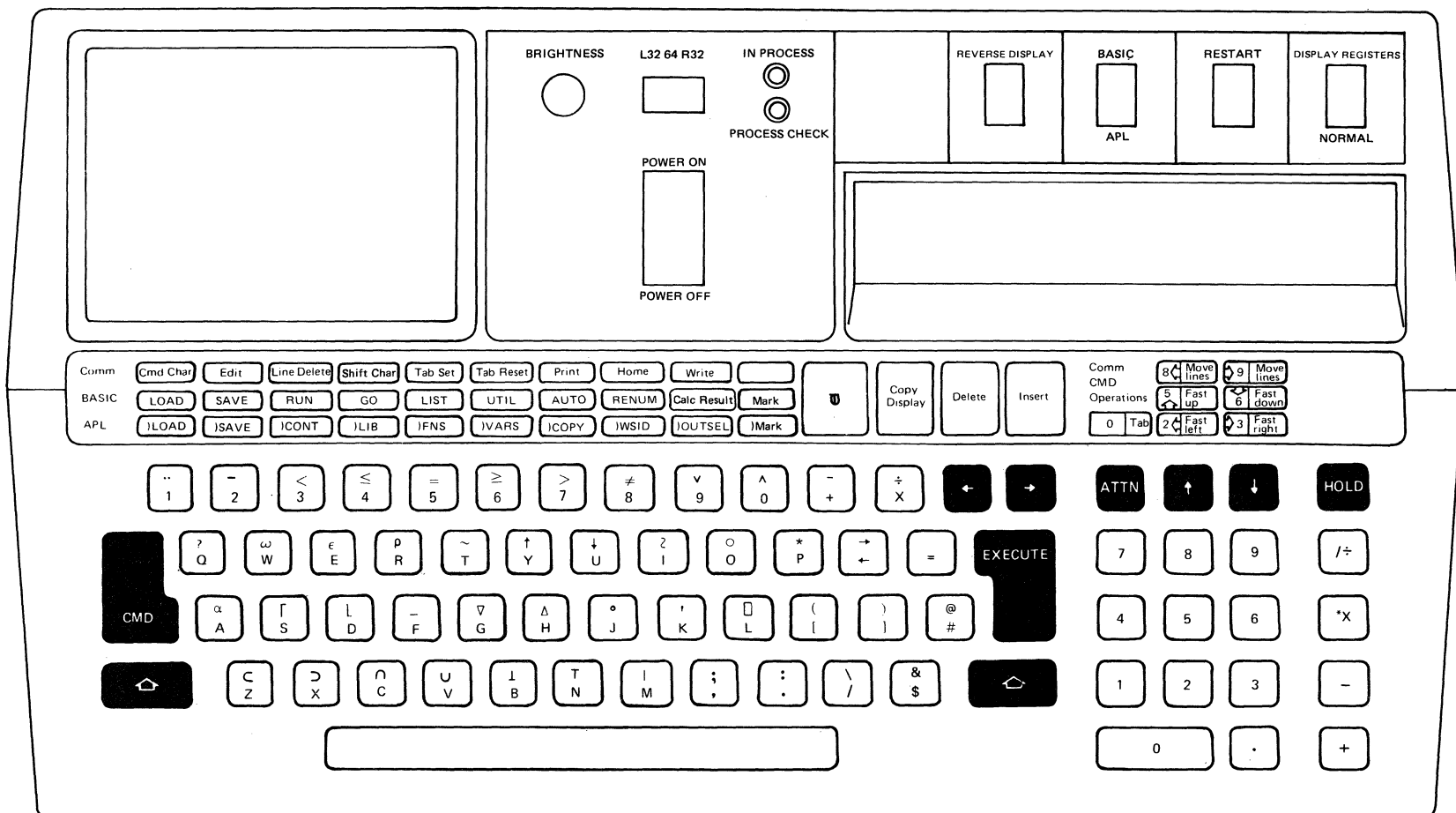
- 1** Tape Internal Cable
- 2** Jackshaft Housing Assembly
- 3** Select Magnet (forward)
- 4** Tape Unit Cable (external)
- 5** Spindle-Select Arm Assembly
- 6** Select Magnet (reverse)
- 7** Tape Control Card
- 8** Belt
- 9** Switch Assembly-File Protect (left) and Cartridge in Place (right)
- 10** Tape LED-PTX Assembly
- 11** Read/Write Head
- 12** Cartridge Stop (2)
- 13** Locking Wheel (4)
- 14** Fan Assembly (5110 only)
- 15** Capacitor
- 16** Tape Motor Assembly
- 17** Brake Arm Spring
- 18** Brake Arm



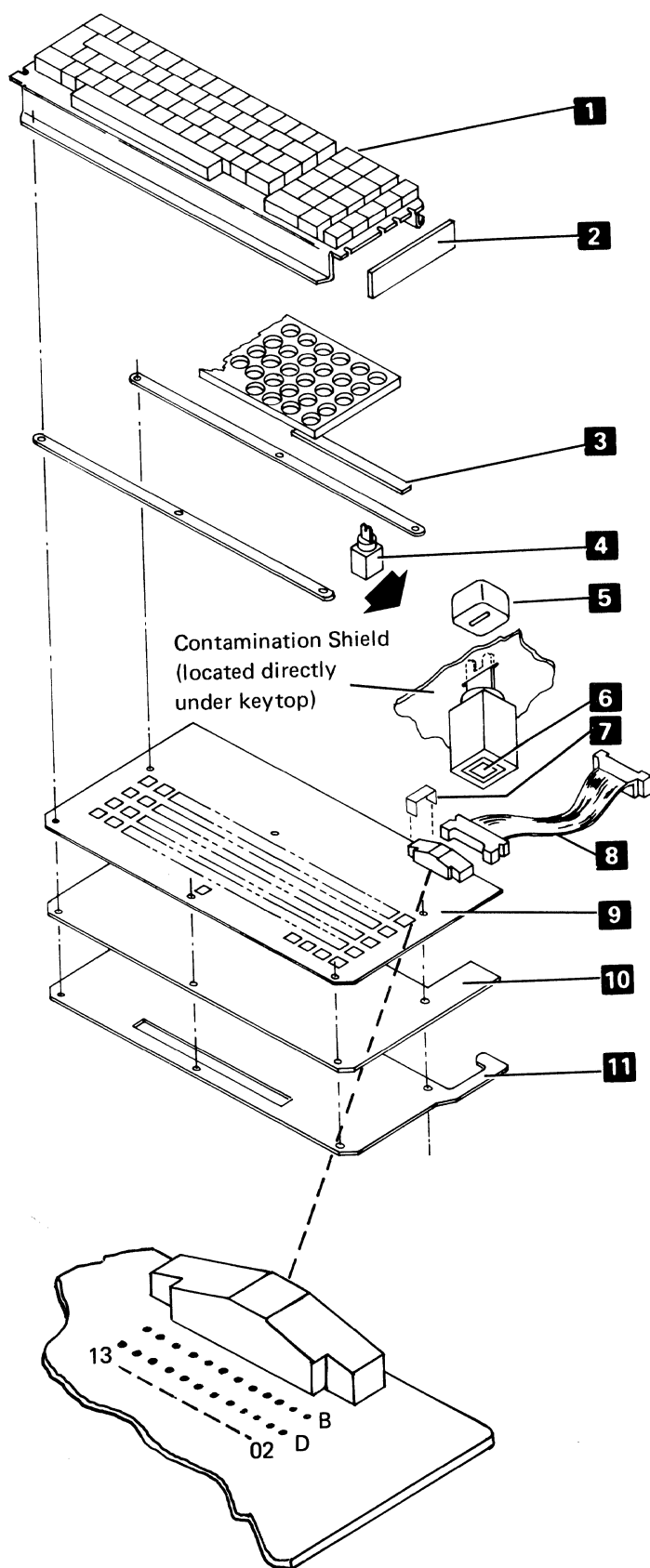
## 204 DISPLAY



Maintenance

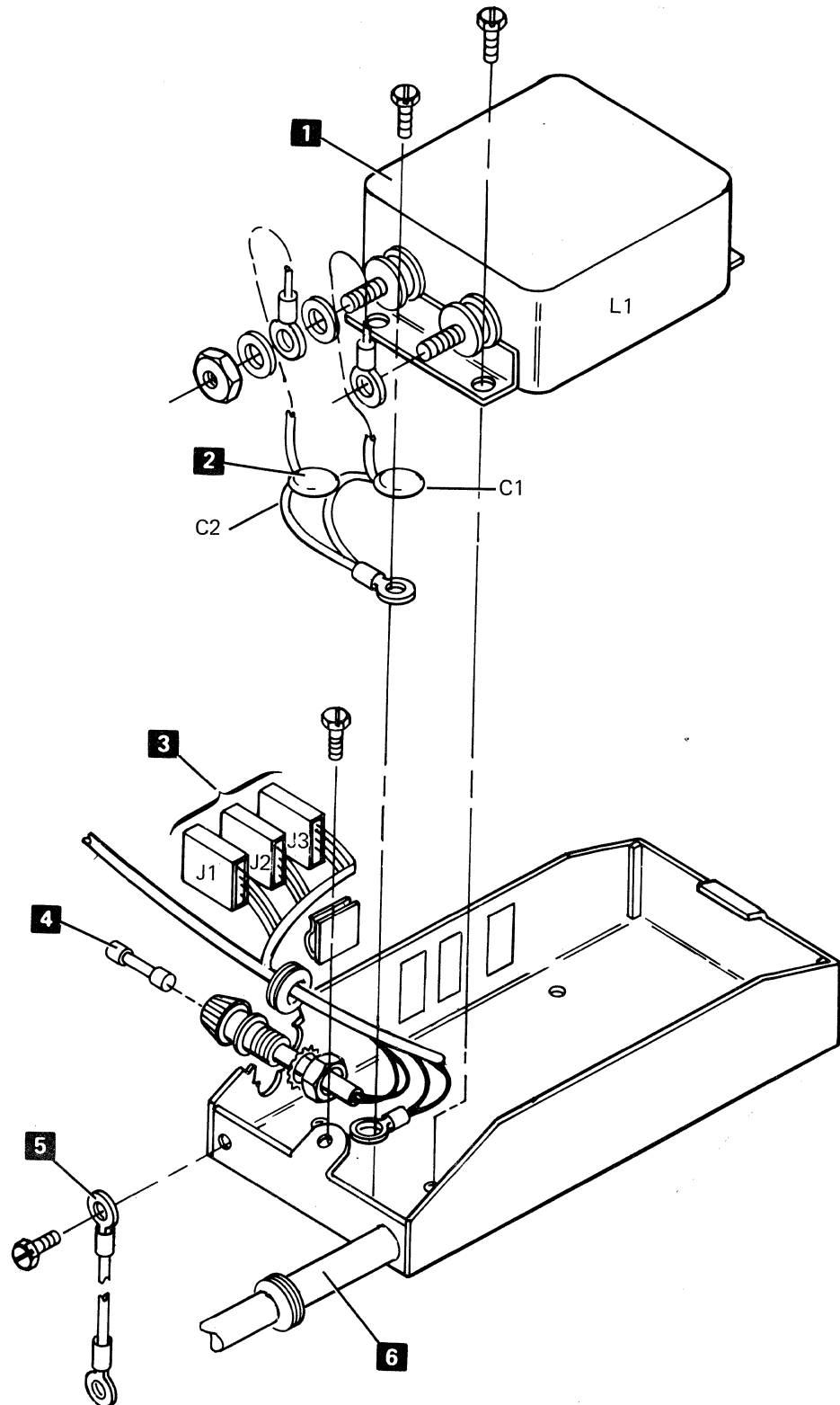


## 206 KEYBOARD



## 207 AC BOX

- 1** Line Filter (L1)
- 2** AC Capacitors (C1, C2)
- 3** AC Plug Sockets (J1, J2, J3)
- 4** Fuse (F1)
- 5** Display Unit Ground Wire
- 6** Line Cord



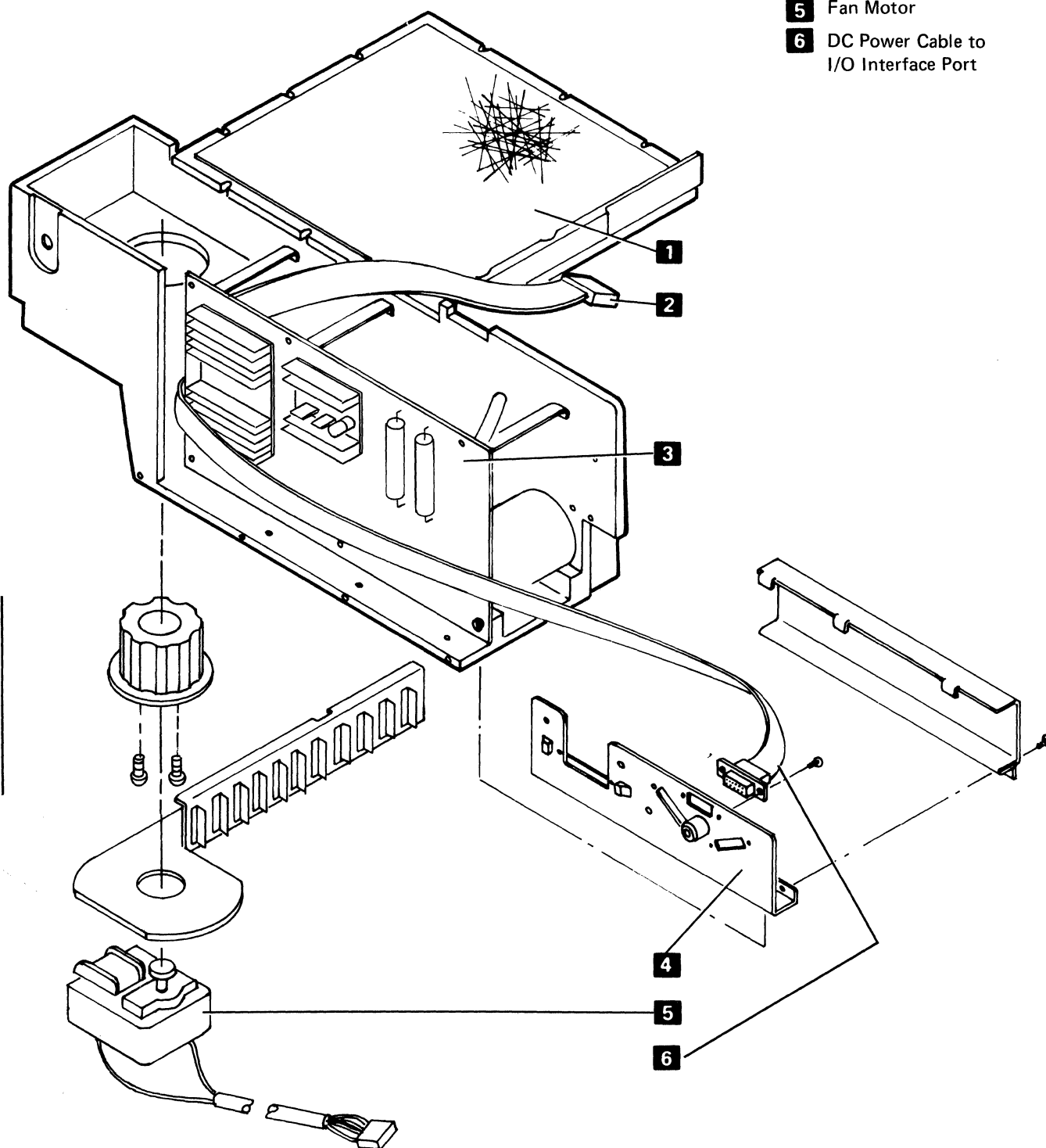
J1 – Power Supply  
 J2 – Fan  
 J3 – Tape Unit

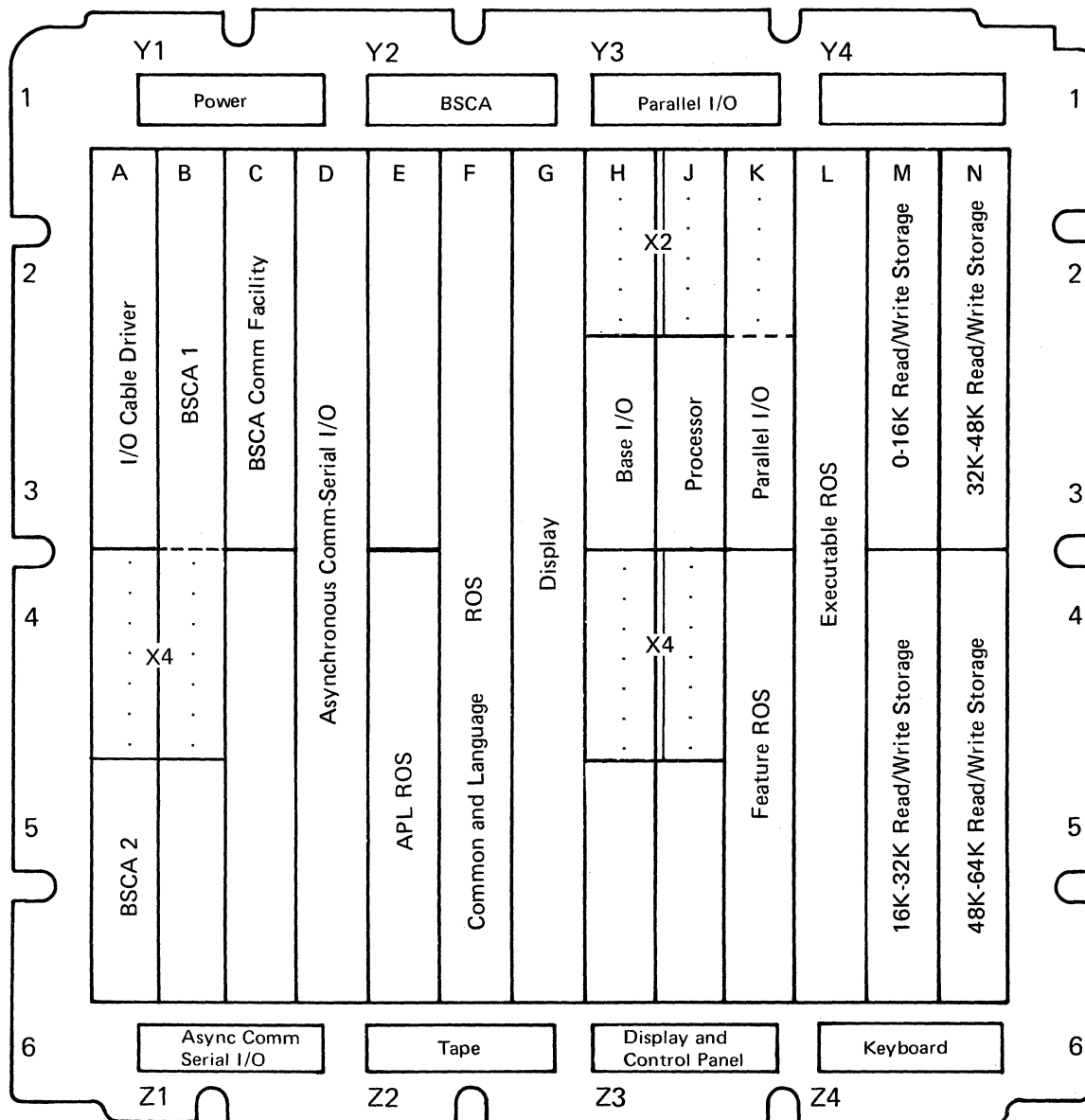


## 208 POWER SUPPLY

- 1** A1 Board
- 2** DC Power Cable (see 272)
- 3** Power Supply PC Board
- 4** Auxiliary I/O Interface Port
- 5** Fan Motor
- 6** DC Power Cable to I/O Interface Port

Maintenance



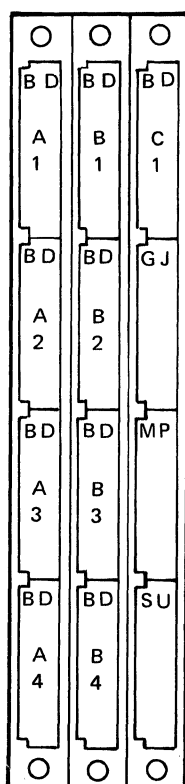


Note: See Section 050 in the Map binder for card part numbers and jumpering.

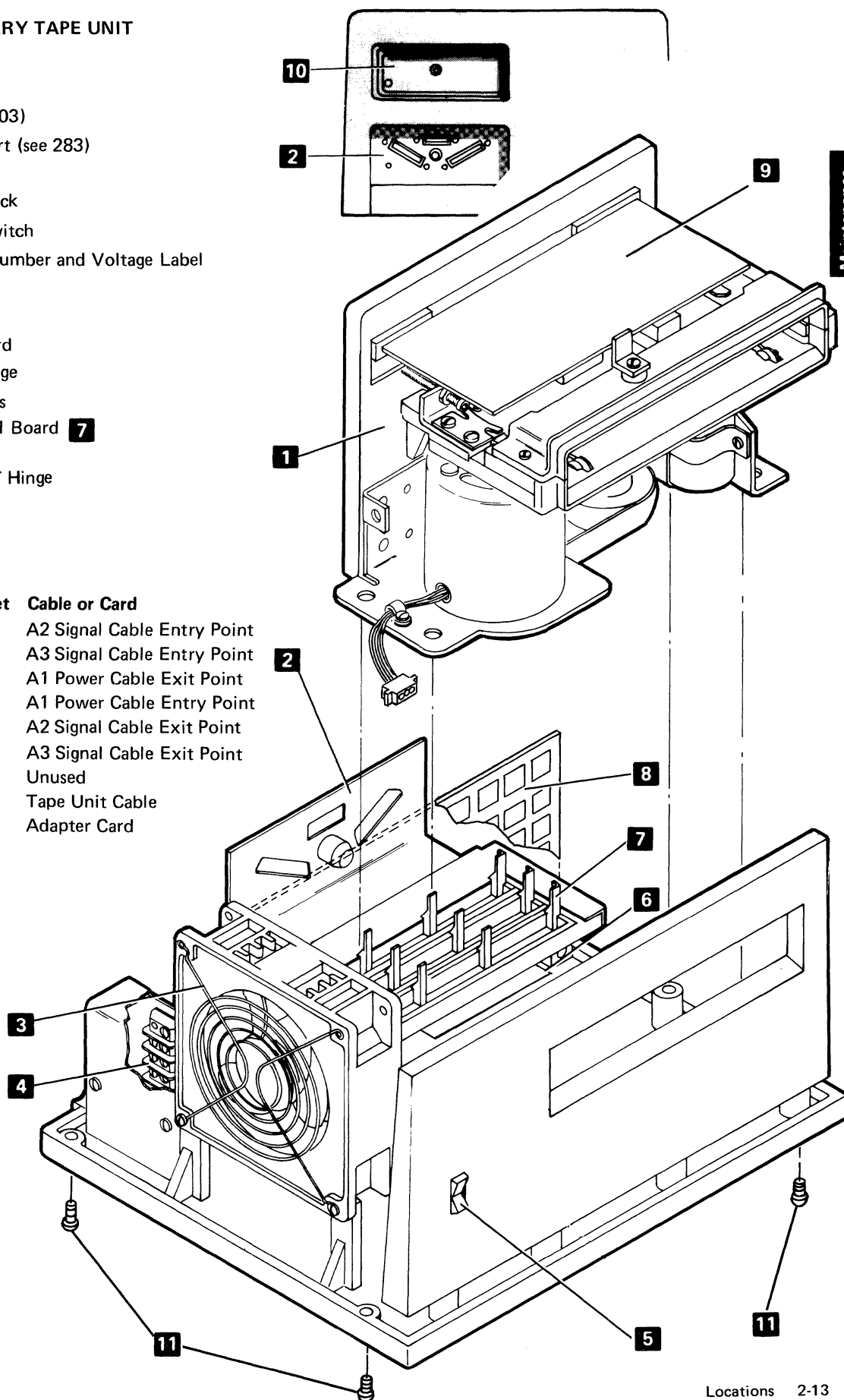
## 211 5106 AUXILIARY TAPE UNIT

- 1** Tape Unit (see 203)
- 2** I/O Interface Port (see 283)
- 3** Fan
- 4** AC Terminal Block
- 5** Power On-Off Switch
- 6** Machine Serial Number and Voltage Label
- 7** A1 Board (logic)
- 8** Adapter Card
- 9** Tape Control Card
- 10** Terminator Storage
- 11** Top Cover Screws

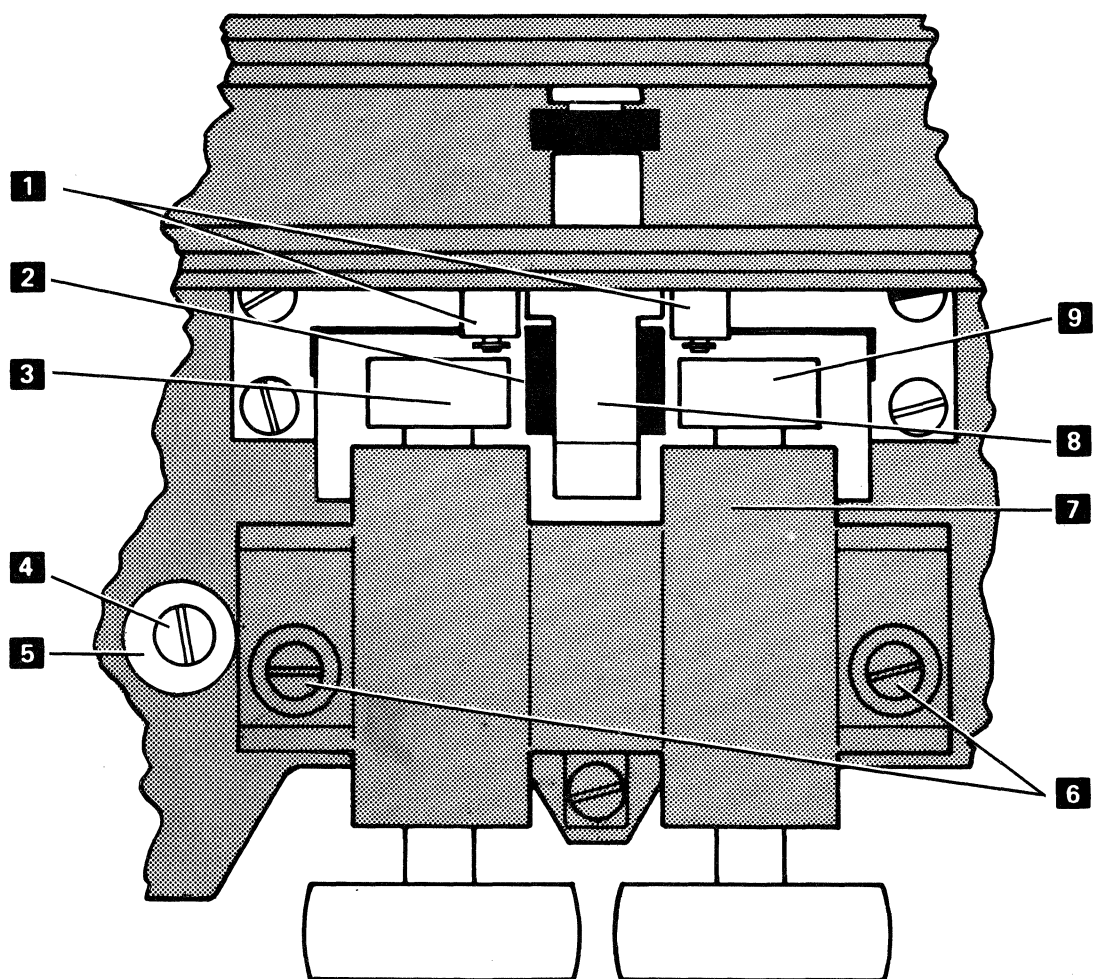
Auxiliary Tape Unit A1 Board **7**  
(plug side)



Socket	Cable or Card
A1	A2 Signal Cable Entry Point
A2	A3 Signal Cable Entry Point
A3	A1 Power Cable Exit Point
A4	A1 Power Cable Entry Point
B1	A2 Signal Cable Exit Point
B2	A3 Signal Cable Exit Point
B3	Unused
B4	Tape Unit Cable
C1	Adapter Card



## 220 JACKSHAFT HOUSING (Part 1 of 2)



## 220 JACKSHAFT HOUSING

(Page 2 of 2)

### Service Check

The jackshaft housing should be centered over the spindle. The jackshaft housing **7** is positioned at the factory using the stop washer **5** as a reference. Check that the jackshaft housing is touching the washer under the stop screw. Then check that the stop screw **4** is tight. If both of these conditions are OK and you still suspect a jackshaft housing problem, do the following:

1. Power down and remove the tape unit from its mounting.
2. Remove the fan.
3. Observe the slight side to side movement available between the spindle carrier arm **8** and the brake arms **1**. Notice that the arm can be easily moved in either direction until the spring tension on the brake arms are met, and with more difficulty as you overcome that tension.
4. Move the spindle carrier arm to the right until the tension of the brake arm spring is just met.
5. Measure the gap (with feeler gauges) between the spindle **2** and the left jackshaft roll **3**.
6. Move the spindle carrier arm **8** to the left until the tension of the brake arm spring is just met.
7. Measure the gap (feeler gauges) between the spindle **2** and the right jackshaft roll **9**. The difference between both measurements must be less than 0.003 inch (0.076 mm) or a jackshaft housing adjustment is necessary.

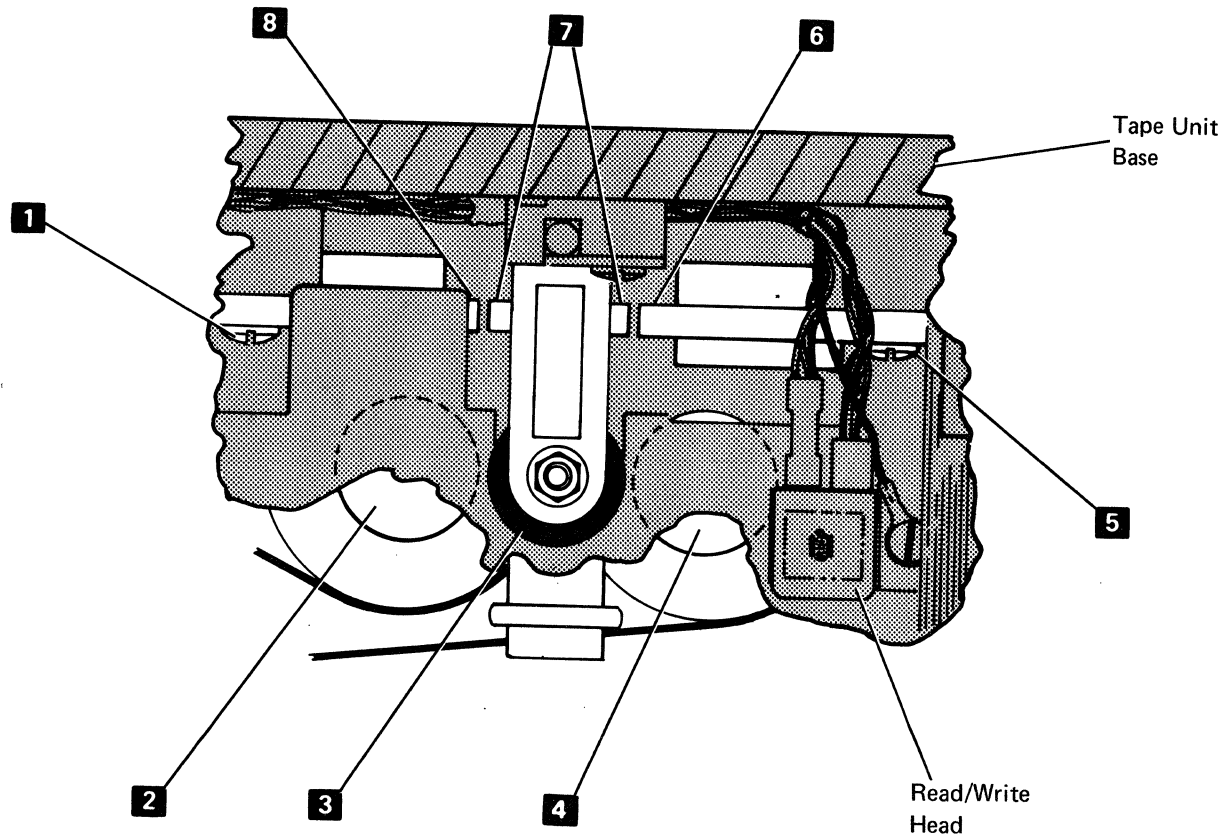
**Note:** If the jackshaft housing must be removed, and a readjustment of the housing is not intended, check to see that the stop washer is against the housing before you remove the housing.

### Adjustment

1. Power down and remove the tape unit from its mounting.
2. Remove the tape drive motor (two screws) and fan to access the jackshaft housing screws **6**.
3. Loosen the two jackshaft housing screws and the stop screw **4**.
4. Slide the jackshaft housing **7** from side to side and note that the unit moves easily until the spring tension is met. More effort is now required to move the unit. Slide the housing towards the stop screw and washer until the spring tension is just met. Tighten the left jackshaft housing mounting screw.
5. Locate the stop washer **5** against the jackshaft housing **7** and tighten the stop screw **4**.
6. Loosen the left jackshaft housing screw **6**. Slide the jackshaft housing to the right until you just meet the spring tension as in step 4. Tighten the left jackshaft housing mounting screw.
7. Measure and record the distance between the stop washer and the jackshaft housing. For example: 0.020 inches. Divide this in half, 0.010 inches, and place this size feeler gauge between the washer and the housing. Now loosen the left jackshaft housing screw and slide the unit to the left until the unit is firmly against the feeler gauge and the washer. Tighten both jackshaft housing screws. Loosen the stop screw, move the stop washer against the jackshaft housing, and retighten the stop screw.
8. Do not jackshaft housing service check.
9. Perform the select magnet service check (see 221).
10. Reinstall the motor and the belt if the service check is OK.

## 221 FORWARD AND REVERSE SELECT MAGNETS

(Page 1 of 3)



## 221 FORWARD AND REVERSE SELECT MAGNETS

(Page 2 of 3)

### Service Check

The jackshaft housing adjustment (220) must be correct before you make this service check.

1. Power down.
2. Remove the tape control card (203).
3. Jumper the following pins on the tape control card socket (230) to select the forward select magnet:  
  
S11 (+12) to B13 (select magnet return)  
U08 (gnd) to B12 (forward select magnet)
4. Insert a 0.009 feeler gauge between the magnet pole faces to be checked (forward **8**, reverse **6**) and the select arm armature **7**. Power up. (Also power up the 5106 Auxiliary Tape Unit if it is to be checked.) The spindle **3** should not rotate. (The jackshaft rolls **2** **4** should be running continuously.)
5. Power down.
6. Insert a 0.007 feeler gauge between the magnet pole faces to be checked (forward **8**, reverse **6**) and the select arm armature **7**.
7. Power up. The spindle **3** should rotate.
8. Power down.
9. Remove the jumpers installed in step 3.
10. Jumper the following pins on the tape control card socket (230) to select the reverse select magnet:  
  
S11 (+12) to D13 (reverse magnet return)  
U08 (gnd) to D12 (select reverse magnet)
11. Repeat steps 4 through 8 for the reverse select magnet. If this service check is OK, remove the jumpers and reassemble.

### Adjustment

The jackshaft housing adjustment (220) must be correct before you make this adjustment.

1. Power down and disconnect the tape unit motor AC cable (207). (J3 on the internal tape unit, quick disconnect on the 5106 Auxiliary Tape Unit.)
2. Remove the tape control card (225).
3. Remove the tape unit.
4. Remove the tape unit motor and fan (203).
5. Loosen the magnet mounting screws (either **1** or **5**) for the magnet being adjusted.
6. Connect jumpers as in step 10 of the *Service Check* for reverse magnet adjustment. Connect jumpers as in step 3 of the *Service Check* for the forward magnet adjustment.
7. Insert a 0.009 feeler gauge between the magnet pole face of the magnet to be adjusted (forward **8**, reverse **6**) and the select arm armature **7**.
8. Power up.
9. Move the magnet and the select arm together until the spindle **3** just touches the jackshaft roll **2** **4** in front of the magnet being adjusted. Tighten the magnet mounting screws **1** **5** slightly. Manually rotate the jackshaft roll. If the spindle turns, tap the magnet lightly to move the spindle away from the jackshaft roll. When properly adjusted, the magnet screws are tight with the spindle just clearing the jackshaft roll.
10. Power down and insert a 0.007 feeler gauge between the magnet pole face and the select arm armature **7**. Power up. If the spindle does not rotate, repeat step 9 of the adjustment procedure.
11. Starting at step 5 of the adjustment procedure, do the adjustment for the other select magnet. After making this adjustment, power down and remove the jumpers.
12. Reassemble in reverse order starting with step 4.

## 221 FORWARD AND REVERSE SELECT MAGNETS

(Page 3 of 3)

Run the following test to check out the tape unit adjustments:

Insert a known good scratch tape cartridge in the 5110 and mark 140 1K files starting at file one using the following table. (This destroys the contents of the tape). If an ALREADY MARKED (APL) or ERROR 566 (BASIC) message appears, press the ATTN key, scroll up one line, enter GO, and press the EXECUTE key.

### Internal Tape Unit

To mark a tape using APL, enter:

)MARK 1 140 1 press the EXECUTE key

After the tape is marked, enter the following and press the EXECUTE key after each line:

▽ F

[1] N←140

[2] 1□ SVO 'T'

[3] L:T←'IN',(5 0TN),'MSG=OFF'

[4] T← 0

[5] ←(0≠N←N-1)/L▽

F

To mark a tape using BASIC, enter:

MARK 1, 140, 1 press the EXECUTE key

After the tape is marked, enter the following and press the EXECUTE key after each line:

10 On ERROR GOTO 40

20 FOR 1=40 TO 1 STEP-1

30 OPEN FL1,'E80', 1, IN

40 CLOSE FL1

50 NEXT I

RUN

Watch the tape motion and listen to the drive. The tape should stop momentarily at each header. A correctly adjusted drive will result in a rhythmic operation. Read failures will cause retries and result in a broken rhythm or halt. If this occurs, the select magnet service check should be done again. If the service check is OK, run the tape read/write diagnostics.

An INVALID FILE ERROR (APL) or an ERROR 121 (BASIC) might occur as file 1 (all the tape on the right spool) tries to load. This is OK. Continue with the check-out using the tape diagnostics.

### 5106 Auxiliary Tape Unit

To mark a tape using APL, enter:

)MARK 1 140 1 2 Press the EXECUTE key

After the tape is marked, enter the following and press the EXECUTE key after each line:

▽ F

[1] N←140

[2] 1□ SVO 'T'

[3] L:T←'IN',(5 0T2000+N),'MSG=OFF'

[4] T← 0

[5] →(0≠N←N-1)/L▽

F

To mark a tape using BASIC, enter:

MARK 1, 140, 1, E40 press the EXECUTE key

After the tape is marked, enter the following and press the EXECUTE key after each line:

10 ON ERROR GOTO 40

20 FOR 1=140 TO 1 STEP-1

30 OPEN FL1,'E40', 1, IN

40 CLOSE FL1

50 NEXT I

RUN



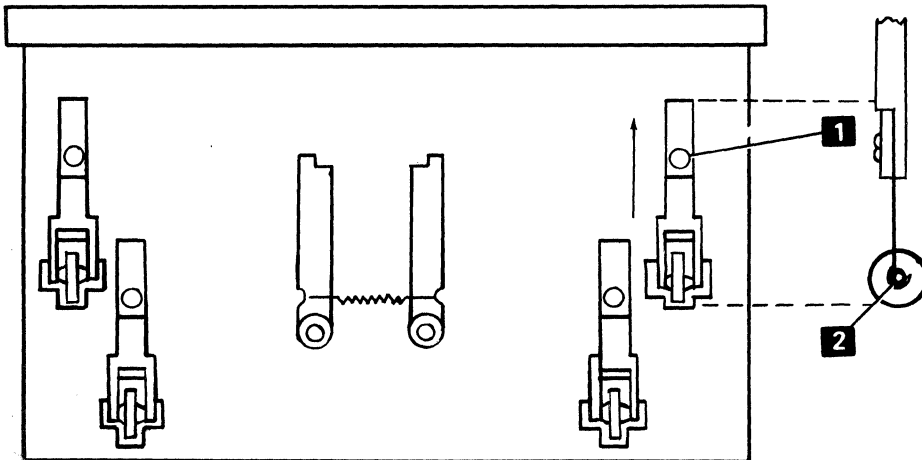
## 222 LOCKING WHEEL ASSEMBLY

### Adjustment

1. Remove the cartridge stops.
2. Loosen the locking wheel mounting screws **1**.
3. Position the locking wheel assembly (4) with the wheel shaft **2** as shown.
4. Slide the locking wheel assembly to the end of the slot as shown and tighten the mounting screws.
5. Adjust all four locking wheels in the same manner.

*Note:* All locking wheels must be adjusted properly to prevent slippage between the capstan and spindle.

6. Adjust the cartridge stops (223).



## 223 CARTRIDGE STOPS

### Service Check

1. Remove the tape control card.
2. Insert the stop gauge (part 1608780) **11** and observe that the leading edge of the middle pad **12** just touches the spindle **1**. Check for a *very slight* or no rocking action when pushing on the ends **10** of the stop gauge.
3. Adjust the stops **6** if the rocking action is significant or if the gap between the gauge and the spindle is greater than 0.002 inch (0.050 mm). If there is any rocking action and if you are not certain that the rocking action is significant, adjust the stops.

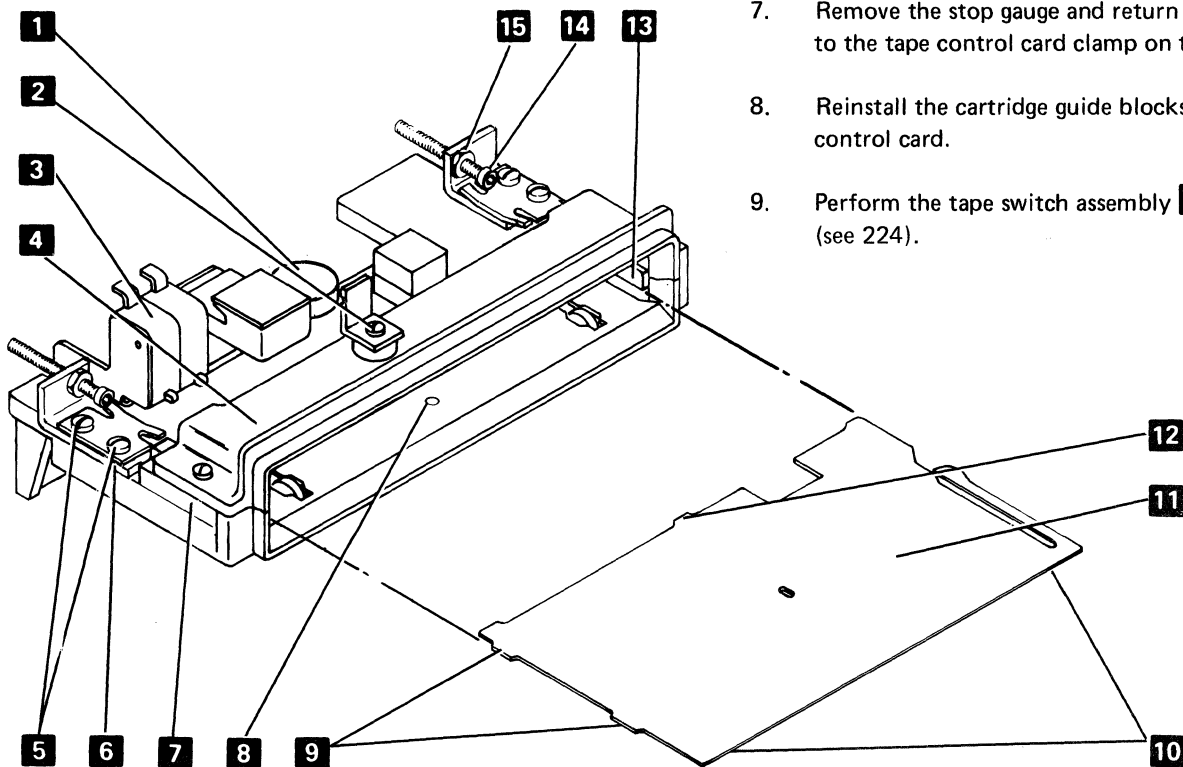
**Note:** A significant gap between the spindle and the stop gauge might inhibit the cartridge from seating against the spindle. A significant rocking action causes intermittent switch failures.

### Adjustment

1. Remove the tape control card (see 203).
2. Remove the bezel **4** (two screws) and both cartridge guide blocks **7**.
3. Loosen the four stop mounting screws **5**, the two jam nuts **15**, and the support screws **14** until the stops move freely.
4. Insert the stop gauge (part 1608780) **11** and locate it against the cartridge side guides **13** and against the spindle **1**. The two stop gauge side pads **9** must simultaneously touch their respective surfaces. Clamp the stop gauge to the upright **8** with the tape control card clamping screw **2**.
5. Position each stop **6** against the stop gauge and tighten the mounting screws **5**.

**Note:** The metal guide above the stop does not have a critical location.

6. Tighten the support screws **14** against the tape unit base until finger tight. Using an allen wrench, tighten the support screws another 1/8 turn (maximum). Then tighten the two jam nuts **15** against the stop. Check that the stop gauge has not moved away from the spindle.
7. Remove the stop gauge and return the clamping screw to the tape control card clamp on the bezel.
8. Reinstall the cartridge guide blocks, bezel, and tape control card.
9. Perform the tape switch assembly **3** adjustment (see 224).



## 224 TAPE SWITCH ASSEMBLY (CARTRIDGE IN PLACE SWITCH AND FILE PROTECT SWITCH) (Page 1 of 2)

### Service Check

Close the file protect window on the cartridge (turn the arrow 180 degrees away from SAFE). Remove the tape control card (see 203).

Insert a tape cartridge into the tape unit and tilt the cartridge away from the switches **1** by pushing the cartridge against the right stop **4**. Both switches must be made before the cartridge capstan **3** touches the spindle **2**. Next, position the cartridge capstan against the spindle and push the cartridge towards the switch assembly **1**. The cartridge must touch the left stop without touching the front of the switch assembly.

### Adjustment

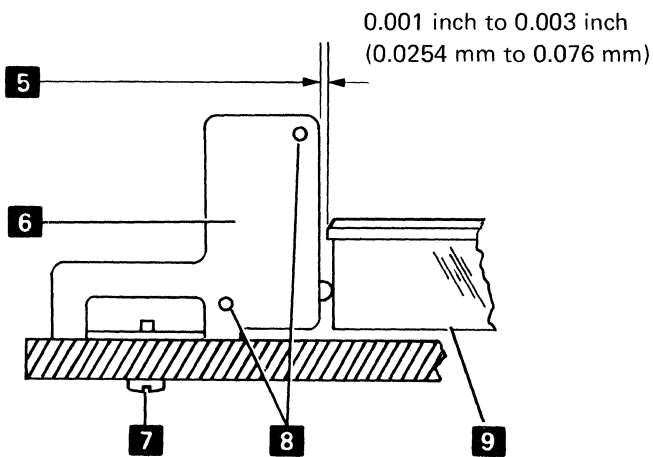
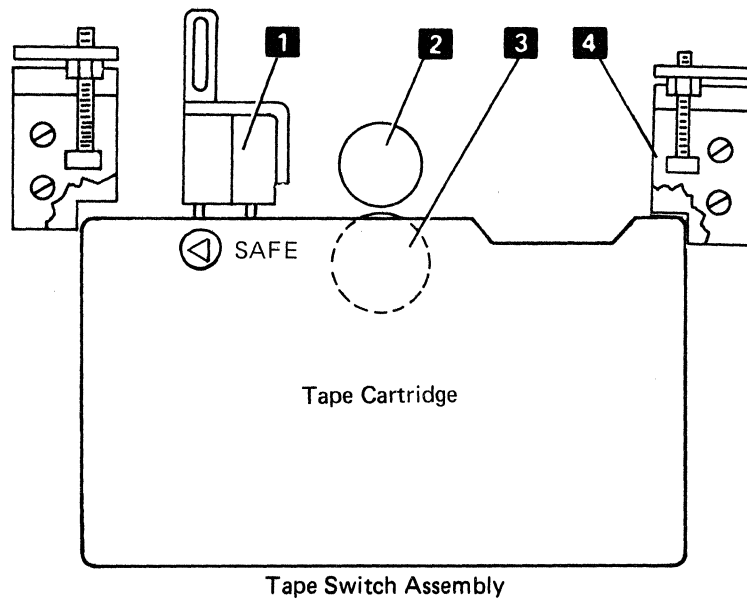
1. The cartridge stop blocks **4** and locking wheels (see 222) must be correctly adjusted before making this adjustment (see 223).
2. Power down. If the switch mounting bracket screw **7** is not accessible from the top remove the tape unit from its mounting. If the switch mounting bracket screw **7** is accessible from the top, then the tape unit does not have to be removed.
3. Check that the switches **1** are aligned to each other on the front of the switch assembly (the side facing the cartridge).

To align the switches:

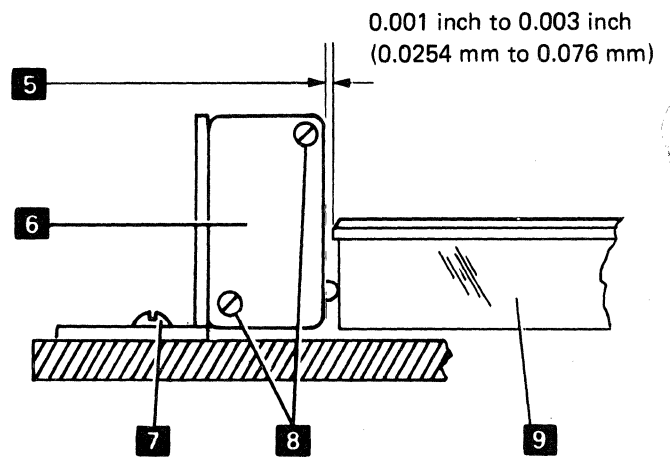
- a. If the switch mounting bracket screw is not accessible from the top, remove the switch assembly. Access to the screw **7** is provided through the motor pin locating slot **10**. Units that have the switch mounting bracket screw **7** accessible from the top do not need to have the switch assembly removed.
- b. Loosen the switch mounting screws **8** and move the switches toward the front of the switch assembly. Tighten the switch mounting screws (this provides maximum plunger travel).
- c. Reinstall the switch assembly; do not tighten the switch mounting bracket screw.

4. Insert a tape cartridge into the tape unit with the file protect window closed (turn the arrow 180 degrees away from SAFE).
5. Tilt the cartridge toward the switches (push cartridge on the left end).
6. Loosen the switch mounting bracket screw. Units that do not have the switch mounting bracket screw accessible from the top, have the access for the screw through the motor pin locating slot **10**. With the switch mounting bracket screw loose slide the switch mounting bracket **6** up until it just touches the tape cartridge **9**.
7. Move the switch bracket away from the tape cartridge 0.025 mm to 0.076 mm (0.001 inch to 0.003 inch) **5** and tighten the switch mounting bracket screw (this provides plunger overtravel).
8. Check the adjustment by doing the service check again.

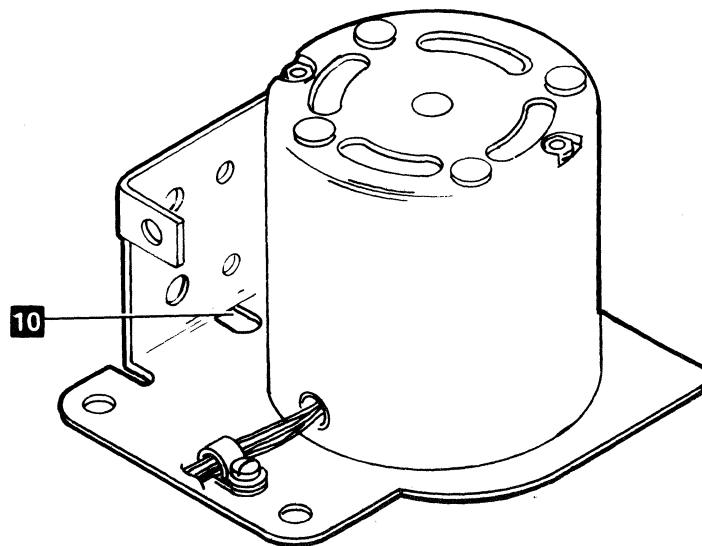
**224** TAPE SWITCH ASSEMBLY (CARTRIDGE IN  
PLACE SWITCH AND FILE PROTECT SWITCH)  
(Page 2 of 2)



Prior Style Tape  
Switch Assembly



Newer Style Tape Switch Assembly



## 225 READ/WRITE HEAD

### Removal

1. Power down.
2. Remove the tape control card **1**.
3. Remove the two plugs on the read/write head **3**.
4. Remove the read/write head mounting screw and the ground strap. Then lift the read/write head from the tape unit.

### Replacement

1. Reverse the removal procedure to install the read/write head. Use the adjustment procedure below.

*Note:* Check that the ground strap position allows the cartridge window to open.

2. Run DSP MDI 860 (tape write diagnostic).

### Adjustment

1. Loosen read/write head.
2. Move read/write head as far forward and as far to the left as possible.
3. Tighten mounting screws.

### Cleaning

1. Use a Kimwipes<sup>1</sup> (part 2162567) to remove loose dirt from the read/write head.
2. Remove tape oxide from the read/write head with isopropyl alcohol (part 2200200) on a Kimwipes<sup>1</sup> (part 2162567). Use a dry Kimwipes<sup>1</sup> to remove any remaining residue.

<sup>1</sup> Trademark of Kimberly-Clark Corporation

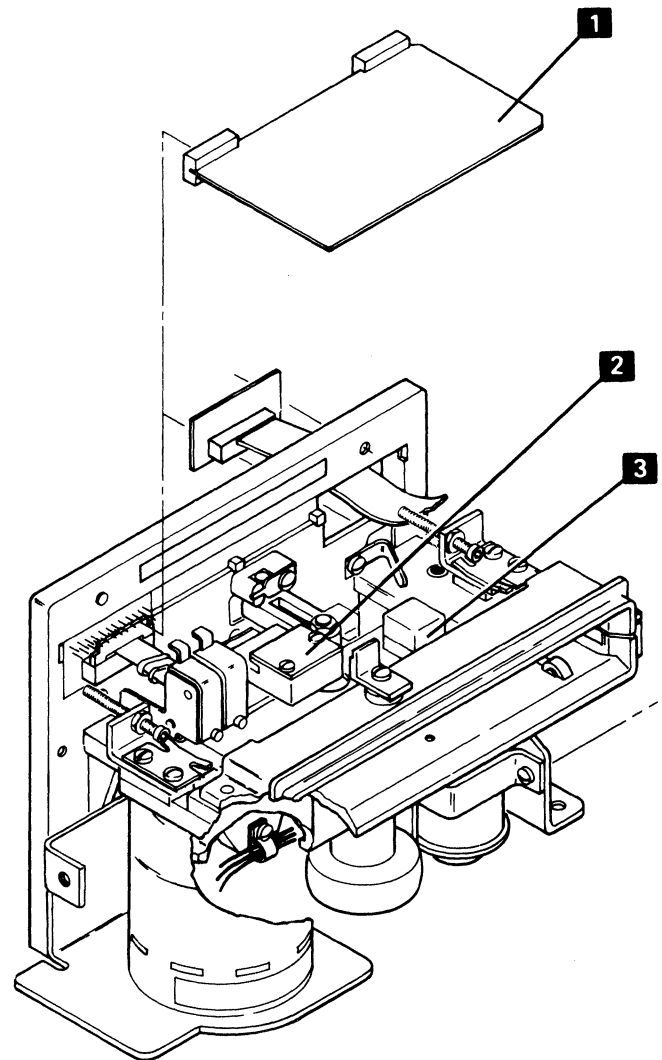
## 226 LED-PTX ASSEMBLY

### Removal

1. Power down.
2. Remove the tape control card **1**.
3. Remove the two plugs on the LED-PTX assembly **2**.
4. Remove the LED-PTX assembly mounting screws (2) and lift the LED-PTX assembly from the tape unit.

### Replacement

1. Reverse the removal procedure to install the LED-PTX assembly.
2. Run DSP MDI 860 (tape write diagnostic).



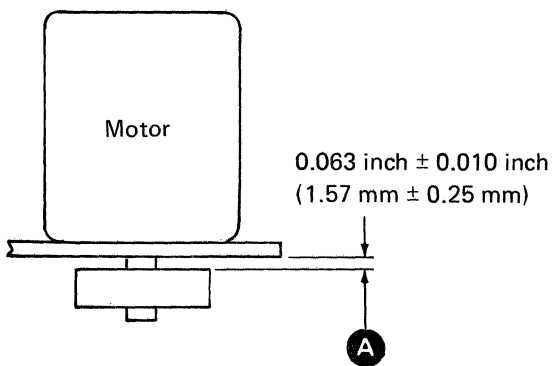
## 227 MOTOR PULLEY

### Service Check

1. Power down and remove the tape unit from its mounting.
2. Power up.
3. Check that the belt is tracking in the center of the motor pulley.

### Adjustment

1. Power down and remove the tape unit from its mounting.
2. Position the motor pulley  $0.063 \text{ inch} \pm 0.010 \text{ inch}$  ( $1.57 \text{ mm} \pm 0.25 \text{ mm}$ ) **A** from the motor mounting bracket and tighten the setscrew (initial setting).
3. Check the belt tracking with the power on. Adjust the motor pulley until the belt tracks in the center of the pulley.



## 228 TAPE POSITIONING AND REWIND

### Manual Tape Positioning

This procedure should be used to manually position the tape if there is very little tape (less than 7.5 feet [228.6 mm]) on one of the reels.

1. To determine if any holes are visible in the tape (see 229). If no holes are visible, observe which reel has the most tape. If the left reel **1** has the most tape, rotate the cartridge capstan **5** clockwise until the tape is past the load point hole **8**. If the right reel **2** has the most tape, rotate the cartridge capstan counterclockwise until the tape is past the early warning hole **7**.

2. When holes are visible, rotate the cartridge capstan according to the particular hole exposed as follows:

BOT **9** and EOT **10** —clockwise

EOT **6** only—counterclockwise

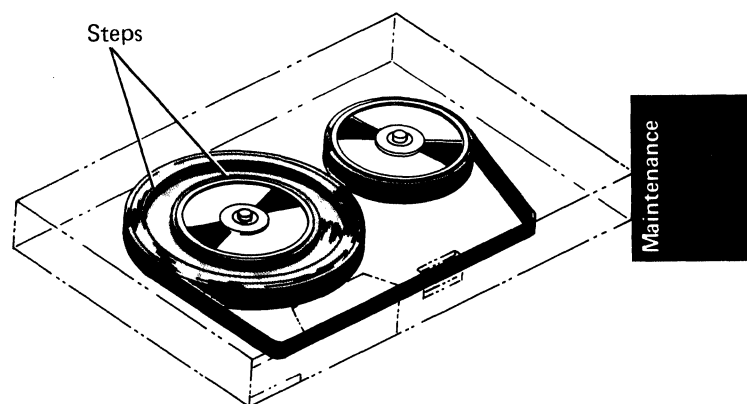
Early warning **7** (most tape on right reel)—counterclockwise

Load point **8** (most tape on left reel)—clockwise

Rotate the cartridge capstan until the tape is positioned between the early warning hole and the load point hole.

### Loose Tape Rewind

Use the following procedure if *steps* are visible in the reels of tape within the tape cartridge. The steps result from the tape cartridge being exposed to a drop in temperature exceeding 30° F (16.70 C).



1. Rewind the tape to the beginning and then find the last file number:

BASIC — REWIND, then UTIL to display the last file number.

APL — )REWIND, then )LIB to display the last file number.

*Note:* If the cartridge is new, omit the UTIL or )LIB operation.

2. Turn the file protect window away from SAFE.
3. Mark the remainder of tape beyond the last file. Use the last file number displayed in step 1:

BASIC — MARK 16, 200, n

APL — )MARK 16 200 n

n = last file number plus 1

*Note:* The mark operation can be performed for file sizes other than 16K bytes.

The above mark operations should return error code 012-APL or 151-BASIC. If any other errors occur, repeat steps 1 through 3.

4. Rewind the entire tape using one of the following:

BASIC — REWIND

APL — )REWIND

## 229 TAPE RETHREADING

1. Lay the tape cartridge on a flat surface with the backplate **A** facing upward.
2. Remove the four mounting screws **B**.

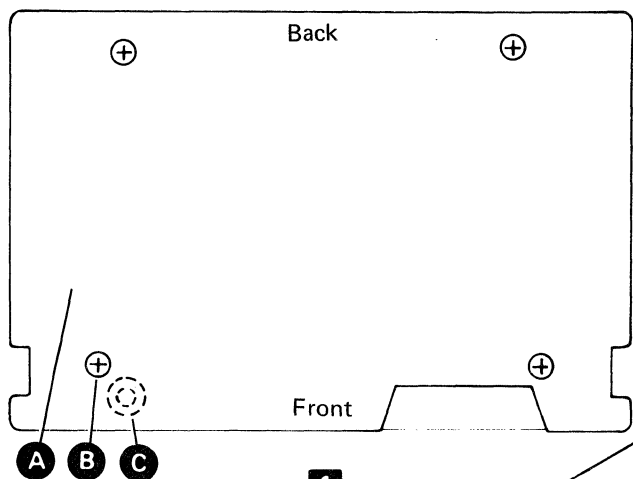
### CAUTION

Leave the plastic cover upside down or the SAFE window and the washer **C** will fall out.

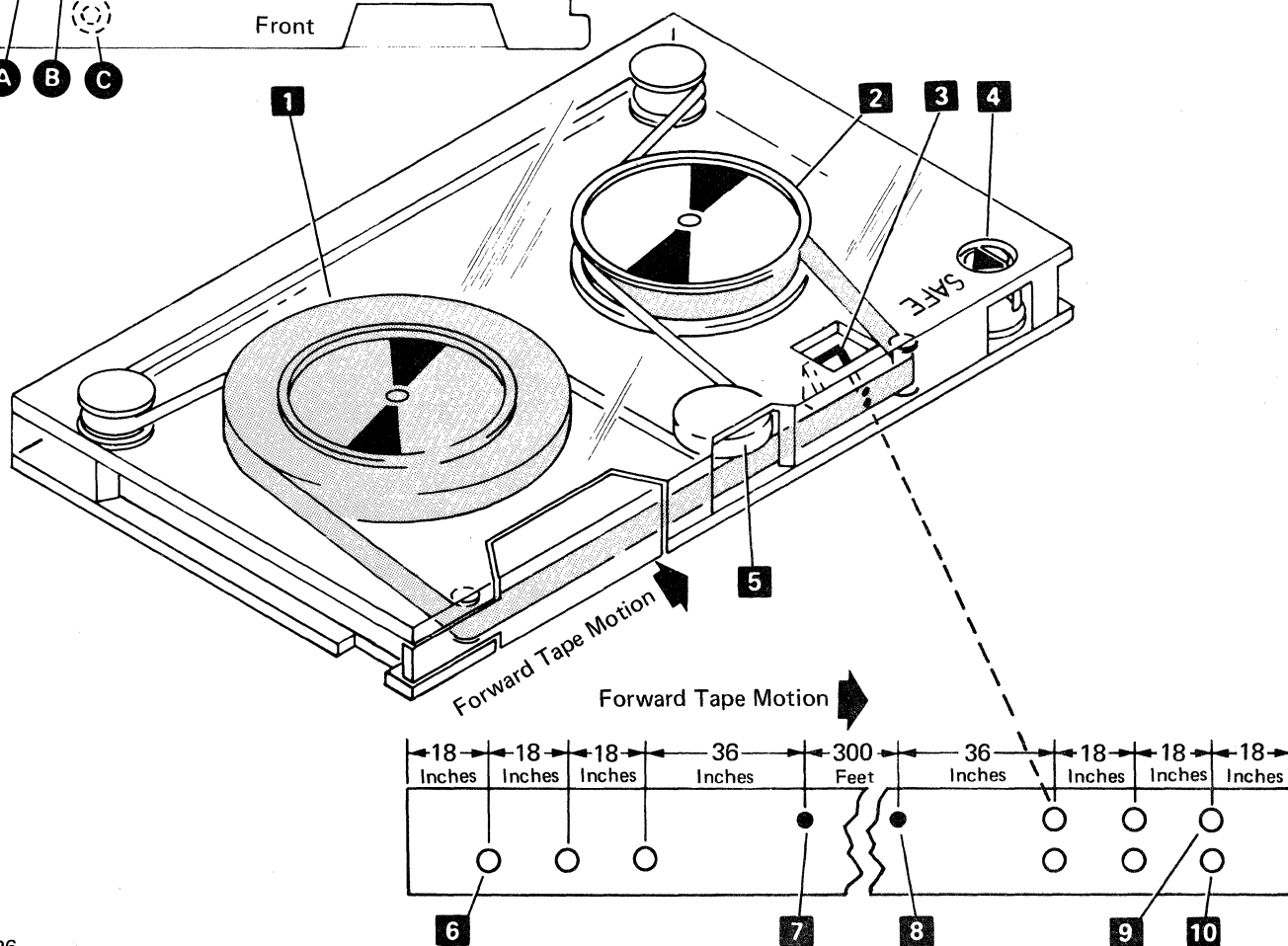
3. Tilt the back edge of the backplate up while lifting the backplate from the plastic cover.
4. Lay the backplate on a flat surface with the tape reels facing upward.
5. Thread the tape as shown. Moisten the first inch of tape on the side facing the reels and stick the tape to the reel.

### CAUTION

Take up all tape slack before sticking the tape to the reel.

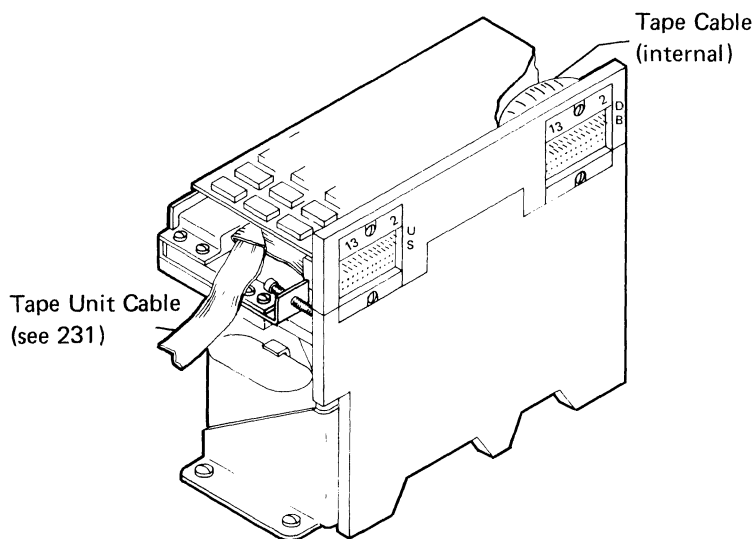


6. Rotate the cartridge capstan **5** to wind the tape on the reel. Rotate until the load point **8** or early warning **7** holes pass the mirror **3**.
7. Fasten the backplate to the plastic cover with the four screws removed in step 2.
8. Check that the SAFE window **4** operates correctly.





## 230 TAPE CONTROL CARD PIN ASSIGNMENTS



Pin	Line Name	Pin	Line Name
-----	-----------	-----	-----------

### To Internal Cable

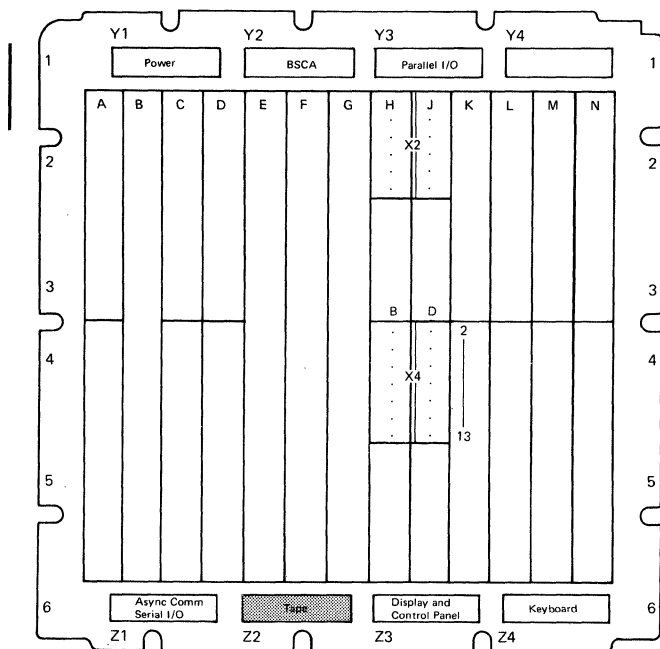
B02	-Erase Channel 0	D02	-Erase Channel 1
B03	+5 Vdc	D03	+5 Vdc
B04	+Channel 0 Coil	D04	+Channel 1 Coil
B05	+Channel 0 Center Tap	D05	+Channel 1 Center Tap
B06	-Channel 0 Coil	D06	-Channel 1 Coil
B07	-Cartridge in Place	D07	+File Protect
B08	Ground	D08	Ground (cable shield)
B09	-Raw Data (read data)	D09	-Raw Data (read data)
B10	+EOT PTX	D10	+BOT PTX
B11	+LED	D11	+12 Vdc
B12	-Forward Magnet Drive	D12	-Reverse Magnet Drive
B13	+12 Vdc	D13	+12 Vdc

### To Tape Unit Cable

S02	-EOT	U02	+Tape Clock
S03	-Erase Inactive	U03	+5 Vdc
S04	-BOT	U04	-Forward
S05	-Diagnostic Mode	U05	-Run
S06	-5 Vdc	U06	-Write Enable
S07	-LED and Erase OK	U07	-Write Data
S08	Ground	U08	Ground
S09	-Read Data	U09	-Channel Select
S10	-Read Clock	U10	-Channel 0 Erase
S11	+12 Vdc	U11	-Channel 1 Erase
S12	-Cartridge in Place	U12	-Select Magnet Active
S13	-12 Vdc	U13	+File Protect

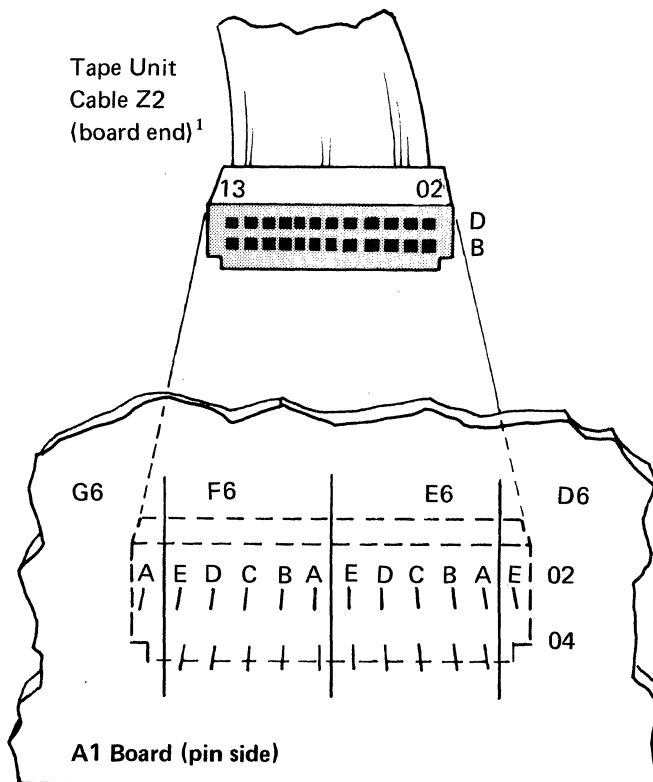
## 231 INTERNAL TAPE – Z2 SOCKET PIN ASSIGNMENTS

**A1 Board (card side)**



See 230

Tape Unit  
Cable Z2  
(board end)<sup>1</sup>

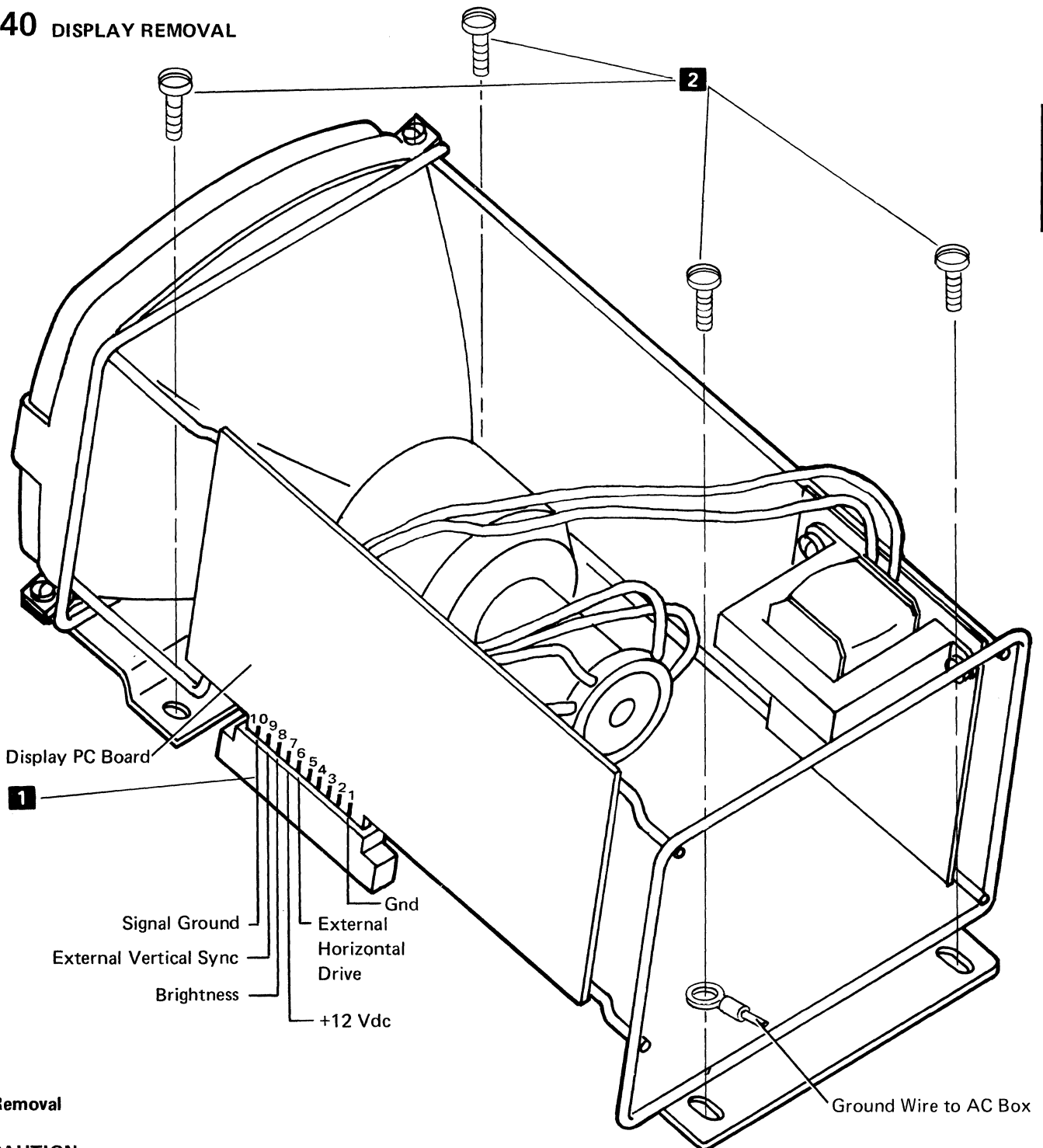


Z2 Cable Pin	A1 Board Pin	Line Name	Tape Control Card Pin	Z2 Cable Pin	A1 Board Pin	Line Name
D02	D6E02	-EOT	S02	U02	B02	+Tape Clock
D03	E6A02	-Erase Inactive	S03	U03	B03	+5 Vdc
D04	E6B02	-BOT	S04	U04	B04	-Forward
D05	E6C02	-Diagnostic Mode	S05	U05	B05	-Run
D06	E6D02	-5 Vdc	S06	U06	B06	-Write Enable
D07	E6E02	-LED and Erase OK	S07	U07	B07	-Write Data
D08	F6A02	Ground	S08	U08	B08	Ground
D09	F6B02	-Read Data	S09	U09	B09	-Channel Select
D10	F6C02	-Read Clock	S10	U10	B10	-Channel 0 Erase
D11	F6D02	+12 Vdc	S11	U11	B11	-Channel 1 Erase
D12	F6E02	-Cartridge in Place	S12	U12	B12	-Select Magnet Active
D13	G6A02	-12 Vdc	S13	U13	B13	+File Protect

<sup>1</sup> See 230 for tape unit end of cable Z2

# Display

## 240 DISPLAY REMOVAL



### Removal

#### CAUTION

Display assembly voltages:  
 Display PC board 340 V  
 CRT 9 KV

1. Power down.
2. Remove the connector **1** at the display PC board.
3. Remove the four mounting screws **2**.
4. Remove the display assembly.

## 241 BRIGHTNESS CONTROL

### Service Check

When you press the bottom of the REVERSE DISPLAY switch, the BRIGHTNESS control adjusts the brightness of the white background. When you press the top of the REVERSE DISPLAY switch, the BRIGHTNESS control adjusts the brightness of the white characters on a dark background.

## 242 REVERSE DISPLAY SWITCH

### Service Check

1. With the BRIGHTNESS control set to the center of its range, press the bottom of the REVERSE DISPLAY switch. The characters displayed should be black on a white background.
2. Press the top of the REVERSE DISPLAY switch. The characters displayed should be white on a black background.

## 243 DISPLAY REGISTERS/NORMAL SWITCH

### Service Check

1. Switch the DISPLAY REGISTERS/NORMAL switch to the NORMAL position.
2. Press 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.

## 244 L32-64-R32 SWITCH

### Service Check

1. Set the DISPLAY REGISTERS/NORMAL switch to the DISPLAY REGISTERS position.
2. Set the L32-64-R32 switch to the 64 position. Each display line should show 64 characters.
3. Set the switch to the L32 position. Each display line should show the left 32 characters with blanks between each character.
4. Set the switch to the R32 position. Each display line should show the right 32 characters with blanks between each character.

## 245 RESTART SWITCH AND LAMP TEST

### Service Check

1. The RESTART switch resets all circuits and initiates the bring up program. When pressed, it supplies voltage to test the lamps.
2. Press 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.

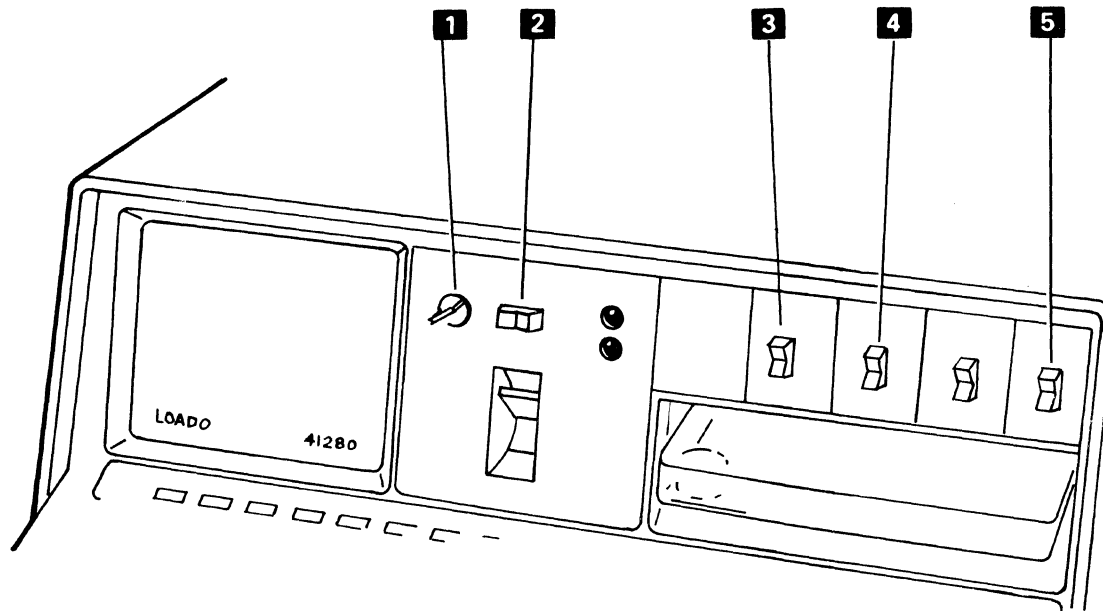
## 246 BASIC – APL SWITCH

### 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, press the RESTART switch. LOAD0 should appear on the display within 25 seconds.
3. Set the BASIC–APL switch to the APL position, press the RESTART switch. CLEAR WS should appear on the display within 25 seconds.

## 247 DISPLAY RASTER ADJUSTMENTS

(Page 1 of 3)



Maintenance

**Note:** The above illustration shows the 5-inch display and control panel. With the REVERSE DISPLAY switch **3** in the *down* position and the BASIC-APL switch **4** in the BASIC position, all characters appear as black characters on a white background (the white background is the raster). With the REVERSE DISPLAY switch **3** in the *up* position, the characters are white and the background is dark.

For the following display raster adjustments, position the L32-64-R32 switch **2** to the 64 or center position and the DISPLAY REGISTERS/NORMAL switch **5** to the DISPLAY REGISTERS position.

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

One of the two types of video display cathode ray units is supplied. One of the display units does not have the horizontal linearity sleeve (see 247, part 2 of 3 item **3**) or a horizontal linearity adjustment potentiometer. Both units carry the same part number.

### 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 **1** on the control panel. Brightness is used instead of contrast because brightness better describes what is happening to the display screen.

This adjustment ensures minimum adjustment of the BRIGHTNESS control **1** when you are changing the position of the REVERSE DISPLAY switch **3**.

1. Center the BRIGHTNESS control **1** on the control panel.
2. Press the top of the REVERSE DISPLAY switch **3** for a dark background on the display screen.
3. 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:

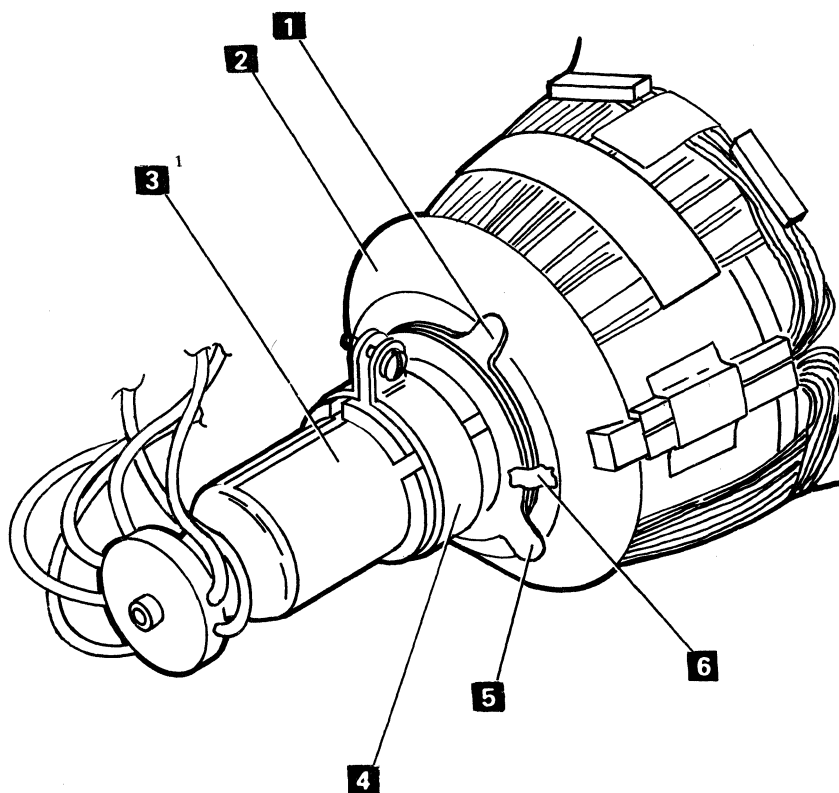
1. Press the bottom of the REVERSE DISPLAY switch.
2. Break the adhesive **6** that seals the ring magnets in place.
3. Adjust the rear ring magnet **5** for horizontal centering.

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:

*Note:* If this adjustment is necessary, mark the position of the horizontal linearity sleeve **3** in case it moves<sup>1</sup> while you are adjusting the yoke.

1. Loosen the yoke collar **4**.
2. Adjust the yoke to correct the tilted display.
3. Tighten the yoke collar.



<sup>1</sup> Not all units are equipped with a horizontal linearity sleeve.

## 247 DISPLAY RASTER ADJUSTMENTS

(Page 3 of 3)

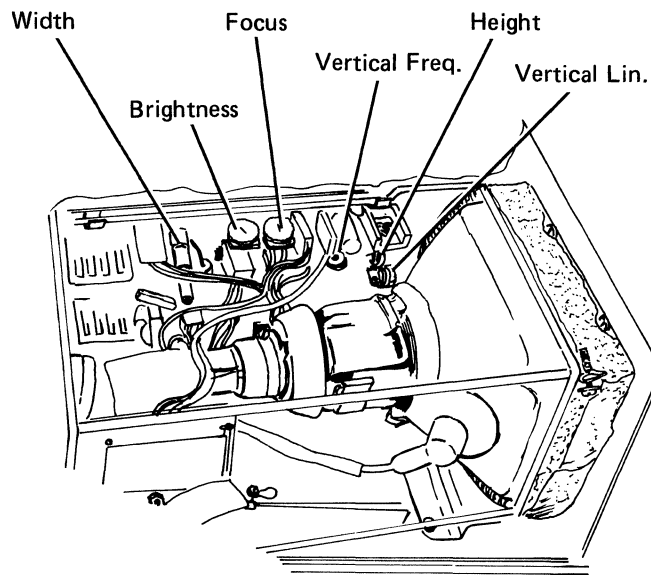
### Horizontal

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, be sure the display is centered properly.

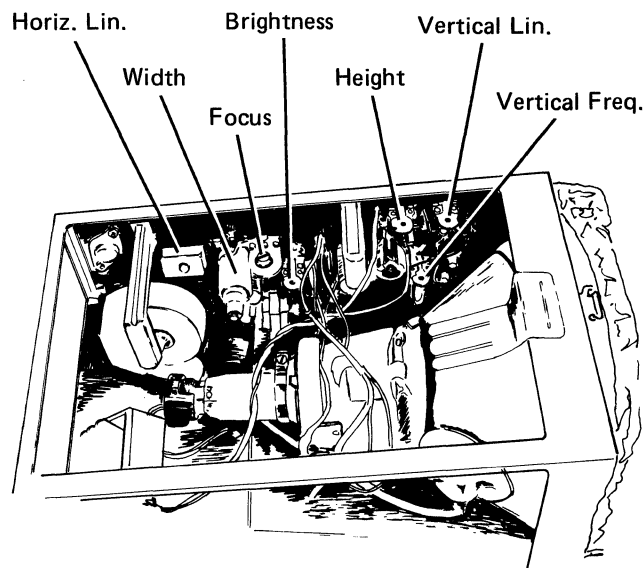
### Vertical

The vertical adjustments (height, linearity, and frequency) 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. If the linearity or height needs adjusting, and the unit has a horizontal linearity sleeve, remove the front cover for easier access to the potentiometers, (see 200).
2. Adjust the vertical frequency potentiometer for a stable display.
3. Adjust the height potentiometer until the desired overall height of the 16 lines is achieved. The vertical frequency might have to be adjusted to keep the display from rolling.
4. 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.
5. Adjust the vertical frequency potentiometer until the display begins to roll, then reverse the adjustment until the rolling stops.
6. Recheck the height and the linearity.
7. Replace the front cover if you removed it in step 1.



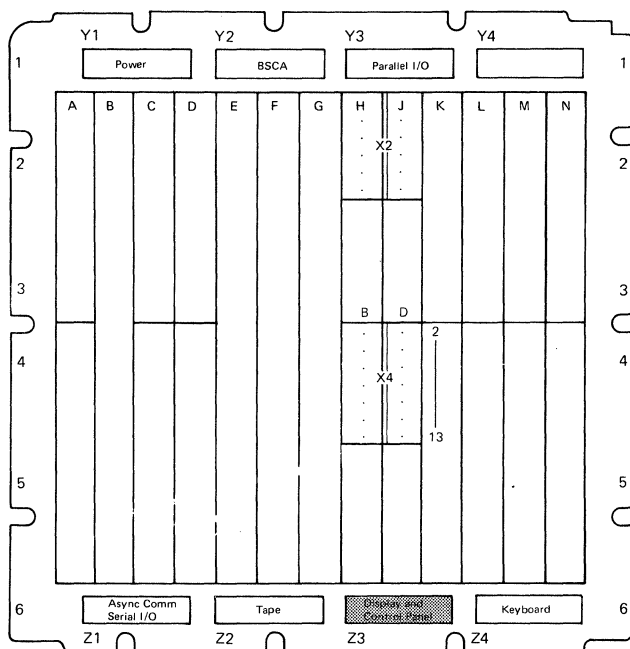
Video display unit with horizontal linearity sleeve



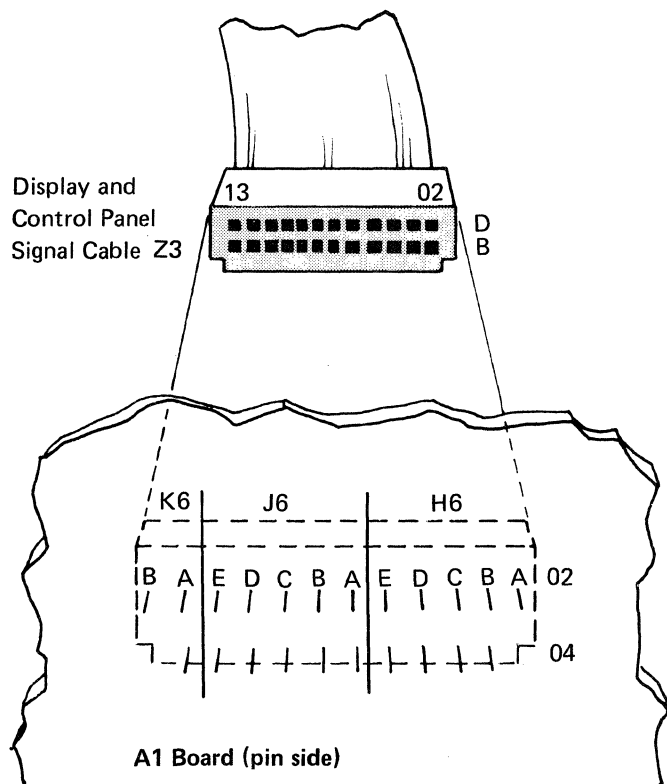
Video display unit without horizontal linearity sleeve

## 248 DISPLAY – Z3 SOCKET PIN ASSIGNMENTS

A1 Board (card side)



See 204, 249

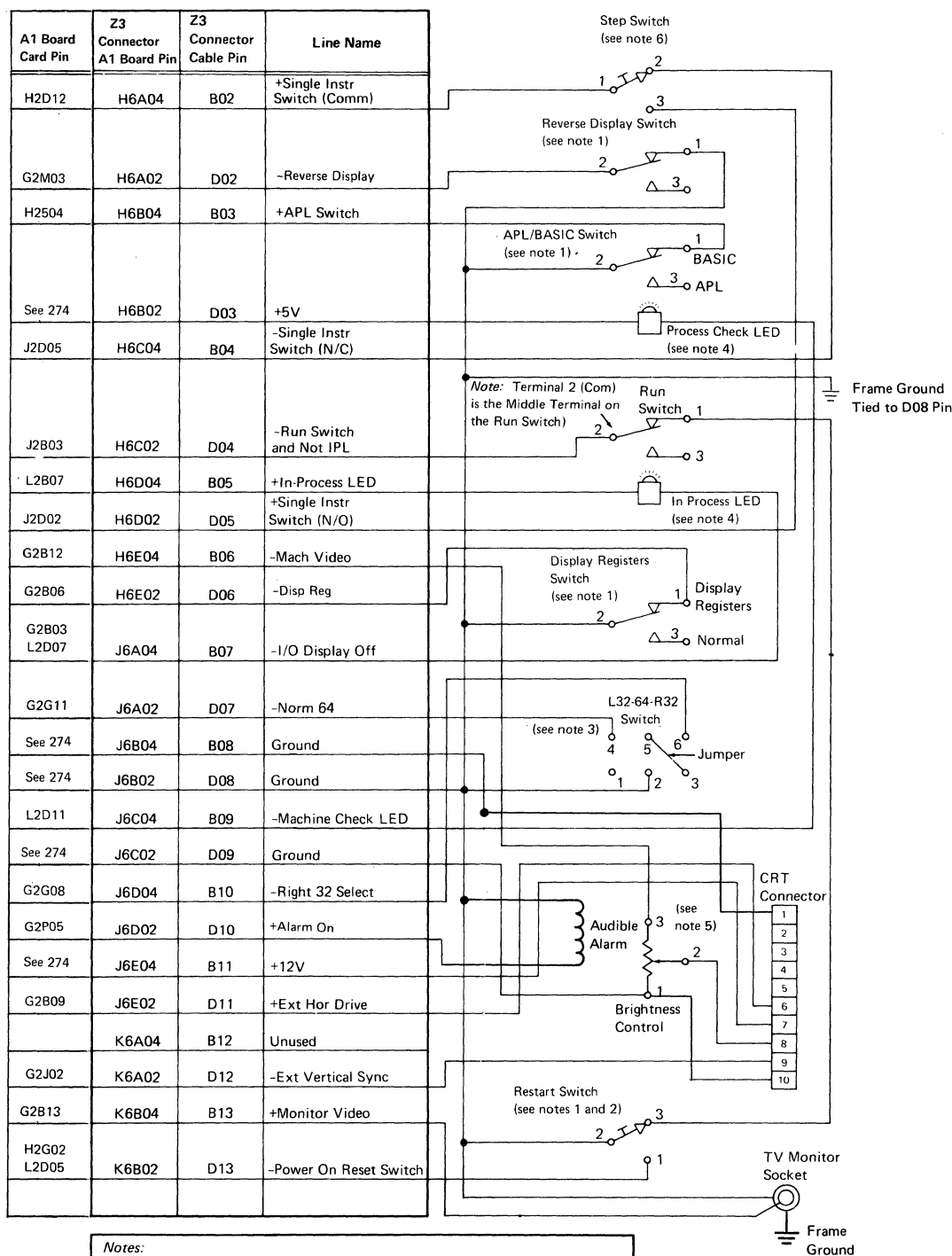


Z3 Cable Pin	A1 Board Pin	Line Name	Z3 Cable Pin	A1 Board Pin	Line Name
D02	H6A02	-Reverse Display	B02	H6A04	+Single Instruction Switch (common)
D03	H6B02	+5 Vdc	B03	H6B04	+APL Switch
D04	H6C02	-Run Switch and Not IPL	B04	H6C04	-Single Instruction Switch (N/C)
D05	H6D02	+Single Instruction Switch (N/O)	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	B10	J6D04	-Right Select 32
D11	J6E02	-External Horizontal Drive	B11	J6E04	+12 Vdc
D12	K6A02	-External Vertical Sync	B12	K6A04	(not used)
D13	K6B02	-Power On Reset Switch	B13	K6B04	+Monitor Video



# 249 DISPLAY AND CONTROL PANEL CABLE

## Z3 Connector to CRT Connector and Control Panel Switches



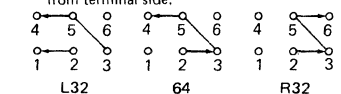
### Notes:

1. Top of switch when in machine.

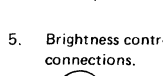


2. Mount in machine with spring up.

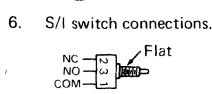
3. Switch contact positions. View from terminal side.



4. White dot or short lead to minus pin.



5. Brightness control connections.



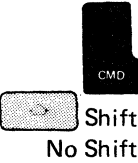
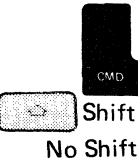
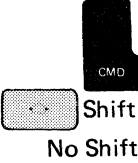
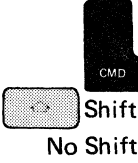
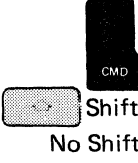
6. S/I switch connections.



## Keyboard

### 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								
	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			
														*	*		*	*				
	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				
	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		

\*Typamatic Key

See the keyboard theory

**Example:** C = Key Code A 9

Key Code

X—A—X      X—9—X  
8    4    2    1    8    4    2    1

Keyboard Bits (see 255)

-Kbd0 -Kbd1 -Kbd2 -Kbd3 -Kbd4 -Kbd5 -Kbd6 -Kbd7 P

Level

+    -    +    -    +    -    -    +    -

## 251 KEYBOARD

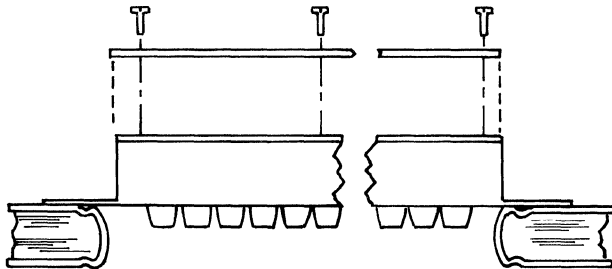
### Removal

1. Power down.
2. Remove the top cover and the front cover.
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. Remove the two screws on each side of the keyboard.
7. 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 (2.54 mm) thick, or fasten it upside down in the machine.



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

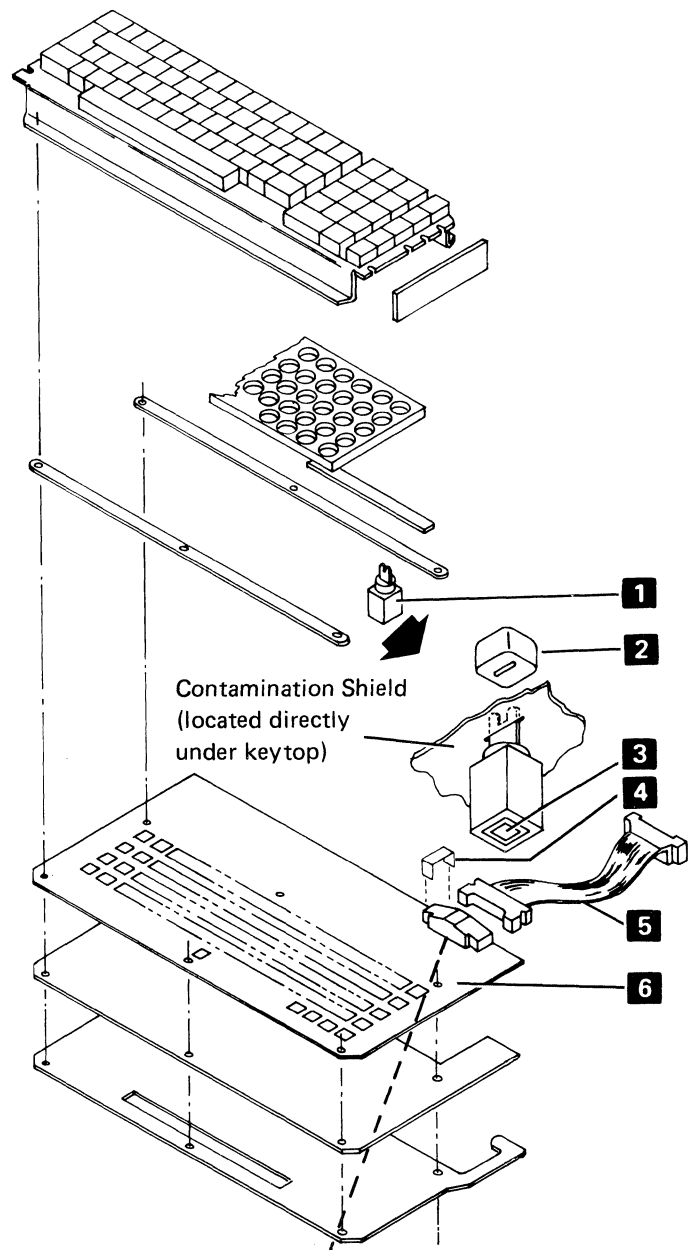
#### CAUTION

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.



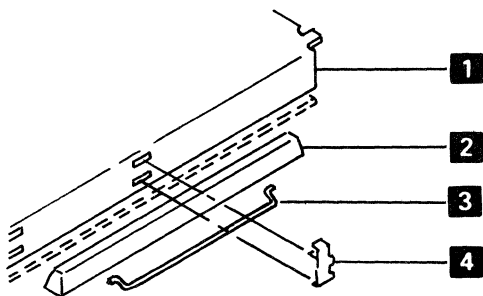
## 252 SPACEBAR

### 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

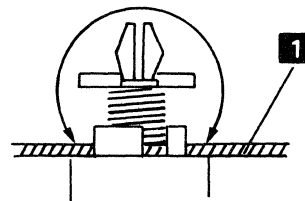
1. Remove the keyboard (251).
2. Use the keytop pulling tool (part 9900373) to lift the keytop buttons from the keys to be removed.
3. Lift one edge of the all keys unit about 0.5 inch (12.7 mm) and push and wiggle the failing key modules down until they snap free.

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

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

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Lift the all keys unit, leaving the loosened modules.



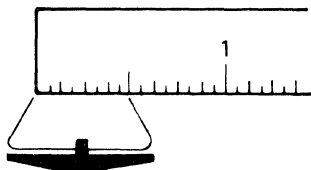
### Installation

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.

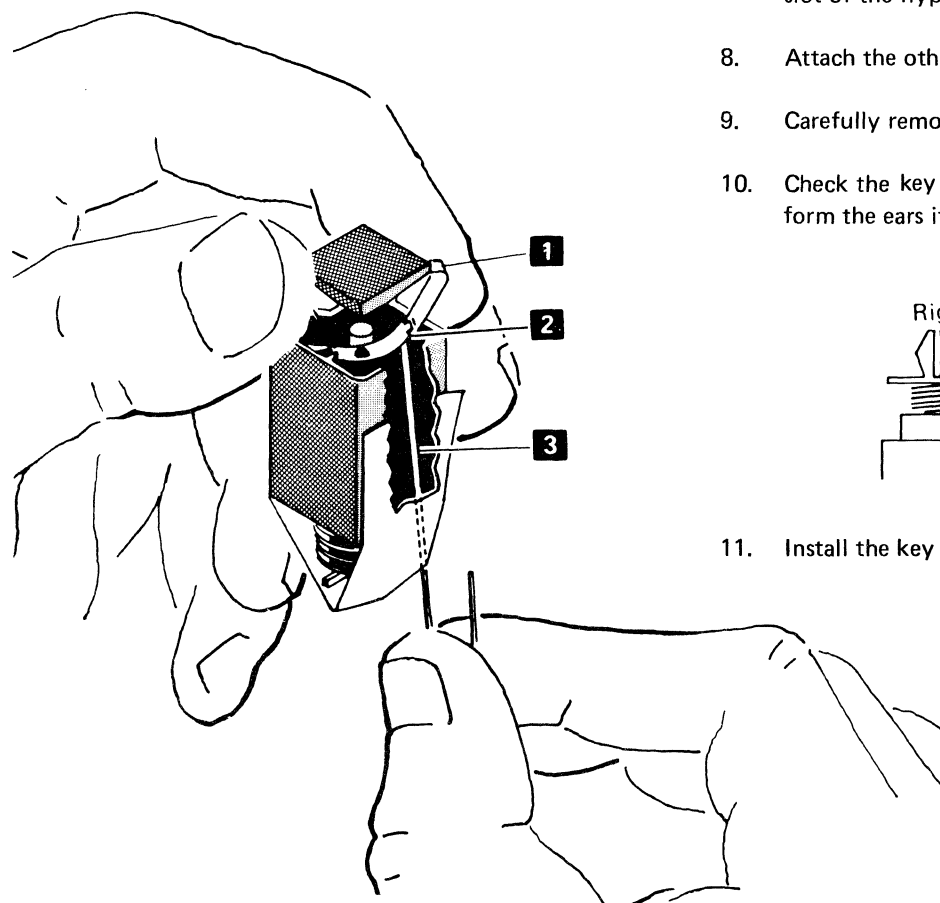
## 254 FLYPLATE REPLACEMENT

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.

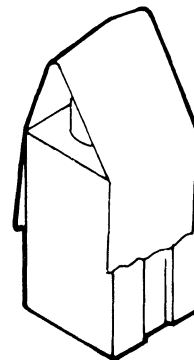
1. Form the spring on the flyplate so that there is 0.5 inch (12.7 mm) between the ends of the spring.



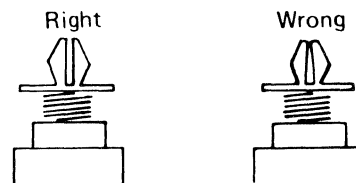
2. Remove the keybutton from the key module and remove the module from the keyboard.



3. Tape the key stem down as shown.



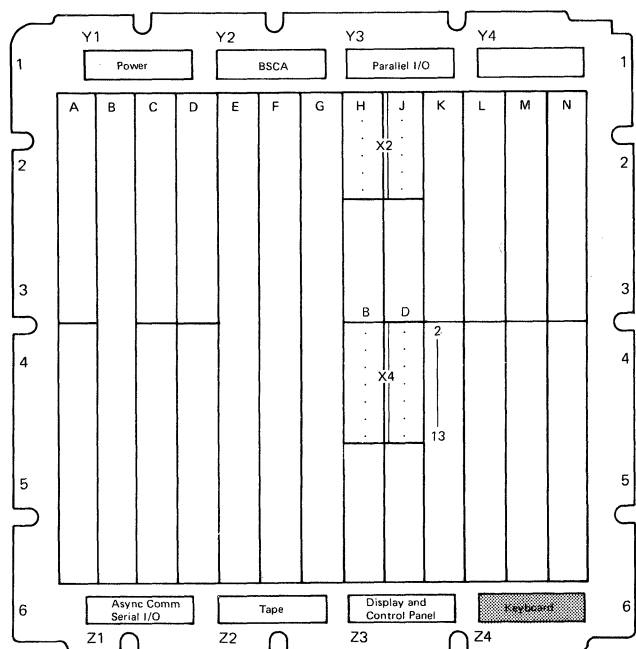
4. Holding the key module and flyplate as shown, line up the ends of the flyplate spring **1** with the tips of the flat spring **2** attached to the key stem.
5. Insert a small stylus or straightened paper clip through one of the access holes in the key module **3**.
6. Push the tip of the flat spring 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.

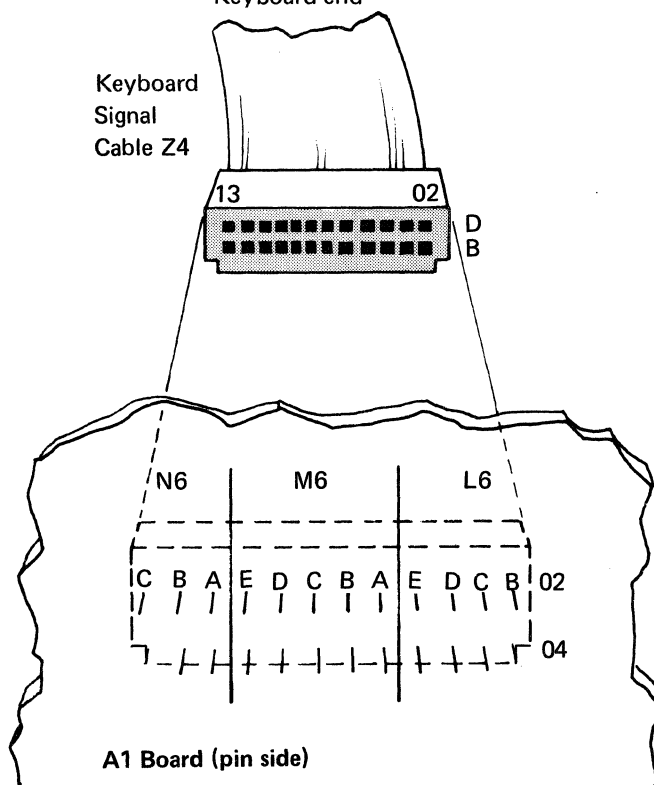
## 255 KEYBOARD – Z4 SOCKET PIN ASSIGNMENTS

### A1 Board (card side)



See 206 for  
Keyboard end

Keyboard  
Signal  
Cable Z4



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

## Power

**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.

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

## 271 POWER SUPPLY

(Page 1 of 2)

### Removal

1. Disconnect the mainline cord from the AC outlet.
2. Remove the power supply outer cover (eight screws).
3. Remove the I/O interface port (three flathead screws).
4. Remove the I/O cable driver (A2) card from the A1 board.
5. Remove the black cover from the underside of the I/O interface port (three screws).

#### CAUTION

Observe the DC power cable from the I/O interface port for folding and routing. The new power supply cable needs to be folded and routed the same way to allow maximum air flow.

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6. Remove the DC power cable from the I/O interface port (two screws).
7. Remove the J1 connector from the AC power box (see 207) and remove the cable from the two clamps holding it to the base.
8. Remove the power supply cover on the end adjacent to the fan; the tabs can be forced out with a screwdriver.
9. Remove the Y1 cable retainer.
10. Disconnect the Y1 connector from the A1 board.
11. Remove the power supply (six screws).

### Replacement

#### CAUTION

When replacing the power supply, refer to the following illustration for the correct cable routing **1**. Improper routing can cause air flow blockage and result in an overheated power supply or damaged cables.

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1. Install the power supply (six screws).

#### CAUTION

Be sure to install the Y1 cable retainer.

---

2. Connect the Y1 connector to the A1 board.

#### CAUTION

Do not pinch any cables.

---

3. Install the power supply cover on the end adjacent to the fan.
4. Connect the J1 connector into the AC power box and clamp the cables (two clamps) to the base.
5. Install the DC power cable in the I/O interface port. Do not tighten the two screws.
6. Using the I/O cable assembly from the 5103 Printer, 5114 Diskette Unit, or the 5106 Auxiliary Tape Unit, fasten the I/O cable assembly to the I/O interface port to ensure proper DC power cable connector alignment. Tighten the two screws holding the DC power cable in the I/O interface port.
7. Remove the I/O cable assembly from the I/O interface port.
8. Install the black cover on the underside of the I/O interface port.
9. Install the I/O cable driver (A2) card into the A1 board.
10. Install the I/O interface port (three screws).

#### CAUTION

The cables to the A2 card must be routed outside the power supply outer cover as shown in reference 200. Improperly routed cables can cause unpredictable errors.

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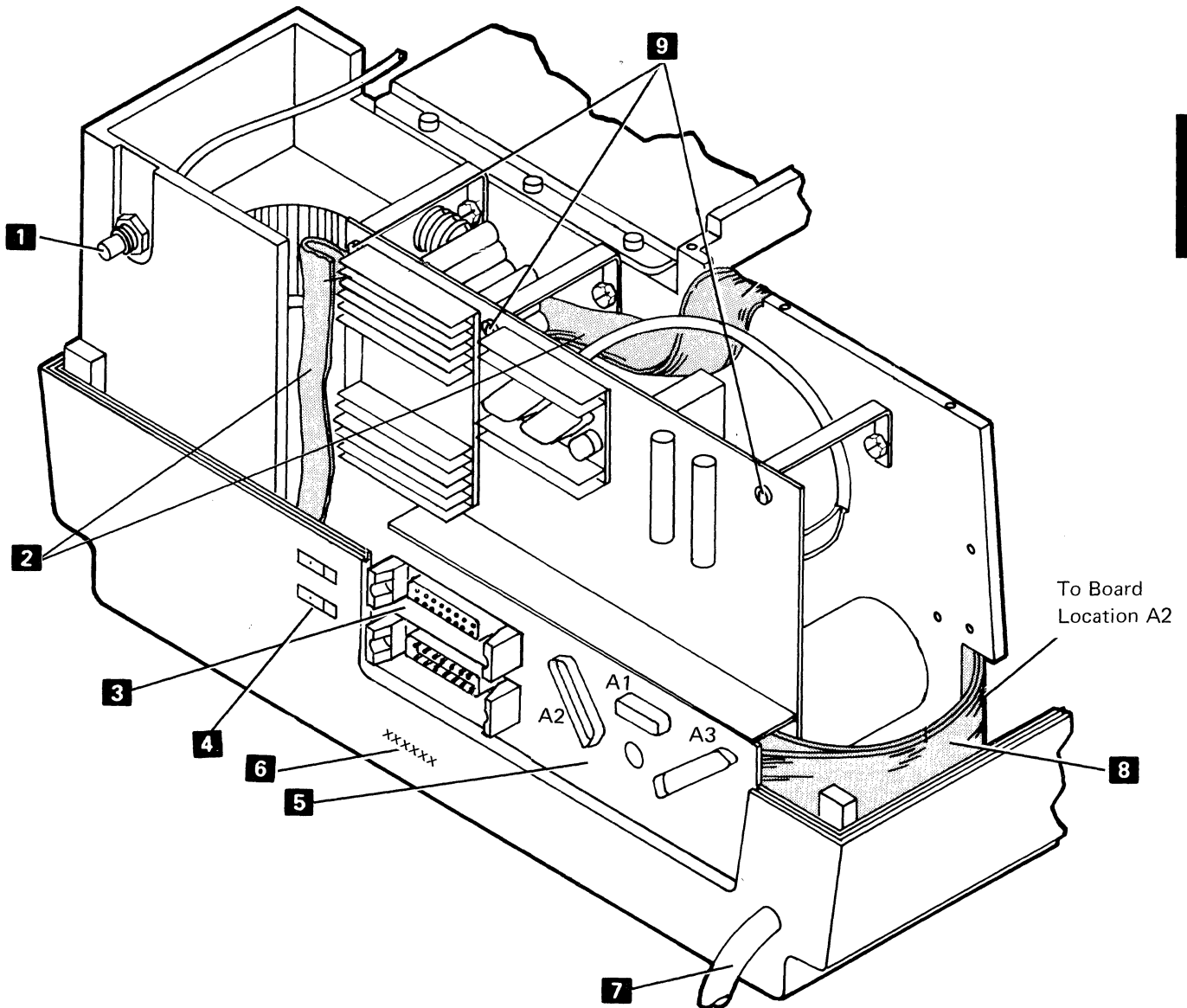
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11. Install the power supply outer cover (eight screws).
12. Connect the mainline cord to the AC outlet.



## 271 POWER SUPPLY

(Page 2 of 2)

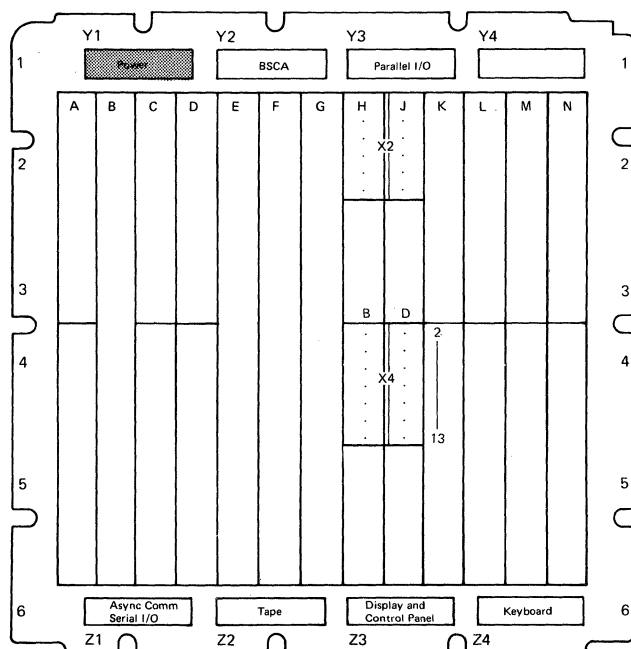


- 1** TV Monitor Socket
- 2** Power Supply Cables
- 3** Communications Adapter Socket
- 4** Label indicating communications socket assignment (see table)
- 5** I/O Interface Port
- 6** Machine Serial Number
- 7** Line Cord
- 8** I/O Cable Assembly
- 9** PC Board Mounting Screws (6 screws)

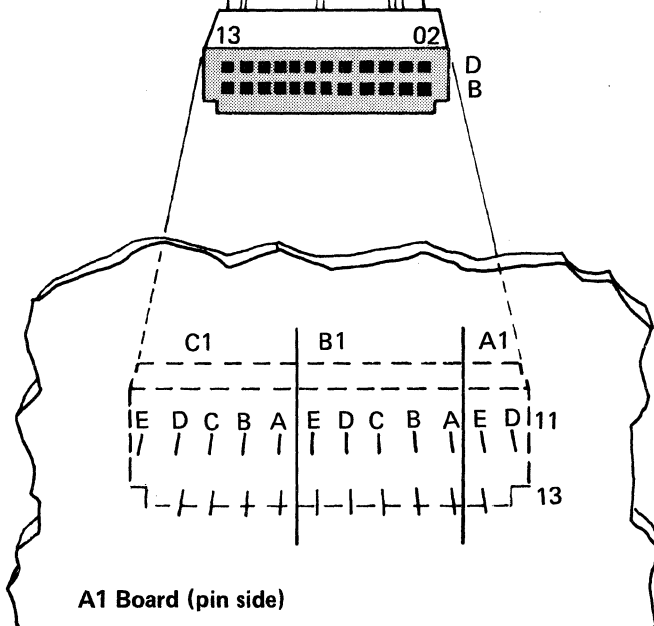
Label	Assignment
S	Serial I/O
P	Parallel I/O
A	Async
B-1	BSCA EIA/CCITT
B-2	BSCA 38LS Switched network
B-3	BSCA 38LS Non-SW/WT PSN
B-4	BSCA DDSA

## 272 POWER – Y1 SOCKET PIN ASSIGNMENTS

### A1 Board (card side)



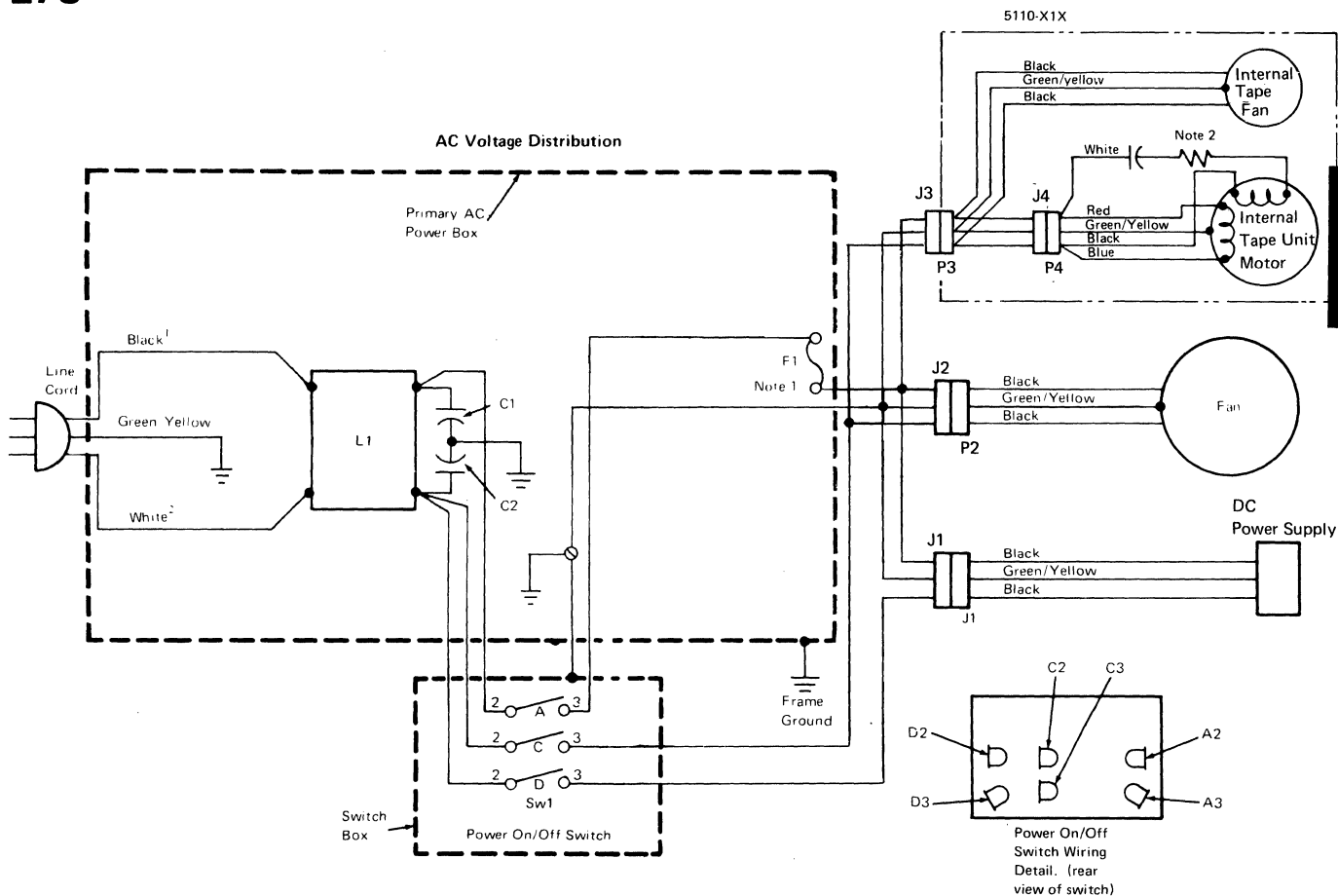
See 208  
Power  
DC Cable Y1



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

## 273 AC VOLTAGE DISTRIBUTION



<sup>1</sup>Brown on 220V and 235V machines

<sup>2</sup>Blue on 220V and 235V machines

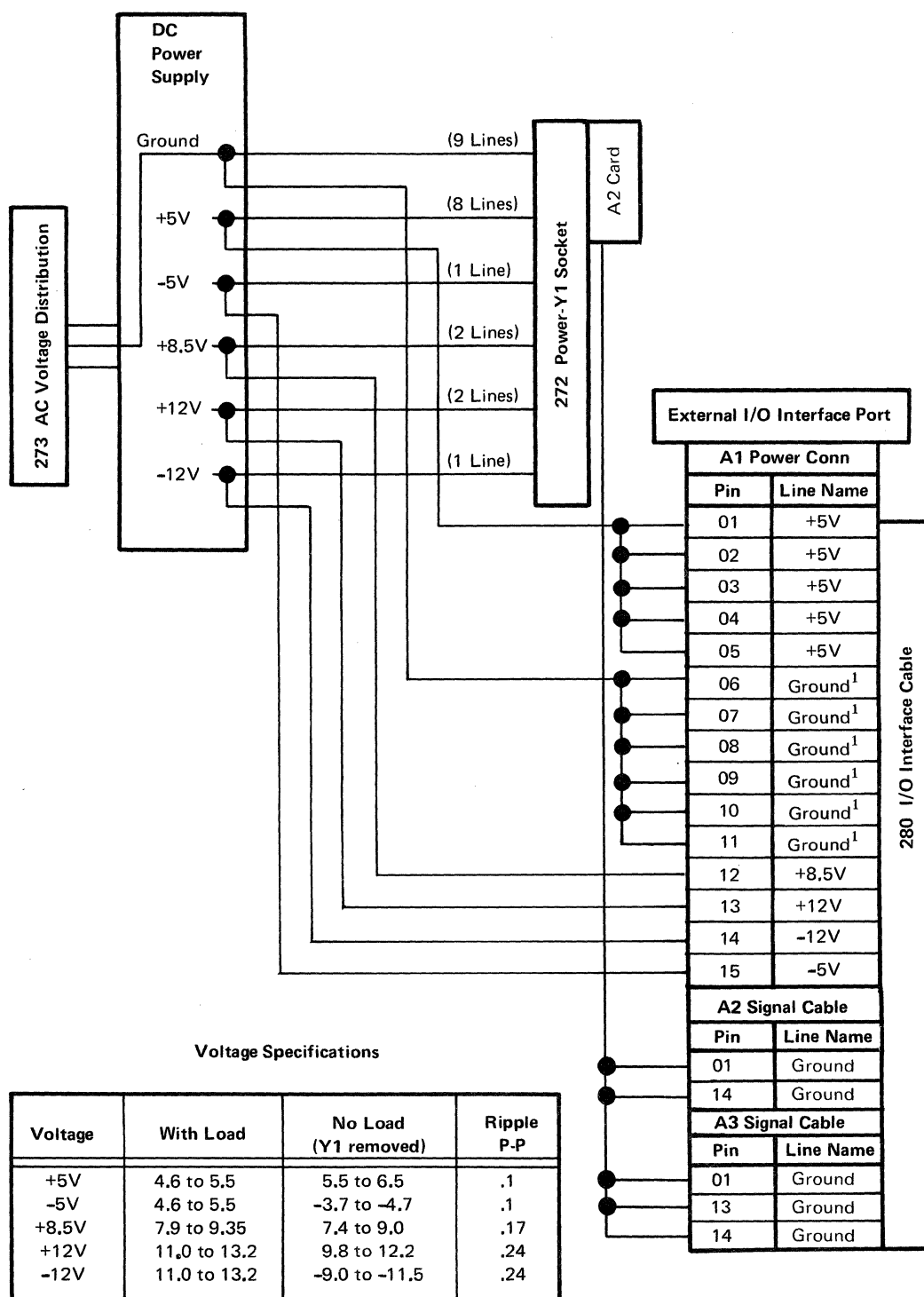
### Notes:

1. F1 is 5A, 125V on both the 100V and 115V machines.
2. Resistor installed on 220V and 235V machines only.

L1 Line Filter  
 J1, 2, 3, 4 Connectors  
 C1, 2 Capacitors  
 F1 Fuse (see note 1)  
 SW1 Power ON/OFF switch

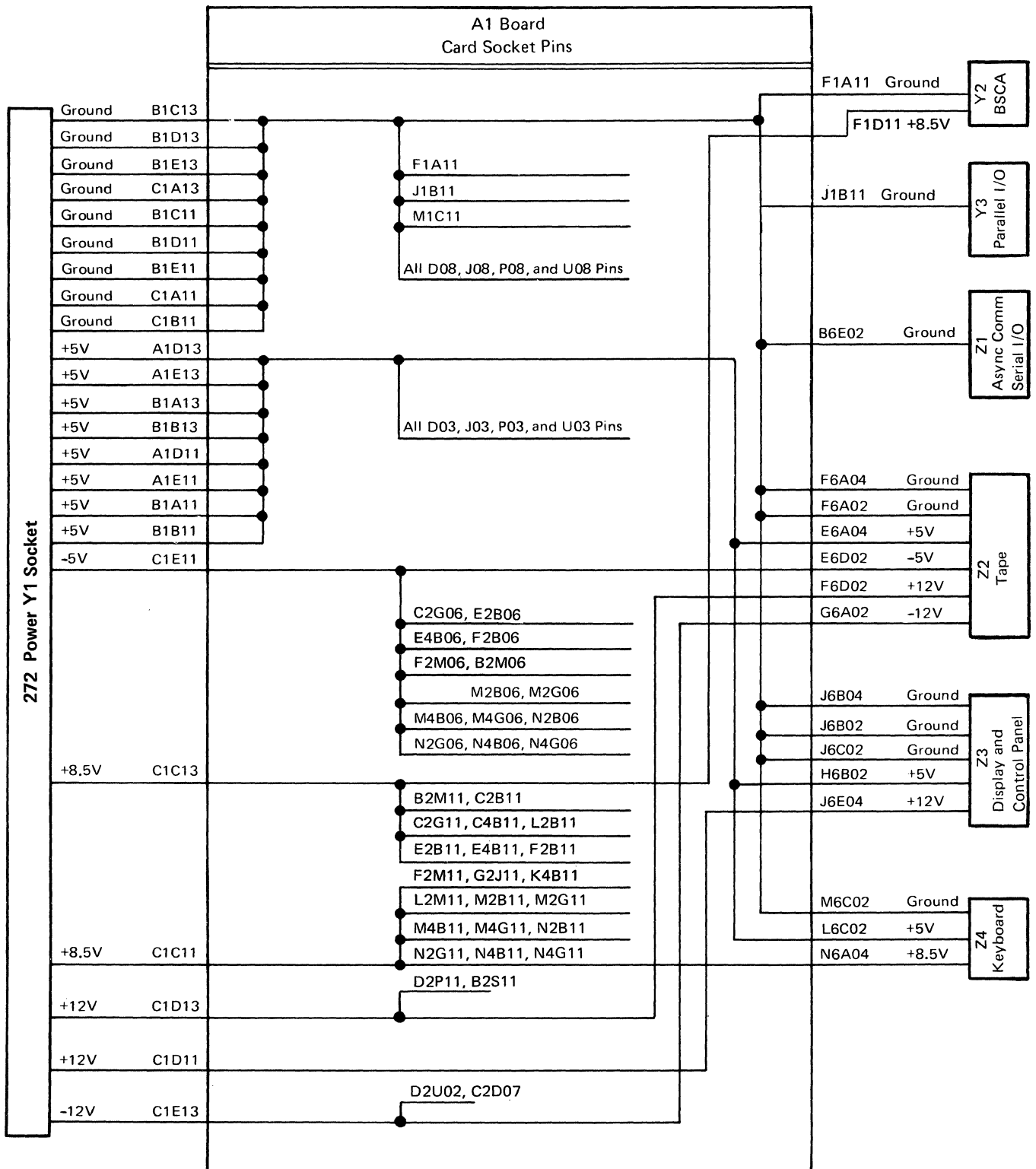
# 274 DC VOLTAGE DISTRIBUTION

(Page 1 of 2)



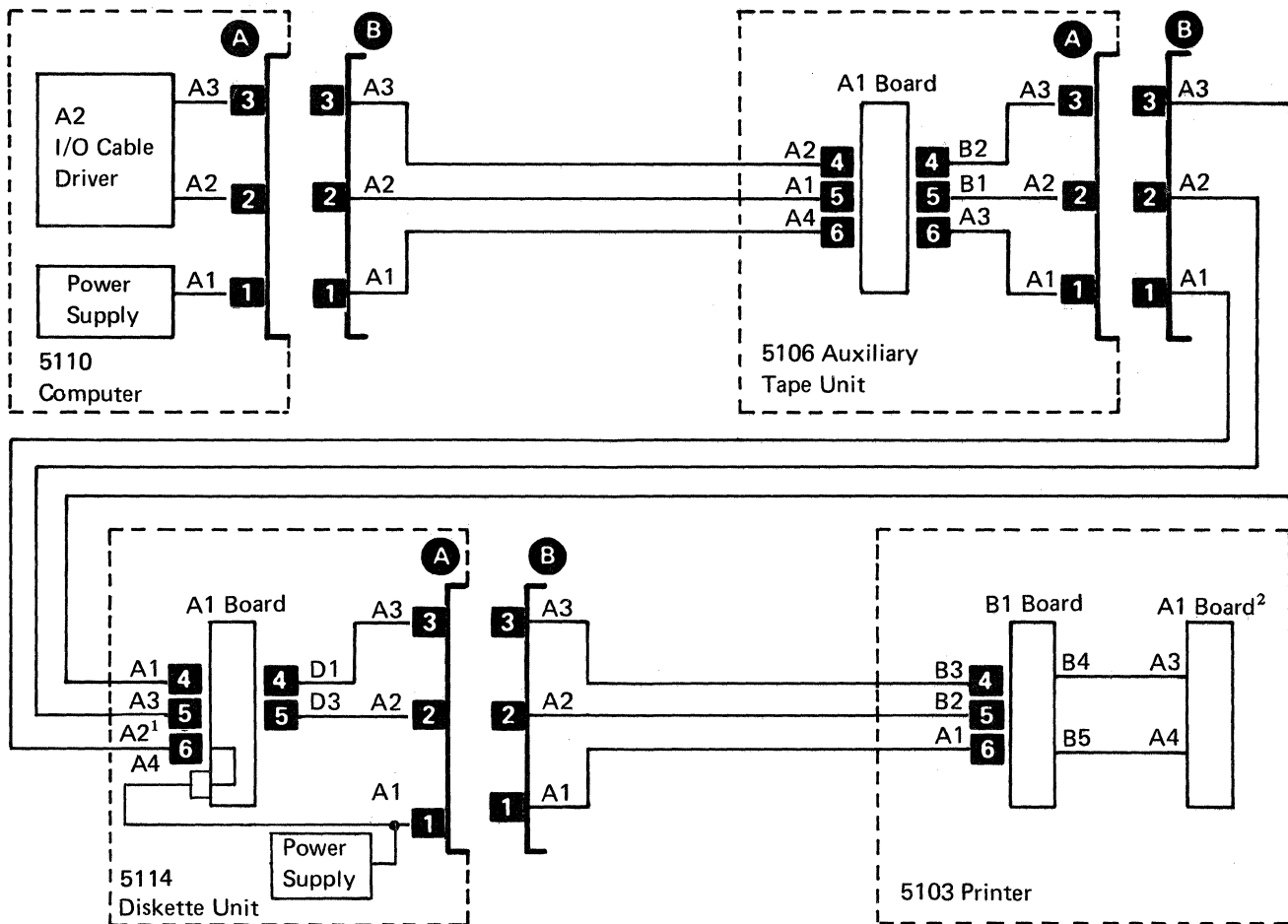
<sup>1</sup> The I/O interface cable does not have wires connected to this pin.

# 274 DC VOLTAGE DISTRIBUTION (Page 2 of 2)



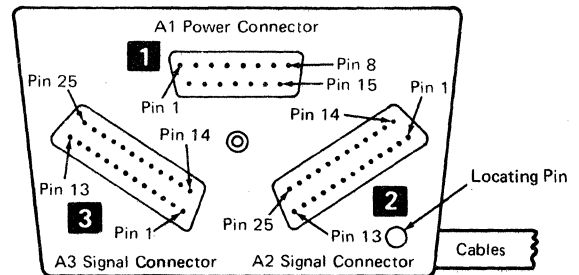
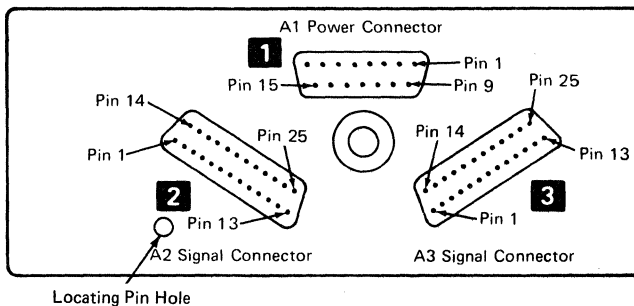
## Features

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



**A** Interface Connector (On Rear of Tape Unit)

**B** I/O Cable Assembly Connector



<sup>1</sup> The 5110 +5 Vdc stops here. The 5114 provides its own +5 Vdc and +5 Vdc for attaching devices.

<sup>2</sup> 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 I/O device.

## 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	= 5114 Diskette Unit
X3Y2	= 5106 Auxiliary Tape Unit

### 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

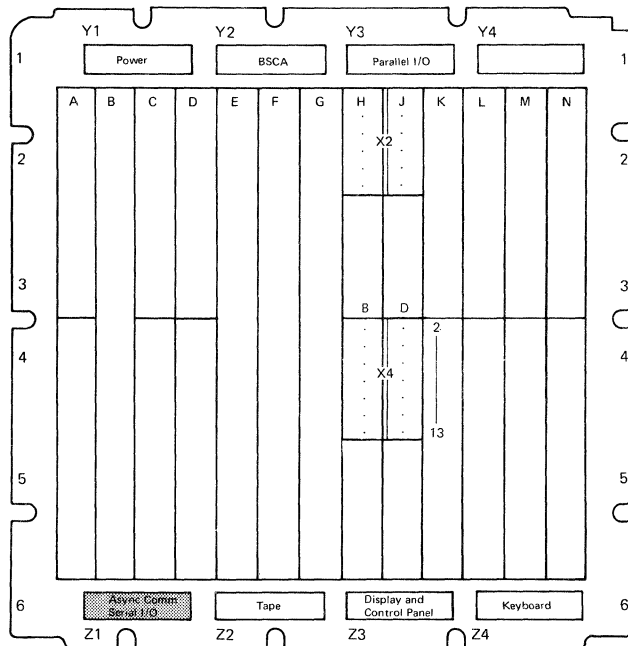
Pin	Line Name
B02	+5 Vdc
B03	+5 Vdc
B04	Unused
B05	Unused
B06	Unused
B07	Unused
B08	Unused
B09	Unused
B10	Unused
B11	+8.5 Vdc
B12	+12 Vdc
B13	Unused
D02	+5 Vdc
D03	+5 Vdc
D04	+5 Vdc
D05	Unused
D06	Unused
D07	Unused
D08	Unused
D09	Unused
D10	Unused
D11	-5 Vdc
D12	-12 Vdc
D13	Unused

#### Notes:

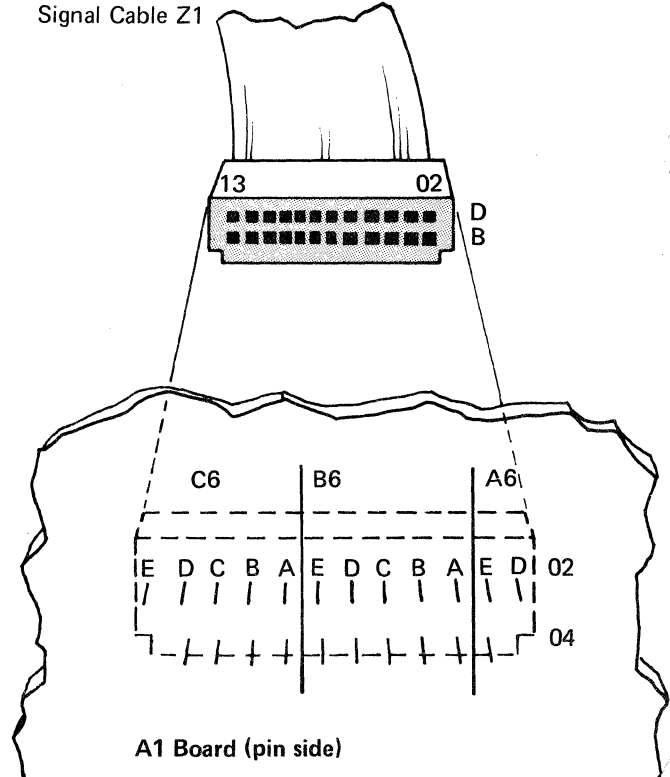
1. This line is grounded at the 5114 Diskette Unit A1-D1 socket. A second 5114 Diskette Unit uses this signal to recognize its subdevice address.
2. The 5114 Diskette Unit generates a power on reset for use by the 5103 Printer and a second 5114 Diskette Unit.

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

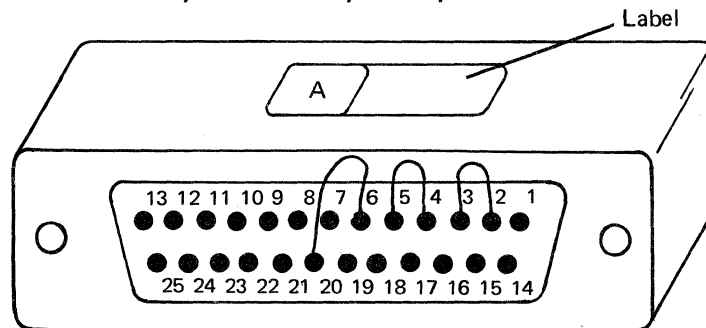
**A1 Board (card side)**



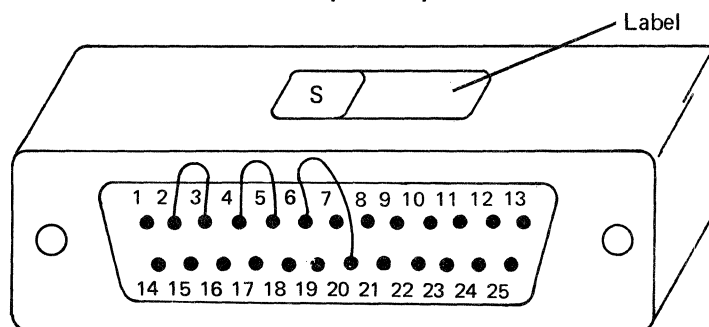
Async Comm/Serial I/O  
Signal Cable Z1



**Async Comm Adapter Wrap Connector**



**Serial I/O Adapter Wrap Connector<sup>1</sup>**



<sup>1</sup> See IBM 5110 Logic Manual logic 450 for wrap connector pin assignments.



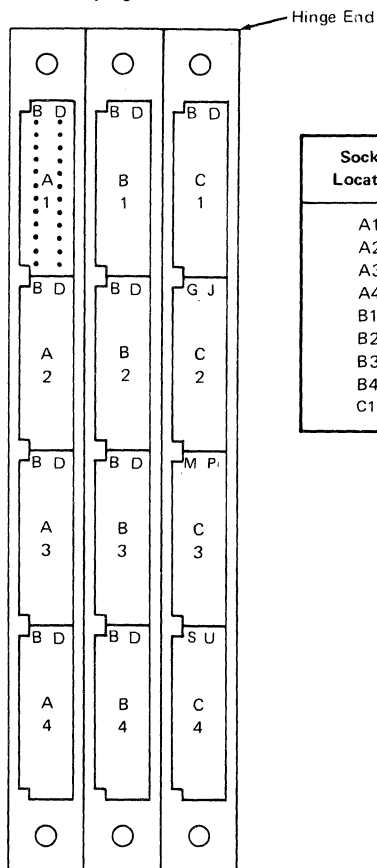
# **282** ASYNC COMM/SERIAL I/O ADAPTERS— Z1 SOCKET PIN ASSIGNMENTS (Page 2 of 2)

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

# 283 5106 AUXILIARY TAPE I/O INTERFACE CONNECTOR

(See 280 for cable pin assignments)

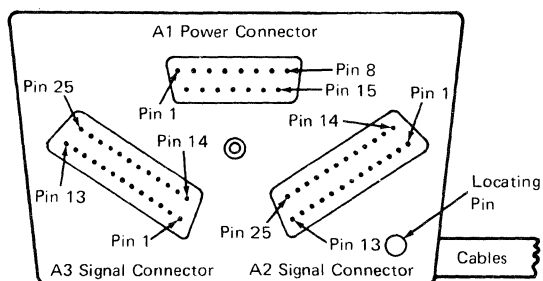
Auxiliary Tape Unit A1 Board  
(plug side)



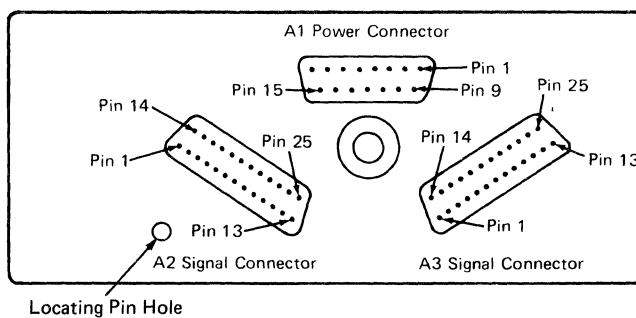
Auxiliary Tape A1 Board  
Socket List

Socket Location	Cable Or Card
A1	A2 Signal Cable Entry Point
A2	A3 Signal Cable Entry Point
A3	A1 Power Cable Exit Point
A4	A1 Power Cable Entry Point
B1	A2 Signal Cable Exit Point
B2	A3 Signal Cable Exit Point
B3	Unused
B4	Tape Drive Cable
C1	Adapter Card

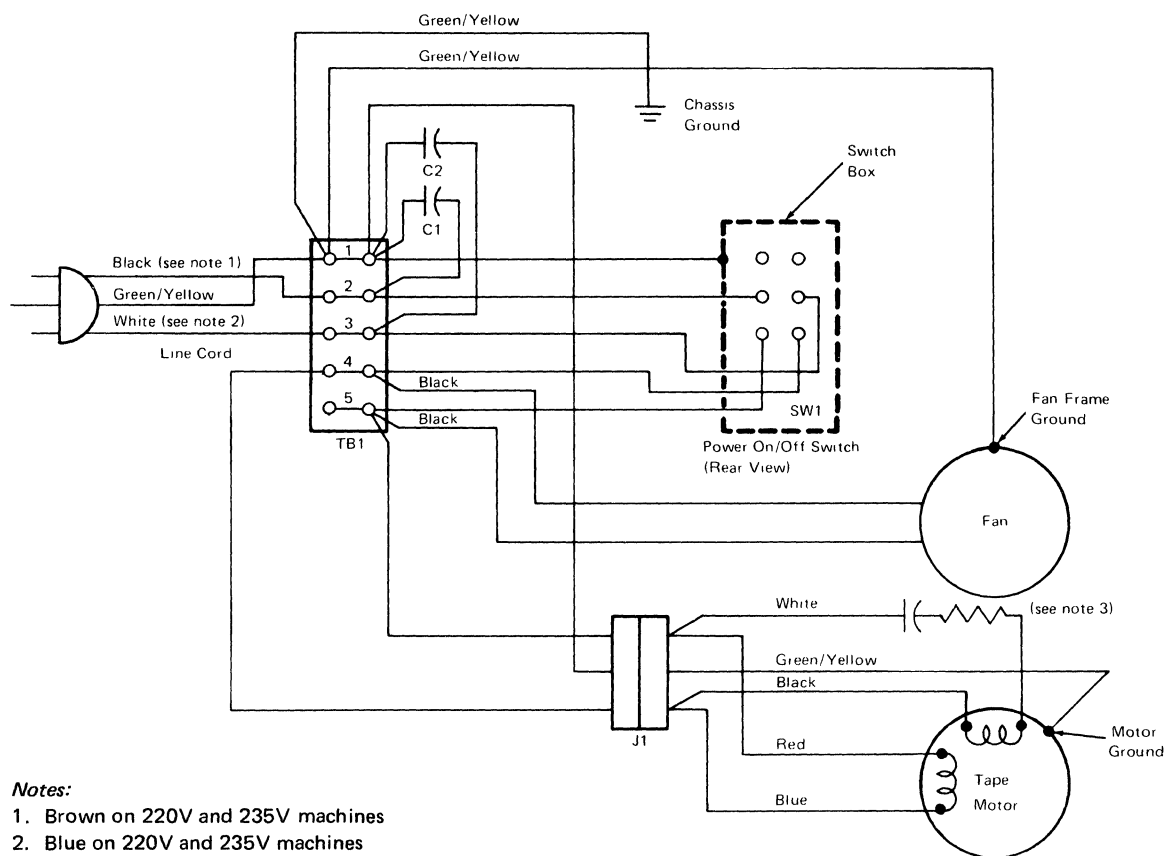
I/O Cable Assembly Connector



Interface Connector (on rear of tape unit)



## 284 5106 AUXILIARY TAPE AC VOLTAGE DISTRIBUTION

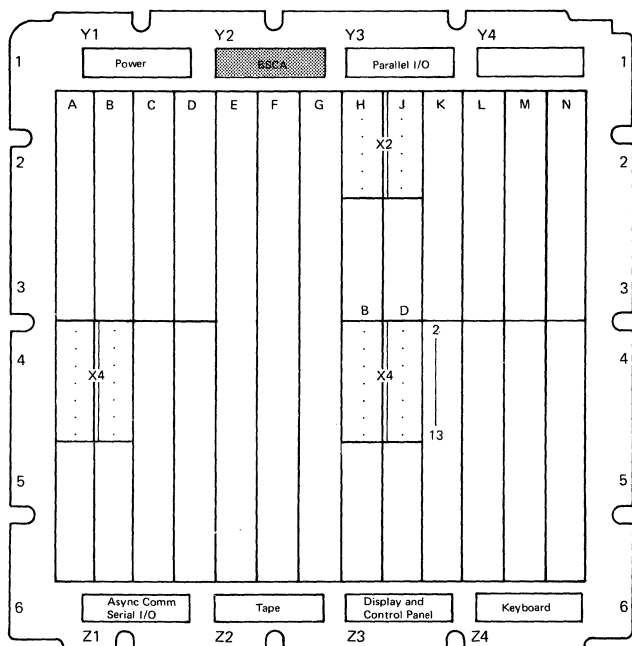


### Notes:

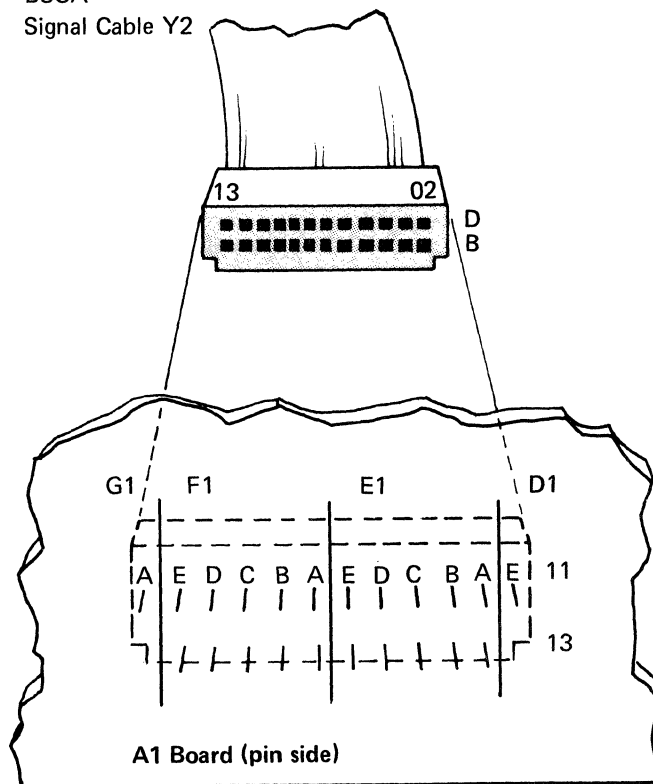
1. Brown on 220V and 235V machines
2. Blue on 220V and 235V machines
3. Resistor installed on 220V and 235V machines only

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

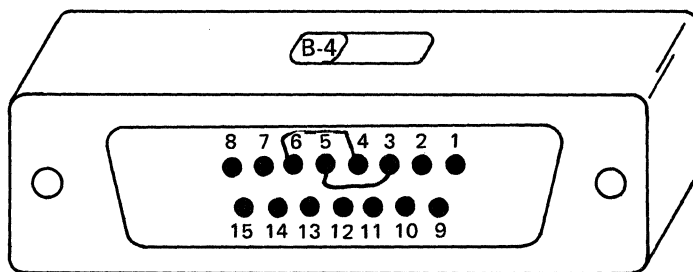
A1 Board (card side)



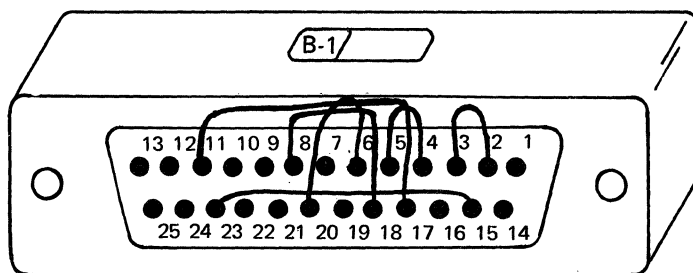
BSCA  
Signal Cable Y2



## DDSA Wrap Connector



## EIA/CCITT Wrap Connector<sup>1</sup>



<sup>1</sup> 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:**

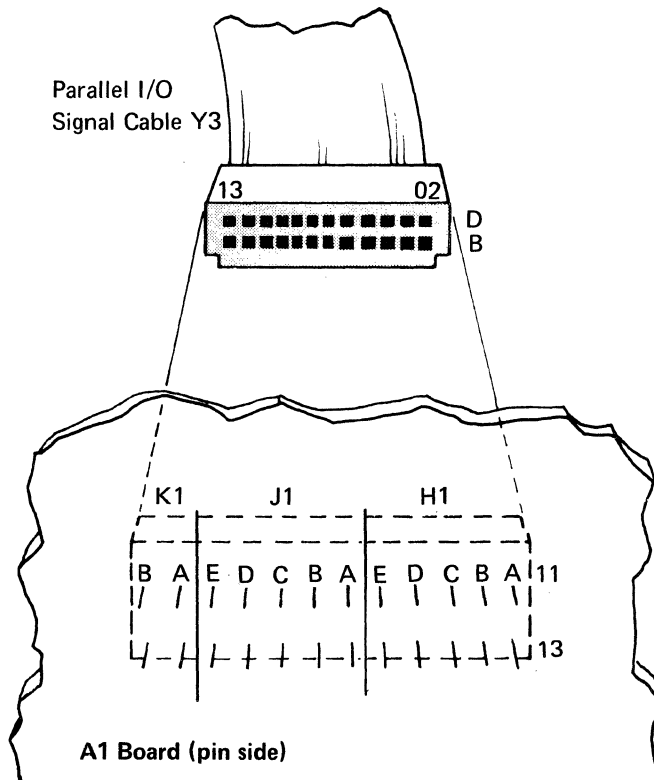
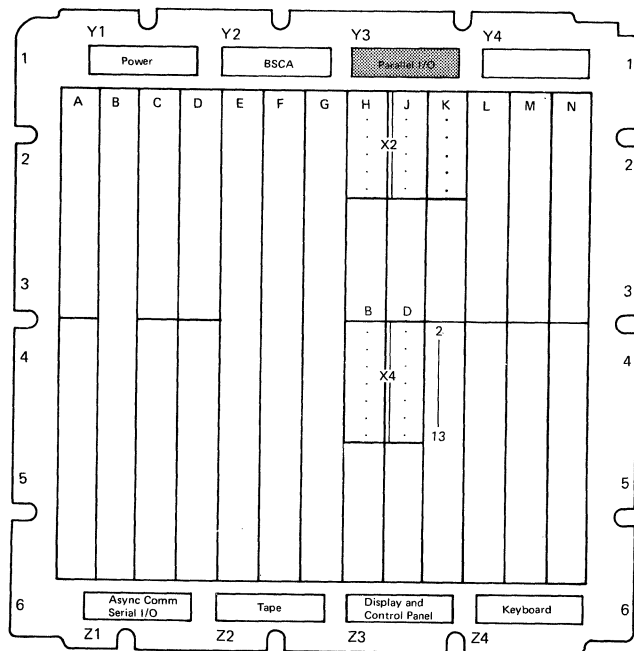
See *IBM 5110 Logic Manual* logic 460 for DDSA wrap connector pin assignments.

See *IBM 5110 Logic Manual* logic 465 for EIA/CCITT wrap connector pin assignments.

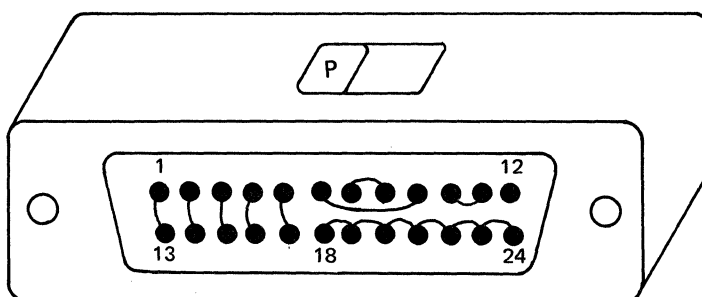
## 286 PARALLEL I/O—Y3 SOCKET AND WRAP CONNECTOR PIN ASSIGNMENTS

**(Page 1 of 2)**

### A1 Board (card side)



## PIO Wrap Connector



## 286 PARALLEL I/O—Y3 SOCKET PIN ASSIGNMENTS

(Page 2 of 2)

A1 Board Pin	Y3 Cable Pin	Line Name	K2 Card Pin	Parallel I/O Connector Pin
H1A11	D02	Data I/O 1	B05	1
H1B11	D03	Data I/O 5	D11	13
H1C11	D04	Data I/O 6	B09	14
H1D11	D05	Data I/O 7	D13	15
H1E11	D06	(not used)	—	—
J1A11	D07	(not used)	—	—
J1B11	D08	Signal Ground	D08	24
J1C11	D09	End or Identify	J04	5
J1D11	D10	Data Valid	G08	6
J1E11	D11	Not Ready for Data	G04	7
K1A11	D12	Interface Clear	J02	9
K1B11	D13	Attention	B13	11
H1A13	B02	(not used)	—	—
H1B13	B03	(not used)	—	—
H1C13	B04	Data I/O 2	D05	2
H1D13	B05	Data I/O 3	D09	3
H1E13	B06	Data I/O 4	D06	4
J1A13	B07	(not used)	—	—
J1B13	B08	(not used)	—	—
J1C13	B09	Data I/O 8	B12	16
J1D13	B10	Remote Enable	G02	17
J1E13	B11	(not used)	—	—
K1A13	B12	Not Data Accepted	G06	8
K1B13	B13	Service Request	G03	10

*Note:* See *IBM 5110 Logic Manual* logic 445 for wrap connector pin assignments.

## 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.

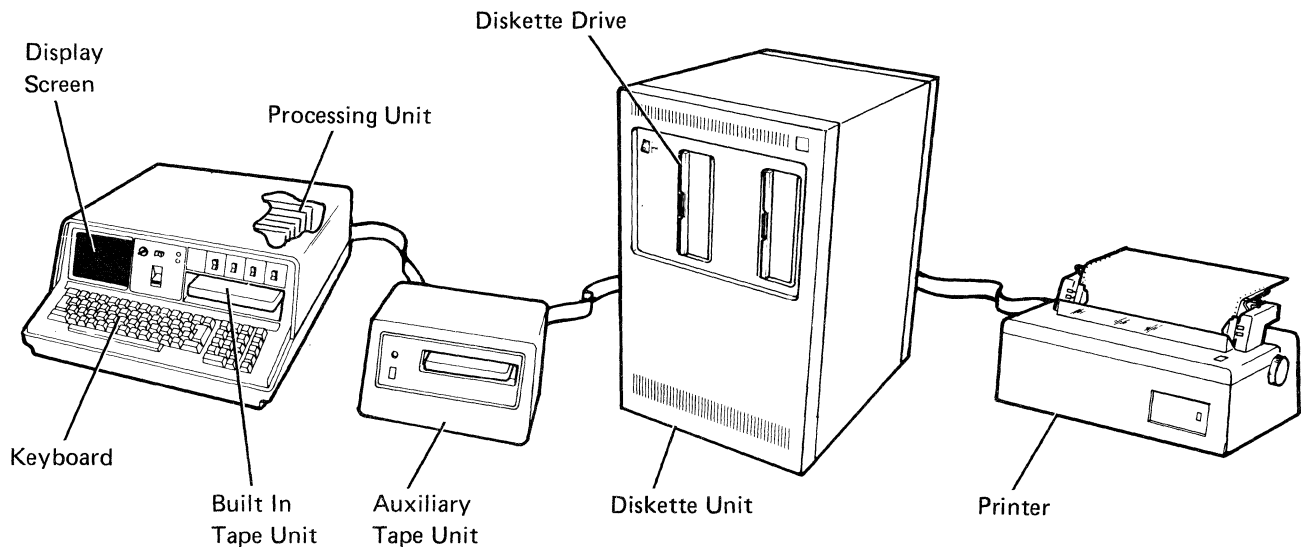


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## Introduction



The 5110 computer is composed of a keyboard, a display unit, a processor, storage, and an integral power supply. The keyboard and the 5" 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 the internal tape unit, 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 5110 computing system.

The input/output devices include an internal tape unit (within the Model 1 only), a 5103 printer, a 5106 auxiliary tape unit, and a 5114 diskette unit.

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

## I/O DEVICES

### The 5103 Printer

The 5103 printer is a wire matrix printer used by the 5110 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 5106 Auxiliary Tape Unit

The 5106 auxiliary tape unit attaches to the IBM 5110 Computer Model 1 through the I/O channel. One 5106 auxiliary tape unit can be attached to a 5110 computing system. The 5106 auxiliary tape unit stores up to 204K bytes of data. It uses the same data cartridge and data format as the internal tape unit of the 5110 computer.

### The 5114 Diskette Unit

The 5114 diskette unit attaches to the 5110 computer through the I/O channel; up to two 5114 units can be attached to a 5110 computing system. Each unit stores up to 1.1 megabytes of data on each diskette drive. Each 5114 unit 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 5110 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 Parallel I/O Adapter Feature

The Parallel I/O Adapter feature allows the 5110 computing system to communicate with control devices via a 16-line bus.

The APL or BASIC language directly controls the feature. The user must load the controlling microprogram into R/W storage.

### The Asynchronous Communications Feature

The Asynchronous Communications feature allows the 5110 computing system to act as a 2740 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 integrated modem, a Digital Data Service Adapter (DDSA), or 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.

### The Audible Alarm Feature

The Audible Alarm feature allows the user to enter language statements that activate the alarm when they are executed.

## 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.

### 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.

### 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 5110 computing system.

<sup>1</sup>Trademark of the American Telephone & Telegraph Co.

### ***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 and the internal tape drive.

### **I/O Cable Driver**

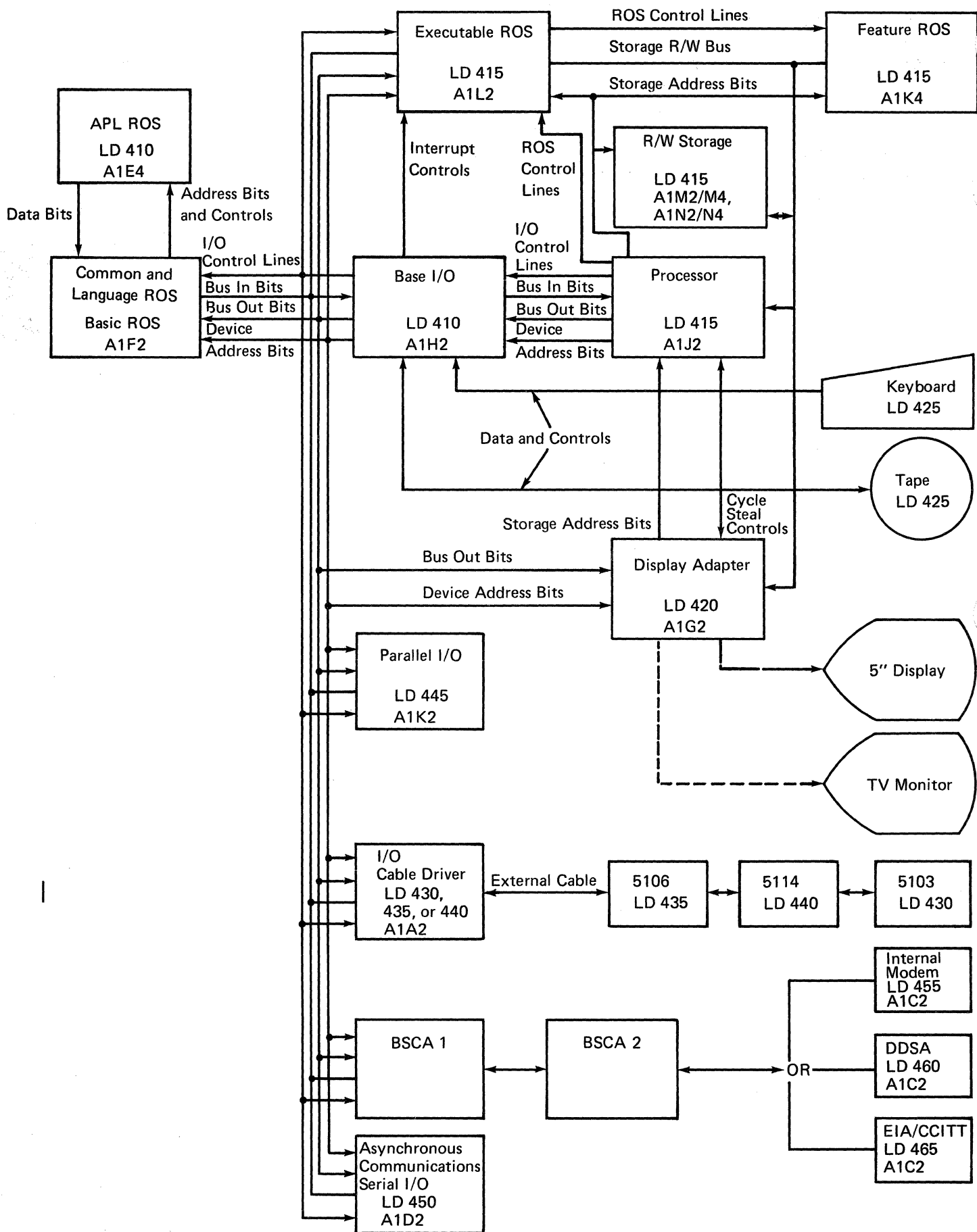
The I/O cable driver card (A2) repowers the signal lines for the 'bus in' line, the 'bus out' line, and the control lines to the external I/O devices.

### **Microprogramming**

Most 5110 operations are controlled by microprograms located in ROS. Some feature microprograms (such as microprograms for the Parallel I/O Adapter feature) are loaded into read/write storage from the tape or diskette.

## Internal Operation of the 5110

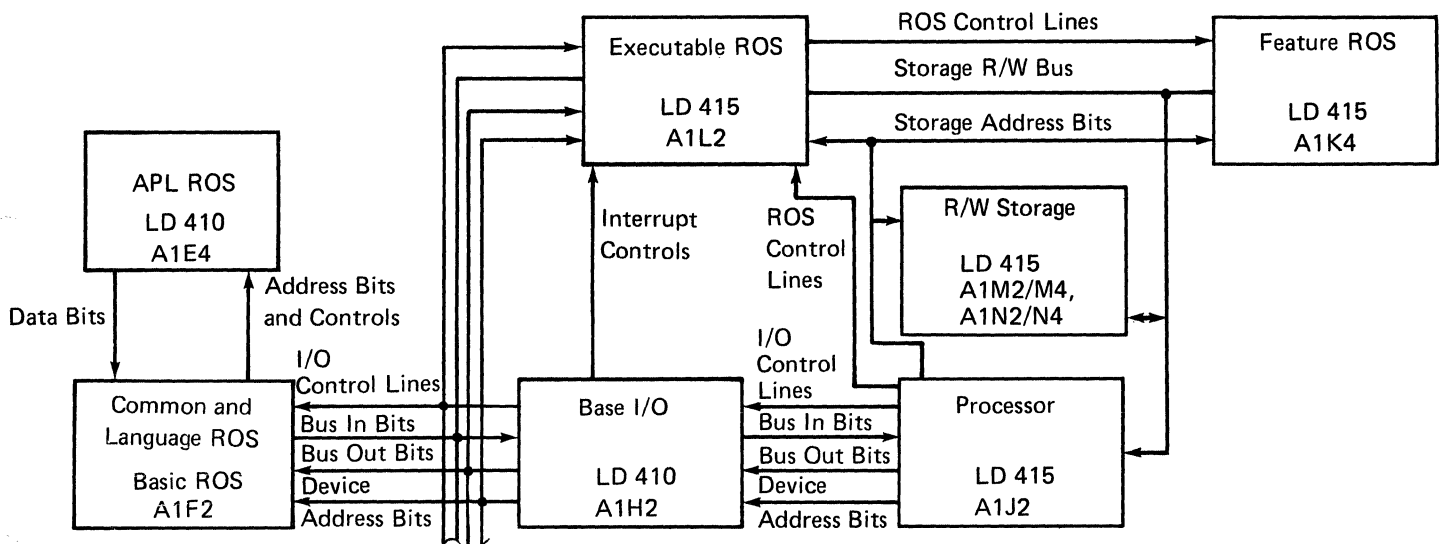
The 5110 computer uses both IBM programs and user written programs. These programs are loaded into read/write storage, usually from tape or diskette. These programs are processed by microprograms to control all the computing and input/output operations of the 5110 computing system. An overview of the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





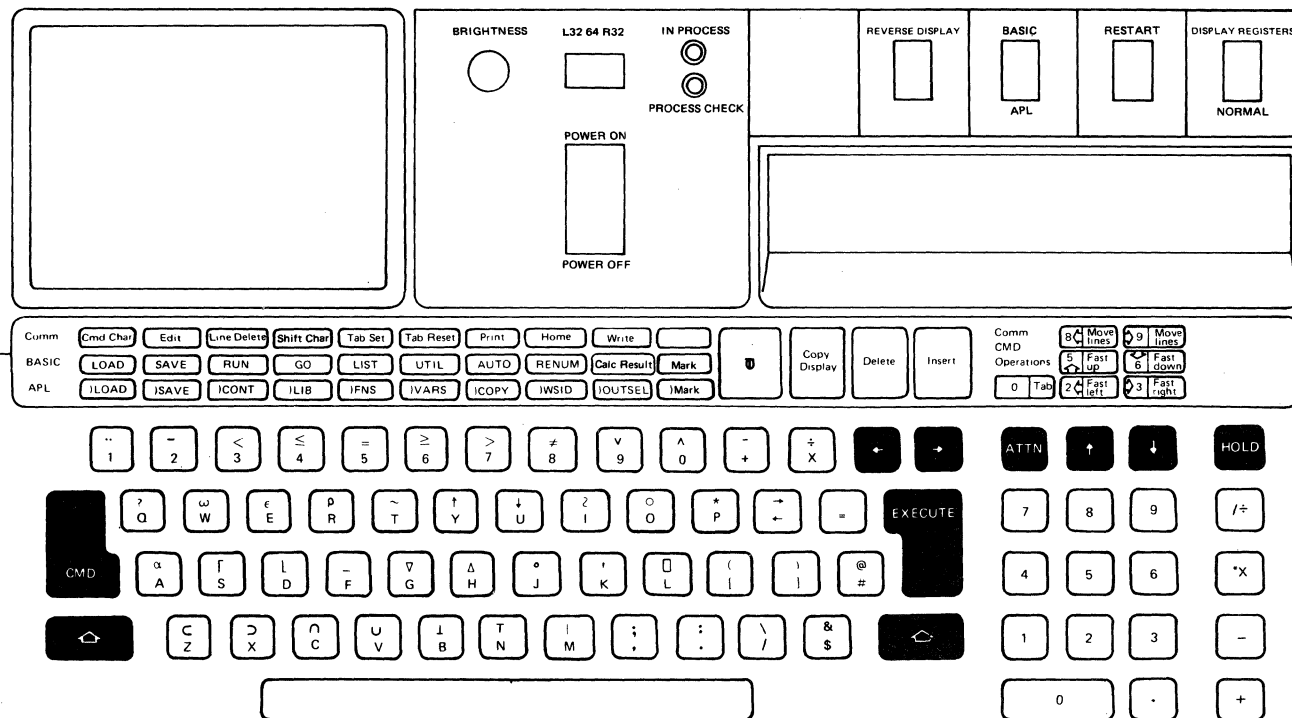
The Common and Language ROS areas contain translation tables, I/O diagnostics, and the APL and BASIC interpreters.

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 tape or 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.

## 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.

**L32-64-R32 Switch:** This controls whether the left half, the right half, or all of the positions of the screen will be displayed. When the switch is in the L32 setting, the 32 leftmost positions of the screen are expanded with blanks between the characters. The 64 setting is the normal display setting; all 64 positions are displayed. When the switch is in the R32 position, the 32 rightmost positions of the screen are expanded with blanks between characters.

**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.

**REVERSE DISPLAY Switch:** This switch changes the display screen to show white characters on a dark background or dark characters on a white background. The BRIGHTNESS control may require adjusting after you have changed the REVERSE DISPLAY switch setting.

**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 pressed 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 press 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 pressed and held down, 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.



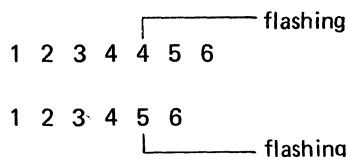
```

1 2 3 4 6 7      flashing
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.



### 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 5110 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 system emulates or appears to have the attributes of the user's language, while each instruction is translated into a language that the system 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 (tape I/O, printer I/O, diskette I/O, and keyboard I/O), the diagnostic control program (DCP), and the APL and I/O supervisor microprograms.

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

- Asynchronous communications
- Serial I/O
- Parallel 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	Parallel I/O
08	Not used
09	Not used
0A	Serial I/O
0B	Not used
0C	Print plot
0D	Diskette drive
0E	Tape drive
0F	Not used

#### Byte 1: Address for Diskette and Tape

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

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

	Tape	Printer	Diskette
00	Sense	Sense	Sense
01	Read	Invalid	Read
02	Write	Print	Write
03	Write last	Print	Write last
04	Find	Invalid	Find
05	Mark	Invalid	Mark
06	Initialize and mark	Invalid	Invalid
07	Rewind	Invalid	Invalid
08	Forward space record	Invalid	Invalid
09	Backspace record	Invalid	Invalid
0A	Find next header	Invalid	Invalid
0B	Write header	Invalid	Write header
0C	Invalid	Invalid	Scan
0D	Invalid	Plot function	Invalid
0E	Invalid	Invalid	Invalid
0F	Invalid	Invalid	Invalid
10	Invalid	Invalid	Find ID
11	Invalid	Invalid	Initialize head
FD	Translate only	Diagnostic	Invalid
FF	Invalid	Invalid	Invalid

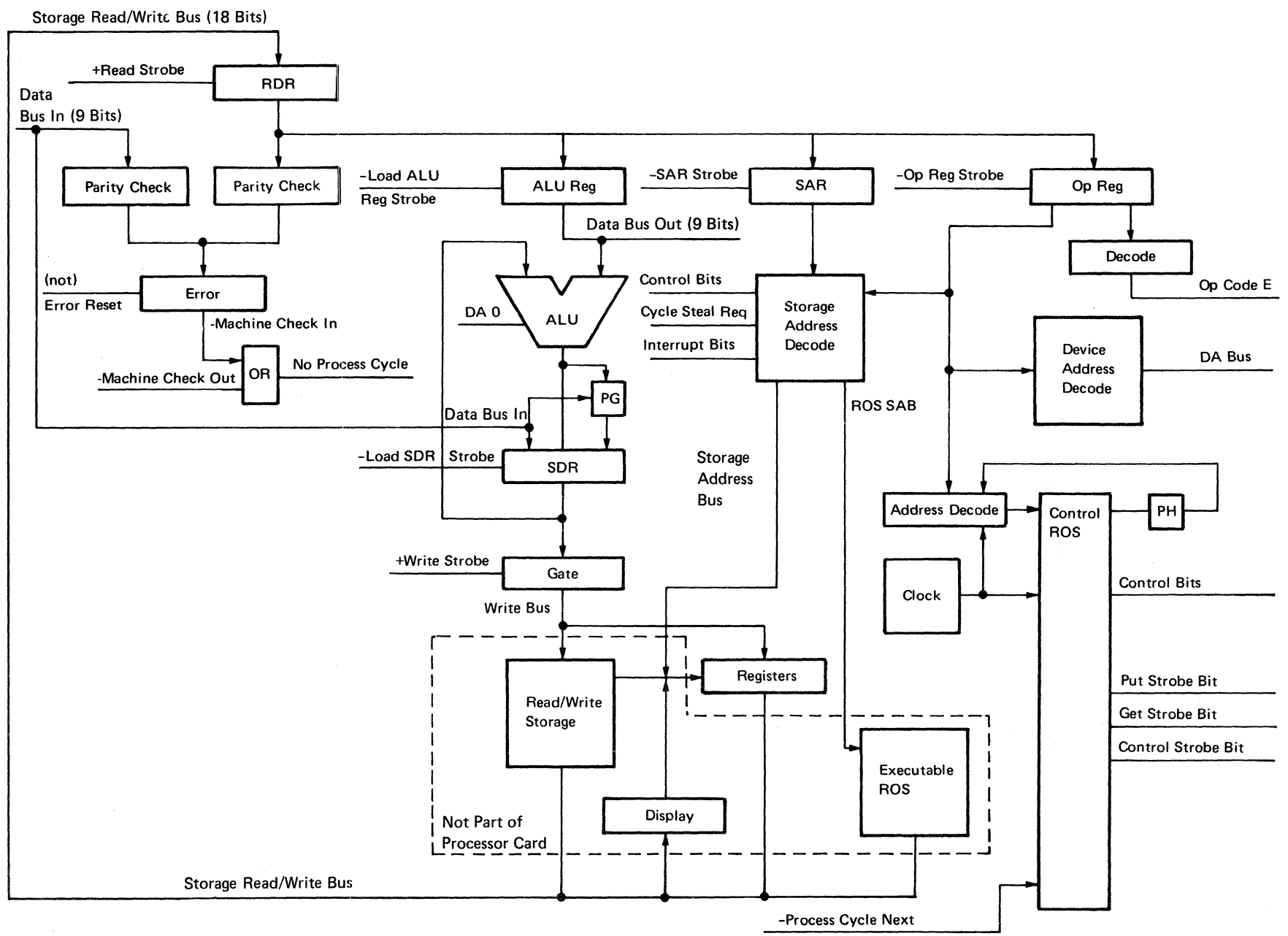
A diskette read operation consists of the following IOCBs and commands:

Command	IOCB Bytes			Action
	0	1	2	
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			Action
	0	1	2	
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 header	OD	80	0B	Updates the end of data (EOD) and completes the closing of the file





## 5110 PROCESSOR

The processor *Data Flow* diagram in the *IBM 5110 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 5110 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.

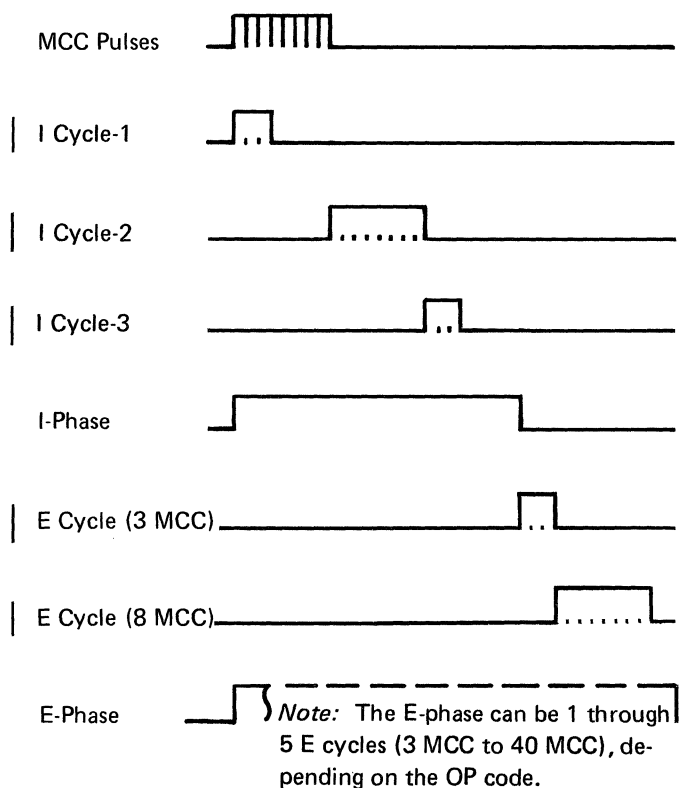
**Control ROS Unit:** The control ROS unit generates the necessary control lines and gating signals for the instruction being executed.

**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—Tape, 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 process 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 following I/O devices: tape unit, printer, auxiliary tape unit, or 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, auxiliary tape—This indicates that a device address check occurred on the auxiliary tape adapter card within the auxiliary tape unit.
- +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, auxiliary tape—This indicates that a parity check occurred on the bus out of the auxiliary tape 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 O) 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 5110 computing system.

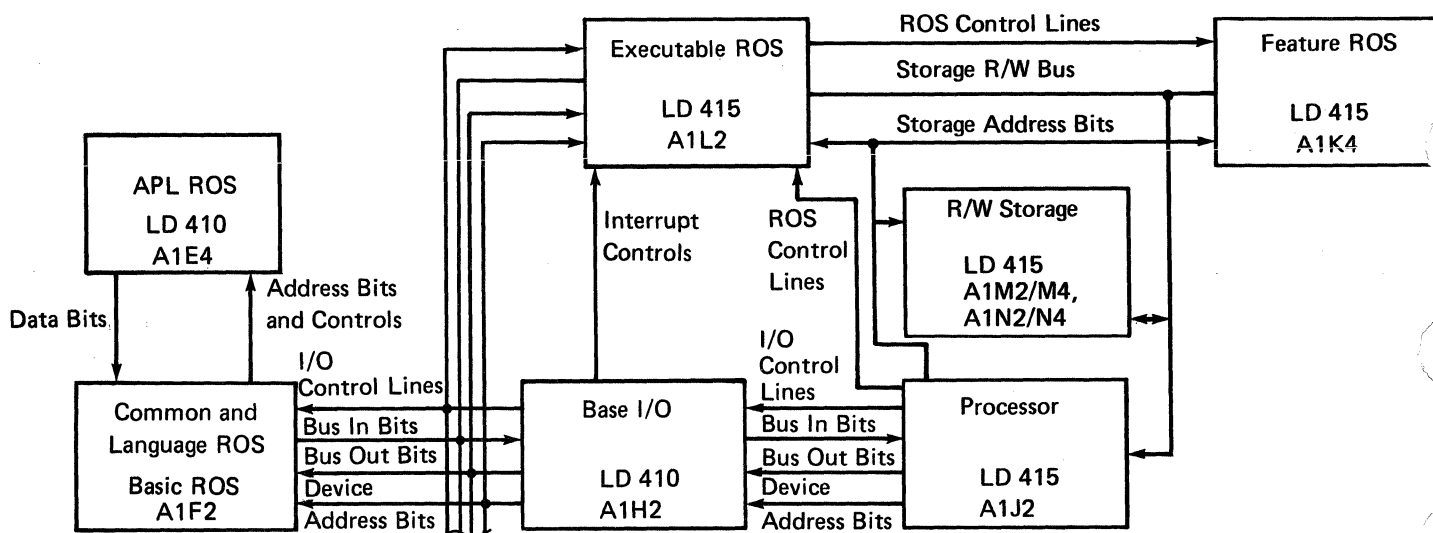
## Executable ROS

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 tape, 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 from 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 or tape 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.

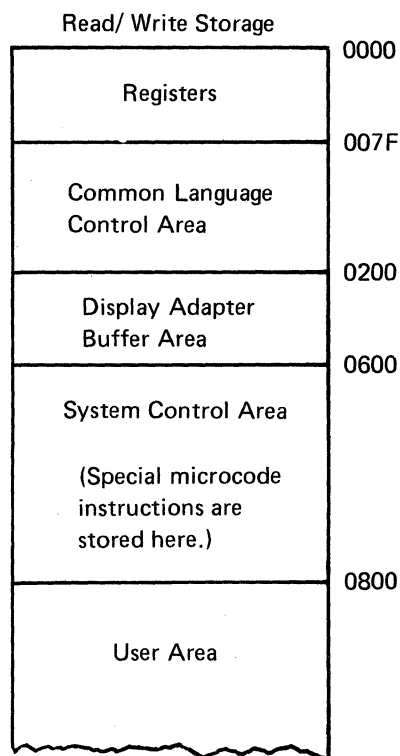
The 16 ROS bits are transferred 8 bits at a time to the 'bus in' line. This transfer is accomplished by two get instructions. The first get instruction transfers the high order byte, and the second get instruction transfers the low order byte. The second strobe signal caused by the get instruction also 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.

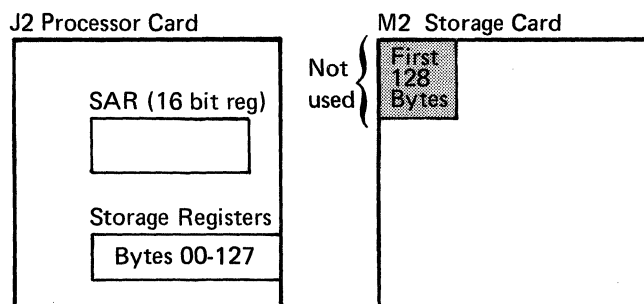
### Card Layout

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.

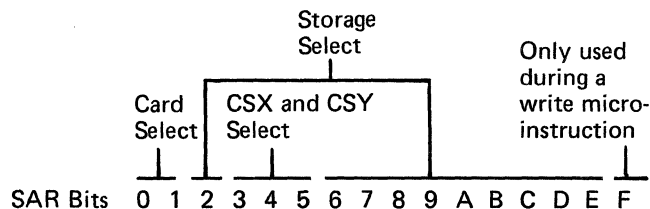
### Storage Address Register (SAR)

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 micro-instruction.

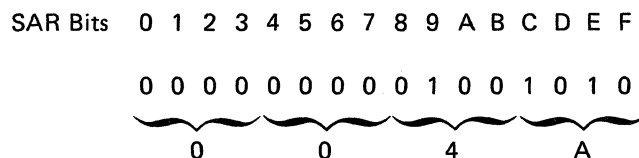
If SAR bits 0-8 are not active (each bit contains a 0), the SAR will use the remaining SAR bits (9 through E) to address the 128-bytes of storage located on the J2 processor card.



### Functions of Address Lines



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



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:

<b>SAR Bit</b> <b>0 1</b>	<b>Card Select</b> <b>Line</b>	<b>Storage</b> <b>Card</b>
0 0	0	M2
0 1	1	M4
1 0	2	N2
1 1	3	N4

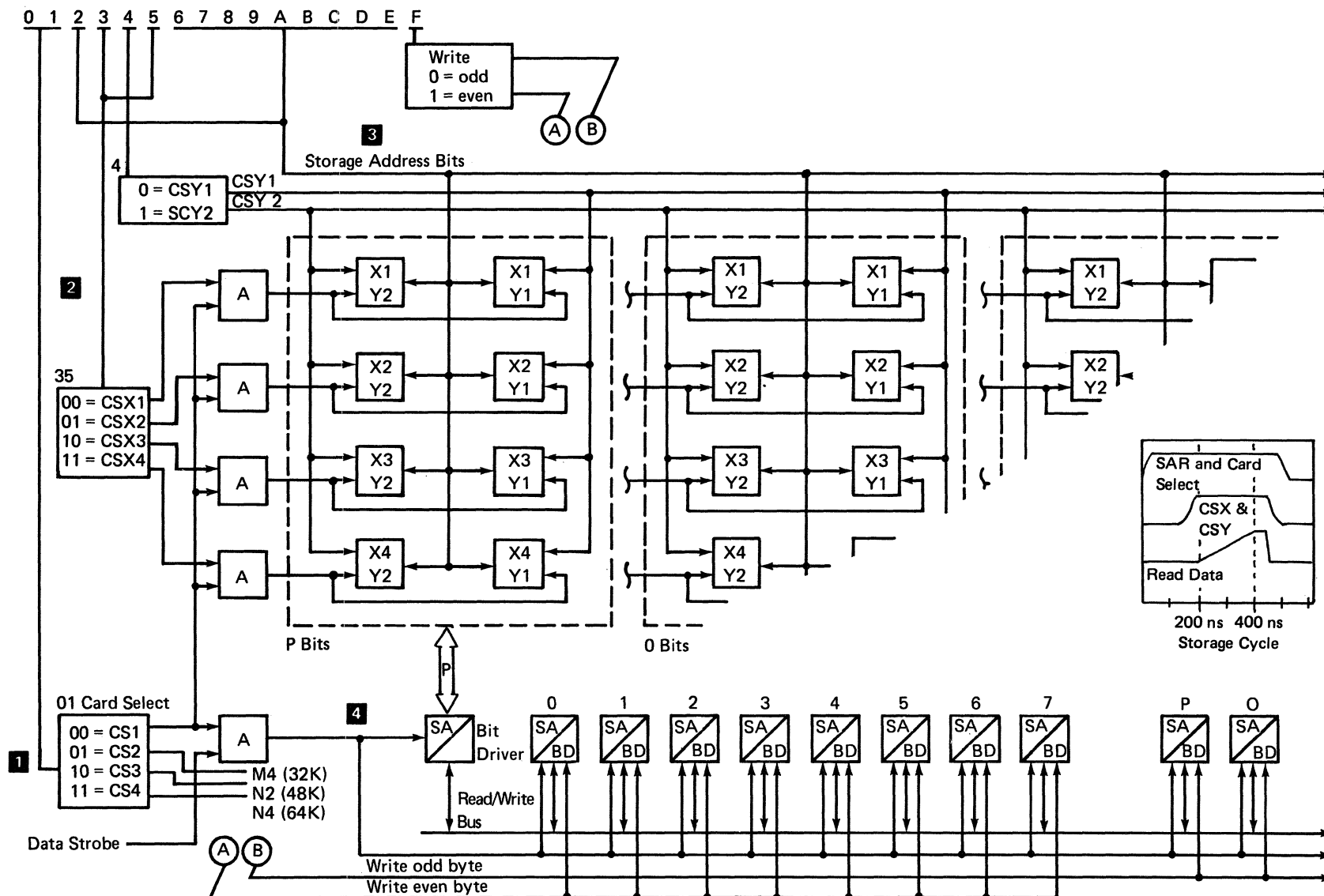
**Chip Select**

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

<b>SAR Bit</b> <b>3 4 5</b>	<b>CSX/CSY Line</b> <b>(Chip Select)</b>
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 5110 computing system. The power on reset signal is generated on the base I/O card and is distributed to all devices.

The adapter for the internal tape unit is located on the base I/O card. This adapter is controlled by microprograms located in executable ROS. The tape adapter sends commands, control signals and data to the tape unit and receives status, data, and clock signals from the tape unit. The tape adapter sends interrupt requests for tape service to the processor.

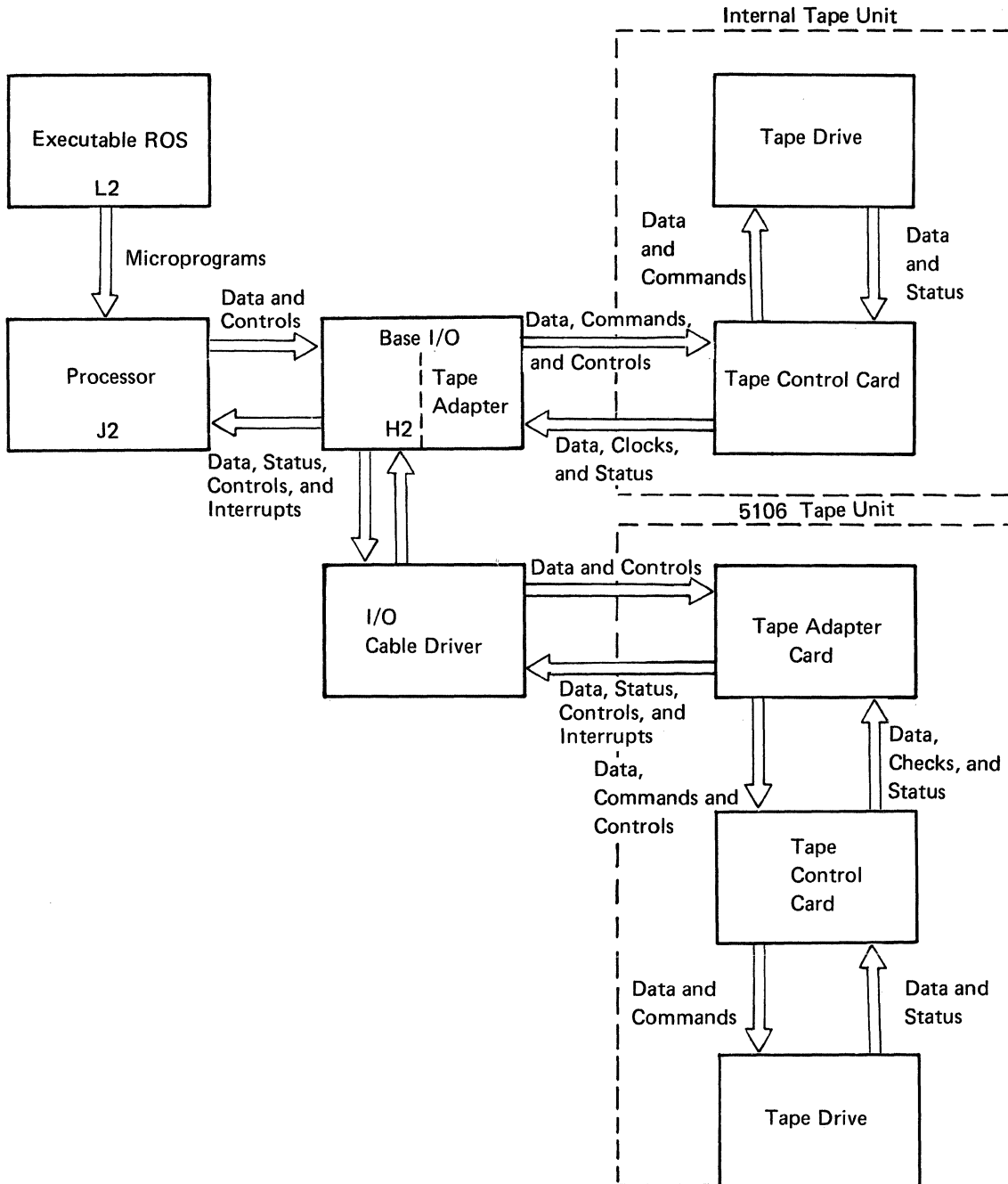
The keyboard adapter is located on the base I/O card (H2). Keyboard data and control information is sent through the adapter to the processor, where microprograms act on the data.

## I/O CABLE DRIVER CARD

The I/O cable driver card (A1A2) supplies line receivers and line drivers for the various attached I/O devices. The Device Address Bus and the Bus Out Bits are repowered and sent to all external devices. The Bus In Bits from these external devices are received, repowered, and sent to the H2 card. The control and clock lines to the external 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.

## TAPE UNIT

Both the 5110 internal tape unit and the 5106 auxiliary tape unit use identical theory and data flow. (The 5106 tape adapter is contained within the external tape housing.)



### **Tape Data Flow**

Microprograms from executable ROS control the movement of data to and from the tape unit by generating control signals. The tape adapter on the base I/O card (H2) controls the signals from the processor and sends commands, data, and control signals to the tape control card. The tape adapter returns data and status information from the tape control card to the processor through the base I/O card.

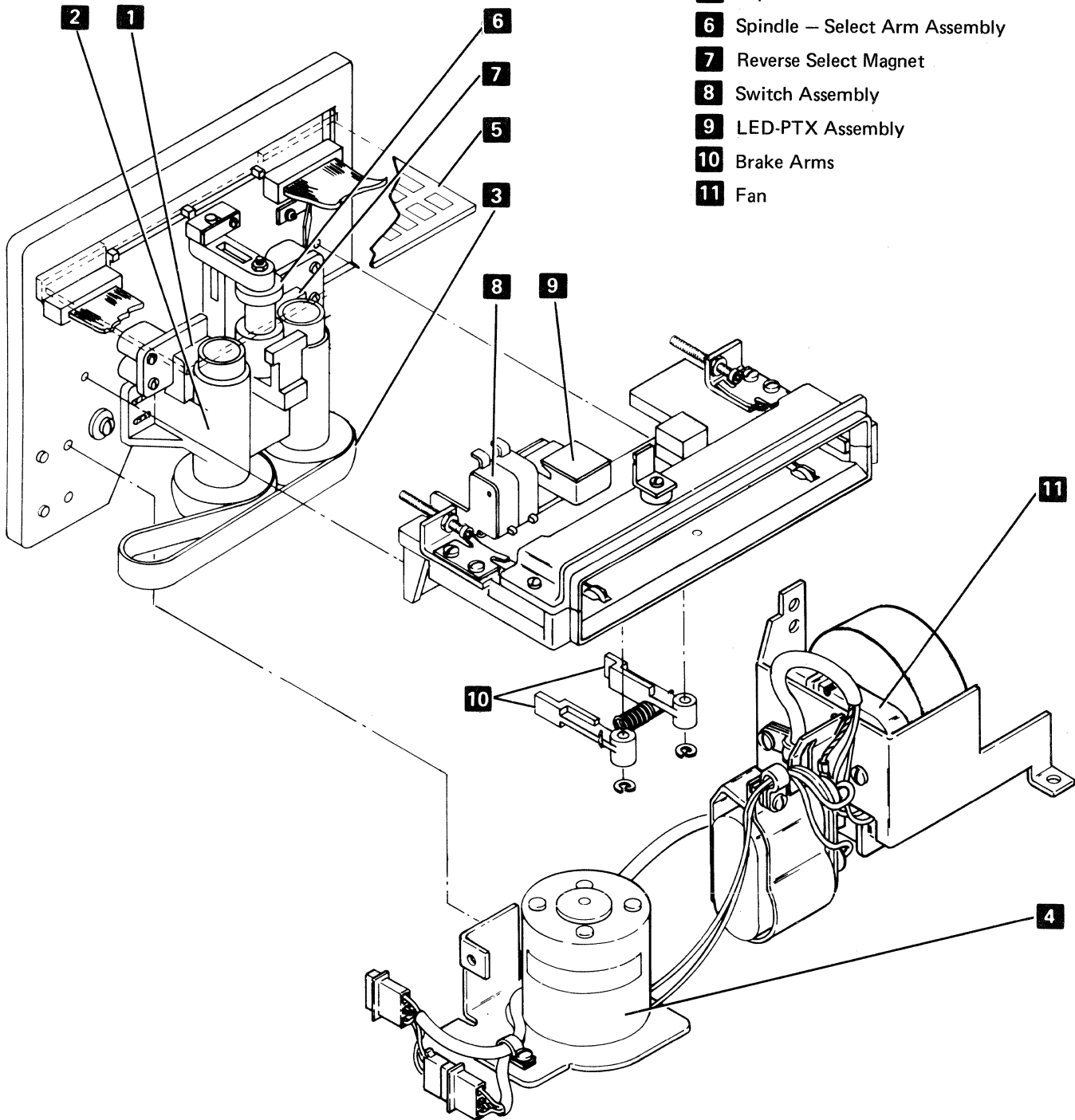
Commands from the tape adapter determine the operations that are performed within the tape unit. The status information sent from the tape adapter to the processor determines the next step of the microprogram. Interrupt requests that are generated within the tape adapter during read or write operations are used by the processor to monitor the tape unit.

### **Tape Drive Components**

A synchronous AC motor, which runs continuously while the power is on, supplies the power to move the tape. The motor, through a drive belt, rotates two jackshaft rollers in opposite directions. The rotating tape drive spindle supplies forward or reverse tape motion when it is attracted to one of the jackshaft rollers by one of the two select magnets. When the select magnets do not attract the spindle carrier, the brake arms hold the spindle stopped.

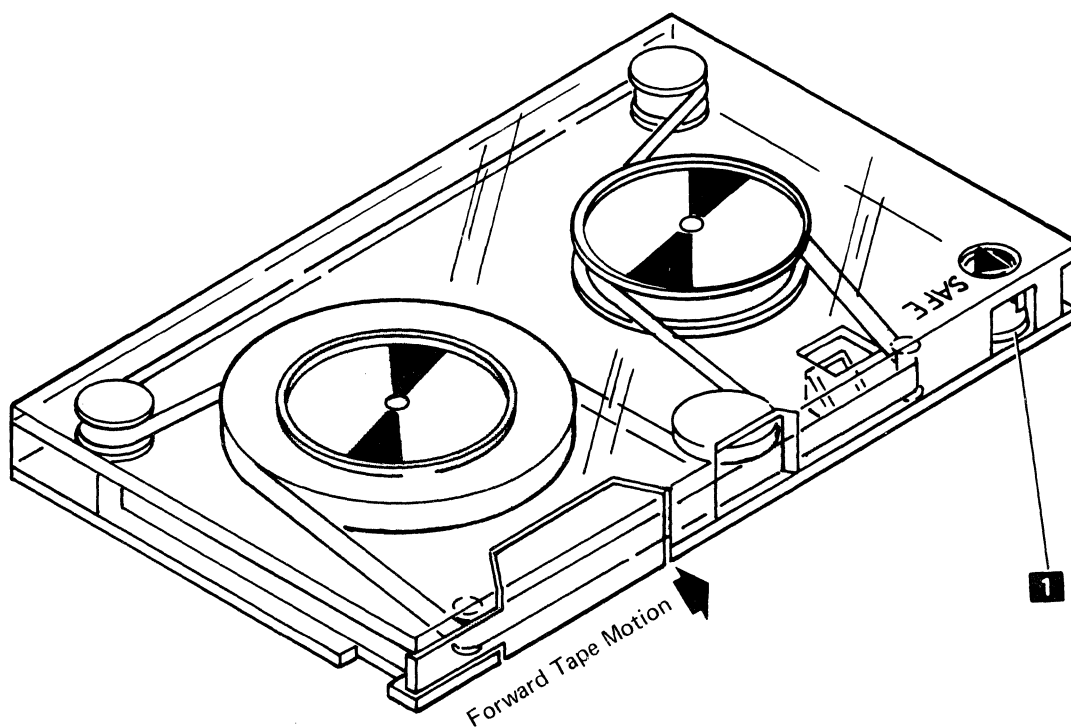
A switch assembly senses the presence of the tape cartridge in the tape unit and the position of the file protect window in the tape cartridge. The tape position is determined by sensing the light from two LEDs; this light is reflected through holes in the tape to two PTXs. The mirror used for this purpose is located within the tape cartridge.

- 1** Forward Select Magnet
- 2** Jackshaft Housing
- 3** Belt
- 4** Motor
- 5** Tape Control Card
- 6** Spindle – Select Arm Assembly
- 7** Reverse Select Magnet
- 8** Switch Assembly
- 9** LED-PTX Assembly
- 10** Brake Arms
- 11** Fan



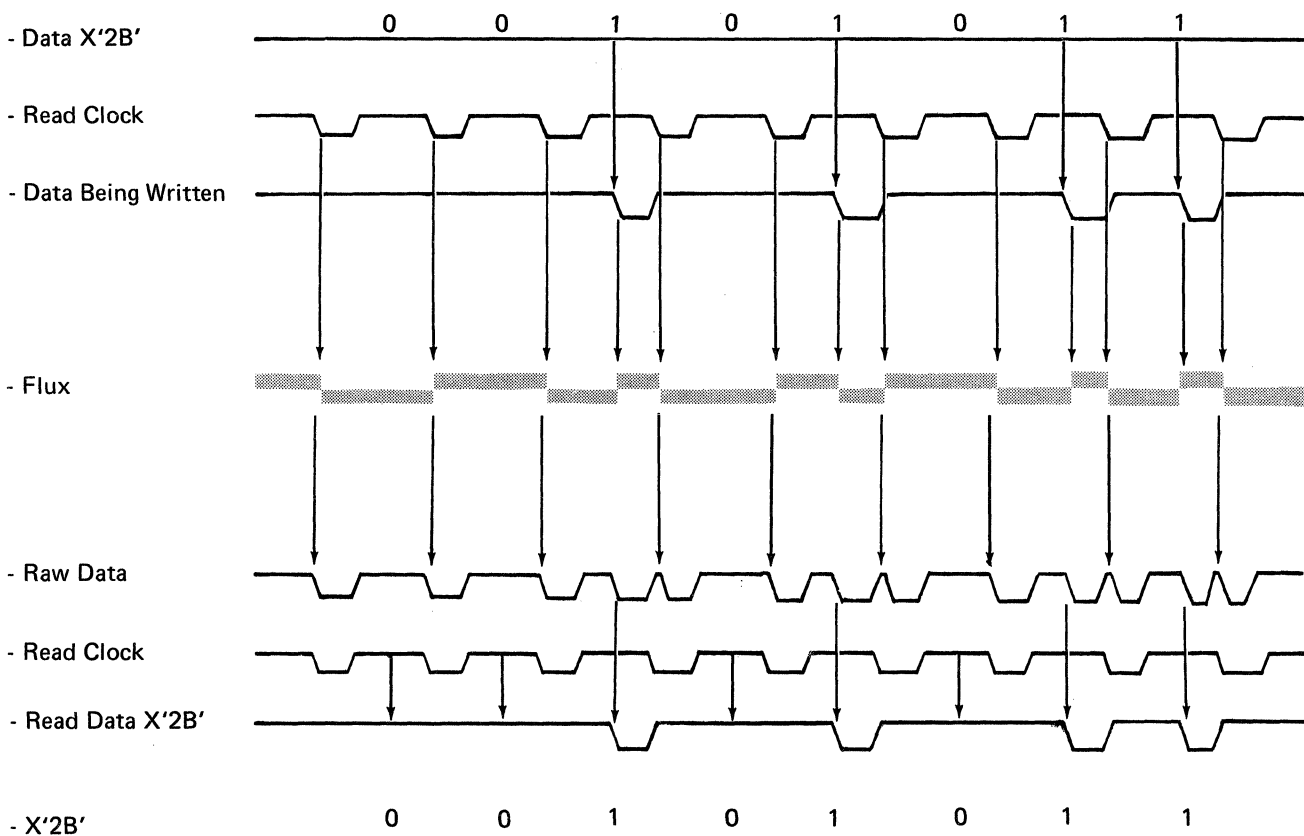
## Tape Cartridge

The tape unit uses the IBM data cartridge to store data and programs. The data cartridge contains 300 feet (91.4 meters) of 1/4 inch (6.35 mm) tape and stores 200K bytes of formatted data. The cartridge is keyed to prevent incorrect insertion in the tape unit. Data files are protected when the file protect window **1** is turned to the SAFE position. If an attempt is made to write to the tape, an error code is displayed, and the write operation will terminate.



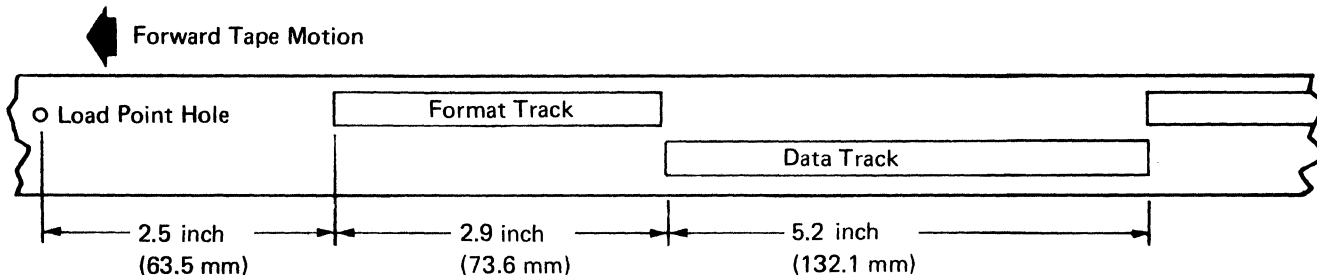
## Tape Writing and Formatting

The tape write logic records a flux reversal on the tape as a clock pulse or a 1 bit of data. A flux reversal occurs when the magnetic field of the write head reverses polarity. Clock pulses are recorded every 31.25 milliseconds; data bits are recorded between clock pulses. Any pulses that appear between clock pulses are read as 1 bits; when no pulse appears between clock pulses, this is read as a 0 bit. Twenty-nine bytes of X'00' are recorded between each record to define clock pulses to the tape write logic. The following example assumes that the 29 bytes of X'00' have already been read.



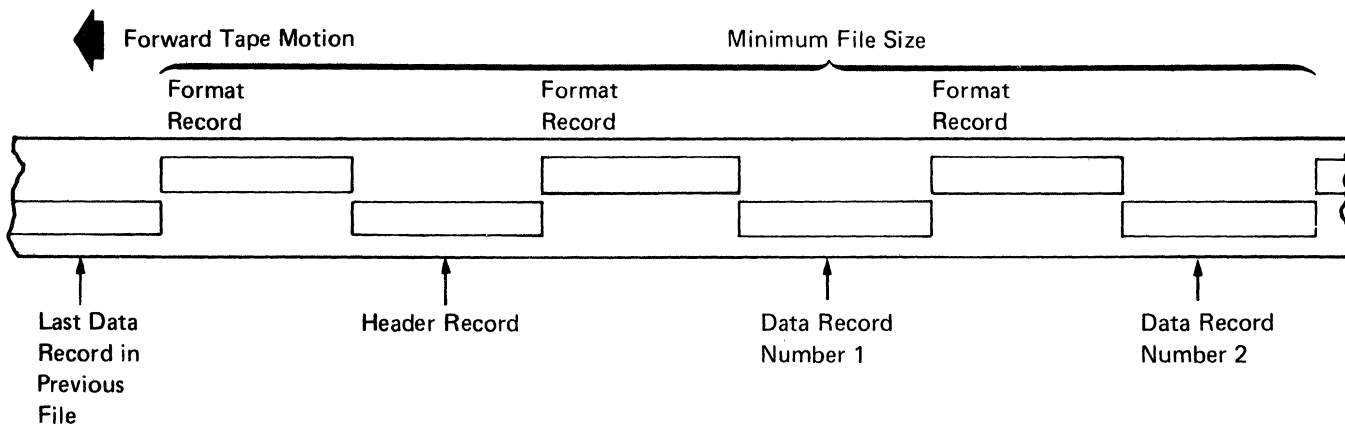
## Tracks

The tape unit records on two tracks. The upper track (channel 0) contains the format records, and the lower track (channel 1) contains the data records. Each track occupies approximately 1/2 the width of the tape. The following illustration shows the relationship between tracks.



## Files

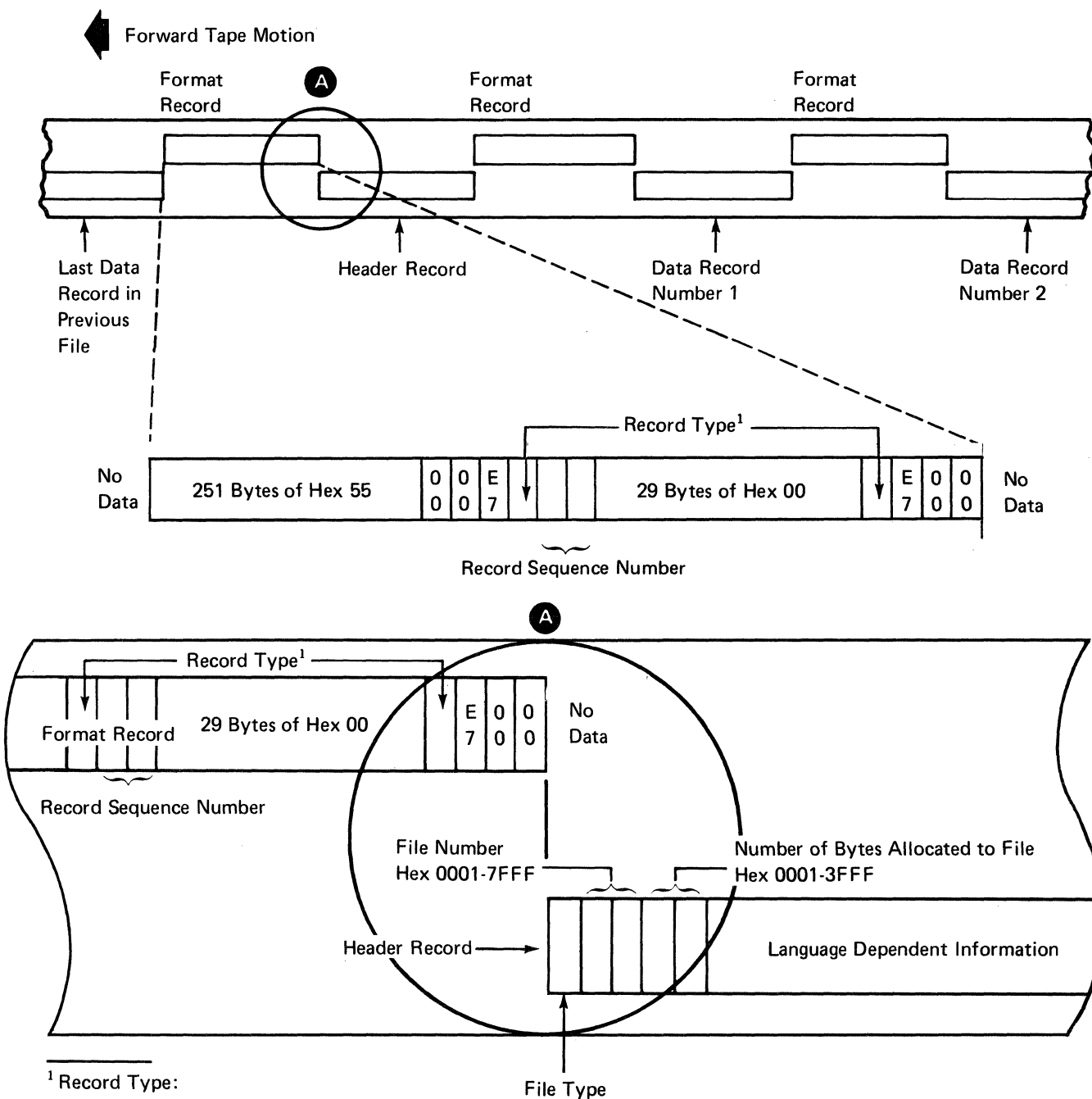
Tape records are grouped into files. A file is made up of a single header record and an even number of data records. The header record and each data record are preceded by a format record that is recorded on the format track of the tape. The following figure shows the arrangement of records on the tape.



## Format Record

The format records are located on channel 0 of the tape. The first 251 bytes of a record are X'55'; they are used as a start/stop zone for the tape unit. The next three bytes are used to provide position and timing information to the processor. The first two of these three bytes are X'00'; they are read, one bit at a time, until the third byte, X'E7', is read. At this point, the tape unit and the processor are synchronized, and the tape adapter switches to byte mode.

The next byte is the record type; it indicates to the processor whether the data track has a header record or a data record written on it. Following this byte is the record sequence byte; it identifies the next record on the data track. The next 29 bytes of X'00' provide a time delay that is used between erasing the data track of one record and writing the data track of the next record. The last four bytes of the format track are used to establish synchronization and to determine the record type if the tape unit is reading in the reverse direction.

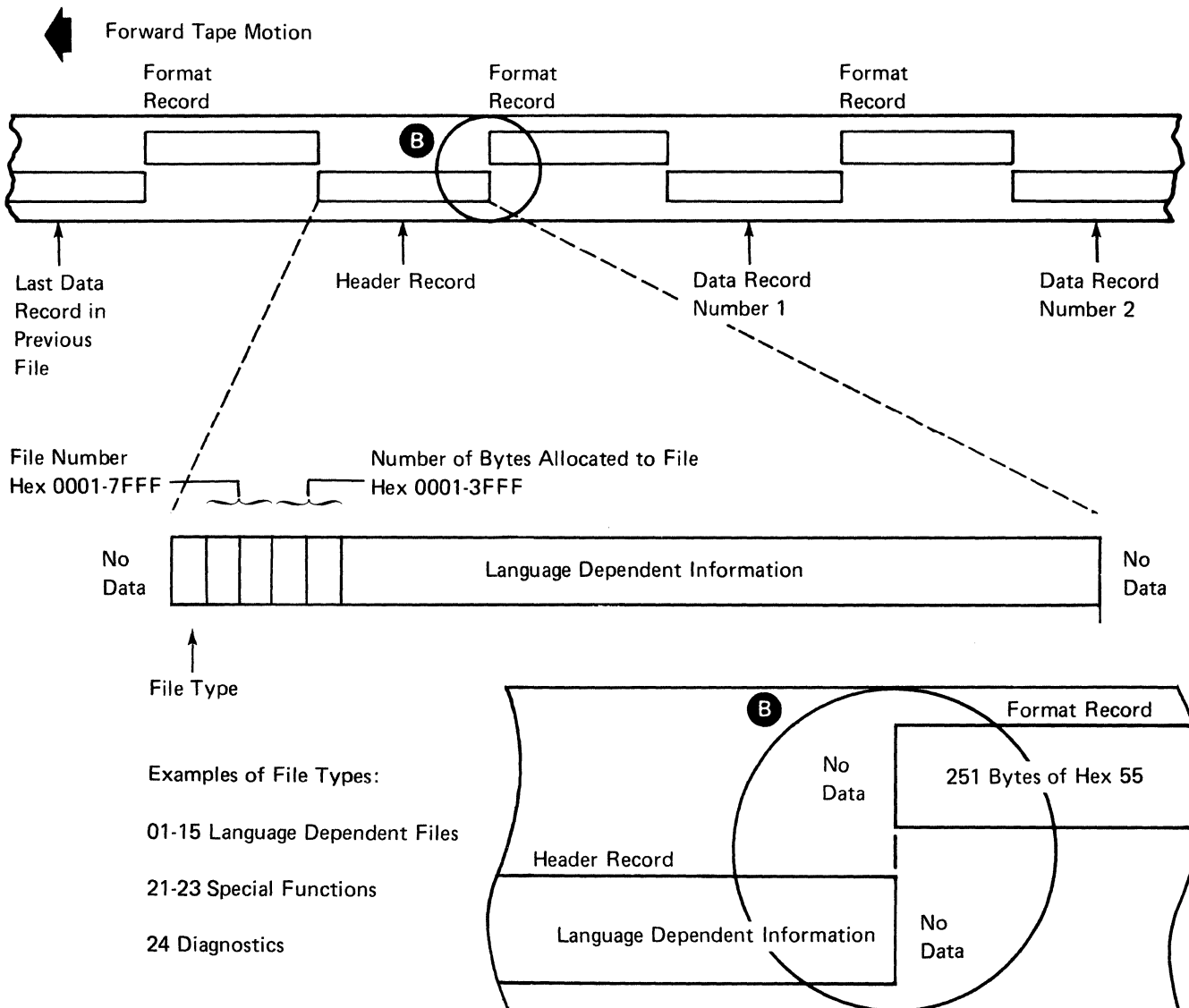


<sup>1</sup> Record Type:  
Header — Hex 81  
Data — Hex 18



## Header Record

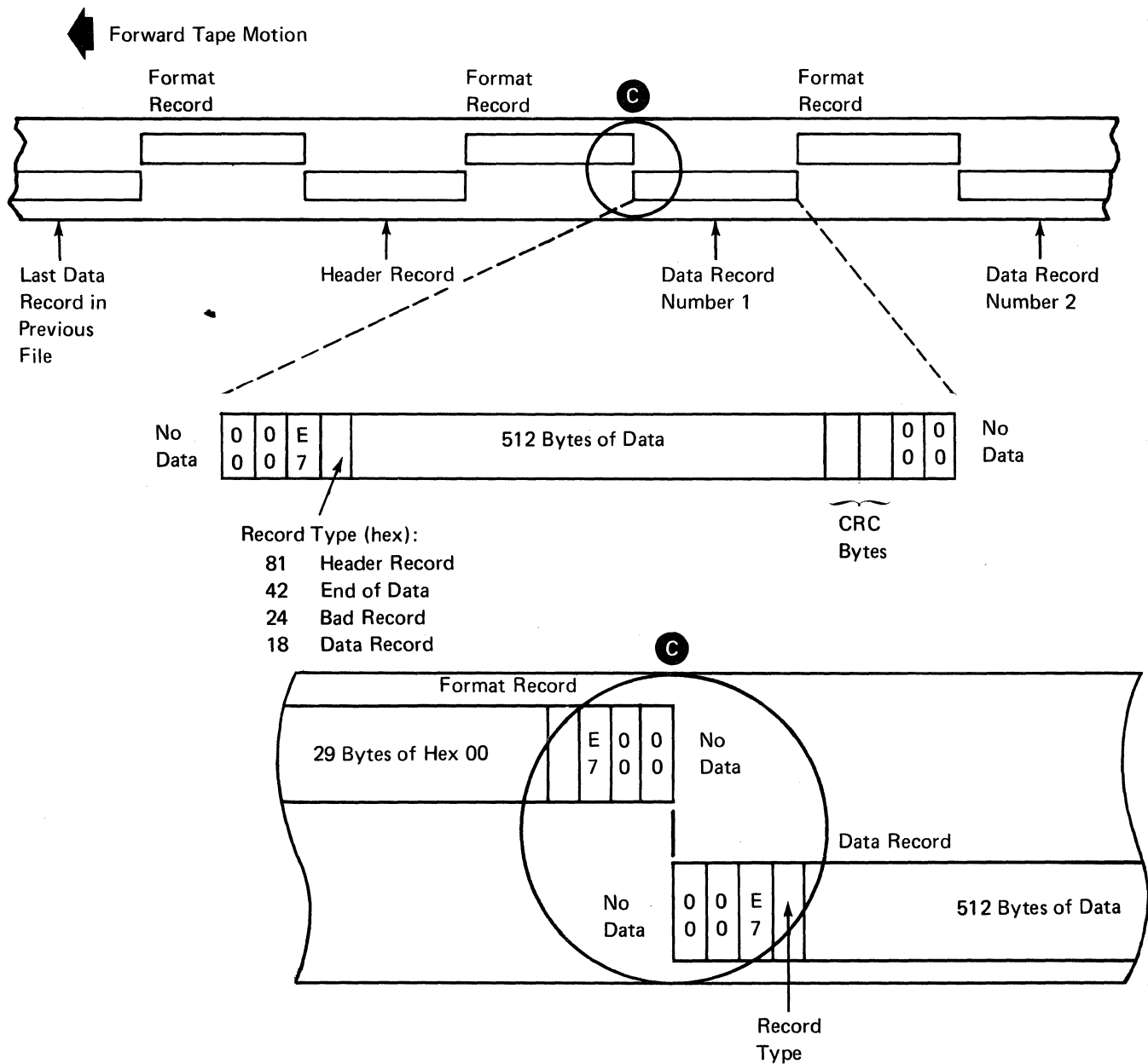
The header record is the first record in a file. Header records are used to identify the contents of the files.



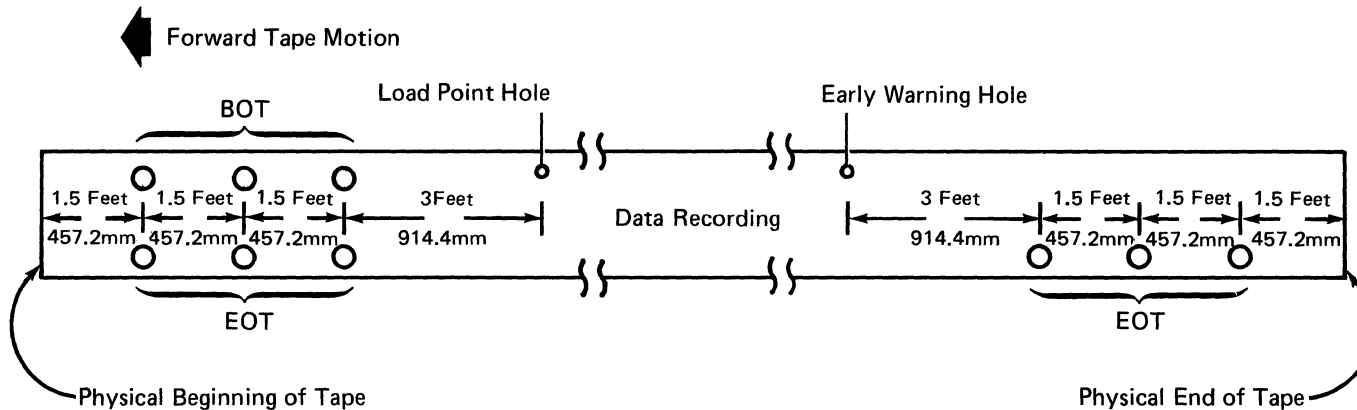
**Note:** The preceding decimal numbers for file type are used by UTIL or LIB commands. DCP1 uses the hex equivalents.

## Data Record

The data records include the recorded data and the cyclic redundancy check (CRC) bytes. The record consists of 512 bytes of data plus the synchronizing and CRC bytes. The processor counts the single byte of the type record and the 512 bytes of the data record and uses the next two bytes for the CRC. The last two bytes in the data record are zeros; they are used to generate extra byte counts up to the 513 bytes. A format record and a header record follow the last record in the last file of a tape; these two records indicate the end of the marked tape.



## Tape Positioning Markers



## Tape Operations

The processor controls the following tape unit operations: mark, search, read, write, rewind, and backspace. The read and write operations occur when the processor is issued a MARK, LOAD, or SAVE command through the keyboard or when a language program function requires tape activity.

### Mark

The mark operation allocates space on tape for write operations. This is done by defining the physical space required to record the desired file.

The mark operation begins by writing a format record that identifies the first record as a header record. This is done by writing a X'81' in the record type area of the format record. The header record contains the file type, the file number, and the file size (given in 1K bytes increments). This information is taken from the MARK command. (A CRC check is made of the header record during the mark operation.)

Each remaining data record is preceded by a format record that is identified by a X'18' in the record type area of the format record. All files and records are written in a sequential order; that is, file 1, containing records 1, 2, and 3, precedes file 2, containing records 1, 2, and 3, and so on.

### Search

The search operation (FIND Command) is used to locate specific files on a tape. Each file must be located before any records can be read or written. The tape adapter moves the tape and selects the format track (channel 0). The contents of the format track locate a header record on the data track (channel 1). The header record describes the file type, the ID number, and the size.

While the tape is moving, the tape control card detects data and clock signals, and the tape adapter interrupts the processor for each data bit (each 31.25 microseconds) until a sync byte (X'E7') is found. The data byte following the sync byte is the record type that identifies the record as either a data record or a header record. After the record type is read from the format track, the processor switches to the data track and reads one bit at a time until the sync byte is found again. The file number is checked against the requested file number. If the correct file is found, the processor terminates the search. However, if the correct file is not found, the processor continues to search each successive record, searching for the desired file.

## **Read**

The read operation occurs during the execution of the SAVE, LOAD, and MARK commands and during search, rewind, and backspace operations. After a successful search, the processor verifies, through the record sequence number, that the records have been read in the proper sequence. After each data record has been read, the two bytes of the CRC are compared with the CRC number generated by the microprogram; if found to be different, a read error is generated.

## **Write**

The write operation occurs during the execution of the SAVE and MARK commands. During a write operation, the tape unit searches for the specified file that has been previously marked. Once the file has been found, the user record is written on the data track and read back for CRC errors. A 'X'42' is written in the record type byte of the last record to indicate the end of the data unless the last record is the end of file.

## **Rewind**

The rewind operation moves the tape in the reverse (clockwise) direction when a '-run' line is received without a '-forward' line. The tape is no longer driven in the reverse direction after the BOT is sensed. The tape coasts to a stop and forward tape motion then moves the load point back to the forward side of the BOT LED-PTX. The tape is then correctly positioned so the processor can read the first file.

## **Backspace**

The backspace operation is similar to the rewind operation; the tape moves in the reverse direction but only until the record byte containing a header is read. At this point, the tape moves forward so the processor can read the entire file.

## **Tape Read Data Flow**

Data is read from the tape one bit at a time. The tape adapter can be programmed to operate in either bit mode or byte mode. During bit mode operation, an interrupt is requested as each bit is stored in the read data register. Tape read clock pulses gate the single bit to the data select register, and the 'interrupt request 2' line tells the processor that data is available from the tape adapter. The 'device address selection' line ANDed with the 'interrupt request 2' line gate the bit to the processor. During byte mode, the data bits are accumulated in the read data register for 8 bit times. Then the 'interrupt request 2' line and the 'device address selection' line gate the byte of data to the processor.

## **Tape Write Data Flow**

The 'interrupt request 2' line tells the processor that the tape unit is ready to accept data. Data to be written is then processed one byte at a time. It is then serialized and sent one bit at a time to the tape adapter through the data bus out. Tape write data leaves the tape adapter; it is then sent to the tape unit under the control of the tape clock. The illustration of the tape read and write operation shows the data patterns.

## **Tape Status**

The tape control card generates the tape unit status that is sent to the tape adapter and stored in the tape status register. Tape status is checked after every command and is gated into the data select register by the 'gate status bit' line. The processor and the microprogram receive the status through the bus in. Some signal lines from the tape control card that are used to generate status are:

'-End of Tape' (EOT)—Indicates that either end of the tape was sensed.

'-Beginning of tape' (BOT)—Indicates that a beginning of tape hole was sensed.

'-Select Mag Active'—Indicates that either the forward or reverse select magnet coil has current.

'-Cartridge in Place'—Indicates the presence of a cartridge in the tape unit.

'-Erase Inactive'—Indicates that neither erase coil has current.

'-LED and Erase OK'—Indicates that the EOT and BOT LEDs have current and that the erase coils are not open.

'+File Protect'—Indicates that the cartridge has its file protect window closed.

The tape status is stored in location 008F and may be read as follows:

Bus In Bit	Bit=0	Bit=1
0	No end of tape	End of tape (EOT)
1 <sup>1</sup>	Device address E response	No device address E response
2	Tape stopped	Tape running
3	No cartridge	Cartridge in place
4	Erase off	Erase on
5	LED or erase defective	LED and erase OK
6	Allow write	File protect
7	Beginning of tape (BOT)	No beginning of tape

## DISPLAY

All data entered through the keyboard is displayed on the 5110 5-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.

<sup>1</sup>Input to status bit 1 is always present.

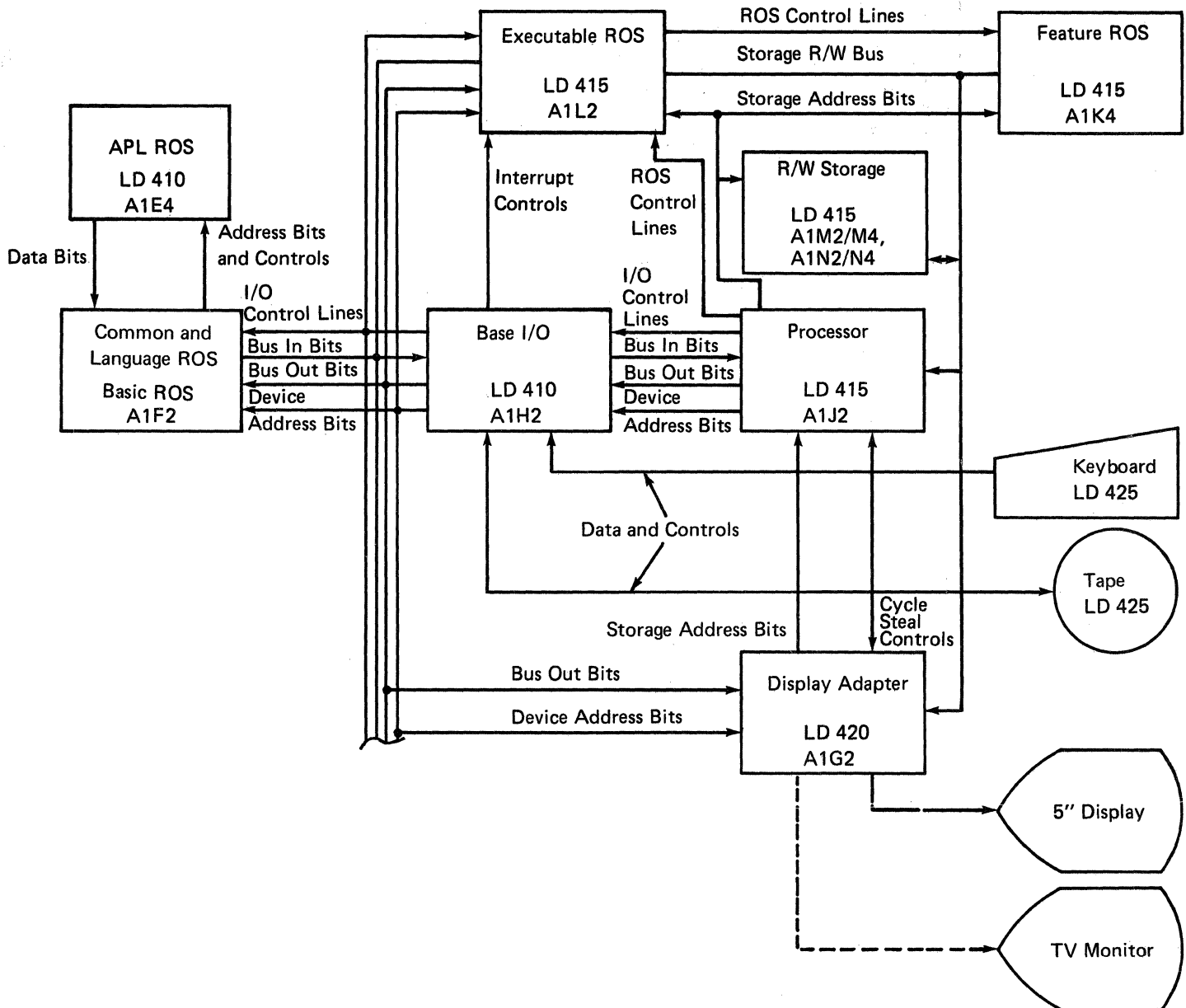
## Addressing

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.

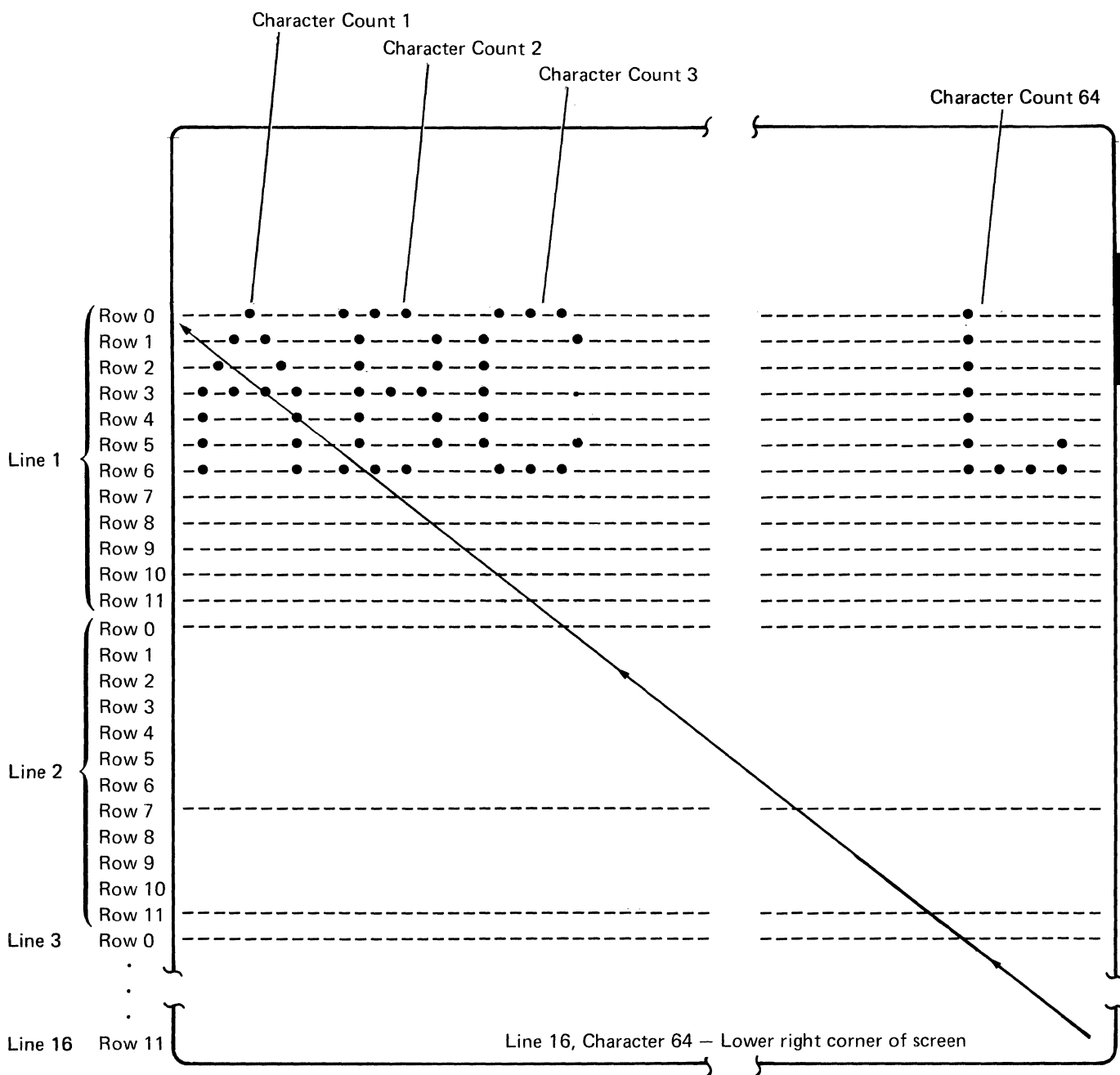
The display adapter responds to device addresses 0 and F. The device address bus and bus out bits are parity checked. Incorrect parity will cause a machine check. The World Trade latch and selector jumper information is loaded when the computer is turned on and when the RESTART switch is pressed. The 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 the ('+monitor composite video' line) to the TV monitor jack.



## Display Counters



Theory

**Note:** The line counter is 0 on line 1, 1 on line 2, . . . , and 15 on line 16.

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, the DISPLAY REGISTERS switch, and the L32-64-R32 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.

The previous discussion applies when the DISPLAY REGISTERS switch is set to the NORMAL position and the L32-64-R32 switch is set to 64 although the differences for other settings is slight. 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.

When the L32-64-R32 switch is set to either L32 or R32, a blank character is inserted between the characters so that only the 32 leftmost or the 32 rightmost characters are displayed. To accomplish this, the sequential bytes are read from read/write storage on every fourth count of the character counter, rather than on every second count. The shift register loads every other count and produces the blanks in between characters.

#### *Display Unit I/O Lines*

When black characters are displayed 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 white characters are displayed 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 controls 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.

If the L32-64-R32 switch is set to L32 or R32, the character counter updates the address every fourth character count. The address lines cause read/write storage to gate the information from the addressed storage positions to the Storage Read/Write Bus and into the display data register.

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. Information is shown simultaneously on the five-inch display screen and on the TV monitor.

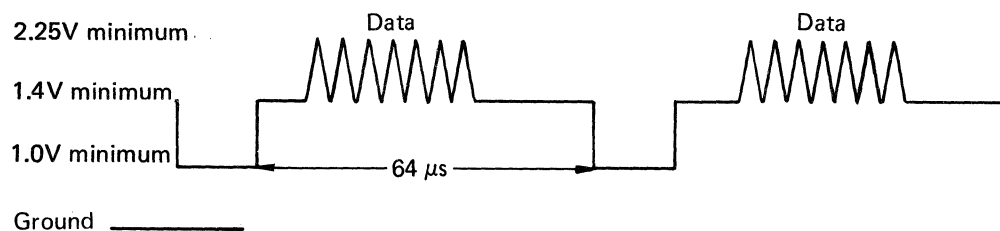
The TV monitor displays the same information as the 5110 five-inch display screen. However, the TV monitor always has white characters on a black background.

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 $\mu$ s
Vertical amp	0.1 V/div
Probe point	A1-K6B04 (+monitor video)
(Use a grounded	
10X probe.)	

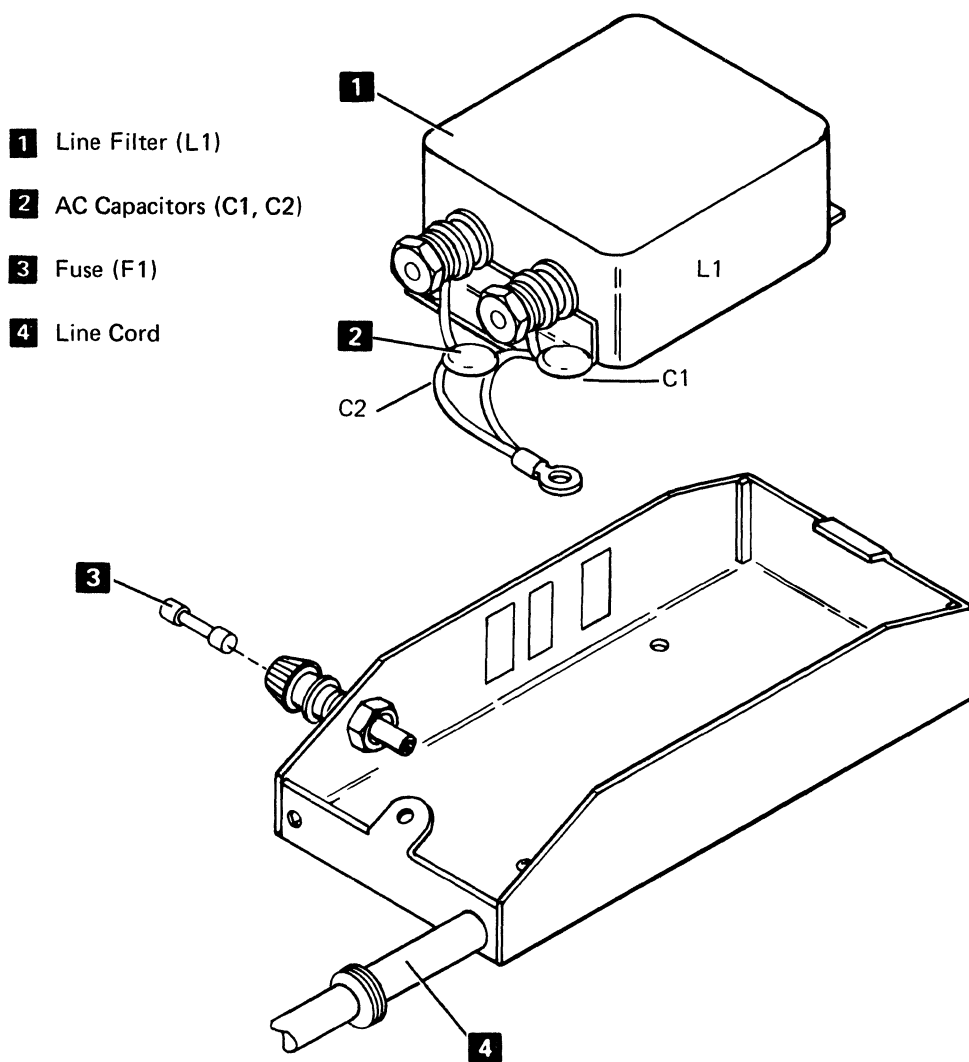
## POWER

The 5110 operates with any of the following five single-phase AC power sources:

- 60 Hz
  - 100 Vac
  - 115 Vac
- 50 Hz
  - 100 Vac
  - 220 Vac
  - 235 Vac

## AC Power Box

AC power enters the 5110 through a line cord **4** that attaches to the filter **1** in the AC power box. The AC power box also contains the AC capacitors **2** and the F1 fuse holder **3**. The power on/off switch controls the distribution of AC power.



## Power Supply PC Board

The PC board uses a small, high power, high frequency transistor switching regulator (TSR) supply to develop five DC voltages for the 5110 system:

+5 Vdc	Basic logic voltage
-5 Vdc	Tape control card, 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	Display unit, tape select magnets, tape LEDs, BSCA cards, and 5114 R1 relay
-12 Vdc	Tape unit, 5114 R1 relay, BSCA cards, and asynchronous communications/serial I/O card

The DC outputs may vary from +10% to -9% of the rated voltage before they affect the operation of the system.

## DC Power Distribution

The five 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. All I/O devices, except the 5103, also have an interface port to which the next device is attached in serial fashion. The 5106, 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.

## Power Supply Protection

The 5110 power supply 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 five seconds before it is powered up again.

## 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. This 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.

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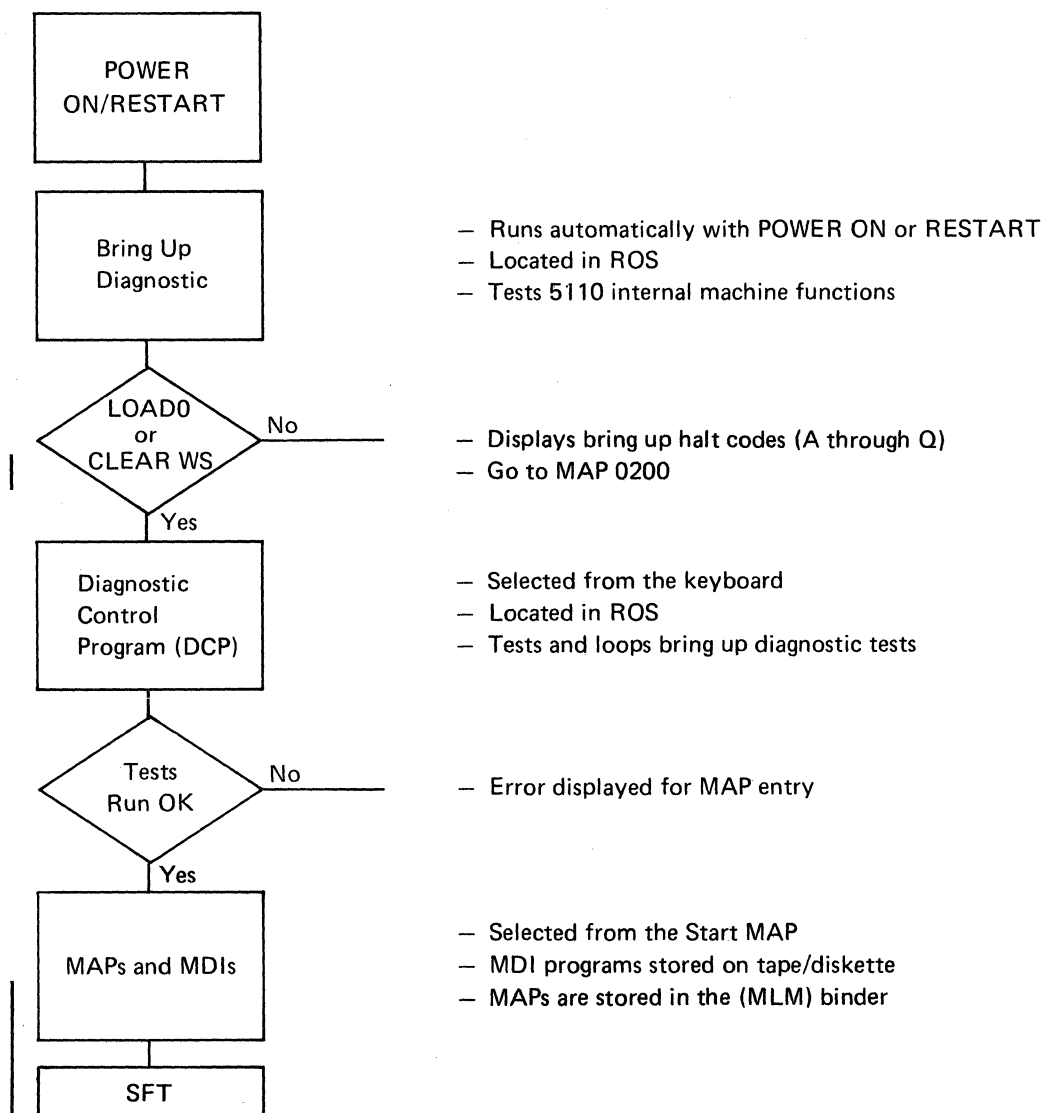
## Diagnostic Aids

### 5110 DIAGNOSTICS OVERVIEW

The 5110 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 *5110 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 5110 problems:





## 5110 DIAGNOSTICS OVERVIEW CHART

The *5110 Diagnostics Overview Chart* and the *Diagnostic Run Summary Chart* provides a quick reference to aid you in selecting and running the 5110 diagnostics. These

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 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).

### Error

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

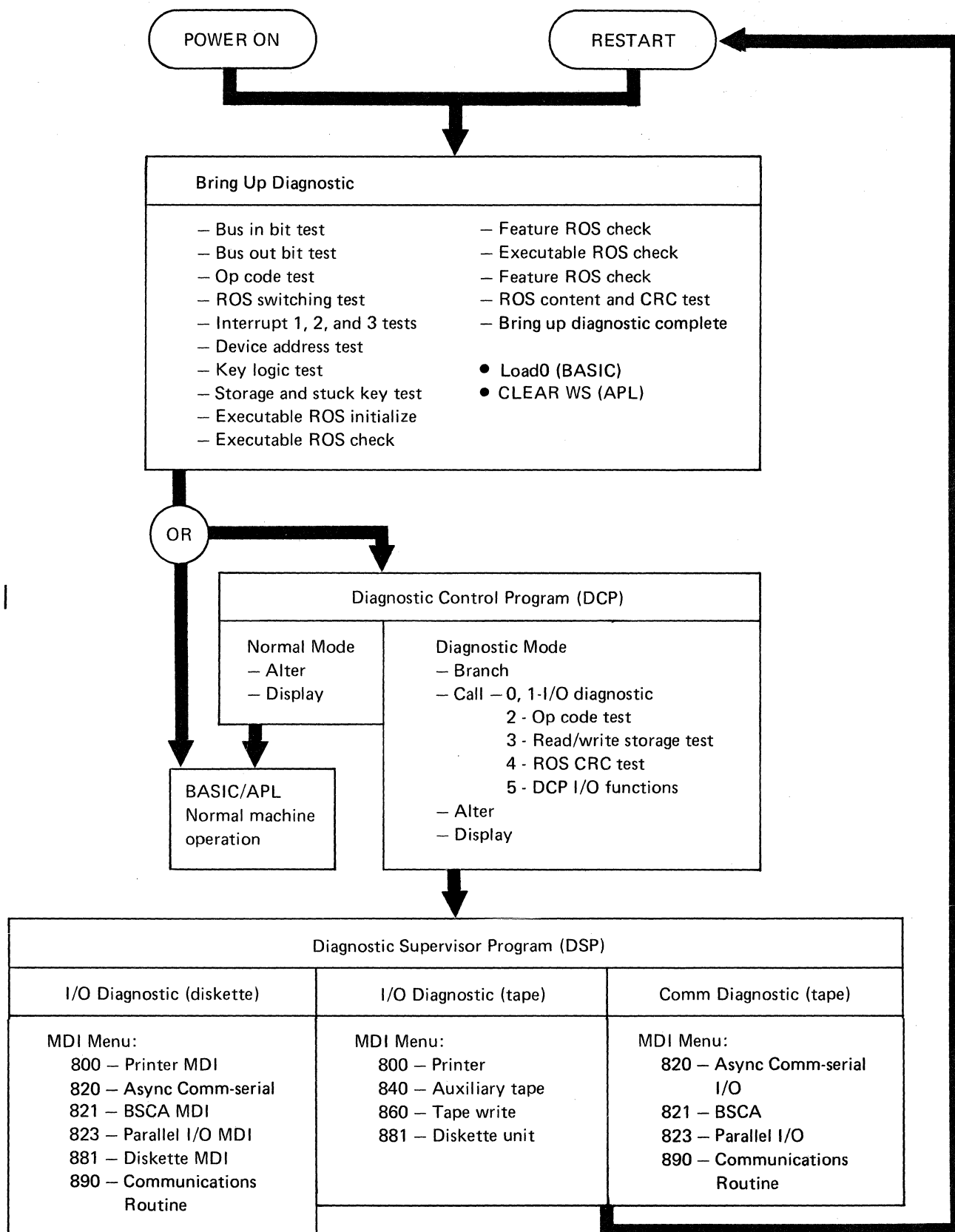
When controlled by DCP, each of these tests loop continuously until an error occurs or the test is stopped by the operator. Call tests 0 and 1 (I/O diagnostics) verify the read operation of the loading device (tape or diskette) circuitry. DCP contains some optional functions that allow you to alter, 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 tape or 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.

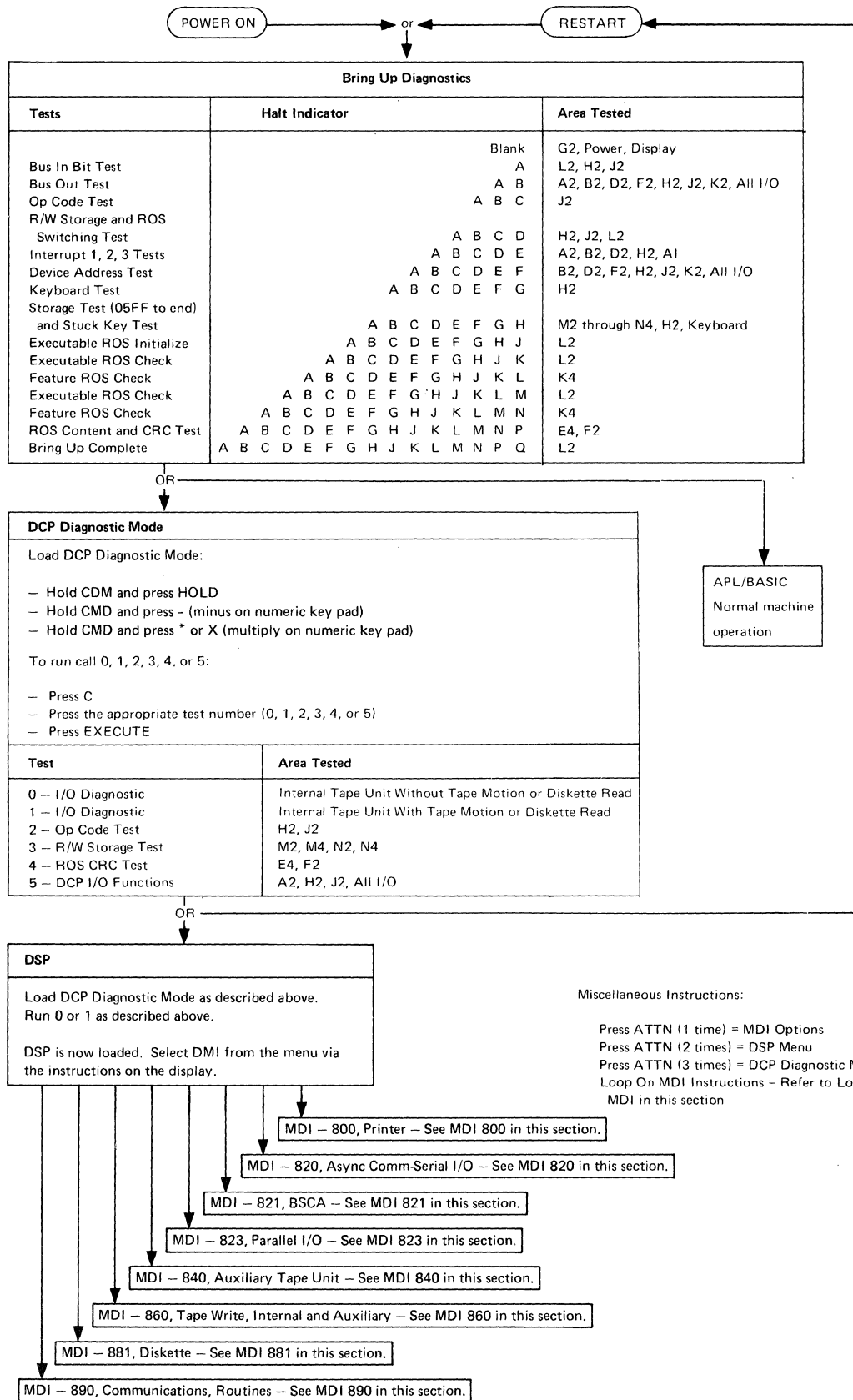
The DSP provides for tracing and looping the MDIs. Tracing allows you to see which path was used in the MDIs.

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.

# 5110 Diagnostics Overview Chart



## Diagnostic Run Summary Chart



## 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 5110.

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, K2, 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, K2, 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# AAAAAAAAAAJ R YRTTYAAAAHAHAJAJAAAJAHAGAJJA  
KDJKPHKJFIRJGUTOEPFKGJJGOROYUJE OFJRMIRLG 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:

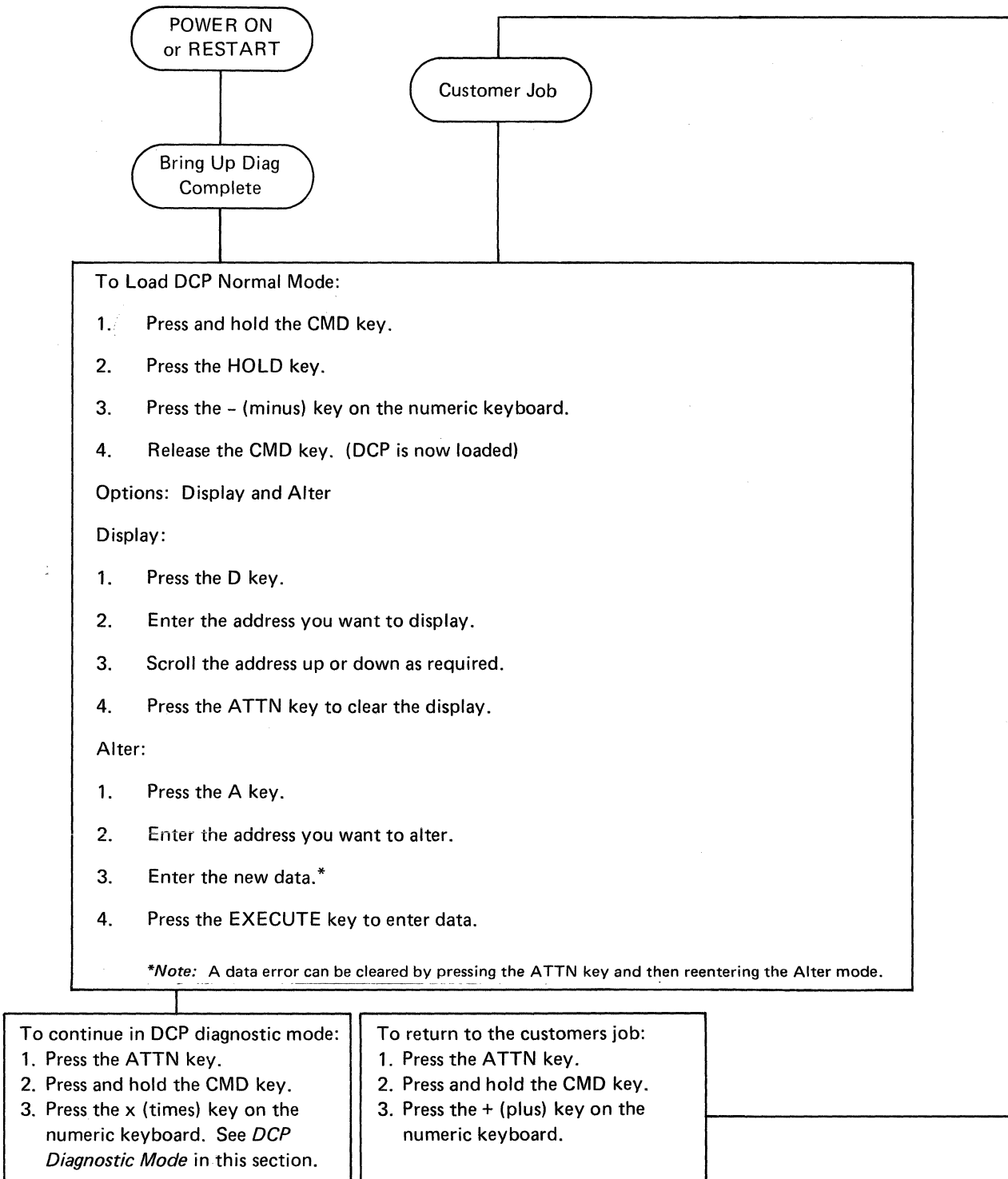
```
AB
```

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 shows the loading of and the options for DCP normal mode.



## 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.

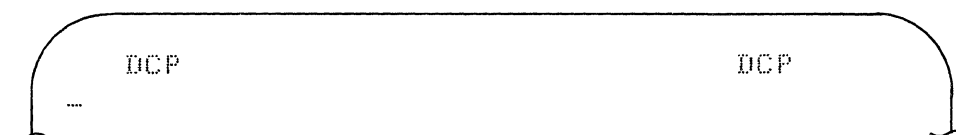
To load the DCP normal mode:

1. Press the HOLD key.
2. Press and hold the CMD key and press the - (minus) key on the numeric keyboard.

To exit<sup>1</sup> 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 header is repeated in both halves of the display; it will appear even if the L32-64-R32 switch is set to display a 32-character line. The cursor flashes (or blinks) whenever the keyboard is operational.



<sup>1</sup>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.

### 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.

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.

### 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.
BX	Branch to extended ROS address.
BR	Branch to read/write storage.

}

If an error occurs, the entry can be cleared by pressing the ATTN key.

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.

DIAG DCP

DIAG DCP

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 \* (asterisk) key on the x (multiple) 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 is used in the tape read tests and, at times, when you receive plant assistance. 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 tape read or 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 (ROLO). 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 tape/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

## *I/O Diagnostic 0*

### 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
```

### DIAG DCP

The I/O diagnostic 0 routine tests the read functions of the internal tape unit or drive 1 of the 5114 Diskette Unit. It performs the same tests as the I/O diagnostic 1 routine with the exception of the forward motion and reverse motion test; therefore, this test provides a faster access to the DSP program.

If a failure is detected during I/O diagnostic 0, 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.

## *I/O Diagnostic 1*

### DIAG DCP

```
1  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
```

### DIAG DCP

The I/O diagnostic 1 routine tests the read function of the internal tape unit or drive 1 of the 5114 Diskette Unit. It also tests the forward and reverse motion on the tape unit. This test provides access to the DSP program.

If a failure is detected during I/O diagnostic 1, the display will guide you to a specific MAP or MDI to isolate the failing field replaceable unit. If the I/O diagnostic 1 runs OK, the DSP menu will be displayed.

### Loading the I/O Diagnostic

#### CAUTION

Do not insert the CE diagnostic cartridge until instructed to do so on the display. The tape might be erased if you insert it too soon.

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 tape read test by holding down the CMD key and pressing the ATTN key.

Pressing the EXECUTE key calls the tape or diskette read program into read/write storage and starts the test.

The CRC is checked when the tape or 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.

Some of the tests in the tape read test require answers to questions put on the display. Follow the instructions given and answer the questions carefully. The following message is also displayed during some of the tests:

- R = retry this test
- L = loop on this test

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 tape or 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 tape or 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 E 80   GO TO MAP 0300
```

OR

```
ERROR   XXX D 80   GO TO MAP 0310
```

Diagnostic  
Aids

#### Loop On Test (Model X1X only)

If an error occurs, pressing the L key causes the program to loop on the present test. After pressing the L key, an F (fail) or a P (pass) is displayed on the bottom right side of the display screen. The F indicates that an error exists, and the P indicates that the test passed (an error does not exist). The F or P indicators are displayed only when a model X1X is tested.

To stop looping, hold down the CMD key and press the ATTN key. This stops the tape read test.

### *Rerun Test*

To run the tape or diskette read test again (because it is still in read/write storage), do the following:

1. Remove the CE diagnostic cartridge or diskette.
2. Press the ATTN key.
3. Enter BR (branch to read/write storage).
4. Enter 2A00 (starting address of the tape read test).
5. Press the EXECUTE key.

Follow the instructions on the display (some loops will not have instructions).

The CE diagnostic cartridge or diskette must be removed before you retry the tape or diskette read test.

Note that once another program has been selected from the DSP menu, the test cannot be run unless it is recalled.

### *Loop On Error Code*

To loop this specific test within the tape diskette read tests, do the following:

1. Press and hold the CMD key.
2. Press the ATTN key.
3. Alter location 2A26 to the error number of the test (this allows you to loop on a specific test).

Looping in this manner is the same as pressing the L key when the instruction PRESS EXECUTE, R, or L is displayed.

See the tape and diskette read test charts in this section for the error numbers.

For example, to loop on error 0912:

1. Press and hold the CMD key and press the ATTN key.
2. Remove the diagnostic tape/diskette.
3. Alter location 2A26 to the error number as follows:
  - Press the A key.
  - Enter 2A26.
  - Enter 0912.
  - Press the EXECUTE key.
  - Press the ATTN key.
  - Enter BR 2A00 (starting address of tape read tests).
  - Press the EXECUTE key.

The tape and diskette read test will execute normally until it reaches the test you selected.

Follow the instructions on the display. Tests run prior to the first display will loop without displaying instructions.

Display messages on the 5110 X1X.

F (fail) — error

P (pass) — no error

The 5110 X2X does not display an F or P message. Looping stops when you press and hold the CMD key and press the ATTN key.



## Tape Read Test Error Chart

Error Code	Meaning	Area Tested
001	ATTN key pressed	Keyboard
002	Incorrect command detected	H2, J2
003	Machine error	H2, tape control card
004	Timeout	Read/write head
005	Cartridge in place errors	Cartridge in place switch
006	File protect error	File protect switch
007	Data error	Tape cartridge, read/write head
008	Sequence error	Tape cartridge, read/write head
009	End of data test	Tape cartridge
010	End of file test	Tape cartridge
011	End of mark test	Tape cartridge
012	End of tape test	Tape cartridge
013	Device not attached	H2
014	Device not selected	H2
901	Device reset error	H2
903	Card logic test error	H2
906	Subdevice address error	H2
907	Interrupt error	H2, tape control card
909	Wrap test—no data	H2
912	Cartridge in place error	Cartridge in place switch
915	File protect error	File protect switch
918	LED/PTX test	LED/PTX assembly
921	LED/PTX test	LED/PTX assembly
924	LED/PTX test	LED/PTX assembly
927	Erase mode test	H2, tape control card
930	Erase mode test—channel 0	H2, tape control card
933	Erase mode test—channel 1	H2, tape control card
936	Select magnet test	Select magnets
937	Forward select magnet status test	H2, tape control card
938	Reverse select magnet status test	H2, tape control card
939	Interrupt error	H2, tape control card
940	Wrap test—no interrupt	Tape control card
943	Wrap test—extra data	Tape control card
946	Wrap test—read/write head	Read/write head
947	Wrap test—no data	Tape control card
948	Cartridge in place error	Cartridge in place switch
949	File protect error	File protect switch
950	End of tape test	Tape cartridge
951	Tape motion test (forward)	Tape motor assembly, forward select magnet
952	Tape motion test (reverse)	Reverse select magnet
953	Tape motion test	Brake arm
954	BOT and EOT test	LED/PTX assembly
957	EOT test	LED/PTX assembly
958	Tape speed test	Cartridge stop blocks
960	BOT test	LED/PTX assembly
963	BOT test	Cartridge stop blocks

(Continued on next page)

## Tape Read Test Error Chart (continued)

Error Code	Meaning	Area Tested
966	Tape speed test	Cartridge stop blocks
970	BOT and EOT test	H2, tape control card
973	Tape speed test	Cartridge stop blocks
982	BOT test	H2, tape control card
983	Read data error	Tape control card
985	Read data error—channel 1	Read/write head
986	Read data error—channel 0	Read/write head
987	Sync byte test—channel 0	Read/write head
988	Sync byte test—channel 1	Read/write head
989	Sync byte test	H2, tape control card
994	Read data error	H2, tape control card
995	Wrap test—no error	Tape control card
996	Wrap test OK	None

## 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	VFO card <sup>1</sup>
013	Test loop write/read	VFO card <sup>1</sup>
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

<sup>1</sup> Some 5114 units may have VFO circuitry on the tape adapter card. See MAP 050.

Op Code Test-2

OC	W	DIAG DCP
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

DIAG DCP

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.

Diagnostic  
Aids

## DIAG DCP

```

3  PRESS EXECUTE
0,1 I/O DIAGNOSTIC
2  OP CODE TEST
3  R/W STORAGE TEST
4  RDS CRC TEST
5  DCP I/O FUNCTIONS

```

## DIAG DCP

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

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

DIAG DCP

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  
5 DCP I/O  
DVG

DIAG DCP

This function allows you to dump read/write storage to a tape or to a diskette. It also allows you to dump a tape or 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 or tape).  
 XXX = file size in K bytes.  
 YY = number of files.  
 ZZ = starting file.

RD	— Selects the read function (from diskette or tape).
WT	— Selects the write function (to diskette or tape).
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).

**TTY** – 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.

*Tape/Diskette Read Format:*

DV@ XXX  
Device Address

R D b A b X X X X b F b #  
File number  
Address  
Read Function

(b = 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:

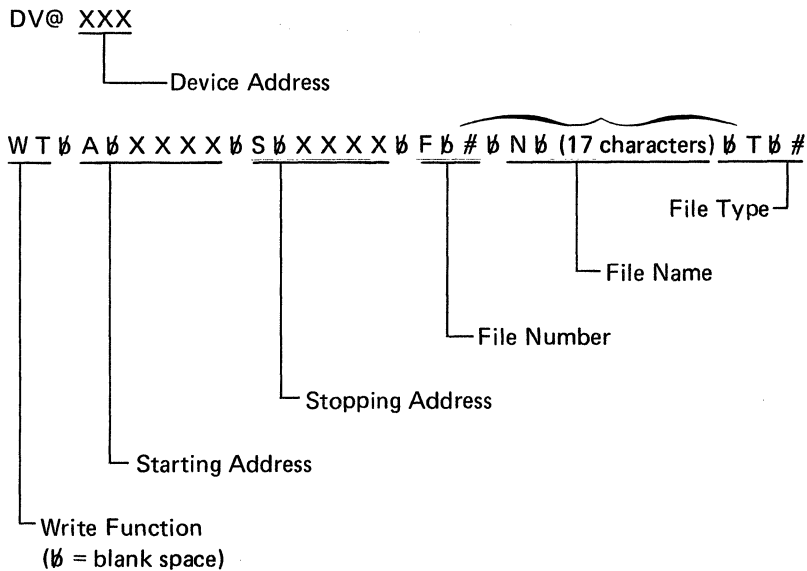
1. Press the ATTN key.
2. Press the C key and the 5 key.
3. Enter D80 (if you are using drive 1).

*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.

# *Tape/Diskette Write Format:*



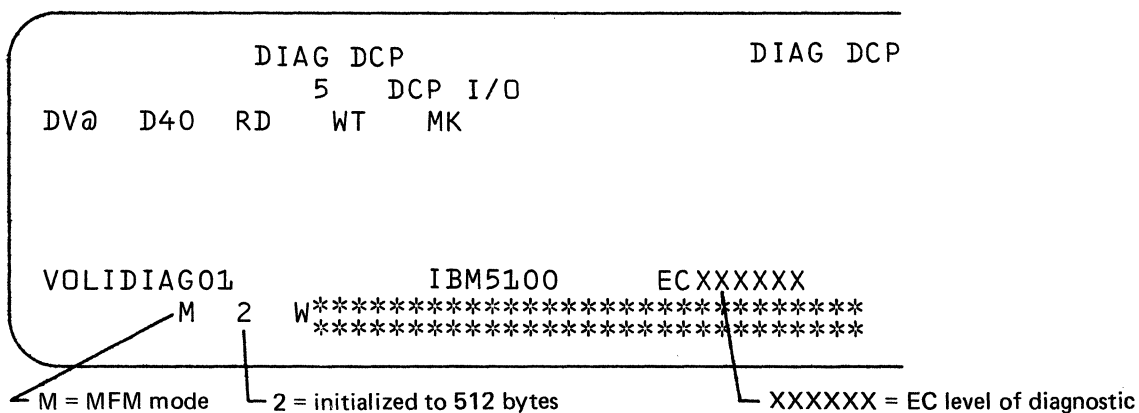
## *Example:*

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 4360150) is initialized to 512 bytes. The VOL I D is displayed using DCP option 5 as:





The diskette can be copied by using the customer's disk to disk copy program that is located on the customer support diskette or tape.

### Caution

The volume label (VOL1D1AG01) is not copied by the disk to disk copy program and the diagnostics will not execute properly unless the volume label is VOL1D1AG01.

---

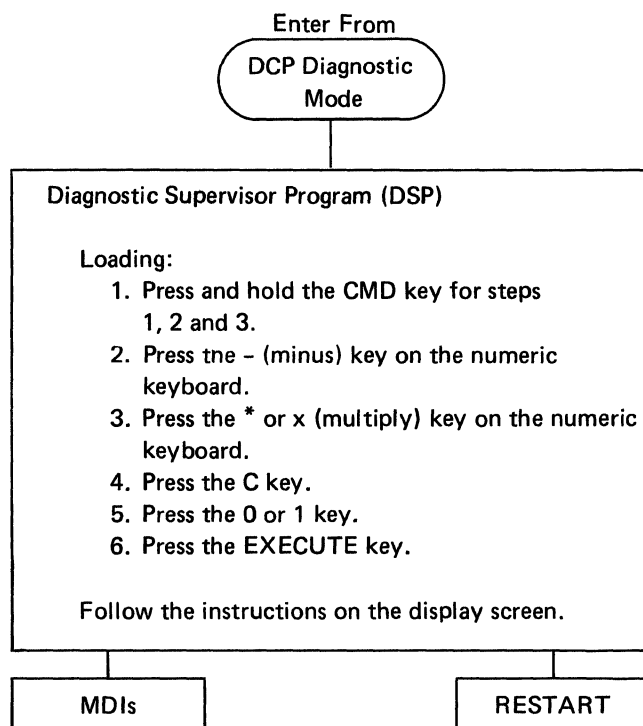
---

---

The DSP controls loading and execution of programs residing on tape or diskette. DSP is located on file one of the tape/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.

### Diagnostic Supervisor Program (DSP)



DSP MENU

EC XXXXXX

820 ASYNCHRONOUS COMM. AND SERIAL I/O MDI  
821 BSCA MDI  
823 PARALLEL I/O MDI  
890 COMMUNICATION ROUTINES

Communi-  
cations  
Diagnostic  
Tape

#--ENTER THE MDI NUMBER TO BE RUN  
#--ENTER 'O' IF THE OPTIONS ARE TO BE DISPLAYED

MENU EC XXXXXX

DSP  
800 PRINTER MDI  
820 ASYNCHRONOUS COMM. AND SERIAL I/O MDI  
821 BSCA MDI  
823 PARALLEL I/O MDI  
881 DISKETTE MDI  
890 COMMUNICATIONS ROUTINES

Diagnostic  
Diskette

#--ENTER THE MDI NUMBER TO BE RUN  
#--ENTER 'O' IF THE OPTIONS ARE TO BE DISPLAYED

DSP MENU EC. XXXXXX

800 PRINTER MDI  
840 AUXILIARY TAPE MDI  
860 TAPE WRITE MDI  
881 DISKETTE MDI

Diagnostic  
Tape

#\_\_\_ ENTER THE MDI NUMBER TO BE RUN  
#\_\_\_ ENTER 'O' IF THE OPTIONS ARE TO BE DISPLAYED  
STATUS: ENTER REPLY

XXXXXX is the current EC number of this tape/diskette  
cartridge.

## 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 a 5110 Model X1X with an internal tape unit are contained in two diagnostic tape cartridges. One cartridge contains MDIs for the 5110, the 5103 Printer, 5114 Diskette Unit, and the 5106 Auxiliary Tape Unit. The other cartridge contains the MDIs for communication features, serial I/O, and parallel I/O.

The MDIs for a 5110 Model X2X without an internal tape unit are contained on a diagnostic diskette. This diskette contains *all* MDIs for the 5110, the 5114, the 5103 Printer, communications features, serial I/O, and parallel I/O.

## 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 } Refers to an answer to a specific question on the display  
N = No } 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  $\frac{\div}{x}$  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.

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After you select the MDI number from the menu and press the EXECUTE key, the 5110 automatically loads the MDI from the diagnostic tape/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	XXXX
1			
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 against 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
RCVC- 15
NEXT STEP NO.-009
DECISION IS (Y,N,B,O,T)
#Y__
```

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__
```



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 options 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 the MDI options on MDI 840 or 844, remove the diagnostic tape cartridge and do not insert it until instructed to do so on the display. The tape might be erased if you insert it too soon. The same restriction applies to the diagnostic diskette when you are running MDI 881.

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### 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

**Note:** If you enter the first letter of a reply in the area, the complete reply is entered.

**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, auxiliary tape MDI, tape write 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.

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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  
 823 Parallel I/O MDI  
 840 Auxiliary Tape MDI  
 841  
 842  
 843  
 844  
 845  
 846  
 847  
 860 Tape Write MDI  
 861  
 881 Diskette MDI  
 882  
 883  
 884  
 885  
 886  
 887  
 888  
 890 Communications Routines  
 894  
 895  
 896  
 897  
 898  
 899

## TAPE WRITE DIAGNOSTIC ROUTINES

These routines are used in MDI 860. The step numbers are the numbers used in MDI 891. Xs in the chart mean any number.

Routine Number	Description	Expected Information		Error Code	Meaning
BT01	Average Velocity Test — Positions the tape file 9 and then begins the bit timing analysis test.	XXXX	XXXX	—	The average speed is computed to two decimal points and returned as a 4-digit decimal number in inches per second. For example, a received number of 4006 is actually 40.06 inches per second. The average speed is taken from the average of 9,192 bit times. The deviation number is returned as the third and fourth bytes.
BT02	Acceleration Test — Checks the speed of the tape from stop to 1500 bits after the tape has reached 20 inches per second.	XXXX		—	The speed at bit 800 is computed to two decimal points and returned as a 4-digit decimal number in inches per second. If the speed is not within the range of 38.1 to 41.9 inches per second for bits 800 to 1500, then that speed is returned.
		Graph			The speed of the 1500 bits is displayed in a graph. The speed in inches per second is the vertical axis and the 1500 bits are the horizontal axis. Each asterisk (*) on the graph represents the average speed of 36 bits on tape.
BT03	Deceleration Test — Checks the speed of the tape for the 1040 bits after the drop of the run line. This speed should be less than 20 inches per second.	XXXX		—	The speed at bit 1040 is computed to two decimal points and returned as a 4-digit decimal number in inches per second.

Routine Number	Description	Expected Information	Error Code	Meaning
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BT03  
(continued)

A graph is displayed if the test fails.

The speed of the 1040 bits is displayed in a graph. The speed in inches per second is the vertical axis and the 1040 bits are the horizontal axis. Each asterisk (\*) on the graph represents the average speed of 26 bits on tape.

BT06

Erase Data on Both Tracks

XXXXXXXXXXXX  
(six 2-digit error codes)

00-14

The program returns six error codes of two digits each. The first four error codes are expected to be 00. If they are not 00, they are the system error codes, 02-14. See *Error Codes* in this section.

The first error code is from a search to file 12.

The second error code is from another search to file 12 and a write header command to this file.

The third error code is from another search to file 12 and a write header command to this file.

The fourth error code is from a write and read of data to file 12.

The fifth error code is from a read of the data on file 12 after it was erased during the read operation. This error code should be 07. This is the first error code expected to be other than 00.

The sixth error code is from a search for file 12 after the format track is erased. This error code should be 08.

Diagnostic  
Aids

Routine Number	Description	Expected Information	Error Code	Meaning
BT11	Peak Shift-Head Azimuth Test on Track 0 using a prewritten pattern of 0's and 1's from file 15 — This test searches to file 15, then reads the data on track 0 in 10 bit timing analysis mode. Speed differences between the odd and even bits should not exceed 10.0 microseconds.	XXXX to XXXX (4-digit decimal number computed to two decimal places)	—	The data returned is the even average and odd average bit time for track 0 in microseconds (see BT34).
BT21	Acceleration Test for Customer Media — This test goes to file 1 and does the acceleration test using BT02.	XXXX	—	The average speed is computed to two decimal points and returned as a 4-digit decimal number in inches per second. For example, a received number of 4006 is actually 40.06 inches per second. The average speed is taken from the average of 9,192 bit times. The deviation number is returned as the third and fourth bytes.
BT22	Sense Test	XX	—	Returns the sense byte from the tape unit.
BT23	Write Read Test — Writes and reads the data in the MASK field on the display onto tape.	XXX . . . XX (up to twelve 2-digit bytes)	—	Returned data is the correct data if there is no error, or the first data to miscompare if there is an error. For example, if the data 012345 is the expected data, 012345012345012345 . . . , for a total of 512 bytes is written onto tape, where 01 is one byte, 23 the next by and 45 the next byte, then repeat. If the data on tape is 012345012345012345012345 ABCDEF, ABCDEF is returned as RCVD on the display so that all 512 bytes need not be displayed.



Routine Number	Description	Expected Information	Error Code	Meaning
BT30	Peak Shift Test on Track 1 — Returns the track 1 data generated during routine BT48. BT48 runs now if it was not run previously.	XXXX to XXXX (4-digit decimal number computed to two decimal places)	—	The data returned is the even average and odd average bit time for track 1 in microseconds (see BT34).
BT31	Symmetry Test on Track 1 — Returns the track 1 data generated during routine BT47. BT47 runs now if it was not run previously.	XXXX to XXXX (4-digit decimal number computed to two decimal places)	—	The data returned is the even average and odd average bit time for track 1 in microseconds (see BT34).
BT34	(see note) Return Data to the MDI for Test Spec Function — This test is not an MDI routine but a sub-routine of BT47, BT48, BT30, and BT31. This test generates an even average number and puts it into the first 4 digits of the MASK. A high number is generated by adding the permissible difference to the low average number and putting this in the last 4 digits of the MASK. The program also generates an odd average number into the RCVD.			<p>All data is in decimal microseconds. For example, if the averages calculated are 33.00 (even average), and 34.05 (odd average), and the permissible difference is 3.0, the information displayed is:</p> <p>TEST — Within limits  MASK — 3300-3600  RCVD — 3405</p>
	<p>Bits: T1 T2 T3 T4  T5 T6</p> <p>Odd average = average of  T1, T3, T5</p> <p>Even average = average of  T2, T4, T6</p>			
BT35 <sup>1</sup>	EOT Hardware Stop Test — This test is similar to TR061 in the auxiliary tape and tape read routines. The difference is that the time-outs are different to make sure that the EOT stop hard works.		0000  0954- 0966	No errors.  See TR061 for explanation of possible error codes.

Note: BT34 is not accessible from MDI

<sup>1</sup> Looping on this test can cause a process check

Routine Number	Description	Expected Information	Error Code	Meaning
BT36	Test Bit Timing Hardware (no tape cartridge inserted) — This test requires two jumpers to run and the tape cartridge must not be inserted. Attach jumpers on tape control card pin B08 to pin S05, and pin U06 to pin U08. The test writes data; therefore it erases the tape. The test determines if the bit timing hardware produces correctly timed interrupts.		0000	No errors.
			0811	Not enough interrupts occurred.
			0812	Interrupt times are incorrect.
BT37	Check System and Diagnostic Error Code — Error codes are generated by the programs each time they are run. This test is used to clarify previous errors. No hardware is exercised by this routine.	XXXXXXXX (two 4-digit error codes)		<p>The last two error codes that were given are returned by this program as an 8-digit number.</p> <p>The first 4 error codes are expected to be 00. If they are not 00 they are the last system error code (02-14, see <i>Error Codes</i> in this section).</p> <p>The last 4 digits are the last error codes from the tape write routines (0800-0960 as described in the error code column of this chart).</p>
BT47	Symmetry Test on Track 0 — Searches to file 12, marks two 2K byte files, and writes zeros on both tracks. The test then reads the data on both tracks in bit timing analysis mode. The permissible difference in speed between the odd and even bits should not be more than 3.0 microseconds.	XXXX to XXXX (4-digit decimal number computed to two decimal places)	—	The data returned is the even average and odd average bit time for track 0 in microseconds (see BT34).
BT48	Peak Shift Test on Track 0 — This test is similar to BT47 but writes an alternating pattern of 0's and 1's. The permissible difference of the 0's and 1's can be a maximum of 8 microseconds.	XXXX to XXXX (4-digit decimal number computed to two decimal places)	—	The data returned is the even average and odd average bit time for track 0 in microseconds (see BT34).

Routine Number	Description	Expected Information	Error Code	Meaning
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BT51 Erase Coils Open Test

0000 No errors.

0808 Status bit 5 is on after an F reset instruction.

0809 Status bit 5 is on after a hex F7 control instruction command (erase channel 0).

0810 Status bit 5 is on after a hex FB control instruction command (erase channel 1).

Status bit 5 indicates LED and erase coils OK.

Diagnostic Aids

## 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.

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 $\pm 3$ 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 $\pm 1$ 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.

Routine Number	Description	Expected Information	Error Code	Meaning
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.
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.

Routine Number	Description	Expected Information	Error Code	Meaning
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 00 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.
PT25V5	Same as PT25V1 except it repeats this sequence five times if there are no errors.	XX XX XX XX SA SB EC 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 XX XX XX SA SB EC TS	50-59	Returns status bytes A and B, an error code, and test status.

## TAPE READ TEST AND AUXILLIARY TAPE DIAGNOSTIC ROUTINES

These routines are used in the DCP tape read test and in MDIs 840-847.

Routine Number	Description	Error Code	Meaning
TR01	Selects the subdevice test. This test is run as the first test in MDIs 840-847. The first time this test is run, it asks you to enter the subdevice address with minimal error checking. Therefore, because you enter the subdevice address, 840-847 can be run on any tape subdevice.	0901	Failure of the F reset command.
		0903	Failure of the subdevice select command.
		0906	Improper response of the subdevice.
TR02	Loops write read (LWR) of data to the base I/O card only, for tape read test, and LWR of data to the tape adapter card for auxiliary tape test.	0909	Incorrect data read back.
TR06	Returns to the MDI section the last error code that occurred when TR061 was run. This test is used only in the auxiliary tape tests, not in the tape read program.	0954	Neither BOT nor EOT status is active.
		0957	EOT status is not active.
		0958	EOT status cannot be cleared.
		0960	BOT status is not active.
		0963	The load point hole (BOT status) cannot be found (refer to 229 for load point hole).
		0966	BOT status cannot be cleared.
TR07	Reads and compares file 1 on the diagnostic tape for correct data using the microprogram.  Error codes 0009 and 0010 are used to determine the end of file 1 and indicate correct operation. Tape read branches to the DSP if the operation is correct.	0994	The data read is not correct.
		0001-0008 0011-0014	
TR08	Tests interrupts from the tape control card.	0907	Interrupts occurred incorrectly.



Routine Number	Description	Error Code	Meaning
TR10	Returns the last error code that occurred to the MDI section. This test is used only in the auxiliary tape tests, not in the tape read program.	0982	Status Error—Beginning of tape status was active once, but is not active now.
		0983	Read Data Error—No interrupt (read clock) was detected from either tape track.
		0985	Read Data Error—No interrupt (read clock) was detected from tape track 0 (format track).
		0986	Read Data Error—No interrupt (read clock) was detected from tape track 1 (data track).
		0987	Read Data Error—No sync byte (hex E7) was detected on tape track 0 (format track).
		0988	Read Data Error—No sync byte (hex E7) was detected on tape track 1 (data track).
TR39	Determines if the diagnostic mode line is active when it should not be active. If it is active, eight read clocks are generated by the tape control card, which, in turn, causes an interrupt from the base I/O (H2) card when one is not expected.	0989	Read Data Error—No sync byte (hex E7) was detected on either tape track.
		0939	An interrupt occurred.
TR40	Checks to determine if the tape clock line and write enable line have become active and that the read clock line is not an open circuit. Every time the write enable line shifts, the read clock line should pulse and cause an interrupt from the base I/O (H2) card.	0940	No interrupts occurred.
TR43	Checks the diagnostic mode line by changing it between write and read operations.	0943	No interrupts occurred.

Routine Number	Description	Error Code	Meaning
TR46	Tests the missing interrupts for wrap through read/write head. This tests the tape control card detector circuits. The select channel line is changed between channel 0 and channel 1 ten times and at least three interrupts must occur.	0946	Less than three interrupts.
TR47	Checks the read data line to determine if it will go both active and inactive. The program generates 10 read clocks on the tape control card and reads the data associated with these read clocks. There must be at least one bit 0 and one bit 1 read for this test to pass. A stuck bit causes all 1's or all 0's to be read.	0947	All 1's or 0's read from tape control card.
TR051 <sup>1</sup>	Moves tape forward for 2 seconds.	0970	BOT or EOT was found; use TR051 or TR052 routines to reposition the tape.
TR052 <sup>1</sup>	Moves tape backward for 2 seconds.	0970	BOT or EOT was found; use TR051 or TR052 routines to reposition the tape.
TR061 <sup>2</sup>	Checks the beginning (BOT) and end (EOT) of tape status indicators. The tape is moved past the single BOT holes and the double BOT/EOT holes. If the test fails, the tape stops immediately.	0954	Neither BOT nor EOT status is active.
		0957	EOT status is not active.
		0958	EOT status cannot be cleared.
		0960	BOT status is not active.
		0963	The load point hole (BOT status) cannot be found (refer to 229 for load point hole).
	<b>CAUTION</b> If an error occurs and the test is retried, the tape might go off the end of the reel.	0966	BOT status cannot be cleared.

<sup>1</sup> If a 970 error results from the EOT hole being in front of the tape mirror, manually move the tape to reposition the EOT hole.

<sup>2</sup> Looping on this test can cause a process check.

Routine Number	Description	Error Code	Meaning
TR73 <sup>3</sup>	Tests the tape speed to determine if the motor speed is correct. The program rewinds the tape to the first set of double holes and counts the time. When the load point hold is found, the time is compared.	0973	Tape speed not close to 40 inches per second.
TR95	Removes the tape cartridge from the tape unit and attaches a jumper between tape control card pin U06 (-write enable) and pin U08 (gnd). Wraps data through the base I/O card and tape control card.	0995	The data returned was incorrect.
		0996	Indicates that TR95 ran and can be rerun by pressing the EXECUTE key.
TR101	Determines if both tape tracks return interrupts and if the sync byte (hex E7) can be read from both tracks.	0982	Status Error—BOT status was active once, but is not active now.
		0983	Read Data Error—No interrupt (read clock) was detected from either tape track.
		0985	Read Data Error—No interrupt (read clock) was detected from tape track 0 (format track).
		0986	Read Data Error—No interrupt (read clock) was detected from tape track 1 (data track).
		0987	Read Data Error—No sync byte (hex E7) was detected on tape track 0 (format track).
		0988	Read Data Error—No sync byte (hex E7) was detected on tape track 1 (data track).
TR0312	Cartridge in place status (10) should not be present.	0989	Read Data Error—No sync byte (hex E7) was detected on either tape track.
		0912	
TR0315	File protect status (02) should be present.	0915	Bad sense bit found.

<sup>3</sup> Looping on this test can cause a process check.

Routine Number	Description	Error Code	Meaning
TR0318	LED on status (04) should be present.	0918	Bad sense bit found.
TR0321	BOT status (01) should not be present; that is, sense bit (01) should be on.	0921	Bad sense bit found.
TR0324	EOT status (80) should not be present.	0924	Bad sense bit found.
TR0327	Erase active (08) status should not be present.	0927	Bad sense bit found.
TR0330	Erase active (08) status for track 0 (format track) should be present.	0930	Bad sense bit found.
	<i>Note:</i> This test leaves the erase coil on.		
TR0333	Erase active (08) status for track 1 (data track) should be present.	0933	Bad sense bit found.
	<i>Note:</i> This test leaves the erase coil on.		
TR0336	Select magnet active status (20) should not be present.	0936	Bad sense bit found.
TR0337	Select magnet active status (20) for forward tape motion should be present.	0937	Bad sense bit found.
	<i>Note:</i> This test leaves the forward tape and select magnet active commands on.		
TR0338	Select magnet active status (20) for reverse tape motion should be present.	0938	Bad sense bit found.
	<i>Note:</i> This test leaves the reverse tape and select magnet active commands on.		
TR0348	Cartridge in place status (10) should be present.	0948	Bad sense bit found.
TR0349	File protect status (02) should be present.	0949	Bad sense bit found.
TR0350	EOT status (80) should not be present.	0950	Bad sense bit found.

## DISKETTE DIAGNOSTIC ROUTINES

These routines are used in MDIs 881 through 888.

Routine Number	Description	Status	Meaning
DTO1	Displays 'ENTER SUBDEVICE ADDRESS'. Tests all I/O resets, the status, and the select and access status of the devices and sub-devices 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. <sup>1</sup> 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. <sup>1</sup>
		02	Bad VFO card. <sup>1</sup>

<sup>1</sup> Some diskette adapter cards have the VFO circuitry on them. See MAP 050.

Routine Number	Description	Status	Error Code	Meaning
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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 volumn 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
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The following test uses the 3742 Alignment Diskette, part 2455026.

DW38	Head Alignment Diagnostic— 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.		
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**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		Meaning
		Status	Data	

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 <sup>1</sup> rate.	96	0733 through 0748	Good test.
		00	2000	No interrupt occurred for 20 milliseconds.
COM04	Tests 300 bps timer interrupt <sup>1</sup> rate.	96	0327 through 0334	Good test.
		00	2000	No interrupt occurred for 20 milliseconds.
COM05	Tests 110 bps timer interrupt <sup>1</sup> 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.

<sup>1</sup> 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 10 bytes of E1 10 bytes of E2 10 bytes of E3	Good test. Long space interrupt detected. Interrupts too frequent. No interrupt occurred.
COM12	Tests that all 0's pattern can be transmitted and wrapped back correctly.	—	10 bytes of 00 10 bytes of E1 10 bytes of E2 10 bytes of E3	Good test. Long space interrupt detected. Interrupts too frequent. No interrupt occurred.
COM13	Tests that all 1's pattern can be transmitted and wrapped back correctly.	—	10 bytes of FF 10 bytes of E1 10 bytes of E2 10 bytes of E3	Good test. Long space interrupt detected. Interrupts too frequent. 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.
COM19	Tests that data set ready and clear to send status bits can be set.	96	—	Good test.
		03	—	Bit cannot be set.
		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 <sup>1</sup> rate constant.	96	8650 through 8680	Good test.
		00	9999	No interrupt occurred within 100 milliseconds.
SIO04	Tests AAAA timer interrupt <sup>1</sup> rate constant.	96	5761 through 5791	Good test.

<sup>1</sup> 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 <sup>1</sup> rate constant.	96	2872 through 2902	Good test.
		00	9999	No interrupt occurred within 100 milliseconds.
SIO06	Tests 004F timer interrupt <sup>1</sup> 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.				
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.

<sup>1</sup>Interrupt frequency is in milliseconds with a decimal implied between the second and third digits from the right.

Routine Number	Description	Returned Data	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.			
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.

## PARALLEL I/O DIAGNOSTIC ROUTINES

These routines are used in MDI 823. MDI 823 consists of seven test routines that exercise the parallel I/O logic card and cables. If an error occurs, the MDI displays an error code and the suspected failing FRU.

Routine Number	Description
PIO-01	Reset F Test—Tests that all parallel I/O driver/receiver circuits can be reset by the 'reset F' line.
PIO-02	Wrap Test—This test must be run with the wrap adapter installed. The wrap test activates the driver circuits, then senses the receiver circuits, and compares the receiver output with the predicted results.
PIO-03	Transceive Test—This test is the same as the wrap test except that a wrap adapter is not used. This test uses the bidirectional characteristics of the parallel I/O drivers/receivers to transfer data from the bus out lines through the drivers/receivers and back into the bus in lines.
PIO-04	Interface Clear Test—Activates the interface clear line driver and checks that all driver circuits are reset.
PIO-05	Attention Test—Activates the attention line driver circuit and checks that the DAV, NRFD, and DNAC line drivers/receivers function correctly.

## 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

Two CE switches, run and step, are located inside the 5110 next to the display assembly. Removing the top cover allows access to these switches. The run switch is the two-position toggle switch and the step switch is the 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.

### 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 (K2)
- Executable ROS card (L2)
- Auxiliary tape 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 position of the L32-64-R32 switch determines the number of registers displayed. In the L32 position, the 32 registers in levels 0 and 2 are displayed. Likewise, in the R32 position, the 32 registers in levels 1 and 3 are displayed. To display all 64 registers, move the switch to 64.

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**

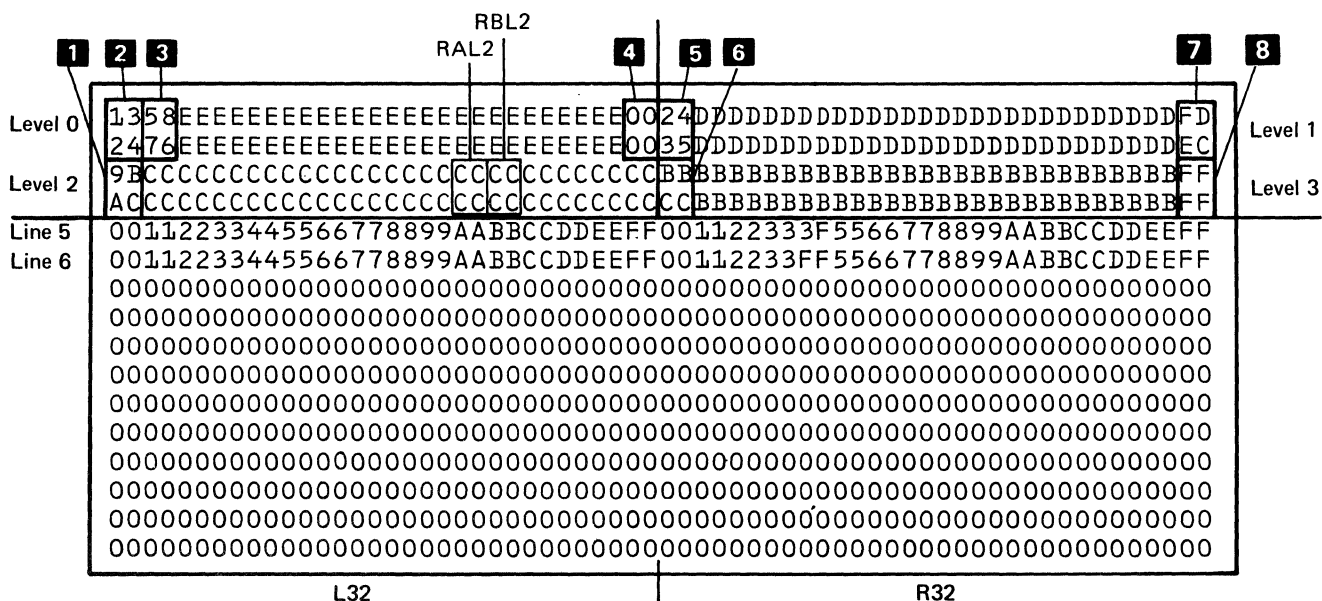
The remaining level 2 registers contain hex CCCC.

R0L3 = hex BCBC **6**  
 RFL3 = hex FFFF **8**

The remaining level 3 registers contain hex BBBB.

### Register Level

Level	Use
0	Normal machine operation.
1	Asynchronous Communications.
2	Printer, tape, diskette, serial I/O, and parallel I/O.
3	Keyboard.



## Read/Write Storage Size

In this example, the read/write storage size = hex 3FFF **5**

The address of the last byte of installed read/write storage is stored in read/write storage halfword hex 00AA **4**.

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)

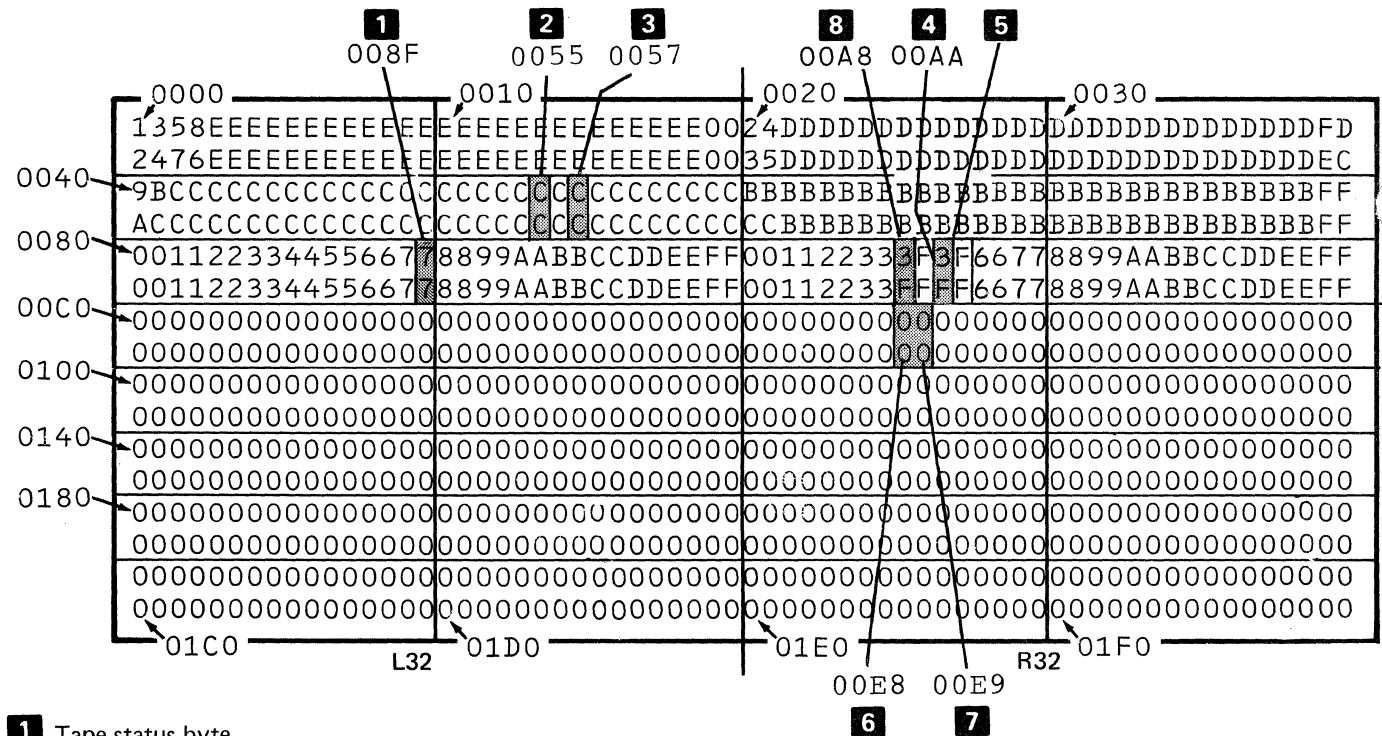
Read/write storage size = hex BFFF — 48K (N2)

Read/write storage size = hex FFFF — 64K (N4)

All other values for read/write storage size are invalid.

Storage location hex 00A8 **8** contains a value that indicates the read/write storage available to the user. If the PATCH program, the Serial I/O microprogram, or the Parallel I/O microprogram are loaded in read/write storage, the value in hex 00A8 will be substantially smaller than the value in hex 00AA.

## Read/Write Storage Addressing



- 1** Tape status byte
- 2** Printer status byte A
- 3** Printer status byte B
- 6** Diskette status byte A
- 7** Diskette status byte B



## 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.

### Tape Status Byte

*Storage Address 008F*

Bus in bit	0	1	2	3	4	5	6	7	
		1							End of tape (EOT).
			1						No device address E response.
				1					Tape running.
					1				Cartridge in place.
						1			Erase on.
							1		LED and erase OK.
								1	File protected.
									1 No beginning of tape (BOT).

### 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

### Tape Status Byte

**Bit 0—End of Tape (EOT):** Indicates that any one of six holes in the tape (three at the beginning and three at the end) generated EOT status.

**Bit 1—No Device Address E Response:** Indicates that status bit 1 was not active.

**Bit 2—Tape Running:** Indicates that the forward or reverse select magnets were selected.

**Bit 3—Cartridge in Place:** Indicates that the cartridge in place switch is active.

**Bit 4—Erase On:** Indicates that either channel 1 or channel 0 erase current was on.

**Bit 5—LED and Erase OK:** Indicates that the EOT and BOT LEDs were conducting and that the erase coils did not have an open circuit.

**Bit 6—File Protected:** Indicates that the file protect switch was made.

**Bit 7—No Beginning of Tape (1 = No BOT):** Indicates that none of the top five holes in the tape generated BOT status.

### 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.

## PRINT PLOT FORMS MOVEMENT EXERCISER PROGRAM

The print plot forms movement exerciser 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 tape cartridge or diskette. The print-out 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.

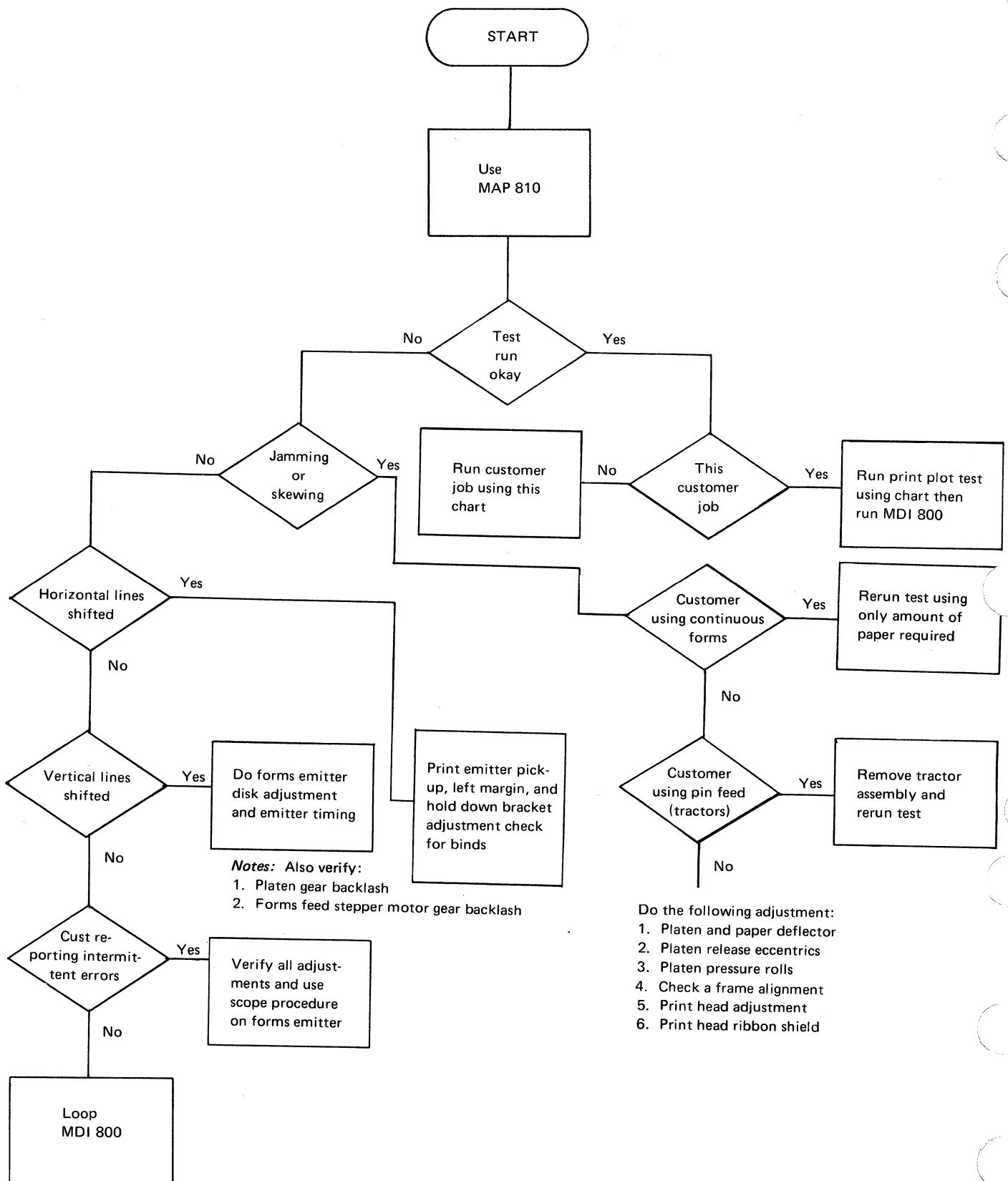
---

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



### 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 5110 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.

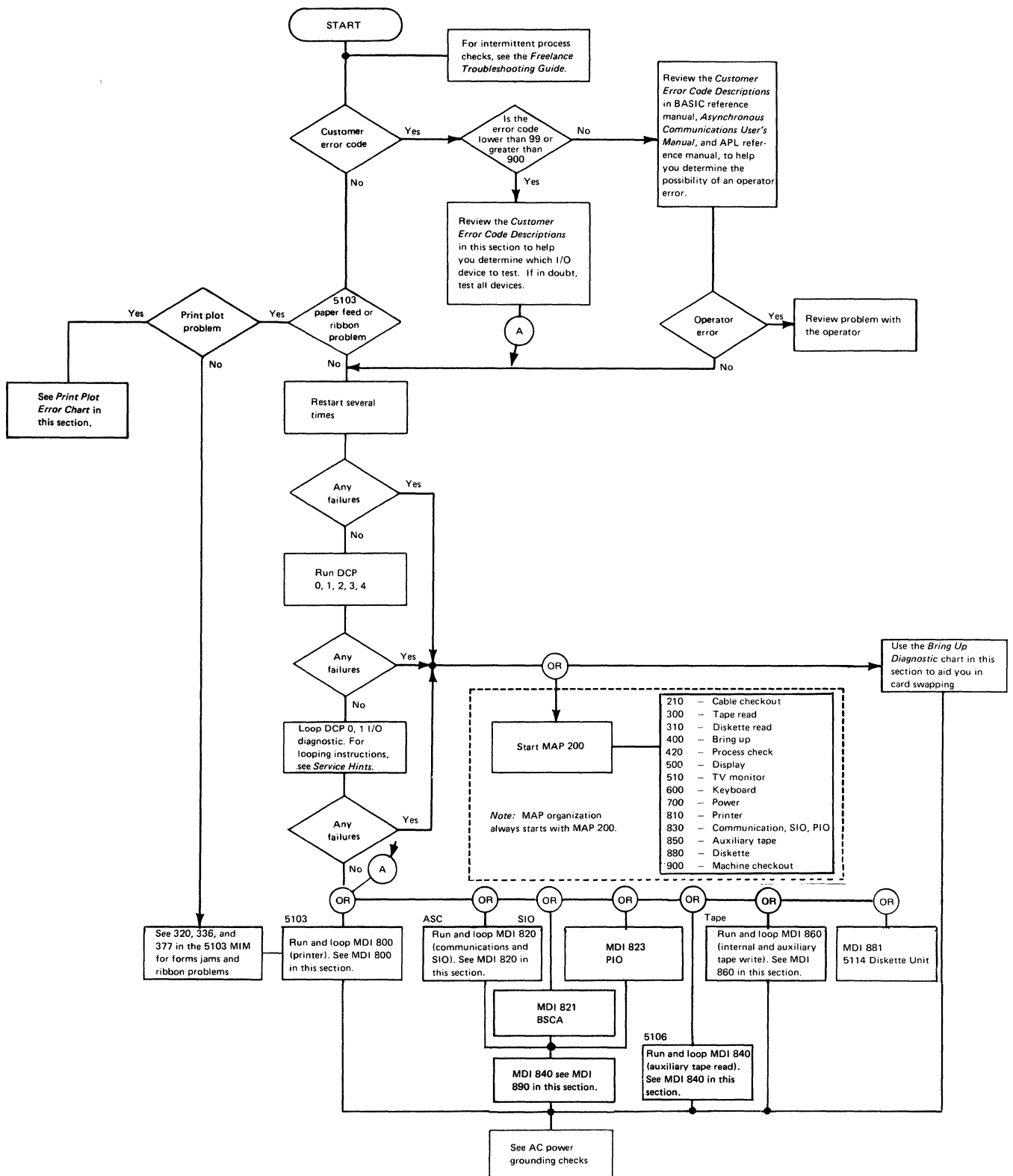
### RECOMMENDATIONS ON FAILURE INFORMATION

The following recommendations are given to assist you in obtaining failure information. Their 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 a tape 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.



# 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 5106	A1-C1P05	5106 A1-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 parallel I/O	K2J06	K2
+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 parallel I/O	K2G05	K2
+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 5106	A1-C1P11	5106 A1-C1
+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).

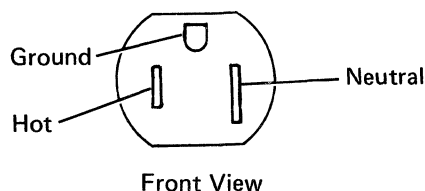
## Tape

Use the following procedure to help you find the cause of intermittent tape errors:

1. Any cartridges that were written before a problem was resolved on the tape drive, can still cause problems.
2. Check the cartridge stops (see 223).
3. Perform the Tape Select Magnet Service Check (see 221).
4. Clean the tape head with isopropyl alcohol and a lint free tissue. Check the head adjustment (see 225). Replace the head if it is worn.
5. Clean the spindle assembly and the drive rolls with isopropyl alcohol and a lint free tissue.
6. Check the cartridge-in-place and file protect switches for proper adjustment (see 224).
7. Reset all the cables and the cards in the tape unit.
8. Check to be sure the tape unit does not face into a strong light or the sun.
9. Make sure the brake arms are the white brake arms and not the black brake arms.

## AC Power Grounding Checks

To check for proper AC power receptacle grounding, measure the AC voltages at the location shown in the following figure. This check does not detect a poor quality ground (high resistance to earth).



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 the AC box capacitors to ensure they are not twisted and their wires crossed.
4. 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 be either a braided cable or a green and yellow wire.

#### 5110 ground locations:

- Bottom cover, center right side
- CRT mounting screen and frame
- Power supply fan motor
- Raceway
- Power switch
- AC power box
- Tape unit motor
- AC capacitor in tape unit
- TV monitor plug

#### 5103 ground locations:

- Left front corner
- Right front corner
- AC line cord
- Flat cable shield clamp
- Left rear of forms tractor

#### 5106 ground locations:

- Tape unit motor
- AC capacitor
- Cooling fan
- Power switch
- AC line cord
- A1 board
- Flat cable shield clamp

#### 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  $\pm 10\%$  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 bus 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.

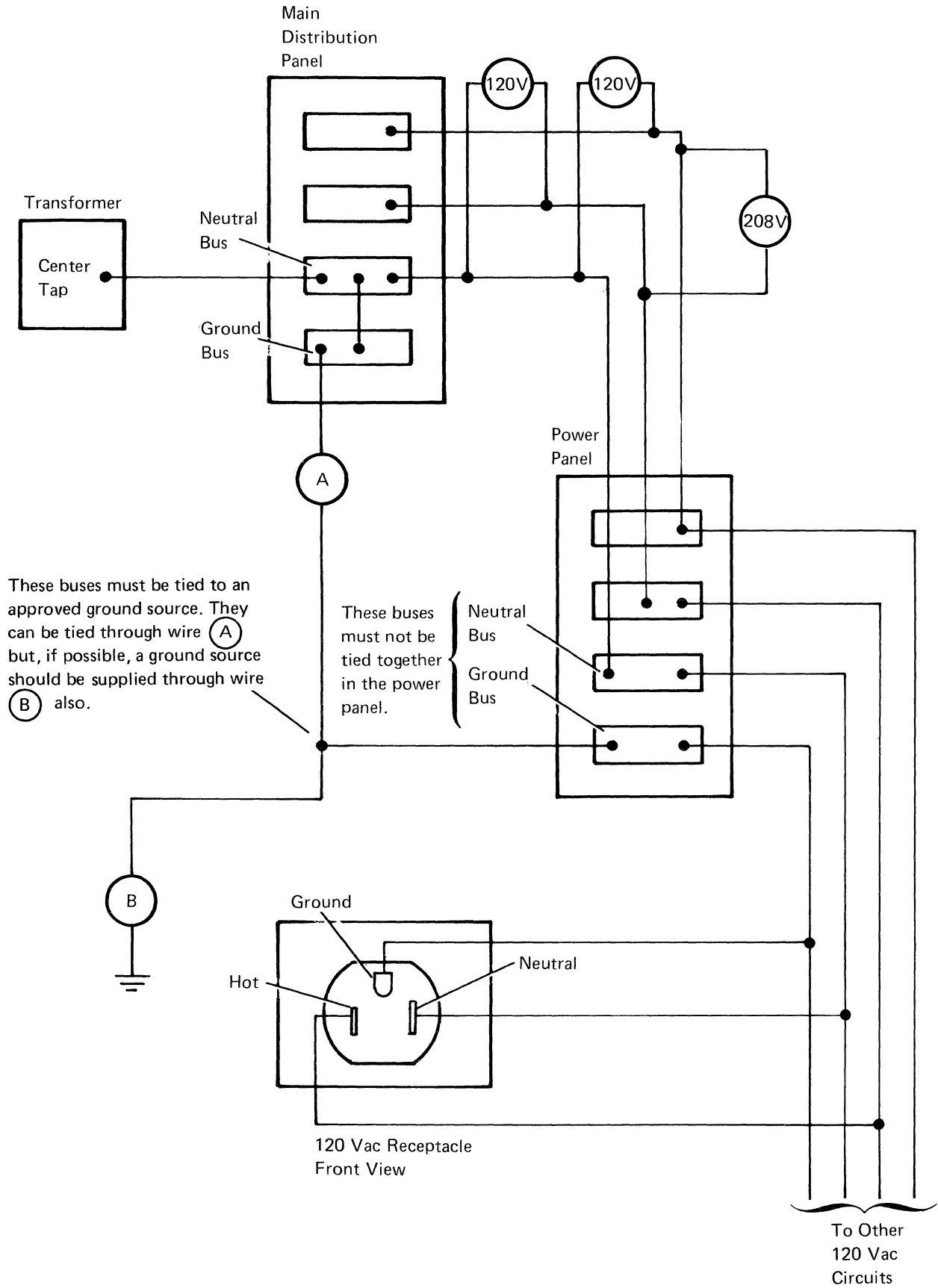
**Ground Bus:** This bus bar is in the power panel. The ground wire for the power source of the 5110 should connect to this bar, along with a wire into the panel from an approved earth ground source.

**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



Diagnostic Aids

## 5110 System Function Test

The system function test consists of four tests that exercise different I/O devices. The tests are:

- System test
- 5114 Diskette exerciser
- 5103 Printer exerciser
- 5106 Auxiliary Tape and internal tape exerciser

The purpose of the system function test is to exercise the 5110 Computer internal tape unit, the 5114 Diskette Unit, the 5103 Printer, and the 5106 Auxiliary Tape Unit. 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 5110 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.

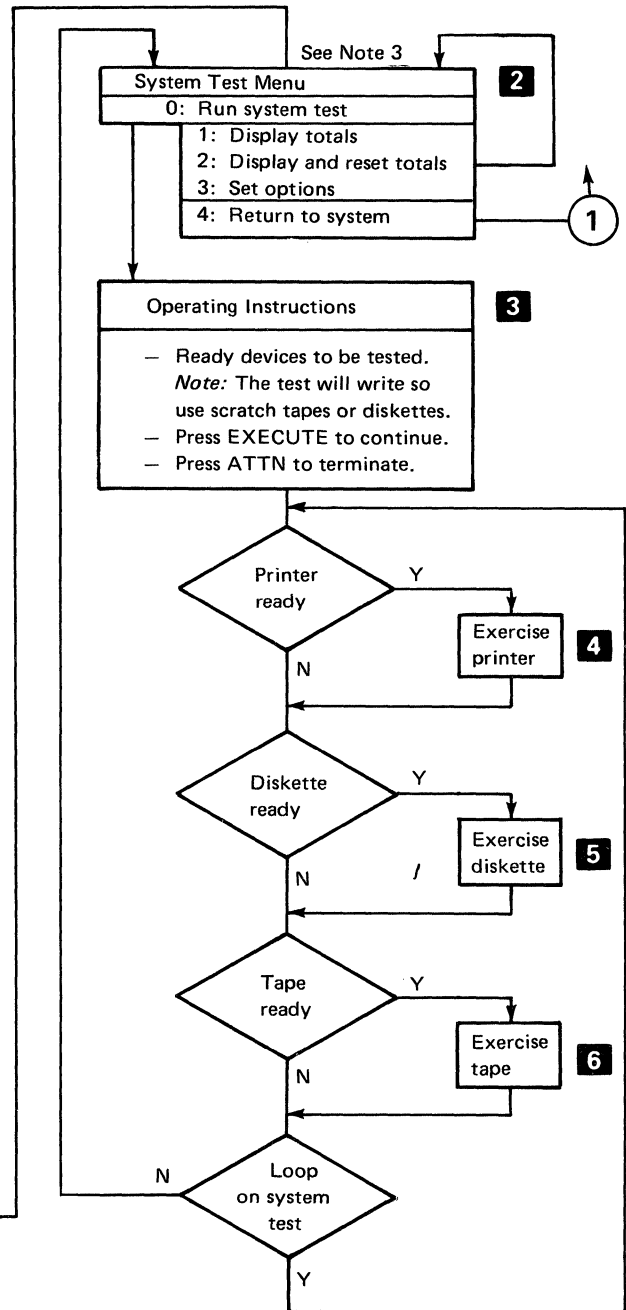
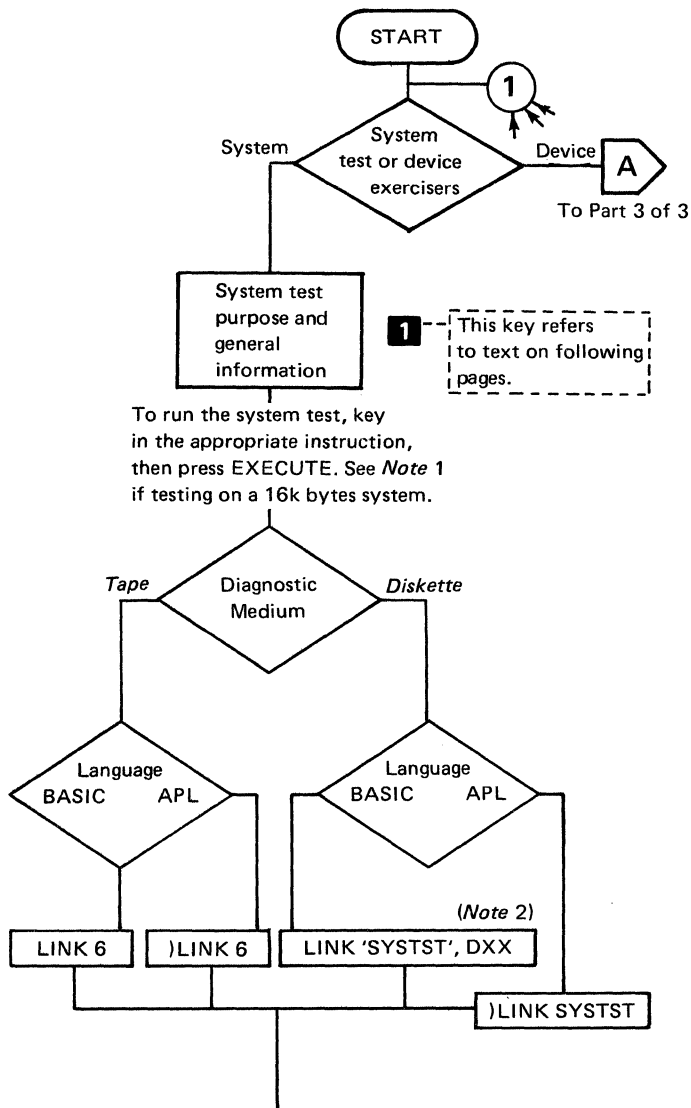
This symptom could indicate that the 5114 Diskette Unit is failing but because of the error retry capabilities of the 5110, the program eventually runs.

**Step 1:** Run the 5110 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 5110 Logic Manual*, SY31-0552.

# SYSTEM FUNCTION TEST OVERVIEW (PART 1 OF 3)



Diagnostic Aids

## 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

#### Diskette Drive 1-4

- |  |  |
|--|--|
| <ul style="list-style-type: none"> <li>• System test:<br/>DV@ E80 or E40 (note 2)<br/>RD A 0B00 F 6<br/>(EXECUTE)</li> <li>• Tape/printer exerciser:<br/>DV@ E80 or E40 (note 2)<br/>RD A 0B00 F 11<br/>(EXECUTE)</li> </ul> | <ul style="list-style-type: none"> <li>• System test:<br/>DV@ DXX (note 2)<br/>RD A 0B00 F 21<br/>(EXECUTE)</li> <li>• Tape/printer exerciser:<br/>DV@ DXX (note 2)<br/>RD A 0B00 F 22<br/>(EXECUTE)</li> <li>• Diskette exerciser:<br/>DV@ DXX (note 2)<br/>RD A 0B00 F 23<br/>(EXECUTE)</li> </ul> |
|--|--|

- 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.

DXX	EXX
D80 = Diskette drive 1	E80 = Internal tape unit
D40 = Diskette drive 2	E40 = 5106 auxiliary tape unit
D20 = Diskette drive 3	
D10 = Diskette drive 4	

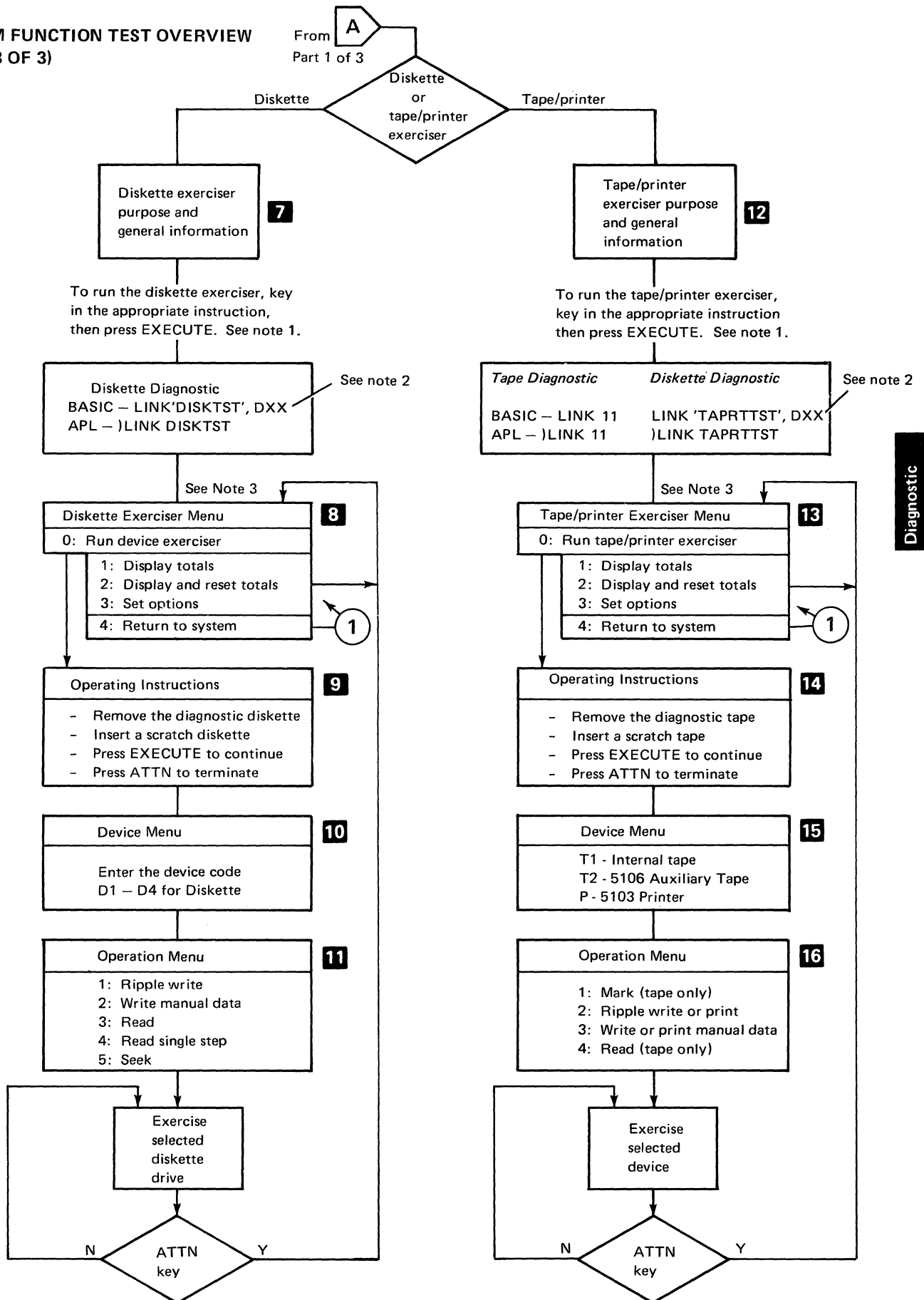
3. Menu description
  - 0: Pressing 0 (zero) and EXECUTE runs the test with the following options on:
    - Stop on error (Y)
    - Print IOC on error (Y)
    - Loop on system test (N)

**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.



# SYSTEM FUNCTION TEST OVERVIEW (PART 3 OF 3)



## 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
0E	40	04	---	6
0E	40	05	---	1
0E	40	05	02	3
0E	40	06	---	1
0E	80	04	---	4
0E	80	05	05	3
0E	80	06	---	1

## 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  
ABCDEFGHIJ<(+I&JKLMNOPQR!\$\*);--/STUVWXYZ!,% >?&^`Δ±∅-→v`:#@'=""^abcdefghijklmnopqrstuvwxyz↑↓\$[L→[]  
jklmnopqr→cπ0)←~stuvwxyz0123456789|¢/0± ABCDEFGHIJ<(+I&JKLMNOPQR!\$\*);--/STUVWXYZ!,% >?&^  
Δ±∅-→v`:#@'=""^abcdefghijklmnopqrstuvwxyz↑↓\$[L→[]jklmnopqr→cπ0)←~stuvwxyz0123456789|¢/0± ABCDEFGHIJ<(+I&JK  
BCDEFGHIJ<(+I&JKLMNOPQR!\$\*);--/STUVWXYZ!,% >?&^`Δ±∅-→v`:#@'=""^abcdefghijklmnopqrstuvwxyz↑↓\$[L→[]  
jklmnopqr→cπ0)←~stuvwxyz0123456789|¢/0± ABCDEFGHIJ<(+I&JKLMNOPQR!\$\*);--/STUVWXYZ!,% >?&^`Δ±∅-→v`:#@'=""^abcdefghijklmnopqrstuvwxyz↑↓\$[L→[]

## **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 first part of this routine marks three 3K byte files on the beginning of the tape. The routine then writes a ripple pattern record of 512 bytes until the 3K files have been completely written.

The second part of this routine reads the 3K files previously written and compares them byte by byte for proper read/write operation.

This routine exercises the internal tape unit first and then the 5106 Auxiliary Tape Unit if both are in the ready state.

## **DEVICE EXERCISERS**

### **7** 5114 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.

## 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
0E	40	04	--	6
0E	40	05	--	1
0E	40	05	02	3
0E	40	06	--	1
0E	80	04	--	4
0E	80	05	05	3
0E	80	06	--	1

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 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** Tape/Print Exerciser

The tape/print exerciser is used to exercise either tape unit (internal or 5106 Auxiliary) or 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 tape/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** Tape/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 tape/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
0E	40	04	--	6
0E	40	05	--	1
0E	40	05	02	3
0E	40	06	--	1
0E	80	04	--	4
0E	80	05	05	3
0E	80	06	--	1

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:

- INSERT SCRATCH TAPE(S)
- PRESS ATTENTION TO TERMINATE

## 15 Device Menu:

- T1 – Internal tape
- T2 – 5106 Auxiliary Tape
- 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)

The mark operation defines files that are 3,072 bytes long. Each file consists of six 512-byte records. The routine begins by marking file 1 at the beginning of tape (BOT) and continues until the end of tape (EOT) is sensed. At this time the tape unit rewinds to the BOT and repeats the operation.

## 2: Ripple Write or Print

### Ripple Write (internal tape or 5106 Auxiliary Tape)

This routine writes a ripple patterned record on each file that has been previously marked. The same pattern used on the 5103 Printer is used for this routine.

Each record within a file is 512 bytes long and is repeated six times to fill the 3,072-byte file. This pattern continues for every file marked until the EOT is sensed. The tape unit rewinds to the BOT and the routine is repeated.

*Note:* This program will not write on previously marked and written customer tapes.

### 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

```
ABCEFGHIC.<(+I&JKLMNOPQR!$*);--/STUVWXYZI,%>?&^"Δ±⊖→→v":#@"="~abcdefghijkl↑↓$[L→[]
BCDEFGHIC.<(+I&JKLMNOPQR!$*);--/STUVWXYZI,%>?&^"Δ±⊖→→v":#@"="~abcdefghijkl↑↓$[L→[]
CDEFGHIC.<(+I&JKLMNOPQR!$*);--/STUVWXYZI,%>?&^"Δ±⊖→→v":#@"="~abcdefghijkl↑↓$[L→[]
DEFGHIC.<(+I&JKLMNOPQR!$*);--/STUVWXYZI,%>?&^"Δ±⊖→→v":#@"="~abcdefghijkl↑↓$[L→[]
EFGHIC.<(+I&JKLMNOPQR!$*);--/STUVWXYZI,%>?&^"Δ±⊖→→v":#@"="~abcdefghijkl↑↓$[L→[]
FGHIC.<(+I&JKLMNOPQR!$*);--/STUVWXYZI,%>?&^"Δ±⊖→→v":#@"="~abcdefghijkl↑↓$[L→[]
GHIC.<(+I&JKLMNOPQR!$*);--/STUVWXYZI,%>?&^"Δ±⊖→→v":#@"="~abcdefghijkl↑↓$[L→[]
HIC.<(+I&JKLMNOPQR!$*);--/STUVWXYZI,%>?&^"Δ±⊖→→v":#@"="~abcdefghijkl↑↓$[L→[]
Ic.<(+I&JKLMNOPQR!$*);--/STUVWXYZI,%>?&^"Δ±⊖→→v":#@"="~abcdefghijkl↑↓$[L→[]
c.<(+I&JKLMNOPQR!$*);--/STUVWXYZI,%>?&^"Δ±⊖→→v":#@"="~abcdefghijkl↑↓$[L→[]
<(+I&JKLMNOPQR!$*);--/STUVWXYZI,%>?&^"Δ±⊖→→v":#@"="~abcdefghijkl↑↓$[L→[]
<(+I&JKLMNOPQR!$*);--/STUVWXYZI,%>?&^"Δ±⊖→→v":#@"="~abcdefghijkl↑↓$[L→[]
(+I&JKLMNOPQR!$*);--/STUVWXYZI,%>?&^"Δ±⊖→→v":#@"="~abcdefghijkl↑↓$[L→[]
+I&JKLMNOPQR!$*);--/STUVWXYZI,%>?&^"Δ±⊖→→v":#@"="~abcdefghijkl↑↓$[L→[]
I&JKLMNOPQR!$*);--/STUVWXYZI,%>?&^"Δ±⊖→→v":#@"="~abcdefghijkl↑↓$[L→[]
&JKLMNOPQR!$*);--/STUVWXYZI,%>?&^"Δ±⊖→→v":#@"="~abcdefghijkl↑↓$[L→[]
JKLMNOPQR!$*);--/STUVWXYZI,%>?&^"Δ±⊖→→v":#@"="~abcdefghijkl↑↓$[L→[]
LMNOPQR!$*);--/STUVWXYZI,%>?&^"Δ±⊖→→v":#@"="~abcdefghijkl↑↓$[L→[]
LMNOPQR!$*);--/STUVWXYZI,%>?&^"Δ±⊖→→v":#@"="~abcdefghijkl↑↓$[L→[]
MNOPQR!$*);--/STUVWXYZI,%>?&^"Δ±⊖→→v":#@"="~abcdefghijkl↑↓$[L→[]
NOPQR!$*);--/STUVWXYZI,%>?&^"Δ±⊖→→v":#@"="~abcdefghijkl↑↓$[L→[]
OPQR!$*);--/STUVWXYZI,%>?&^"Δ±⊖→→v":#@"="~abcdefghijkl↑↓$[L→[]
PQR!$*);--/STUVWXYZI,%>?&^"Δ±⊖→→v":#@"="~abcdefghijkl↑↓$[L→[]
QR!$*);--/STUVWXYZI,%>?&^"Δ±⊖→→v":#@"="~abcdefghijkl↑↓$[L→[]
R!$*);--/STUVWXYZI,%>?&^"Δ±⊖→→v":#@"="~abcdefghijkl↑↓$[L→[]
!$*);--/STUVWXYZI,%>?&^"Δ±⊖→→v":#@"="~abcdefghijkl↑↓$[L→[]
);--/STUVWXYZI,%>?&^"Δ±⊖→→v":#@"="~abcdefghijkl↑↓$[L→[]
```



### 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 provides you with a 128-character write field that can be filled or partially filled with any characters. This pattern is repeated four times to make a 512-character record. This record image is repeated six times to make up the 3,072-byte file. The tape unit will write every file previously marked until the EOT. The tape unit rewinds to the BOT, and the routine is repeated.

### 4: Read (tape only)

This test reads any marked and written file to the EOT, rewinds, and repeats itself. Cyclic redundancy checking (CRC) occurs during the read operation.

## 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 00020000009000100000F7F20000048240000
```

### Device Address

Address in Hexadecimal	Device
05	Printer
0D	Diskette unit
0E	Tape unit

### Subdevice Address

Address in Hexadecimal	Subdevice
80	Diskette drive 1
40	Diskette drive 2
20	Diskette drive 3
10	Diskette drive 4
02	Auxiliary tape unit
01	Internal tape unit

## I/O Command

Code in Hexadecimal	Diskette	Printer	Tape
00	Sense	Sense	Sense
01	Read		Read
02	Write	Write (output to printer)	Write
03	Write Last	Same as Write	Write Last
04	Find		Find
05	Mark		Mark
06			Initialize and Mark
07			Rewind
08	Forward Space		Forward Space Record
09			Backspace Record
0A			Find Next Header
0B	Write Header		Write Header
0C	Scan		
0D		Plot Function	
0E			
0F			
10	Find ID (diagnostic only)		
11	Initialize Head (diagnostic only)		
FD			Translate 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 represents 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 internal and auxiliary tape units, and diskette drives 1 and 2.

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
Internal tape	BASIC	002-014	E	80
Internal tape	APL	002-014	0	01
Auxiliary tape	BASIC	002-014	E	40
Auxiliary tape	APL	002-014	0	02
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
5114 Diskette	BASIC	001-045	D	80—Drive 1 40—Drive 2 20—Drive 3 10—Drive 4
5114 Diskette	APL	001-045	0	11—Drive 1 12—Drive 2 13—Drive 3 14—Drive 4
Parallel I/O	BASIC	002-014, 020-033	7	80 Command 10 Control 04 Data out 02 Data in
Parallel I/O	APL	002-014, 020-033	7	1 Command 2 8-bit data out 3 8-bit data in 4 Control 6 Data out 7 Data in
BSC	BASIC	002-014, 080-099	6	80 Data file 40 Data file 08 Command file 04 Command file

Device	Language	Error Code XXX	Device Address Y	Subdevice Address ZZ
--------	----------	-------------------	---------------------	-------------------------

BSC	APL	002-014, 080-099	6	1 Data file 2 Data file 5 Command file 6 Command file
-----	-----	------------------	---	--

#### TAPE ERROR CODES

Device	Error Code	Description
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	Error xxx	Device Address y	Subdevice Address zz	
Tape	002	E	zz	Invalid Command for Device or Invalid Sequence for Device Incorrect device address or file number specified by the user or user attempted to access the tape file 0.
	003	E	zz	Status Error—Incorrect status sensed. The most recent status byte is located at address hex 8F (see <i>Status</i> under <i>Tape Adapter I/O Lines</i> in Section 4).
	004	E	zz	Time-Out—Data cannot be found on tape, or a rewind operation exceeded three minutes. (Data might not be found if the tape is positioned where there is no data or if the tape unit failed.) A time-out occurs during the rewind operation if the tape unit fails to sense the load point hole. If the tape unit senses the larger BOT/EOT holes, the tape moves forward looking for the load point hole until the time-out occurs.
	005	E	zz	Cartridge Not Inserted—With a cartridge inserted, status bit 3 is 0 but should be 1.
	006	E	zz	File Protect—The file protect arrow is pointed to SAFE for a write operation. Status bit 6 is sensed as a 1 but should be 0 (indicates tape can be written).
	007	E	zz	Cyclic Redundancy Check Error—The data track CRC is bad (see <i>Error Checking</i> in Section 3). Obtaining a correct CRC requires proper operation of all read/write components in the tape unit. Defective components or a defective tape can cause this error. An excessively used tape can cause 007 errors. Tape life is several thousand head passes on a customer cartridge and approximately 500 head passes on a diagnostic tape cartridge.
	008	E	zz	Records or Files Out of Sequence—Format record sequence numbers or header file numbers are not read in the correct order (see <i>Tape Writing and Formatting</i> in Section 3). This can be caused by the removal of the tape cartridge while it is being written. The information on the file cannot be used.

Device	Error Code		Description
Error xxx	Device Address y	Subdevice Address zz	
009	E	zz	End of Data—End of data (hex 42) was read from the record type byte of a data record when end of data was not expected. The tape unit is not usually the cause of this error.
010	E	zz	End of File—A read or write operation was attempted beyond the last record on the file. The tape unit is not usually the cause of this error.
011	E	zz	Specified File Number Cannot Be Found—A hex FF (end of marked tape) was read from the header record file type byte before the user specified file was found. The tape unit is not usually the cause of this error.
012	E	zz	Physical End of Tape—EOT status bit 0 was sensed as a 1, which indicates an EOT was sensed. An incorrect number of files or an incorrect file size can cause this error.
013	E	zz	Tape Unit Not Ready—An incorrect device address was specified by the user for the tape unit, or there was no status response from the tape unit.
014	E	zz	Specified Subdevice Is Not Attached—An invalid subdevice was specified by the user, or an expected subdevice status was not sensed.
800 through 999	E	zz	Diagnostic Error Generated by Diagnostic Sections. See <i>Diagnostic Program Routines</i> or MAP 300 for error definitions.

## DISKETTE ERROR CODES

Device	Error Code		Description
Error xxx	Device Address y	Subdevice Address zz	
Diskette	001	D	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 $166.7 \pm 4.2$ 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	Command Reject—This error occurs when: <ul style="list-style-type: none"> <li>• The diskette code receives an IOCB without the proper device address.</li> <li>• The diskette code receives an IOCB with an invalid command.</li> </ul>

Device	Error Code	Description
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	Error xxx	Device Address y	Subdevice Address zz	
Diskette (continued)	002	D	zz	<ul style="list-style-type: none"> <li>• 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.</li> <li>• A mark command is given and one of the following conditions existed: <ul style="list-style-type: none"> <li>– The number of files to mark is set to zero.</li> <li>– The beginning file plus the number of files to mark exceeds the maximum number of labels for the diskette mounted.</li> <li>– The beginning file number (determined by the prior find command) is equal to zero.</li> </ul> </li> <li>• 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.</li> <li>• A physical read or write operation is given with an invalid cylinder or sector number.</li> <li>• A relative read or write command is given with a buffer size of zero.</li> </ul>
	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.
	013	D	zz	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: <ul style="list-style-type: none"> <li>• On a mark command when a header cannot be written and verified or logically deleted and verified.</li> <li>• On a write header command when a header cannot be successfully read.</li> <li>• On a sense command when the volume label cannot be successfully read.</li> <li>• On a find or mark command when a header cannot be read.</li> </ul>



Device	Error Code	Error Code		Description
	Error xxx	Device Address y	Subdevice Address zz	
Diskette (continued)	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 or All IDs of a Track—All IDs of a track were read with a CRC error.
	019	D	zz	CRC Error or Data Mismatch on Data Write—A data mismatch, 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.
	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: <ul style="list-style-type: none"> <li>• The first four bytes did not contain volume 1.</li> <li>• The sector was marked as a control record.</li> </ul>

Device	Error Code	Description		
	Error xxx	Device Address y	Subdevice Address zz	
Diskette (continued)	025	D	zz	<p>Invalid Media (improper volume 1 parameters)—One of the following conditions was encountered while the volume 1 label was being verified:</p> <ul style="list-style-type: none"><li>• The volume surface indicator indicated a diskette 1, and the diskette sense bit indicated a diskette 2 or diskette 2d.</li><li>• The volume surface indicator was not a diskette 1 (hex 40), diskette 2 (hex F2), or diskette 2d (hex D4).</li><li>• The volume surface indicator indicated a diskette 2d, but the record length indicator was a space (hex 40).</li><li>• The record length indicator was not a space (hex 40), 1 (hex F1), 2 (hex F2), or 3 (hex 2).</li><li>• The extent arrangement volume 1 (72) was not blank.</li><li>• The special requirements indicator volume 1 (73) was not blank.</li><li>• The label standard version volume 1 (79) was not a W.</li><li>• The volume surface indicator indicated a diskette 1 or a diskette 2, but the record length indicator was hex F3.</li><li>• 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).</li></ul>
	026	D	zz	<p>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.</p>
	027	D	zz	<p>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'.</p>
	028	D	zz	<p>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.</p>
	029	D	zz	<p>Key Search Failure—When the scan command was executed, the first sector read was greater than the search argument.</p>

Device	Error Code	Description
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	Error xxx	Device Address y	Subdevice Address zz	
Diskette (continued)	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.
	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: <ul style="list-style-type: none"> <li>• 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.</li> <li>• A read command when an alternate sector relocate (control flag) control record is encountered.</li> </ul>

Device	Error Code	Error Code		Description
	Error xxx	Device Address y	Subdevice Address zz	
Diskette (continued)	038	D	zz	<p>Invalid Header Parameters—This can occur on a mark command if:</p> <ul style="list-style-type: none"> <li>Any header on the diskette has an EOE past cylinder 741.</li> <li>Any header on the diskette has a BOE greater than the EOE.</li> <li>Any header on the diskette has nondecimal extents.</li> </ul> <p>This error can occur on a find command if:</p> <ul style="list-style-type: none"> <li>Any of the above conditions is true for the found file.</li> <li>The first four bytes of the found file do not contain HDR1.</li> <li>The record length indicator in the header does not match the record length indicator in the volume label.</li> <li>A diskette 2d is sensed with a diskette 1 or diskette 2 basic exchange type indicator (hex 40).</li> <li>The EOD field is greater than 1 plus the EOE.</li> </ul>
	039	D	zz	<p>Attempted to Delete a Protected Header—This error can occur if the user attempts to remark or delete a file that contains an expiration date or a write protect indicator.</p>
	040	D	zz	<p>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.</p>
	041	D	ZZ	<p>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.</p>
	042	D	zz	<p>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.</p>
	043	D	zz	<p>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.</p>

Device	Error Code	Error Code		Description
	Error xxx	Device Address y	Subdevice Address zz	
Diskette (continued)	044	D	zz	Control Record Read—This error occurs under the following conditions: <ul style="list-style-type: none"> <li>• A control record is encountered during a physical read.</li> <li>• A sequential relocate or a logical delete control record is encountered on relative read when the sequential relocate is prohibited.</li> </ul>
	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

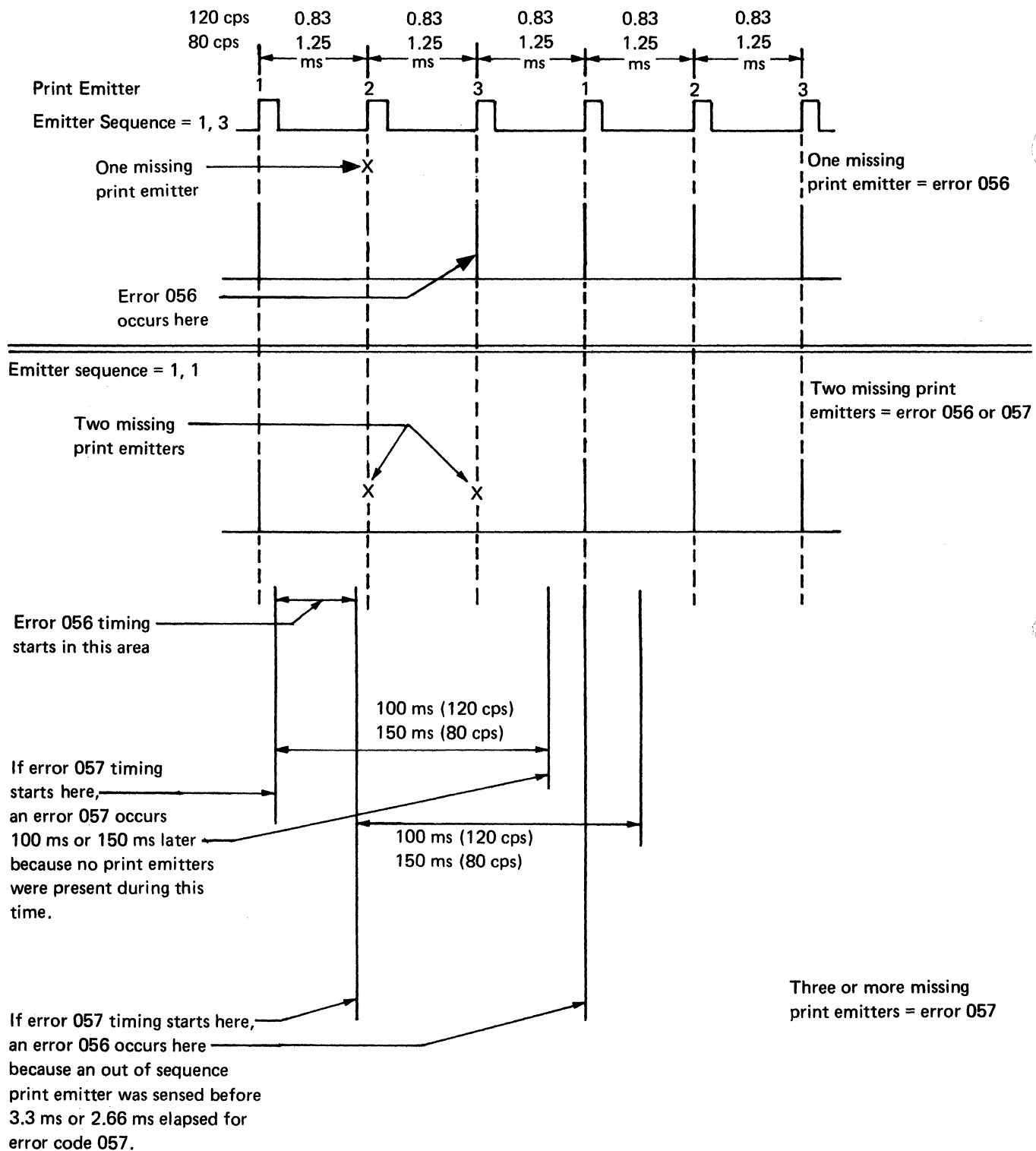
Device	Error Code	Error Code		Description
	Error xxx	Device Address y	Subdevice Address zz	
5103 Printer	013	5	00	Printer Not Attached—An incorrect device address was specified by the user for the printer, or the returned status on bus in was hex FF.
	047	5	00	Print Position Error—The print head was 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).

Device	Error Code	Description		
	Error xxx	Device Address y	Subdevice Address zz	
5103 Printer (continued)	054	5	00	Wire Check—Indicates that 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
	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 <i>Print Emitter Error Timing</i> following these error codes.)  Failures that prevent the carrier from moving such as a broken belt can cause a 057 error.

Device	Error Code	Error Code		Description
	Error xxx	Device Address y	Subdevice Address zz	
5103 Printer (continued)	058	5	00	<p>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.</p> <p>Timer accuracy is checked by running the printer diagnostic program (MDI 800).</p>
	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	<p>System error—Level 2 busy and the microcode timer timed out.</p> <ul style="list-style-type: none"> <li>• IOB status required use of level 2.</li> <li>• Level 2 busy flag is on in the IOB flags (HOLD will reset level 2 busy flags).</li> </ul>
	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	<p>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.</p> <p>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.</p>

**Note:** Error code 06X is reserved for the print plot function.

# **Print Emitter Error Timing (Nominal Timings)**







Device	Error Codes	Description
	<b>Error xxx</b>	<b>Device Address yyy</b>
SIO (continued)	003	yyy <ul style="list-style-type: none"> <li>• The I/O device is attached with the wrong cable.</li> <li>• The I/O device power is not on.</li> <li>• The wrong mode (modem, ignore, terminal, or set is specified).</li> <li>• The I/O device hardware fails.</li> </ul>
	004	yyy The I/O device hardware fails.
	010	yyy The 5110 recognized an end-of-file condition. This condition can be caused when: <ul style="list-style-type: none"> <li>• Both the CMD key and 0 key are pressed.</li> <li>• With the 5110 in modem mode, data terminal ready from the I/O device is off during a receive operation.</li> <li>• With the 5110 in terminal mode, data set ready from the I/O device is off during a receive operation.</li> </ul>
	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, K2, 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, K2, 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, K2, C2, D2, H2, all I/O	Level 1 – C2 or D2 Level 2 – A2, K2, H2, tape control card, 5106, 5103, and 5114 Level 3 – H2 or keyboard
ABCDEF <sup>1</sup>	Tests all device addresses.	0 – J2, 1 – F2, 4 – H2, Kybd 5 – 5103, 6 – C2, 7 – K2, 8 – D2, D – 5114, E – H2, tape drive, 5106	Probe the device address error on the device.
ABCDEFG <sup>1</sup>	Tests the keyboard.	H2	None
ABCDEFGH <sup>1</sup>	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 <sup>1</sup>	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

<sup>1</sup> 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 non-executable ROS and does a CRC check on each ROS module. The display shows ROS XX YY, where XX identifies the card. (See <i>ROS Content</i> and <i>CRC Errors</i> .)	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.

#### ROS Content and CRC Errors

ABCDEFGHJKLMNP

ROS XX YY    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).  
 ERROR ZZZ    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).

#### PARALLEL I/O ERROR CODES

Device	Error Code		Description	
	Error xx	Device Address y	Subdevice Address zz	
PIO	02	7	zz	Command Error—Invalid command to device or invalid parameter to command device.
	09	7	zz	End of Data—Empty buffer returned to APL on input.
	10	7	zz	End File—The user pressed the CMD key and the zero key on the numeric keyboard.
	13	7	zz	Not Attached—The microprogram or the hardware for parallel I/O was not present.
	14	7	zz	Invalid Device Address—The user specified an invalid device or sub-device address.
	20	7	zz	Invalid ∇ (Del) Command—The user sent an invalid command to an output device that operates in seven bit mode, or the user sent a command other than ∇ Q to an eight-bit device or a device in eight-bit mode.

Device	Error Code		Description	
	Error xx	Device Address y	Subdevice Address zz	
PIO (continued)	21	7	zz	Attempt to Talk, but Not Addressed to Talk—A device dependent output was attempted on the 5110, but the 5110 is not a talker.
	22	7	zz	Attempt to Listen, but Not a Listener—A device dependent input was attempted on the 5110, but the 5110 is not a listener.
	23	7	zz	Trying to Talk, but No Listeners—The interface signal lines were at the wrong level.
	24	7	zz	Two Controllers on the Interface—Another device on the interface was sending attention.
	25	7	zz	Interface clear from another device on the interface.
	26	7	zz	Invalid talker address given for serial poll.
	27	7	zz	Incomplete parallel or serial poll.
	28	7	zz	Invalid listener address for parallel poll configure or disable.
	29	7	zz	Invalid SP field for parallel poll configure.
	30	7	zz	In parallel poll, there was not a multiple of three bytes between ∇ L or ∇ 0 and ∇ M.
	31	7	zz	Attempt to transmit a take control remote message.
	32	7	zz	Parity Error—Invalid parity was detected in seven-bit mode when the parity parameter was either even or odd.
	33	7	zz	Invalid data character given for BASIC eight-bit output.

#### 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 ROL0 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 plug and the AC tape motor plug at the AC box. 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.



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.
166 APL halts in BASIC.	The problem shows up in new tapes (unmarked) copied by the tape copy program.	Do not use new unmarked tapes as output for the tape copy program. Mark the new tapes with at least one file before using.
003 through 010 intermittent errors.	Check the customer grounding and the 5110 grounding.	Check to see if customer is using an ungrounded extension cord.
003 and 004 errors when marking new tapes.	None.	Replace the LED/PTX assembly.
003, 004, and 007 errors.	Check for bad solder connections at paddle cards and cable connectors. Also check for strands of wire shorting to pins.	Replace or repair the cables and verify that all connections are good.
003, 004, 007 and 008 errors.	None.	Replace the L2 card.
004 and 007 errors on diagnostics and customer jobs.	Moving the cable that goes to the CRT away from the tape control card causes the problem to disappear.	Replace the CRT.
004 and 007 errors.	Loose read/write head.	Replace the read/write head.
004, 005, 006, 007, and 008 errors.	The customer usually sees only 005 errors, but can create 007 errors unknowingly.	Adjust tape microswitches for .025 mm (.001 inches) to .076 mm (.003 inches) clearance (adjust for maximum overtravel).
	Locking wheels are not centered or seated properly in the base.	Adjust the locking wheels (see 222) and check the adjustment by pulling the cartridge out about 3 cm (1/8 inch) and releasing it. The cartridge should seat in the tape unit.
004, 007, and 008 errors.	Excessive retries.	Check the select magnet and the jackshaft adjustments. (See 220 and 221.)
	The motor locks up or does not move the tape properly.	Replace the motor.

Symptom	Isolation Aid	Fix
004, 007, and 008 errors. (continued)	The tape rubs against the cartridge base plate or plastic top.	Reposition the tape on the spools by doing a )LIB or UTIL; then mark a file to the end of tape and do a rewind.
007 errors.	Extra bytes are written in the data record field on the diagnostic tape cartridge during a CMD0 or CMD1.	Check out the tape by doing a )LIB or UTIL on the diagnostic tape cartridge. If this works, load the failing file using the DCP I/O function.  If there is an error in the data, an 007 error will be displayed. You can rebuild the damaged file using a known good tape and DCP C 5. (See <i>DCP I/O Function</i> in <i>Diagnostic Aids</i> .)
	The display is not blanked during tape operations.	IN PROCESS and PROCESS CHECK leads are swapped. (See 249 for correct wiring.)
007 and 008 errors.	The spindle is glazed from improper contact pressure between the spindle and the tape cartridge. This causes retries and tape errors.	Clean the spindle and drive rolls using isopropyl alcohol.
010 and 012 errors.	The customer cannot copy a complete tape to another tape or complains that tapes have different storage capacity.	All tapes have 204K bytes storage capacity. New files require .5K bytes for each file header. This must be considered when you set up the files.
Noisy tape drives.	Spindle or jackshaft bearings.	Replace as required.
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'.

## 5110 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.

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### General Tips

- Try to force the failure when running diagnostics by:
  - Vibrating the machine/cards/connections.
  - Raising the machine temperature (unplug the blower).

### CAUTION

Do not exceed 20 minutes.

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- 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
  - K2—Parallel I/O card
  - 5106 Auxiliary Tape Unit
  - 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 tape units (internal and auxiliary) or the complete tape units (physically or electrically). To swap electrically, swap the cable in the Z2 socket of the 5110 A1 board with the cable socket in socket B4 of the Auxiliary Tape Unit. The internal tape unit address is now E40 (BASIC) or 002 (APL).

- To loop the tape or diskette read diagnostic (call 0).
  - 1—Load and run call 0 until the first stop occurs.
  - 2—Insert the diagnostic cartridge.
  - 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.

### CAUTION

Stop looping only during a rewind operation. You can damage the diagnostic cartridge if you stop it at any other time.

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### Tape File Recovery

This procedure can be used to recover tape files before and after a defective file (CRC in header). To identify a defective file, do a UTIL or )LIB of the cartridge starting with file 1.

Use the following example, files 1 through 4 are good, file 5 is defective (CRC in header), files 6 through 10 are good. By using the normal load and save commands, you can save files 1 through 4. When file 5 is reached (defective file), remove the cartridge and manually move the tape forward past a load of the file 6, and repeat the load and save operations for fields 6 through 10. (Be sure to save to a different tape and mark as required.) By marking file 4 on the defective tape one K larger than it was, you can reuse the tape. All files past file 3 are now lost.

## 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 tape, 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.

## Tape Mark

This procedure allows you to remark (initialize) a tape if file 1 is defective (CRC in header). Be sure to recover all files after file 1 before using this procedure. Recover all data possible before doing this. Use the file recovery procedure first.

1. Rewind the tape and do a UTIL or )LIB to ensure file 1 is defective.
2. Rewind the tape to the load point (single hole in tape).
3. Remove the tape and wind the load point hole onto the right reel.
4. Jumper U10 to U08 on the back of the tape unit (control card pin side) (230).
5. Insert the tape and with a thin screw driver reach in from the right side of the tape unit and push the jackshaft to the left. This causes the tape to move forward. Move the tape forward about six inches.
6. Release the jackshaft.
7. Remove the jumper.
8. Rewind the tape.
9. Mark the tape starting in file 1.

## 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.

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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. Disconnect the CRT connector if a display is not needed.
6. All 5110 cards except read/write storage can be pulled with power on.
7. All pins except voltage pins can be tied down.
8. Check all voltages.
9. Disconnect the fan motor to heat the machine and aggravate the failure.

### CAUTION

Do not exceed 20 minutes of machine operation without fan running and covers installed.

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### 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.

### Read/Write Head (007) Errors

The following read/write head adjustment procedure might decrease 007 tape errors:

1. Remove the tape control card.
2. Loosen the read/write head.
3. Position the read/write head against the front and left of the mounting recess and tighten the mounting screw (facing the front of the machine).
4. Make sure the read/write head grounding wire clears the cartridge door when the cartridge is inserted.

5. Clean the read/write head with isopropyl alcohol part 220020C and lint free tissue.
6. Replace the tape control card and test the 5110 using the tape read test and MDI 860.

### 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

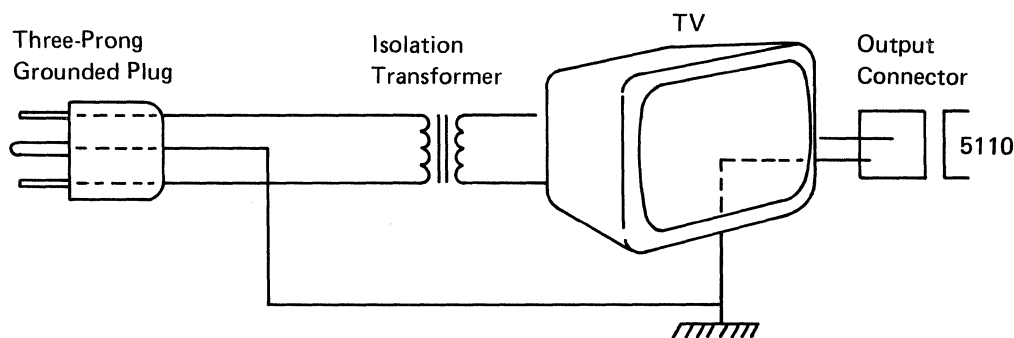
Generally, modifying a standard TV set and using it as a video monitor yields less satisfactory results than a regular video monitor. This is because the same level of quality is not built into TV receivers as is found in monitor class units. For example, the contrast and resolution are not as good on 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.

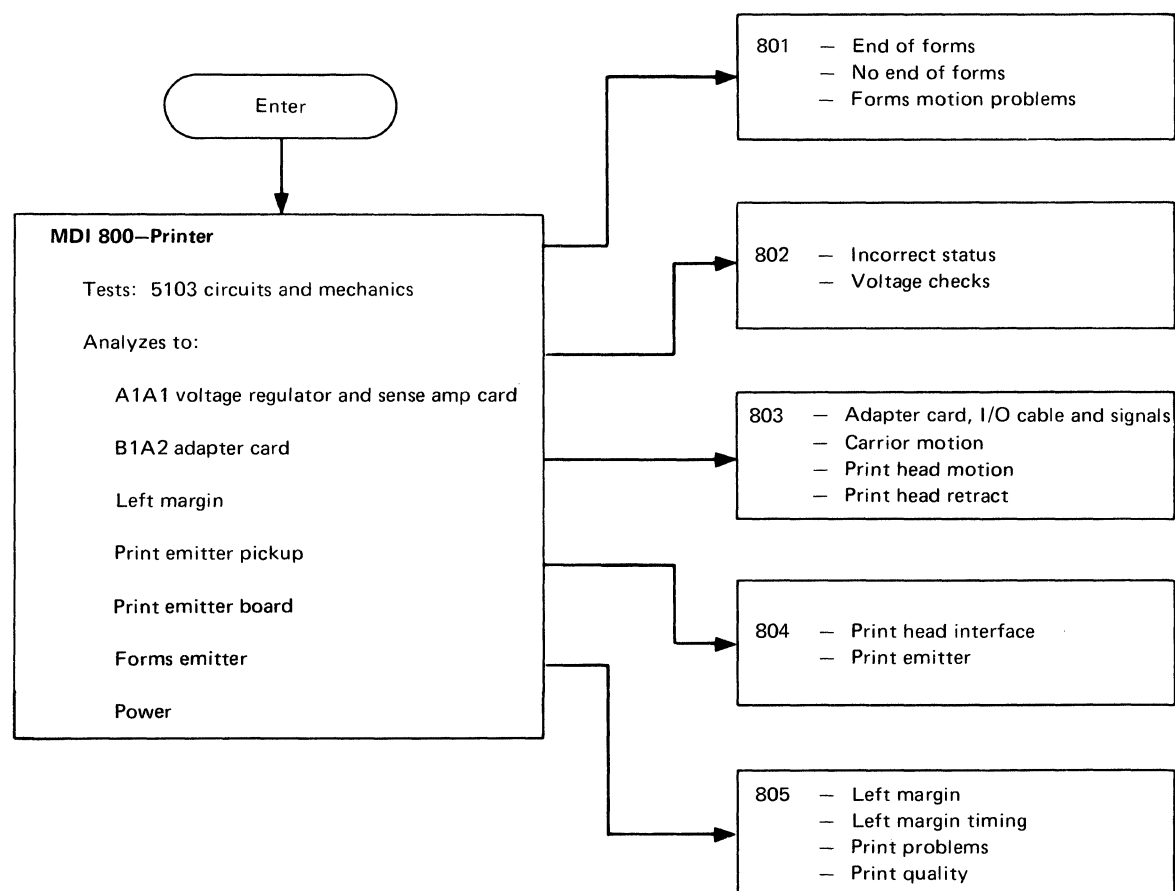


**Note:** If a TV receiver is modified for use as a video monitor, IBM accepts no responsibility for safety precautions during conversion and hookup for damages incurred to the TV receiver or 5110 or for the quality of the TV receiver as a video monitor.

## 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 microprocessor and read/write storage
- Timer interrupts
- SYN character detection
- Data terminal ready
- High speed and low speed operation
- Data path of the BSCA card and the communications facility logic card

### MDI 823—Parallel I/O

This MDI tests the parallel I/O logic card in the K2 card socket. When this 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 *Parallel I/O Diagnostic Routines* in this section.

#### MDI 823—Parallel I/O

Tests: Parallel I/O logic card K2

Analyzes to:

- Data path
- Software resets



## MDI 840—Tape Read

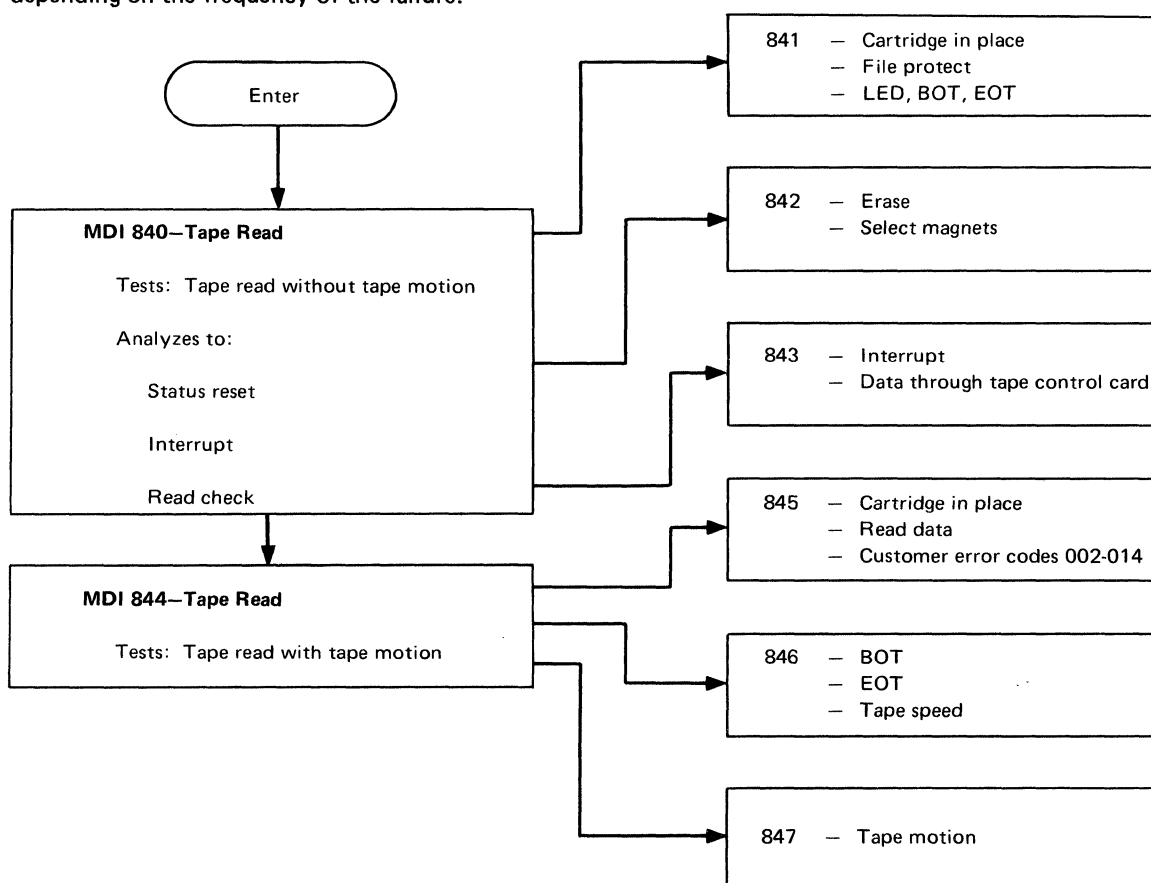
This diagnostic has two parts:

1. MDI 840 tests the tape unit without tape motion.
2. MDI 844 tests the tape unit with tape motion.

The chart on this page shows the relationship of MDI 840 through MDI 847. Be sure to record the information in the status bytes for at least the first failure in order to compare status information with the MDI routine causing the halt. See the Tape Status Byte information in this section.

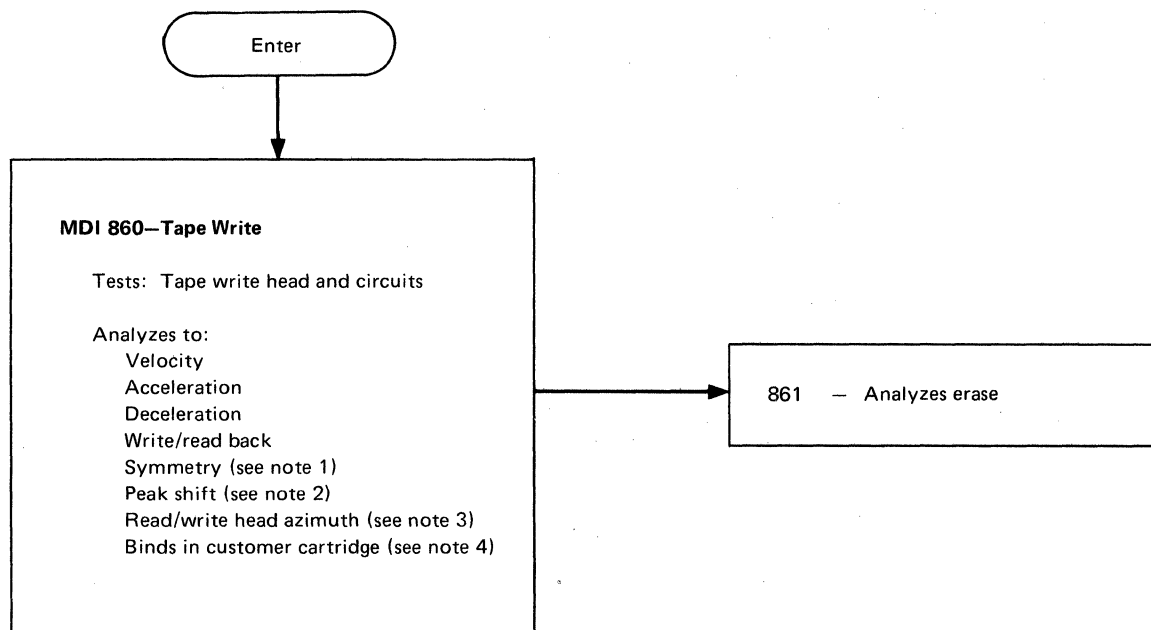
MDIs 840 and 844 cannot be looped together. To loop on MDI 840, load MDI 840 and remove the tape cartridge before running the MDI. Go to the option menu to set up the loop. To loop on MDI 844, load and run MDI 844. Go to the option menu to set up the loop. See *MDI Options* in the *Diagnostic Aids* section of this manual.

MDI 840 and 844 can be run for both the internal tape or the unit 5106 Auxiliary Tape Unit. However, a confusion factor exists because all references are to the 5106 Auxiliary Tape Unit. Also, the MDI subsection has to be loaded from the internal tape unit and might be difficult to load depending on the frequency of the failure.



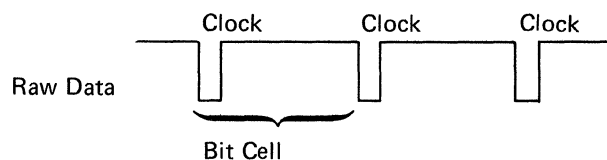
## MDI 860—Tape Write

This MDI tests all the tape write functions of the internal tape unit and the 5106 Auxiliary Tape Unit. The MDI test also analyzes all failures except erase as shown in the following chart. The erase function is tested in MDI 861. Be sure to record the tape status on at least the first failure. See the Tape Status Byte information in this section.

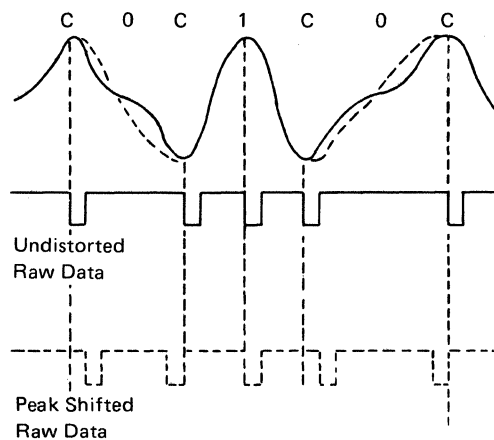


**Notes:** The following notes are for instructional purposes only. The drawings are not meant to be scope pictures as the diagnostics are designed to check the tolerances.

1. Symmetry—The bit cells are of equal duration. This is a function of the tape read/write channel. The tape velocity tested OK in a previous routine.



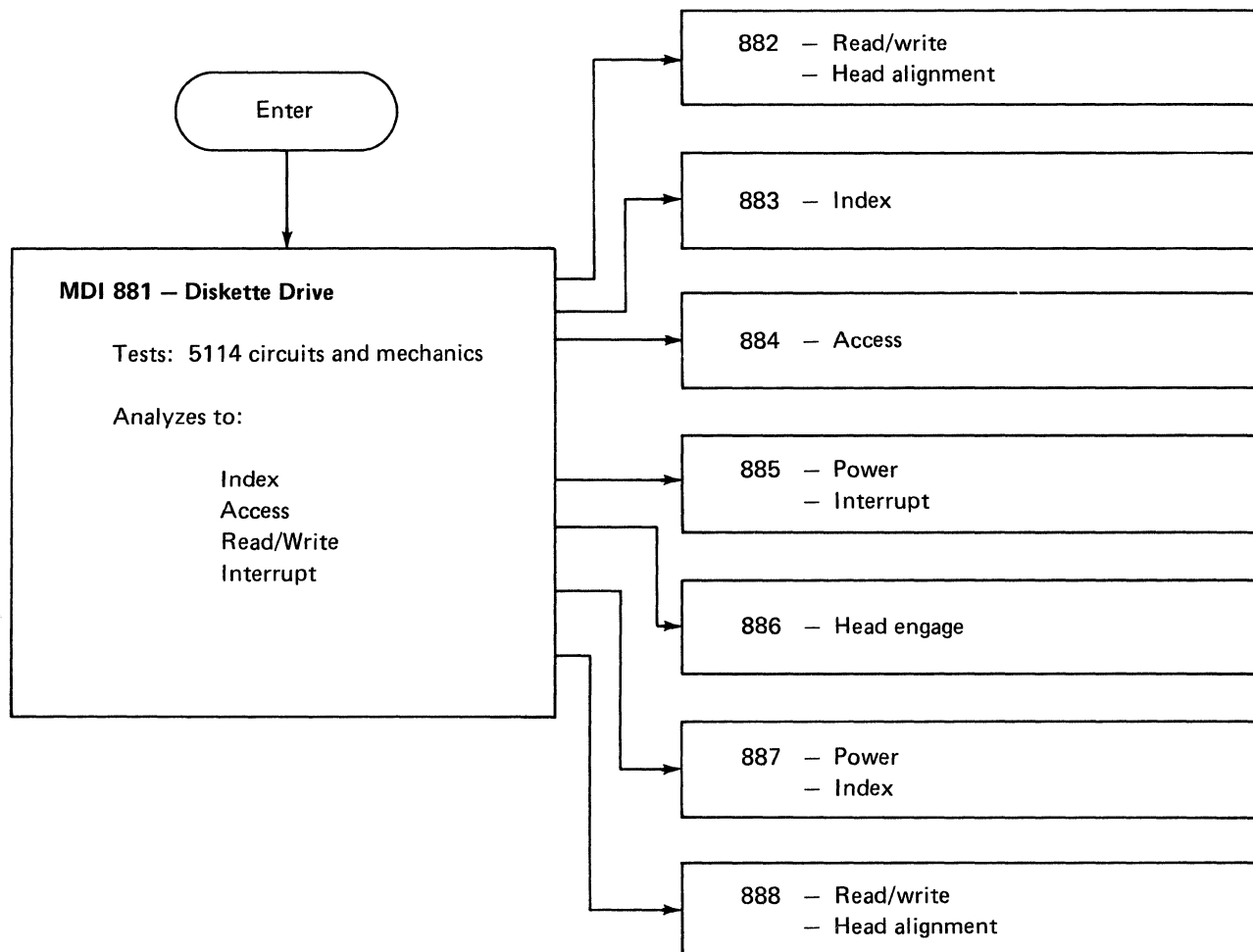
2. Peak Shift—The timing shift of the analog signal peaks is due to the bit pattern and to the tape to read/write head relationship. This is a function of reading tape.



3. Azimuth—The physical angular alignment of the read/write head gap with the recorded transitions on the tape. Azimuth is similar to skew, but due to recording data serial by bit and by character (as opposed to parallel recording on 7 and 9 track tape), it is referred to as azimuth.
4. Binds in Customer Cartridge—All tape write tests must run satisfactorily with the diagnostic cartridge prior to inserting the customer's cartridge.

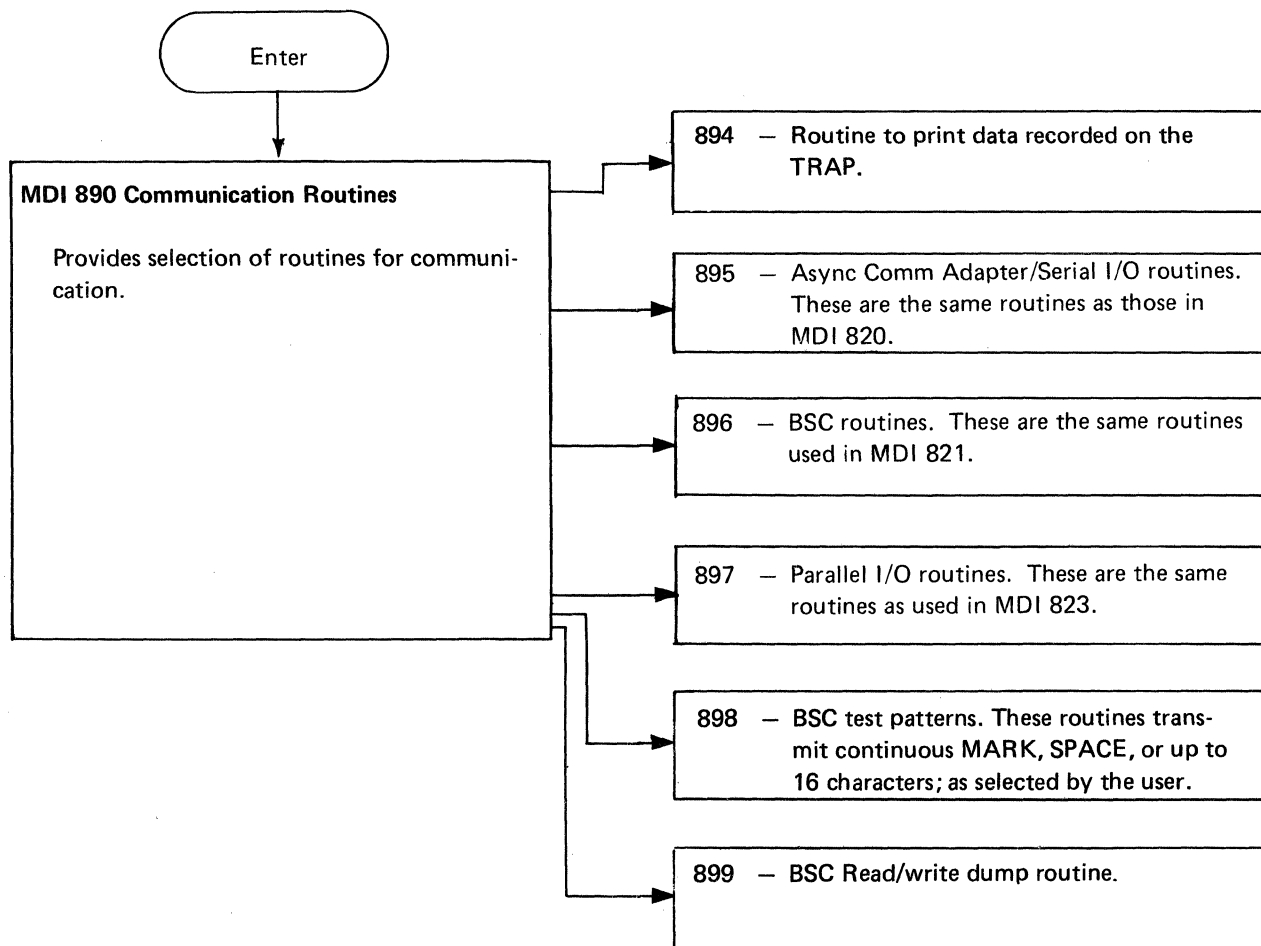
## MDI 881 – DISKETTE DRIVE

This MDI checks all of the diskette functions. If MDI 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 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 fan is 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 5110 MLM binder by inserting its back cover into the slot in the front cover of the 5110 MLM binder. Place the 5110 Parts Catalog and the 5110 Maintenance Information Manual into the 5110 MLM binder.

### Cover Cleaning

Use a mild soap or isopropyl alcohol (part 2200200). **DO NOT** use IBM cleaning fluid.

## 5110 Specifications

### Dimensions:

	Front	Side	Height
Inches	17.5	24.0	8.0
Millimeters	445	609.6	203

**Weight:** 50 pounds (24 kg)

**Heat Output/hr:** 780 BUT/hr

### Power Requirements:

AC Voltage (single phase)	Hertz	kVA
100V	50	0.4
100V	60	0.4
115V	60	0.4
220V	50	0.4
235V	50	0.4

### Power Cord Specifications (220, 235):

Cable OD— $0.4 \pm 0.015$  inches ( $10.16 \pm 0.38$  mm)  
 Shields—none  
 Conductors—3  
 Conductor size—16 Awg ( $1.3 \text{ mm}^2$ )

## 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.

## 5110 I/O DEVICE CONFIGURATIONS

### IBM 5103 Printer, IBM 5106 Auxiliary Tape Unit, and IBM 5114 Diskette Unit to the IBM 5110 Computer

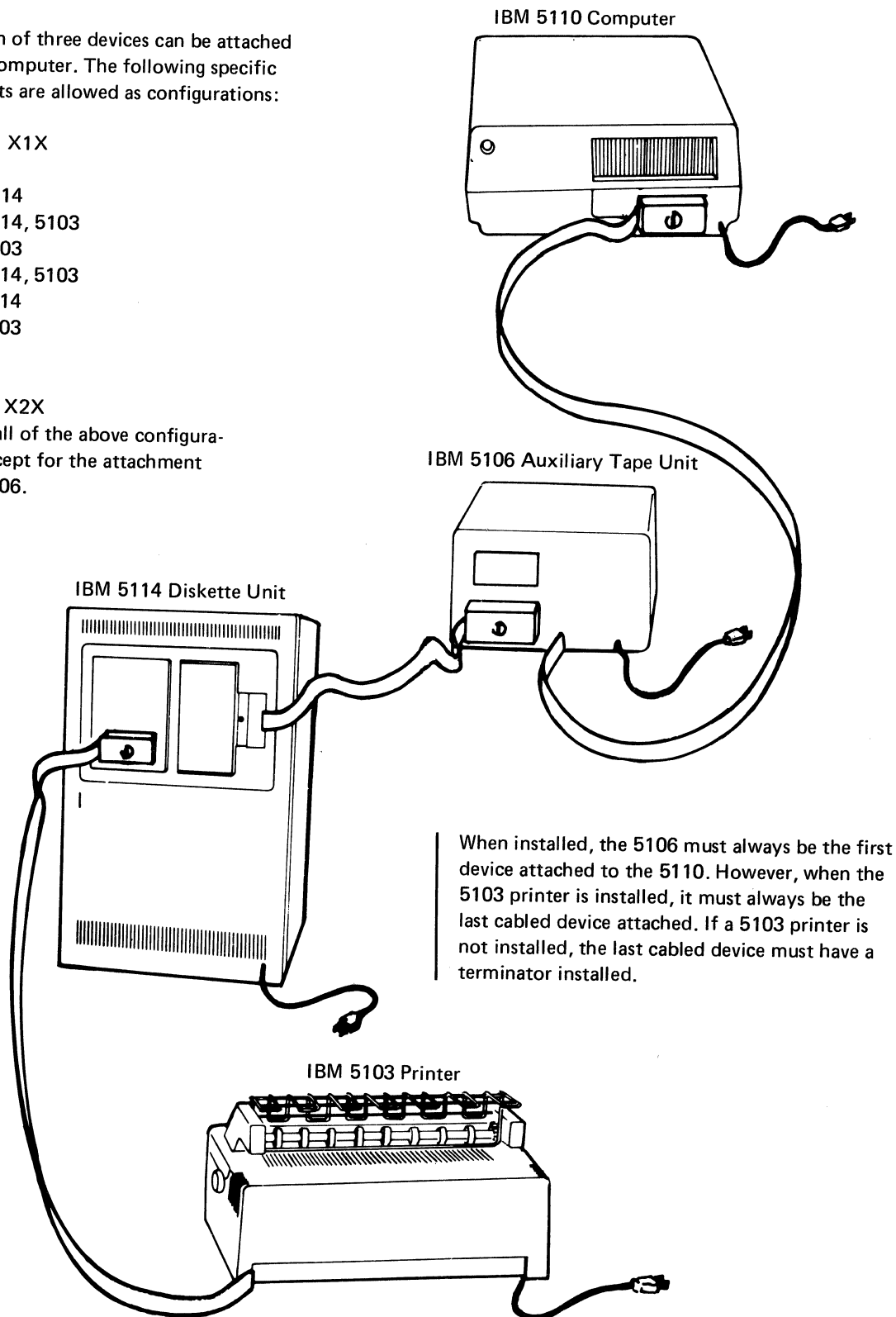
A maximum of three devices can be attached to a 5110 computer. The following specific arrangements are allowed as configurations:

#### 5110 Model X1X

5106  
5106, 5114  
5106, 5114, 5103  
5106, 5103  
5114, 5114, 5103  
5114, 5114  
5114, 5103  
5103

#### 5110 Model X2X

Accepts all of the above configurations, except for the attachment of the 5106.



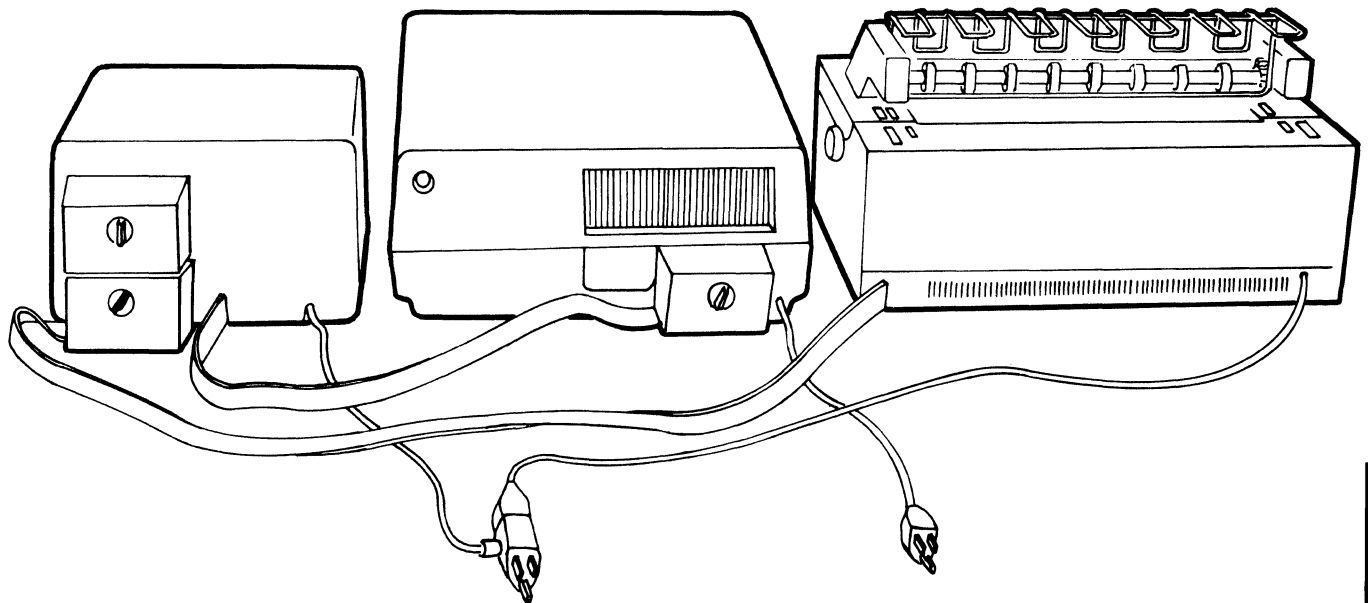


**IBM 5106 Auxiliary Tape Unit and IBM 5103 Printer to  
the IBM 5110 Computer**

IBM 5106 Auxiliary Tape Unit

IBM 5110 Computer

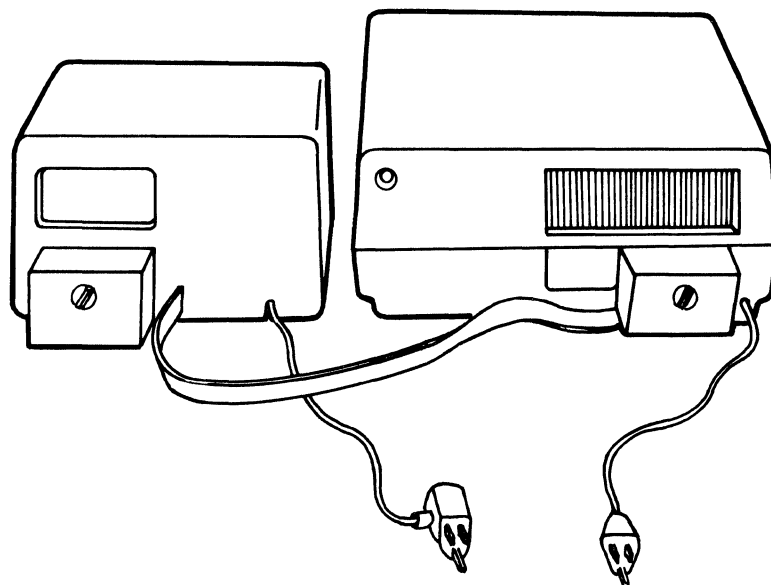
IBM 5103 Printer



**IBM 5106 Auxiliary Tape Unit to IBM 5110 Computer**

IBM 5106 Auxiliary Tape Unit

IBM 5110 Computer



## IBM 5106 AUXILIARY TAPE UNIT

### Prepower Check

Check with the customer to verify that the AC voltage outlet is grounded properly.

### Cable Installation

1. Turn the 5110 POWER switch off (down).
2. Attach the line terminator to the cable connectors on the back of the 5106 Auxiliary Tape Unit.
3. Attach the external I/O interface cable assembly to the back of the 5110.

### Power On Check

1. Make sure that the POWER switch is off (down).
2. Connect the mainline cord to the AC power outlet.
3. Turn the POWER switch on (up).
4. Observe the 5110 for signs of overheating or smoke. Turn the POWER switch off (down) immediately if any abnormal conditions are noted.
5. Check that the fan is turning.
6. Use the Auxiliary Tape MAP 0850 to check the 5110 operation and performance.
7. Replace the cover.

### Completion of Installation

The 5106 Auxiliary Tape serial number is on a tag on the bottom of the base.

### Cover Cleaning

Use a mild soap or isopropyl alcohol (part 2200200).  
**DO NOT** use IBM cleaning fluid.

### Safety

Remove all electrical power from the 5106 Auxiliary Tape Unit by unplugging the mainline cord.

### IBM 5106 Auxiliary Tape Unit Specifications

#### Dimensions:

	Front	Side	Height
Inches	13.25	9.85	7.1
Millimeters	336.5	250	180

*Weight:* 18 pounds (8 Kg)

*Heat Output/hr:* 130 BTU/hr

#### Power Requirements:

AC Voltage (single phase)	Hertz	kVA
100V	50	0.1
100V	60	0.1
115V	60	0.1
220V	50	0.1
235V	50	0.1

#### Power Cord Specifications (220, 235):

Cable OD—0.4 ± 0.015 inches (10.16 ± 0.38 mm)  
Shields—none  
Conductors—3  
Conductor size—16 Awg (1.3 mm<sup>2</sup>)

#### Operating Environment:

Temperature 60°F to 90°F (15.6°C to 32.2°C)  
Relative humidity 8% to 80%  
Maximum wet bulb 73°F (22.8°C)

## Tools and Test Equipment

## 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

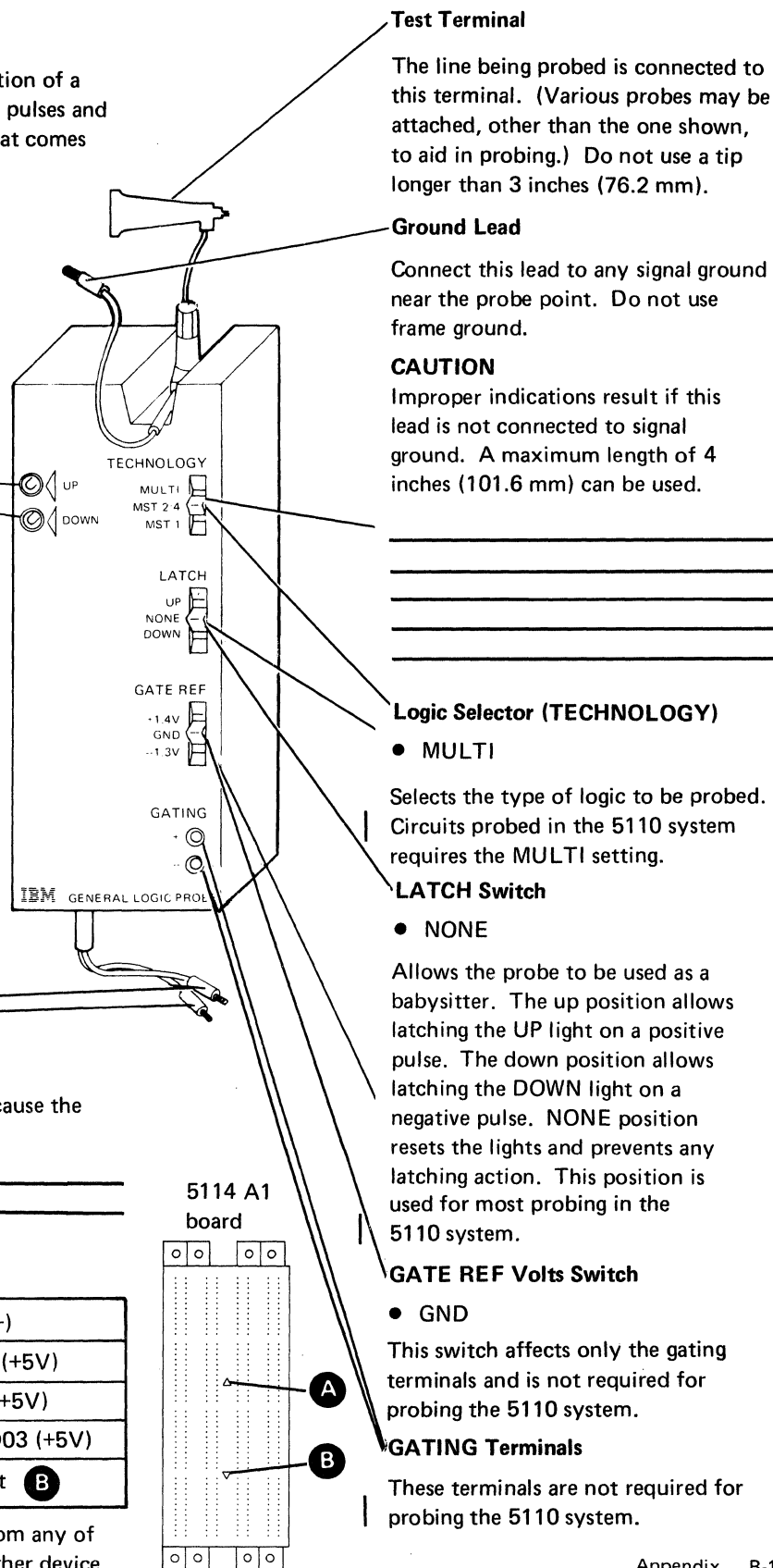
## CAUTION

Improper connection of the power lead might cause the probe to malfunction.

Connect the probe power leads as follows:

	Black (-)	Other (+)
5110	M2D08 (Gnd)	M2D03 (+5V)
5103	TP-G6 (Gnd)	TP-V4 (+5V)
5106	A1-A4D08 (Gnd)	A1-A4D03 (+5V)
5114	See inset <b>A</b>	See inset <b>B</b>

*Note:* Power for the probe can be obtained from any of the above devices when you are probing any other device.



## 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.

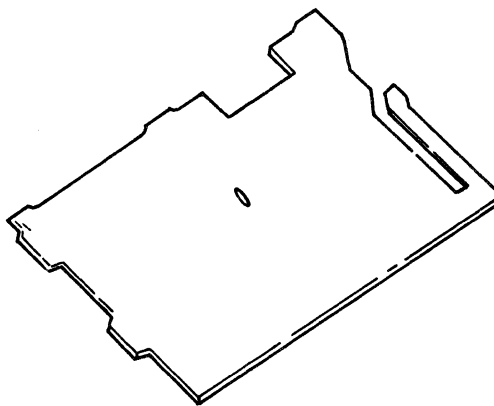
$$\text{Act Vol} = \frac{6 \times 4.8}{5.8} = 4.97 \text{ Vdc}$$

## 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.

## TAPE CARTRIDGE STOP GAUGE (part 1608780)

This gauge is part of the basic ship group and is used to adjust the tape cartridge stops.



## 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**

		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

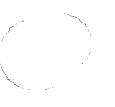
*From hex to decimal:* Locate each hex digit in its corresponding column position and note the decimal equivalents. Add these to obtain the decimal value.

Example:      **Hex Value**                      **Decimal Equivalent**

**Columns**

**4 3 2 1**

3	0	C	F	
				15
				192
				0
				12,288
				<hr/>
				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

**BOT:** Beginning of tape

**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.

**EOT:** End of tape

**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

**jackshaft:** A mechanical device in the tape unit that transfers motion from the motor (via a belt) to the spindle

**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

**spindle:** A mechanical device in the tape unit for transferring motion from the jackshaft pulleys to the cartridge capstan

**steps:** An offset that occurs in a reel of tape when exposed to extreme temperature drops

**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 5-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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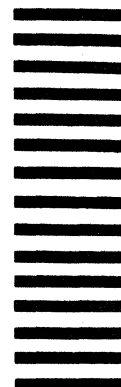
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