TEK INSTRUCTION MANUAL

Part No. 070-2827-01
Product Group 61

MicroLab I

067-0892-00/01/02/03/04

Instruction Manual

Tektronix
COMMITTED TO EXCELLENCE

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Please check for change information at the rear of this manual

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Tektronix®
COMMITTED TO EXCELLENCE

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PREFACE

Introduction

This Instruction Manual supports the TEKTRONIX MicroLab I, a test fixture and demonstration aid for TEKTRONIX microprocessor development products.

Documentation Overview

The MicroLab I support documentation consists of one primary manual (this MicroLab I Instruction Manual) and several supplemental manuals, one for each of the MicroLab I personality cards.

About This Manual

This manual is divided into two parts. The first part of this manual explains the operating structure of the MicroLab I, and the commands that affect the operation of the MicroLab I.

The second part of this manual contains servicing information, and is designed to be used by trained service technicians. This manual is not designed as a training tool. The intent is to provide a detailed theory of operation that will allow a technician to locate a problem to a particular component on a circuit board.

WARNING

The second half of the manual explains the internal workings of the MicroLab I, and contains servicing instructions that are for use by qualified personnel only. Don't perform any servicing other than that contained in the operating part of this manual unless you are qualified to do so.

Revision History

Revision history information is included in the text and diagrams as they are revised and reprinted. Original manual pages have an @ symbol in the bottom inside corner of the page. Existing pages of a manual, when revised, have a revision code and date in place of the @ symbol. New pages added to a section, whether they contain old, new, or revised information, will have the @ symbol.

Slashed Zeros (Ø)

Zeros are slashed in this manual only when needed for clarity.

Hexadecimal Notation

All addresses are in hexadecimal notation except where otherwise noted.

Change Information

Change information is located in the back of this manual in the CHANGE section. Change information should be entered into the body of the manual when the manual is received.

CONTENTS

WARNING

THE FOLLOWING SERVICING INSTRUCTIONS ARE FOR USE BY QUALIFIED PERSONNEL ONLY. TO AVOID PERSONAL INJURY, DO NOT PERFORM ANY SERVICING OTHER THAN THAT CONTAINED IN OPERATING INSTRUCTIONS UNLESS YOU ARE QUALIFIED TO DO SO.

ILLUSTRATIONS

TABLES

OPERATORS SAFETY SUMMARY

The general safety information in this part of the summary is for both operating and servicing personnel. Specific warnings and cautions will be found throughout the manual where they apply, but may not appear in this summary.

Terms

In This Manual

CAUTION statements identify conditions or practices that could result in damage to the equipment or other property.

WARNING statements identify conditions or practices that could result in personal injury or loss of life.

As Marked on Equipment

CAUTION indicates a personal injury hazard not immediately accessible as one reads the marking, or a hazard to property including the equipment itself.

DANGER indicates a personal injury hazard immediately accessible as one reads the marking.

Symbols

In This Manual

This symbol indicates where applicable cautionary or other information is to be found.

As Marked on Equipment

⚡ DANGER high voltage.

⏚ Protective ground (earth) terminal.

⚠ ATTENTION—refer to manual.

Grounding the Product

This product is grounded through the grounding conductor of the power cord. To avoid electrical shock, plug the power cord into a properly wired receptacle before connecting to the power input or output terminals. A protective ground connection by way of the grounding conductor in the power cord is essential for safe operation.

Use the Proper Power Cord

Use only the power cord and connector specified for your product.

Use only a power cord that is in good condition.

Refer cord and connector changes to qualified service personnel.

Use the Proper Fuse

To avoid fire hazard, use only the fuse specified in the parts list for your product, and which is identical in type, voltage rating, and current rating.

Refer fuse replacement to qualified service personnel.

Do Not Operate in Explosive Atmospheres

To avoid explosion, do not operate this product in an atmosphere of explosive gases unless it has been specifically certified for such operation.

Do Not Remove Covers or Panels

To avoid personal injury, do not remove the product covers or panels. Do not operate the product without the covers and panels properly installed.

SERVICING SAFETY SUMMARY

FOR QUALIFIED SERVICE PERSONNEL ONLY

Refer also to the preceding Operators Safety Summary.

Do Not Service Alone

Do not perform internal service or adjustment of this product unless another person capable of rendering first aid and resuscitation is present.

Use Care When Servicing With Power On

Dangerous voltages exist at several points in this product. To avoid personal injury, do not touch exposed connections and components while power is on.

Disconnect power before removing protective panels, soldering, or replacing components.

Power Source

This product is intended to operate from a power source that will not apply more than 250 volts rms between the supply conductors or between either supply conductor and ground. A protective ground connection by way of the grounding conductor in the power cord is essential for safe operation.

The TEKTRONIX MicroLab I.

Section 1

GENERAL INFORMATION

Introduction To MicroLab I

The MicroLab I is a tool used to test and demonstrate microprocessor/microcomputer development systems. The MicroLab I can be "personalized" to act like any of a number of microprocessor- or microcomputer-based computers.

NOTE

For purposes of simplicity, references in this manual to the term microprocessor will apply equally to microcomputer devices, except where otherwise stated.

Purpose

The MicroLab I is designed to take the place of prototype equipment in an environment where a microprocessor development system is demonstrated or tested. The functions of the MicroLab I are:

- to test an Emulator Processor and its Prototype Control Probe.
- to demonstrate the use of an Emulator Processor, and at the same time, a microprocessor development system.

The following paragraphs briefly describe each of these functions.

Testing

The MicroLab I provides a circuit with known characteristics. This allows an Emulator Processor and Prototype Control Probe to be checked for proper operation. There are also tests contained in the MicroLab I operating system that are designed to excercise the Emulator Processor and its probe.

Demonstration

The MicroLab I acts like a prototype circuit, which allows the capabilities of an Emulator Processor to be demonstrated.

Overview

The MicroLab I supports a wide variety of microprocessors and microcomputers. In order to make the MicroLab I perform like a specific microprocessor-based product, a circuit board called a "personality card" is connected through the MicroLab I front panel. The personality card contains circuitry and firmware that, in effect, cause the MicroLab I to become a specific microprocessor-based computer.

The MicroLab I mainframe contains the general interface logic (including I/O ports, RAM, keyboard and display) used by all the personality cards. Therefore, to make the MicroLab I act like an 8085-based computer, all that's required is an 8085 Personality Card.

Most personality cards contain a microprocessor or microcomputer device. The device is located in a zero-insertion-force (ZIF) socket. When the MicroLab I is used to test or demonstrate an Emulator Processor, the device is removed, and the Prototype Control Probe plug is inserted into the socket.

Features

With some personality cards, the MicroLab I is capable of operating on a stand-alone basis. When the personality card is installed, and a microprocessor or microcomputer is installed in the personality card, the MicroLab I becomes a complete mini-computer.

Front Panel

The MicroLab I can be operated completely from the front panel. There's no need to connect a terminal, or any other support devices. The front panel features include:

- An 8-digit, 7-segment LED display. The display shows you address and data information, as well as commands and error messages.
- A 25-key keypad used for command, data, and address entry.

I/O Ports

Three I/O ports are available on the MicroLab I:

- An RS-232-C compatible I/O port configured for use with a terminal. The terminal is not totally supported in the MicroLab I operating system. Certain keypad commands will send data to a terminal connected to this port.
- An RS-232-C compatible I/O port configured for use with a modem. The modem port is not supported in the MicroLab I operating system.
- A cassette tape serial I/O port using the "Kansas City" recording format. The cassette port is fully supported by the MicroLab I operating system. The cassette tape recorder used must be supplied by you, and cannot be ordered from Tektronix, Inc.

The MicroLab I also contains a bus expansion connector that allows you to directly access the microprocessor's data, address, and control lines.

Memory

The MicroLab I contains 4K x 8-bit RAM. This RAM can be reconfigured into a 2K x 16-bit format for use with 16-bit personality cards. In both the 2K and 4K configuration, a 1K-byte block of memory is software relocatable.

Diagnostics

The MicroLab I is capable of performing the following testing routines.

- Internal self-test routines are included for MicroLab I performance verification.
- External test routines are available for verifying the operation of an Emulator Processor and Prototype Control Probe.

Firmware

The MicroLab I operating system is, in most cases, contained within PROM devices on the personality card used. Some personality cards require that the MicroLab I operating system be loaded from a disc, via a microprocessor development system. The MicroLab I operating system has the following capabilities.

- Hexadecimal display and modification of memory or register contents.
- Program start, program interrupt (with some personality cards), and program continue from the keyboard.
- Program dump to and load from the optional cassette tape recorder.
- Eight user-definable function keys.

FUNCTIONAL OVERVIEW

The MicroLab I is divided into two major operational sections: the MicroLab I mainframe, and the personality card. These two sections are shown in Fig. 1-2.

The personality card contains the microprocessor device, a PROM-based monitor for the MicroLab I, memory address decoding, control signal generation, and I/O decoding logic.

The MicroLab I mainframe contains the remainder of the circuitry, including RAM, that is required for microprocessor operation.

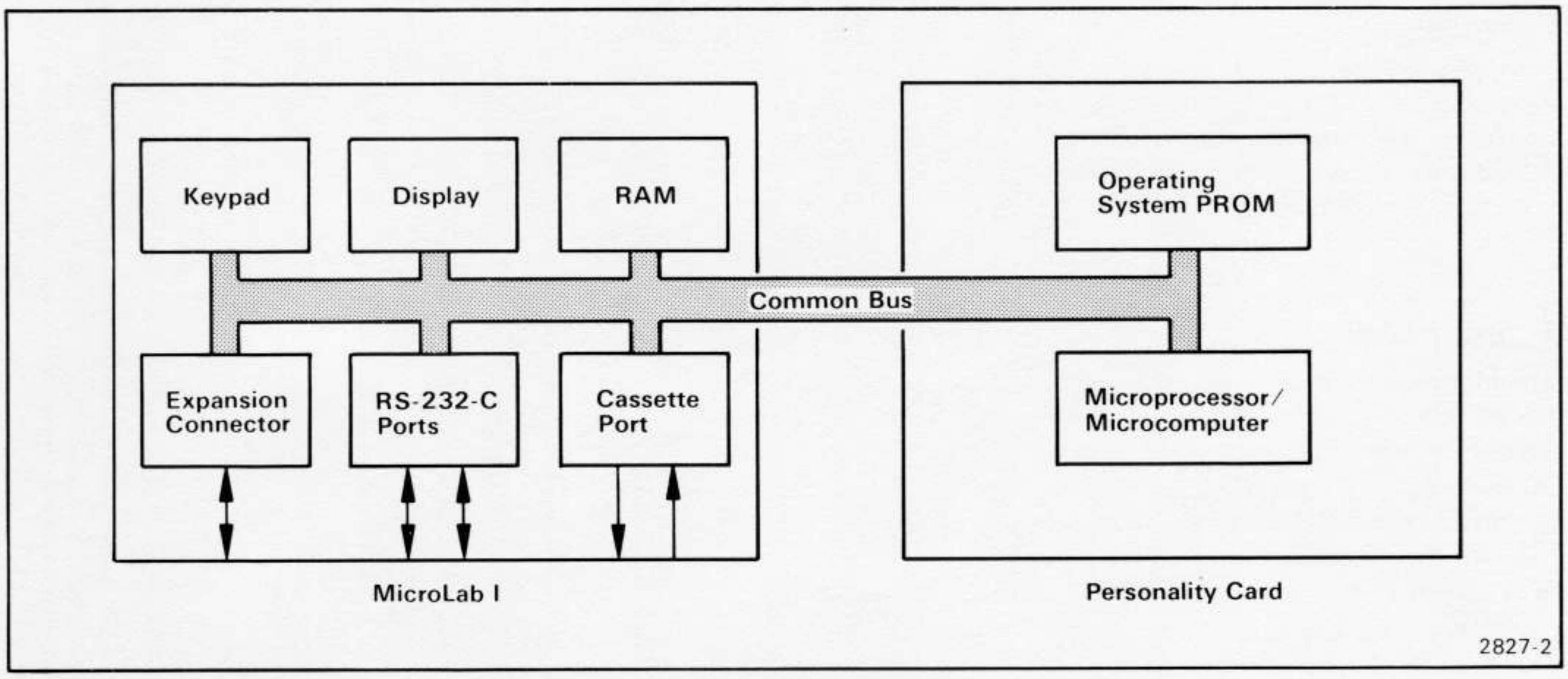

Fig. 1-1. MicroLab I And Personality Card Block Diagram.

The MicroLab I and personality card share a common bus, and are interdependent for operation.

NOTE

The circuitry on the personality card is microprocessor dependent. That is, an 8085 personality card won't contain the same logic as an 1802 personality card. The personality card description given in the first two sections of this manual is generalized, except where a specific example is given. The personality card supplements located in Sections 3 and 11 of this manual give specific information for each card.

MicroLab I/Personality Card Communication

Note in Fig. 1-2 that the MicroLab I and the personality card are connected by a bus. This bus carries the address, data, and control information between the two circuit boards. For example, if a key is depressed on the MicroLab I keypad, the keypad/display encoder converts the key press to digital information and places the information on the MicroLab I internal bus. The bus transfers the information to the personality card. On the personality card, decoding logic converts the information to a form that can be understood by the microprocessor. The microprocessor is under control of the MicroLab I monitor (usually located on the personality card) and reacts to the information according to monitor instructions.

The MicroLab I Monitor

The MicroLab I operates from a monitor that will reside either in PROM on the personality card, or will be loaded from a microprocessor development system into MicroLab I RAM. Where the monitor resides depends on the personality card used.

The monitor is primarily reponsible for responding to entries made on the MicroLab I keypad, and reacting accordingly. We'll talk more about monitor functions later in Section 2.

Section 2

OPERATOR FAMILIARIZATION

Introduction

In this section, we're going to talk about how to operate the MicroLab I. The first thing we'll do is make a demonstration run on the MicroLab I with an 8085 Personality Card mounted. Even if you don't have an 8085 Personality Card, it should be fairly easy to follow through the demonstration. After the demonstration run, we'll discuss each of the major functions of the MicroLab I, in the following order:

- Keypad Definitions
- MicroLab I Self Test
- Cassette Tape File Storage and Retreival
- Programming F1-F8
- Using The Spare RS-232-C (terminal) Port
- Using the Spare RS-232-C (modem) Port
- Programming the MicroLab I Display And Keypad

A list of possible error messages can be found at the end of this section.

Demonstration Run

In this demonstration run, we'll place five numbers in the MicroLab I memory, then add the five numbers together and place the sum in another memory location. Here is a listing of the program we'll enter.

```
                        ;ORG 3090
                        ;THIS ROUTINE ADDS FIVE VALUES LOCATED
                        ;IN 3080-3084 AND PLACES SUM IN 3110
                        ;
                        ;
3090    XRA A           ;CLEAR ACCUMULATOR
3091    LXI H,3080      ;LOAD BEGINNING ADDRESS INTO H,L
3094    MVI B,05        ;LOAD PASS COUNTER VALUE (5) INTO B
3096    ADD M           ;ADD CURRENT MEMORY LOCATION TO ACCUMULATOR
3097    INX H           ;INCREMENT H,L REGISTER BY 1
3098    DCR B           ;DECREMENT PASS COUNTER (B) BY 1
3099    JNZ,3096        ;IF PASS COUNTER NOT ZERO, ADD NEXT NUMBER
309C    STA,3110        ;STORE ACCUMULATOR (SUM) IN 3110
309F    JMP,0000        ;JUMP TO MONITOR
```

NOTE

This demonstration run makes use of the 8085 Personality Card—if you want to go through the demonstration run, you'll need a MicroLab I with an 8085 Personality Card installed. However, an 8085 Personality Card is not required to understand the sequence of the run.

The MicroLab I doesn't have an assembler, so all code must be entered in hexadecimal notation. The MicroLab I facilitates entry of hex code by doing a lot of housekeeping chores, as we'll see next.

Code Entry

The following steps will lead you through program entry and execution.

1. Make sure the 8085 Personality Card is fully inserted into the MicroLab I.
2. Turn the power switch ON. It's located on the right side of the MicroLab I. The display will show "8085" on the left side and the firmware version on the right side. Then display will blank, and be replaced with "HELLO".
3. Press the LOAD ADDRESS key. The display will now show "CAP XXXX" (the last four digits could be any hexadecimal number). "CAP" stands for "current address pointer" and means the MicroLab I address pointer is pointing to the address displayed. We'll talk more about the CAP later in this section.
4. Enter the address (in this case, 3080) of the first data byte to be added. When you press the first number key, the address portion of the display will disappear and be replaced by each number as you enter it. When you've entered all four address digits, the MicroLab I will move the address to the left side of the display, and show the data at that address on the right side.
5. Now press the AUTO key. The display will place a dash between the address and the data. This means the MicroLab I is in the AUTO mode. AUTO stands for "auto load and increment". The MicroLab I will now automatically increment to the next address after each data byte is entered. It's not necessary to press any key other than the data value to be entered into memory.
6. Now enter the first data value. For the purposes of this demonstration, we'll add 1, 2, 3, 4, and 5. So, enter 01 on the keyboard. Notice that each entry is echoed to the display.
7. Enter 02,and notice that the address increments by 1 when you enter the first digit. Now enter 03, 04, and 05. The address part of the display should show 3084 after you've entered 05.

8. Now that the data is loaded, we need to get out of the auto-increment mode. Press the SHIFT key. As soon as the SHIFT key is pressed, the display will show "rEAdY". The SHIFT key can be used to escape from all monitor controlled functions except a program you write, the self- and processor-test routines, and programmable key functions. We'll talk about all these functions later.

The preceeding steps load our five data values into memory. Now we'll load the body of the program.

1. Press "LOAD ADDRESS".
2. Enter 3090 on the keyboard. Address 3090 is the beginning of the add routine.
3. Press AUTO again. The following list of hexadecimal digits is the add program in its object code state. The list reads from left to right, top to bottom. Enter the first value at the upper left side of the list, and work your way across the page, then move to the next line down.

AF 21 80 30 06 05 86 23 05 C2

96 30 32 10 31 C3 00 00

4. When you've entered the last 00, press SHIFT to escape from the auto-increment mode.

The program is now entered into MicroLab I memory. Program execution is next.

1. Press LOAD ADDRESS and enter 3090 (the beginning of the program).
2. Press GO. The 8085 will now execute the program, then return control to the monitor. You'll see the MicroLab I display show "8085 XX", then "HELLO". This means the program is finished.

To look at the value stored in memory, press the LOAD ADDRESS key and enter 3110. Location 3110 should contain 0F, the hexadecimal sum of the five numbers entered.

This ends the demonstration of the MicroLab I. We haven't used all the facilities available in the MicroLab I, nor have we explained all their functions. That's coming up next.

Keypad Definitions

The MicroLab I keypad is laid out in five rows of five keys each, as shown in Fig. 2-1.

Sixteen of the keys are dual-function. In the normal mode, the 16 keys act as a hexadecimal keypad. In the shifted mode, the keys take on special functions. The nine command keys in the outer ring are used to operate the MicroLab I.

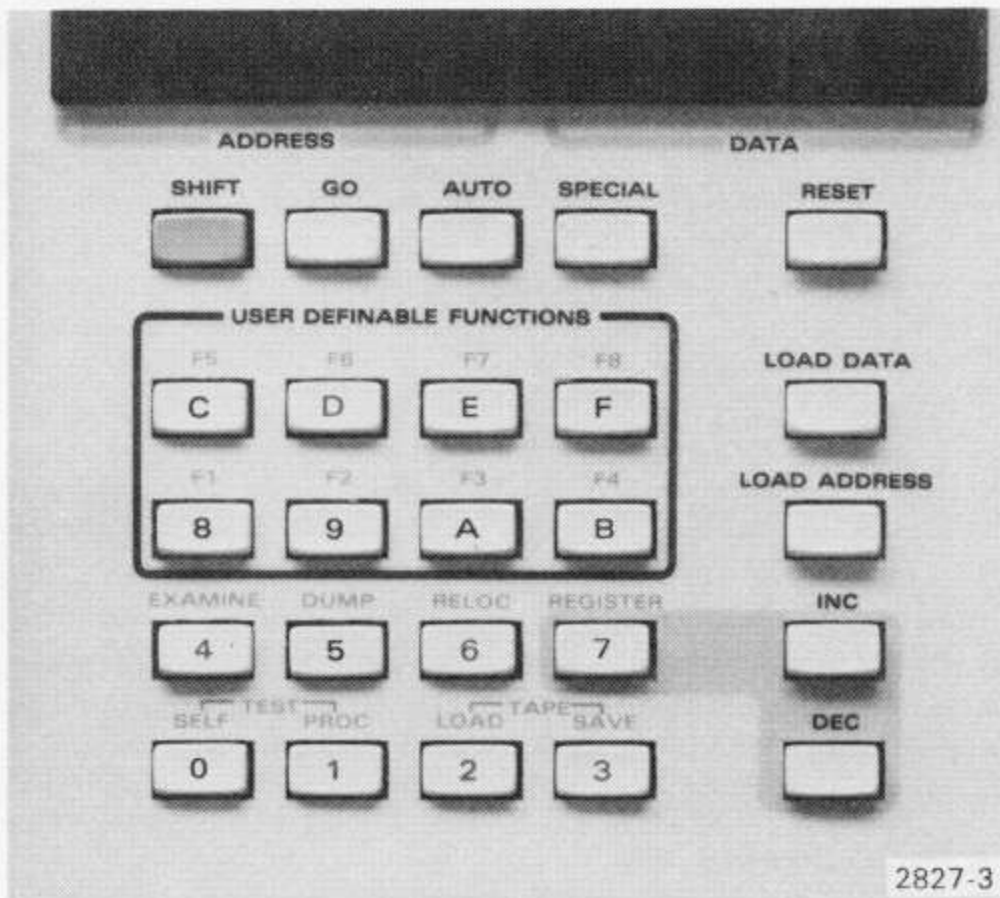

Fig. 2-1. The MicroLab I Keypad.

The outer keys control the MicroLab I. The inner keys are dual-function keys.

In this text, we'll talk about each key individually, giving the key's function and use.

RESET Key

The RESET key issues a master reset to the entire MicroLab I. Current program execution is interrupted, and control is returned to the MicroLab I monitor. When RESET is pressed, the LED display is cleared, and the name of the personality card in use is displayed, followed by the word "HELLO".

LOAD ADDRESS Key

This key allows you to enter an address from the MicroLab I keypad. When you first press LOAD ADDRESS, the display will show "CAP XXXX". This indicates the position of the current address pointer. As you enter the address, the four rightmost digits are replaced with the values you enter. When the last digit is entered, the address is moved to the left, while the data contained at that address is displayed on the two rightmost LEDs. You must enter any leading zeros found in the address.

@

LOAD DATA Key

After you've selected an address with the LOAD ADDRESS key, the LOAD DATA key can be used to change the information contained within that address. Pressing LOAD DATA causes a dash to appear on the display between the address and data. Then, any two hexadecimal numbers you enter will be stored at that location.

Again using the 8085 Personality Card as an example, if you press LOAD ADDRESS, the display will read "CAP XXXX" (the Xs won't appear on the display, but indicate the current address pointer value). Then the next four hexadecimal digits you enter will replace the address shown. After the last address digit is entered, the two right-hand LEDs will display the data at that address.

Now, if you press LOAD DATA, the dash will appear between the address and the data. The next two hexadecimal values you enter will be shown on the display and simultaneously placed into the address you specified. As soon as the last data value is entered, the dash will disappear.

If you should decide that the data value you entered is wrong, simply press LOAD DATA again and enter the correct value. As with LOAD ADDRESS, leading zeros must be entered.

LOAD DATA is a single action key. Each time you want to change data, you'll have to press the LOAD DATA key.

The display will show an error code if you try to load data into the following locations:

- an area where no memory exists
- an address that contains the operating system, whether it be in RAM or PROM

INC Key

The INC key increments the displayed address by 1. INC is used to examine sucessive address contents. If the INC key is held down, the function will be repeated until the key is released.

Once a starting address has been entered with the LOAD ADDRESS key, the INC key can be used to increment the address to the next location you might want to change with the LOAD DATA key. Simply increment to the address you want, press LOAD DATA, and enter the new data value.

DEC Key

The DEC key is used in exactly the same way as the INC key, except that the address is decremented by 1.

AUTO Key

The AUTO key simplifies and speeds program entry into the MicroLab I. AUTO stands for "auto increment and load data". Once a beginning address has been established, the AUTO function will automatically increment the address each time you enter a data value.

For example, if you press LOAD ADDRESS, and then enter 3100, the data at 3100 will be shown on the right side of the display. When AUTO is pressed, the display will place a dash between the address and data. The next two hexadecimal values entered will be displayed as data and simultaneously entered into the address shown. After you've entered the value, the AUTO function forces the MicroLab I to the next address and again enters the LOAD DATA mode. In this way, you can enter a string of data into successive address locations with no extra keypresses.

To escape from the AUTO mode, press the SHIFT key. The display will show "rEAdY".

GO Key

The GO key causes the MicroLab I to begin program execution at whatever address the CAP is pointing to. For example, if your program begins at location 3100, use the LOAD ADDRESS key to enter 3100 on the display. Then press GO. The MicroLab I will begin execution at location 3100.

SPECIAL Key

The SPECIAL key causes the current program execution to be interrupted. The address of the instruction interrupted is displayed, along with the value at that location. In some personality cards the microprocessor register values are saved in memory when the SPECIAL key is pressed.

SHIFT Key

The SHIFT key has two functions. It allows you to escape from functions such as AUTO, and it enables the second set of key functions printed in orange on the keypad. The SHIFT key must be pressed each time a shifted function is required.

Hexadecimal Keys

The keys labeled 0–F are the hexadecimal entry keys. Each of these keys has a second, shifted, function that we'll talk about next.

Shifted Functions

EXAMINE (*SHIFT* 4) Key

The EXAMINE key displays the contents of the address pointed to by the current address pointer (CAP). For example, pressing *(SHIFT)* EXAMINE will show the current CAP address and its contents. Both the INC and DEC keys can be used in their normal fashion to look at other register contents.

DUMP (*SHIFT* 5) Key

The DUMP function causes the contents of a specified memory range to be dumped onto the LED display, or onto the screen of a terminal. When *(SHIFT)* DUMP is entered, the display will show "SA" (starting address). Enter the four-digit address of the first location you want dumped. When the final digit of the starting address is entered, the display will show "EA" (ending address). Enter the last address you want dumped. When the last digit of the ending address is entered, the MicroLab I will begin dumping the information onto the display (and onto the terminal screen).

If a terminal is used, the dump can be paused by pressing the terminal's space bar. To continue the dump, press the space bar again.

RELOC (*SHIFT* 6) Key

A 1K-byte portion of MicroLab I RAM is software relocatable. That is, a 1K-byte block of RAM can be relocated to a new beginning address by using the RELOC key. The 1K block cannot be relocated to a reserved address space, such as the address space allocated to the system monitor. The block will be relocated in 1K address increments. For example, you can't relocate the RAM to 3FFF, but you can relocate it to 4000. If an odd address, such as 3FFF is entered, the monitor will relocate the RAM to the next lower address boundary (3C00 in this case).

When you press *(SHIFT)* RELOC, the current address boundary will be displayed. If you enter a new base address, the address will be echoed back to the display as you enter it. As soon as the last address digit is entered, the display will blank, then show "rEAdY". If you just want to check the base address, press *(SHIFT)* RELOC, note the address, and press SHIFT again.

REGISTER (*SHIFT* 7) Key

The REGISTER key allows you to examine and alter the microprocessor register contents. For example, (using the 8085 Personality Card) pressing (*SHIFT*) REGISTER will cause the contents of the program counter to be shown on the display. When you press INC, the next register will be displayed and so on, through all the registers. The order in which the registers are displayed is determined by the personality card used.

The register contents can be altered simply by entering a new value from the hexadecimal keys. To escape from the register mode, press SHIFT.

If an optional terminal is attached to the MicroLab I, the register contents are displayed in table format on the terminal screen.

SELF TEST (*SHIFT* 0) Key

The SELF TEST key puts the MicroLab I and personality card through a series of tests to verify proper operation. Later in this section, we'll discuss the self test functions in detail.

PROC TEST (*SHIFT* 1) Key

The PROC TEST is used to test an Emulator Processor and its Prototype Control Probe that is plugged into the ZIF socket on the personality card. The PROC TEST features are dependent on which personality card is used. Refer to the personality card supplement for more information on this test.

TAPE LOAD (*SHIFT* 2) Key

The TAPE LOAD key is used to load a file from cassette tape into the MicroLab I memory. When *(SHIFT)* TAPE LOAD is pressed, the word "FILE" is shown on the display. This is your cue to enter a two-digit file name. After the file name is entered, the monitor will display "SEArCH", and scan the tape for the file specified. If the file is not found, press SHIFT to escape. If the file is found but the file header cannot be verified, the display will show "ERROR C8". If the file is found and the header is verified, the monitor will verify the contents of each block in the file by testing the checksum. The checksum value is verified twice. If an error occurs in the first checksum, the display will show an "ERROR C9". If the error occurs in the second checksum, the display shows "ERROR CA".

If there are no checksum errors, the display will show the beginning address of the file just loaded.

TAPE SAVE (*SHIFT* 3) Key

The TAPE SAVE key allows files stored in MicroLab I memory to be saved on cassette tape. When *(SHIFT)* TAPE SAVE is pressed, the display shows "FILE". After you enter a two-digit file name, the display will show "SA" (starting address). Enter a four-digit beginning address. When the last address digit is entered, the display will clear, then show "EA" (ending address), and wait for an ending address. After you enter an ending address, the display will show "GA". The "GA" display is the starting address of the program you want to save. For example, if your executable code exists from 137B to 2000, and a data table exists from 1000 to 137A, you'll want to enter 137B as the "GA" value. Later, when you load the program to run it, the "GA" address is loaded into the CAP to tell you where the beginning of exacutable code is.

Once the "GA" value is entered, the monitor will pause for about three seconds, and then begin dumping the contents of the specified address range onto tape. As each byte is written, the address and data are shown on the display. When the last address is written, the display will show the ending address and the data at that location.

F1—F8 (*SHIFT* 8—F)

These keys are programmable, and we'll discuss how to program them, and some of their possible uses, later in this section.

PROCEDURES

Introduction

The next few pages will help you make use of the capabilities of the MicroLab I. In this part of the manual, we'll talk about the following subjects:

- using the cassette tape port;
- programming the user-definable keys;
- using the MicroLab I with an optional terminal;
- programming the MicroLab I display and keypad;
- relocating a 1K block of RAM; and
- using the self-test features of the MicroLab I.

Cassette Tape File Storage and Retrieval

MicroLab I is able to store and retrieve files from a relatively inexpensive cassette tape recorder. (The recorder is an option provided by the you.) The recording format is called "Kansas City Standard". This standard is a fairly forgiving recording method in terms of recorder and tape quality. Data is recorded asynchronously at 300 baud. There are eight data bits and one stop bit used, with even parity detection.

Each file has a two-digit hexadecimal name assigned to it. This file name is entered when the file is first stored. Files are retrieved simply by specifying the file name.

Tape Recorder Quality

A word here about the kind of tape recorder you'll use with the MicroLab I. Although the "Kansas City Standard" is a slow, simple standard that will work with almost any quality audio cassette tape recorder, good judgement should be used. A low-priced tape recorder using the cheapest tape possible may work, but results will be much more satisfactory if you use high quality tape in a medium priced machine. If the recorder you use has an automatic volume setting feature, it should be disabled in some way so that you can set the recording level.

Be sure not to touch the tape surface while handling the cassette, and don't store the cassette around electrical equipment that radiates a high magnetic field (such as a television set). The tape you buy should be the kind called "leaderless tape". Most commercial cassette tapes have a mylar leader about six inches long. If you don't use leaderless tape, make sure the first file you store does not begin on the leader.

Leave several seconds of space between the files you store. This allows you to easily tell where one file stops and another starts. In this way, you can listen to the tape at fast forward, and stop at the file you want to recover.

Using the MicroLab I Cassette Tape Storage System

There are two audio jacks on the left side of the MicroLab I (see Fig. 2-2). On the bottom of the MicroLab I, you'll find a plate which tells which of the jacks is used for input, and which is used for output. As shown in Fig. 2-2, the leftmost jack receives data from the cassette recorder. The rightmost jack outputs data to the recorder.

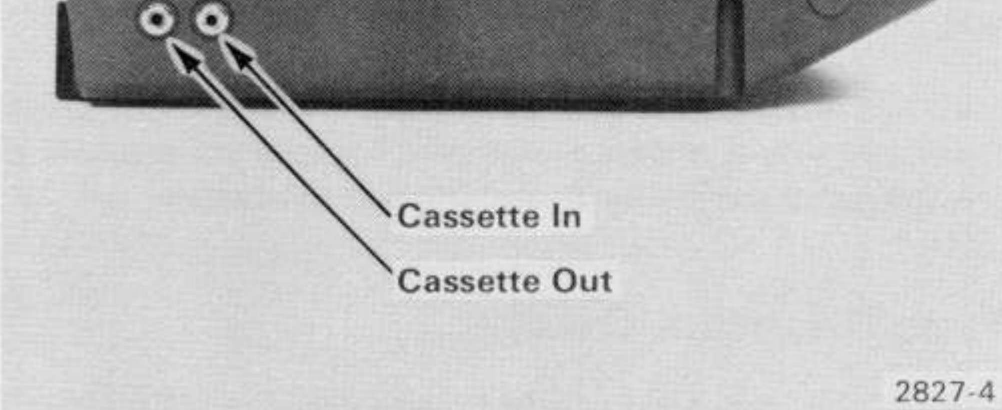

Fig. 2-2. The MicroLab I Cassette Port.

The Cassette Port allows you to store programs on cassette tape.

The lid of the MicroLab I contains two audio cables that terminate in audio plugs. Connect one cable to the OUT jack on the MicroLab I, and the other cable to the IN jack. The free end of the OUT cable goes to the cassette recorder's earphone jack. The free end of the IN cable connects to the recorder's AUX input jack.

NOTE

If there is no AUX jack on your recorder, the microphone input jack may be used; however, a minor equipment modification is required. Refer to Connecting a Cassette Recorder in Section 4 of this manual, for information.

Storing Files

If you're storing files on a new tape, be sure to position the tape so that recording doesn't start on the leader. If the file is to be stored on a tape that already has some files on it, be sure to position the tape after the last file. It is possible to store a new file over an old file.

When you have the tape recorder connected to the MicroLab I and are ready to store a file, perform the following procedure.

1. Press *(SHIFT)* TAPE SAVE. The MicroLab I will then display "FILE". "FILE" is a request for the file name.
2. Enter the two hexadecimal digits that represent the name of the program you want to store. Each digit will be shown on the display. When the last digit is entered, the display will blank, then show "SA".
3. "SA" stands for starting address. Enter the beginning hexadecimal address of the routine to be saved. When the last digit is entered, the display will blank again, then show "EA".
4. When "EA" is displayed, the MicroLab I is asking for the ending address of the program you want to store. Enter the four-digit address.
5. At this point, you must turn on the tape recorder. The next thing you enter will be the "GA" (go address). The go address is the location to which the current address pointer (CAP) will be set following the tape load routine. The go address should represent the beginning of executable code. As soon as this address is entered, the MicroLab will begin feeding the program to the recorder.
6. Enter the four digit "GA" address. As soon as the last digit is entered there will be about a three second pause, and then the MicroLab I will begin sending the file to the recorder. As each address is sent to the recorder, the MicroLab I will show the address and its contents on the display.
7. When the display stops incrementing, the program has been stored and you can stop the recorder.

Loading Files

Files are loaded from tape in much the same manner as they are stored, except that you don't need to specify the beginning and ending address. All you specify is a file name. If a tape is positioned at its beginning, MicroLab I will search through all the files on the tape until it finds the correct file. As soon as the file is found, it is loaded.

To speed up the loading procedure, position the tape at the beginning of the file before using the load command. You can do this by either noting the file's position with the tape counter found on some recorders, or you can note the time it takes to fast forward the recorder to the file.

Following is the procedure to load a tape file into the MicroLab I.

1. Press *(SHIFT)* LOAD TAPE. The MicroLab I display will show "FILE".
2. Enter the two-digit file name.
3. As soon as you enter the file name, the MicroLab I display will read "SEArCH". This indicates that the MicroLab I is searching for the file.
4. Press the play button on the recorder. The MicroLab I will read the file name header on each file until it finds the correct file. As soon as the file is found, the information will be read from the tape recorder. Each address will be displayed on the MicroLab I readout as it is loaded.

I Can't Get The Tape To Load. What Do I Do?

There are a number of possible reasons why a tape file won't load.

- Your tape reader heads are dirty.
- The volume on the tape recorder is set too high or too low. The volume control should be set at about mid-range.
- The tape used to record the file is of low quality, wrinkled, or hasn't been erased. Always use good quality tape. If you're using a previously recorded-on tape, make sure the tape is completely erased before storing programs.

As the MicroLab I reads the file, it will test for checksum errors, file header errors, and parity errors. If an error is detected, the MicroLab I will stop loading the tape. If this occurs, press the SHIFT key to get out of the tape load mode.

Programming F1–F8

Eight of the MicroLab I's hexadecimal keys are programmable. When a key is properly programmed, pressing it will cause the MicroLab I to jump to a routine you have written.

Each personality card has a user-definable key vector table allocated to it in MicroLab I RAM. The table's exact location in RAM varies with the personality card. Each vector table is 16 addresses long, and is divided into eight address pairs. The address pair locations will contain the address of a routine to be jumped to.

Let's suppose that a personality card is assigned addresses 3004 through 3013 for its key vector table. Starting with address 3004, each pair of addresses (3004-3005, 3006-3007, etc.) contains the address that the MicroLab I will jump to when one of the programmable keys is pressed. Table 2-1 lists the key vector table for our example personality card, and the programmable key assigned to each of those locations.

Table 2-1
The Example Personality Card Key Vector Table

3004–3005	3006–3007	3008–3009	300A–300B
F1	F2	F3	F4
300C–300D	300E–300F	3010–3011	3012–3013
F5	F6	F7	F8

Each address pair is programmed with the destination address that you want the microprocessor to jump to when that particular key is pressed. For example, if you stored 44 in location 3008 and F0 in location 3009, pressing *(SHIFT)* F3 would cause the microprocessor to jump to location 44F0 and begin execution. The lower address (3008) contains the low-order byte of the destination address. The higher address (3009) contains the high-order byte of the destination address.

F1–F8 are programmed in the following manner:

1. Press the LOAD ADDRESS key.
2. Enter the lower address of the address pair for the key you want to program.
3. Press the AUTO key.
4. Enter the four-digit address that you want the microprocessor to jump to when the key is pressed.
5. Press SHIFT to stop entering data.

Once you've programmed the user programmable key vector, it need not be programmed again, except in the following circumstances:

- if you want to change the key vector;
- if you press the RESET key; or
- if the MicroLab I main power is shut off.

Using PROM to Store The Key Vector Table

Recall that the personality card contains a spare PROM socket. At reset, the MicroLab I monitor checks the socket for the presence of a PROM. If a PROM is present, the monitor loads the first 16 PROM locations into the personality card's key vector table automatically. This means you can program a PROM with the key vectors you'll most often want. The use of a PROM in this situation does not prevent you from programming the key vector table directly, as outlined before. Those capabilities still exist. The PROM just speeds the process.

If you try to use the programmable keys without setting up the key vector table (either with a PROM or directly), the MicroLab I will ask you to do so by displaying "dEFInE", and then "rEAdY".

Using the MicroLab I With A Terminal

The input/output capabilities of the MicroLab I can be increased by using an optional terminal. The MicroLab I has an RS-232-C terminal port located on the right side of it's chassis. (It's the upper connector in Fig. 2-3.) This port can communicate with your terminal at any standard baud from 110 to 9600.

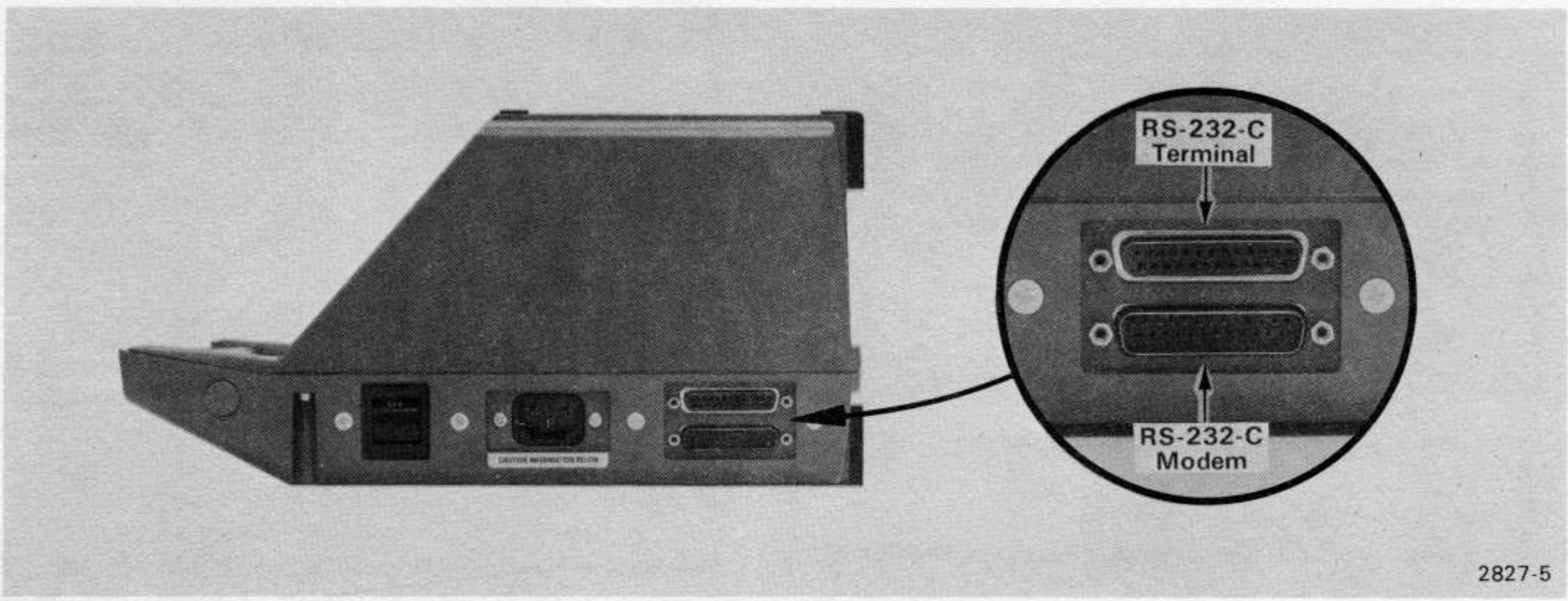

Fig. 2-3. The MicroLab I RS-232-C Ports.

Although these ports are not supported by the MicroLab I monitor, software can be written to access them.

@

Connecting the Terminal

In order to connect a terminal to the MicroLab I, perform the following procedure:

1. Connect the terminal to the MicroLab I RS-232-C port.
2. Set the MicroLab I baud rate by moving jumper J1070 (if you're a qualified service person, see Section 4 to set jumper J1070), or;
3. Set the terminal baud rate to match the MicroLab I baud rate.
4. Turn on the MicroLab I and the terminal.

The Terminal I/O Locations

The MicroLab I uses Motorola 6850 asynchronous communications interface adapters (ACIAs) for serial communications. The I/O locations for the terminal port ACIA are personality card-dependent. For the 8085 Personality Card, the terminal port is located at I/O addresses 0084 and 0085. Location 0085 is the data address. Location 0084 is the port status address. The Instruction Manual Supplement for your particular personality card lists these I/O addresses.

The terminal port status byte is arranged in the following configuration:

IRQ	PE	OVRN	FE	CTS	DCD	TDRE	RDRE
7	6	5	4	3	2	1	0

2827-6

Fig. 2-4. The MicroLab I Terminal Port Status Byte.

The status bits are read as follows:

IRQ interrupt request

PE parity error

OVRN overrun

FE framing error

CTS clear-to-send is low (the ACIA will not transmit unless CTS is high)

DCD data-carrier-detect is low

TDRE the transmit data register (TDRE) is empty

RDRE the receive data register is empty

See the Motorola Microcomputer Data Library for more information concerning the operation of the 6850 ACIA.

The Terminal Port Connector

The following is a list of terminal port connector pin assignments. Your terminal must make use of the same pin configuration.

Table 2-2
The RS-232-C Port Connector Configuration

Pin #	Use
1	Protective Chassis Ground
2	EIA Transmitted Data (to RXDATA on ACIA)
3	EIA Received Data (to TXDATA on ACIA)
4	EIA Request To Send (to CTS on ACIA)
5	EIA Clear To Send (to RTS on ACIA)
6	EIA Data Set Ready
7	Signal Ground
8	EIA Data Carrier Detect
20	EIA Data Terminal Ready

All other pins are not used.

Using The RS-232-C MODEM Port

The lower 25-pin connector shown in Fig. 2-3 is a spare RS-232-C compatible port. This port is not supported by the MicroLab I firmware, but may be accessed by a routine you can write. The I/O address of the spare port is personality card-dependent. The spare port is located at I/O addresses 00X8 (control/status) and 00X9 (data). The X varies with each personality card. See the supplement for your personality card.

The spare RS-232-C port is controlled by a Motorola 6850 ACIA. Location 00X9 is the data read/write address, and location 00X8 is the ACIA control address. One note on using this port - if the incoming CTS line is not high, the ACIA will not transmit data. The spare port connector pins are wired in the same manner as the terminal port. The spare port status byte is configured in the same way as the terminal port status byte.

Programming the MicroLab I Display and Keypad

Both the MicroLab I keypad and the display can be accessed by your program. The keypad and display exist at I/O addresses. These addresses are specific to the personality card you're using.

Reading the Keypad

The MicroLab I keypad is fully hardware decoded, and exists as a single byte of information at I/O location XXX2. (The X's vary with the personality card used. See the supplement for your personality card.)

The keypad byte is organized as shown in Figure 2-5.

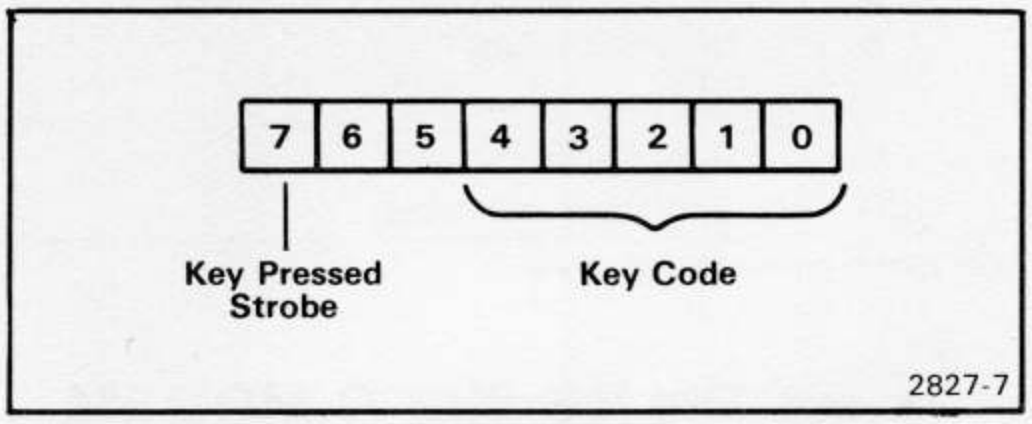

Fig. 2-5. The MicroLab I Keypad Byte.

Bits 5 and 6 of the byte are not used. Bits 0 through 4 equate to a hexadecimal code for each key. The key codes are listed in Table 2-3.

When a key is pressed, the keypad data is stored in a latch at location XXX2. In order to clear that latch in preparation for a new key press, you must write to XXX2. For example, if you wanted to read in a new key value, you would have to do the following procedure:

1. Write to I/O address XXX2. It doesn't matter what you write. This action clears the key latch.
2. Wait for 7 milliseconds. It takes this long for the latch to clear. You can use NOP instructions to delay 7 milliseconds if necessary.
3. Read I/O address XXX2.
4. Test for bit 7 high. This indicates that a key has been pressed. If bit 7 is low, loop back and read the address again.
5. Read the key code that was entered.

The RESET and SPECIAL keys use dedicated lines in hardware, and cannot be read from XXX2.

Table 2-3
MicroLab I Key Codes

Key	Coding
0	80
1	81
2	82
3	83
4	84
5	85
6	86
7	87
8	88
9	89
A	8A
B	8B
C	8C
D	8D
E	8E
F	8F
DEC	90
INC	91
LOAD ADDRESS	92
LOAD DATA	93
SHIFT	94
GO	95
AUTO	96
NO KEY	00

Writing To The Display

The MicroLab I readout is an 8-digit latched hexadecimal display. The display can be accessed at MicroLab I port XX80. The address of the port is dependent on the personality card. The display is organized in the manner shown in Fig. 2-6.

Notice that each digit has a hexadecimal value assigned to it. You'll also see in Table 2-4 that each displayable character has a value assigned to it. The digit value is used in combination with the value of the character you want to display, in the following manner.

Using the 8085 Personality Card, suppose you wanted to display an upper case H on digit number 5. In Fig. 2-6 you can see that digit 5 has a value of A0. Checking in Table 2-4, you'll find that an upper case H is represented by a hexadecimal 11. In order to display H on digit 5, you must ADD the digit's address with the character value.

Digit Value	=	A0
Character Value	=	+11
		=B1

@

Value	00	20	40	60	80	A0	C0	E0
Digits	0	1	2	3	4	5	6	7

2827-8

Fig. 2-6. The MicroLab I Display Organization.

The MicroLab I display is organized into eight digits, numbered from left to right.

Now, if your program writes B1 to 8085 Personality Card I/O port 0080, an H will appear on digit number 5, and will remain there until you change it.

Table 2-4 lists all the characters you can display on the MicroLab I readout, with their corresponding hexadecimal values.

Table 2-4
MicroLab I Display Characters

Display	Value
0	00
1	01
2	02
3	03
4	04
5	05
6	06
7	07
8	08
9	09
A	0A
b	0B
C	0C
d	0D
E	0E
F	0F
blank	10
H	11
L	12
r	13
o	14
P	15
y	16
n	17

Table 2-4 (cont.)

Display	Value
'	18
=	19
J	1A
–	1B
U	1C
c	1D
?	1E
blank	1F

Relocating a Block Of RAM

You can use commands from the front panel to relocate a 1K-byte segment of MicroLab I RAM to a new beginning (base) address. Suppose that a program required a 1K-byte segment of RAM be available starting at address FC00. All you need to do is press *(SHIFT)* RELOC, and enter the new base address.

NOTE

If you try to enter an address that is not a multiple of 1K, the MicroLab I monitor will automatically re-position the RAM to the next lower segment.

As an exercise, press the following keys:

1. *(SHIFT)* RELOC. The display will show "rEL XXXX". The XXXX address is the value your personality card will automatically move the RAM to at power up or reset. For the 8085 Personality Card, the initialization address is 3C00. It may be different for the personality card you're using, so check in the personality card Instruction Manual supplement.
2. Enter FC00. As you enter each digit, that value will be echoed onto the display. When the last digit is entered, the display will blank, and then say "rEAdY".
3. Now press *(SHIFT)* RELOC again. The display should show you the new base address for the relocatable RAM.
4. To escape from the RELOC command without changing the base address, press SHIFT again. The display will show "rEAdY".

If the MicroLab I is shut off, or the RESET key is pressed, the relocatable RAM will automatically be moved to the lowest base address possible. If an address is entered that falls into the restricted catagory (operating system PROM space, for example), the MicroLab I will display an error message.

If you enter an address that is not a 1K increment from 0000, the MicroLab I will automatically move the relocatable RAM to the next lower allowable base address. For example, if you tried to enter FF00 in the previous example, the MicroLab I would have simply changed the display and base address to FC00.

Self-Test

The self-test feature of the MicroLab I checks the internal operations of the MicroLab I and personality card. The self-test is initiated from the keypad, and each step is echoed to the MicroLab I display.

The self-test function checks the following elements of the MicroLab I:

Self-Test 0	The personality card low-order ROM checksum is calculated and verified.
Self-Test 1	The personality card high-order ROM checksum is calculated and verified.
Self-Test 2	The MicroLab I RAM is tested for read/write capability.
Self-Test 3	The MicroLab I relocatable RAM is moved to each possible location.
Self-Test 4	The MicroLab I display is tested.
Self-Test 5	The MicroLab I keypad is tested.
Self-Test 6	The two RS-232-C ports are tested.
Self-Test 7	The cassette tape port is tested.

If you want to test the RS-232-C ports and the cassette port, you'll need to obtain a standard RS-232-C cable and one of the cassette tape audio cables supplied with the MicroLab I. These ports are tested by "wraparound". That is, one RS-232-C port feeds signals to the other RS-232-C port, and the cassette output feeds the cassette input. The RS-232-C port "wraparound" requires that one end of a standard RS232-C cable be plugged into one port, while the other end is plugged into the other port. The cassette port "wraparound" requires that one of the cassette port audio cables be plugged in to both the cassette port input and output.

Starting the Self Test

To start the self test function, press *(SHIFT)* SELF TEST. The display will show "Sn". "Sn" indicates that the MicroLab I wants to know which of the eight tests you want to do first.

NOTE

Certain personality cards do not perform all eight tests. Check the Instruction Manual supplement for your particular personality card.

Self-Test 0

Press the 0 key. The display will show "SELF 0". This indicates that the self test routine is checking the personality card low-order ROM checksum.

Self-Test 1

As soon as the checksum is verified, the MicroLab I display will show "SELF 1". Self-test 1 checks the personality card high-order ROM checksum. When the ROM checksum test is finished, the display shows "SELF 2".

Self-Test 2

The "SELF 2" test writes two hexadecimal values to each MicroLab I RAM location, then reads the values to check for data integrity. The original RAM contents are not changed.

Self-Test 3

The next test, "SELF 3", checks the relocatable RAM feature of the MicroLab I. The 1K byte segment of relocatable RAM is moved to every possible base address. After each move, the first and last locations in the RAM are written to and read from verify that relocation occurred. After this test, the relocatable RAM is left at the default location for the personality card used.

Self-Test 4

"SELF 4" tests the MicroLab I display. Each character, starting with 0, is placed in each digit location. The test begins by placing 0 in the rightmost digit, then moving the 0 across the display to the leftmost digit. Then a 1 is placed in the rightmost digit and moved across the display. This test continues until every printable character has been displayed. It's up to you to visually verify that the display is functioning correctly, since it's impossible for the MicroLab I to test the LEDs themselves.

During the "SELF 4" test, you should see the following characters:

0 1 2 3 4 5 6 7 8 9 A b C d E F H L r o P Y n '
J - U c ?

Self-Test 5

Next, the keypad is checked in an interactive test called "SELF 5". "SELF 5" is displayed briefly on the screen, and then replaced with "0". This is a request for you to press the 0 key on the MicroLab I keypad. As soon as you press 0, the display will change to "1". The display will increment through the entire hexadecimal portion of the keypad in this fashion. As each character is displayed, press the corresponding key. After the hexadecimal portion of the keypad has been tested, you are requested to press the outer ring of control keys. The following displays will require the following key presses:

dEC	=	DEC
L Ad	=	LOAD ADDRESS
SHIF	=	SHIFT
AU	=	AUTO
InC	=	INC
L dA	=	LOAD DATA
Go	=	GO

Following the "SELF 5" test, the MicroLab I begins the port tests.

Self-Test 6

"SELF 6" is the RS-232-C port test. If the ports haven't been wrapped to one another, the display will show "nO dCd". This means a data carrier detect signal wasn't detected. If the ports have been wrapped to one another, but are not set at the same baud rate, an error will occur. If the ports pass the test, the MicroLab I will go on to the next test.

Self-Test 7

The cassette port test requires that the port be wrapped around to itself. If the port isn't wrapped around, the display will show "SELF 7", then "Error S7". After indicating the error, the MicroLab I hold the display until any command key is pressed.

If no errors were detected, the display will show "rEAdY".

Error Codes

The remainder of this section is devoted to the error codes you might see while using the MicroLab I. Each error code is listed, along with a short explanation of what the code means.

EO An attempt to write to the memory location specified has failed. This error might be encountered when using either the LOAD DATA or AUTO functions.

E1 An attempt has been made to write to a reserved memory space. Make sure you're writing to MicroLab I RAM space and not system monitor space. This error might be encountered when using either the LOAD DATA or AUTO functions.

01 You've tried to relocate a 1K-byte segment of RAM into the memory space reserved for the MicroLab I monitor.

The following error codes might be encountered while performing a Self-test.

SO The MicroLab I monitor PROM failed the low-order checksum test during Self-test 0.

S1 The MicroLab I monitor PROM failed the high-order checksum test during Self-test 1.

S2 The MicroLab I RAM failed a read/write test during Self-test 2.

S3 The MicroLab I failed to sucessfully relocate a 1K-byte segment of RAM during Self-test 3.

S5 This error code can mean one of two things: during Self-test 5 you pressed a key out of sequence, or the keypad decoder has failed.

S6 This error indicates that either the RS-232-C ports weren't wrapped around to one another, or that a line has failed within one of the ports.

S7 This error indicates that either the cassette port wasn't wrapped around to itself, or the port has failed.

The following error codes may be encountered while performing a cassette port tape load.

Ax This error indicates a tape read error. The x portion of the error code represents the high nibble of the ACIA status register, and should be interpreted in the following manner:

- x = 1 — framing error
- x = 2 — data overrun
- x = 3 — parity error

BO This error indicates a non-ASCII hexadecimal character has been read.

C8 The file has failed a file header checksum validation.

C9 The file has failed a block header checksum validation.

CA The file has failed a second checksum validation.

E0 This error indicates that the file could not be loaded into memory due to a memory failure.

E1 This error indicates that the file tried to load itself into a reserved memory space.

The next error codes might be encountered while trying to load a file onto tape.

CB The program starting address you entered is greater than the ending address. "SA" must be a lower number than "EA".

A0 This error indicates that the MicroLab I has not received a clear-to-send (CTS) signal from the cassette port ACIA.

Using the Expansion Connector

At the rear of the MicroLab I is a socket that will accept an expansion cable. The expansion cable can be connected to circuitry outside the MicroLab I for additional I/O, memory, or whatever functions may prove useful. The expansion connector is connected to the address, data, and control lines of the microprocessor or microcomputer used in a specific personality card. The lines are buffered within the MicroLab I wherever possible, but your external circuit should provide line receiver and driver devices for all lines to insure proper line loading and signal stability within the MicroLab I.

The expansion connector cable (with the label up) plugs into the socket at the rear of the MicroLab I. The other end of the expansion cable is shown in Fig. 2-7.

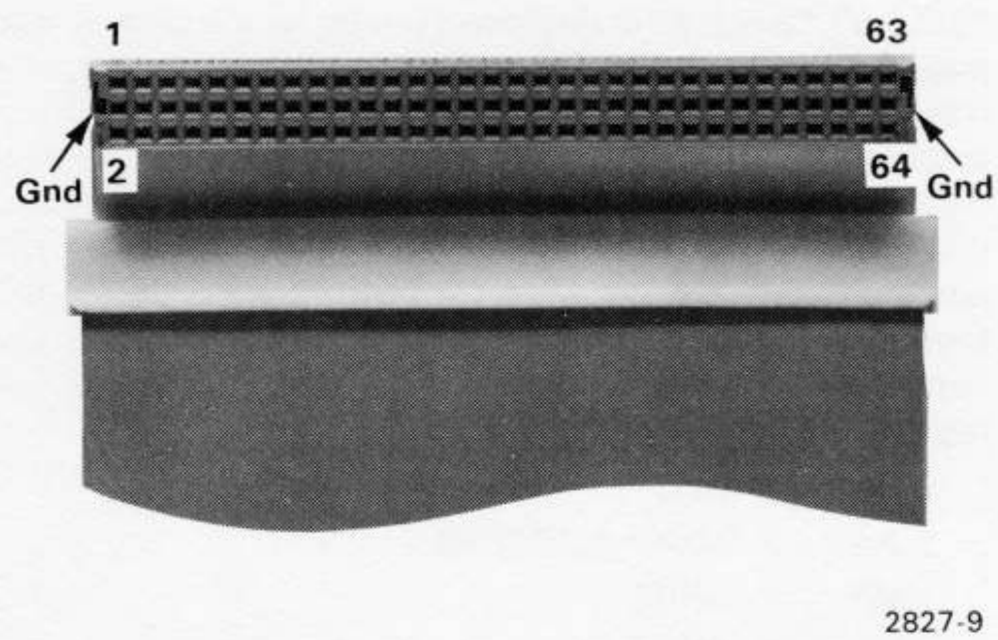

Fig. 2-7. Expansion Connector Cable.

The top row of connectors in the cable socket are all odd numbered. The bottom row of connectors are all even numbered. The middle row of connectors are all attached to MicroLab I ground.

As you can see in Fig. 2-7, the cable socket is configured with all the odd numbered lines across the top, and all the even numbered lines across the bottom. The schematics at the rear of this manual show what signal lines are attached to the expansion connector.

SPECIFICATIONS

The following electrical characteristics are valid only if the instrument has been calibrated at an ambient temperature between +20 C and +30 C, and the instrument is operating at an ambient temperature between 0 C and +55 C.

Items listed in the Performance Requirements column of the Electrical Characteristics are verified by completing the calibration procedure listed in this manual. Items listed in the Supplemental Information column may not be verified in this manual; they are either explanatory notes or performance characteristics for which no limits are specified.

ELECTRICAL CHARACTERISTICS

Table 2-5
Power Supply

Characteristics	Performance Requirements	Supplemental Information
ac Input Voltages	100 Vac ± 10% 120 Vac ± 10% 240 Vac ± 10%	Switch Selected
Frequency Range	50-60 Hz ± 3%	
Output Voltages	+12 Vdc ± 5% −12 Vdc ± 5% +5 Vdc ± 5%	@350 mA 50 mV Ripple @130 mA 50 mV Ripple @3.2 A 50 mV Ripple
Voltages Available To Personality Card	+5 Vdc +12 Vdc −5 Vdc	@1.2 A @100 mA @100 mA
Power Dissipation	50 Watts (Max.)	

ENVIRONMENTAL CHARACTERISTICS

Table 2-6

Characteristics	Description
Temperature	
Operating	0°C to +40°C (+32°F to +104°F)
Storage	-62°C to +85°C (-79°F to +185°F)
Altitude	
Operating	4,500 m (15,000 ft.) maximum
Storage	15,000 m (50,000 ft.) maximum
Humidity	
Operating	80% relative (max.), non-condensing
Storage	80% relative (max.), non-condensing

PHYSICAL CHARACTERISTICS

Table 2-7

Characteristics	Description
Net Weight	Approximately 5 kg (11 lbs.)
Dimensions	33 cm (13 in)W x 32 cm (12.5 in)D x 17 cm (6.7 in)H

Section 3

PERSONALITY CARD OPERATOR FAMILIARIZATION

INTRODUCTION

This section is devoted to the operator familiarization part of the personality card Instruction Manual supplements shipped with your personality card. The supplements can be divided into two parts. The operator's information goes within this section. The service information goes within Section 11.

WARNING

THE FOLLOWING SERVICING INSTRUCTIONS ARE FOR USE BY QUALIFIED PERSONNEL ONLY. TO AVOID PERSONAL INJURY, DO NOT PERFORM ANY SERVICING OTHER THAN THAT CONTAINED IN OPERATING INSTRUCTIONS UNLESS YOU ARE QUALIFIED TO DO SO. REFER TO OPERATORS SAFETY SUMMARY AND SERVICE SAFETY SUMMARY PRIOR TO PERFORMING ANY SERVICE.

Section 4

INSTALLATION

Introduction

In this section we'll talk about:

- unpacking and repacking the MicroLab I and personality cards;
- preparing a work site for the MicroLab I;
- installing personality cards in the MicroLab I; and
- checking out the MicroLab I.

Packaging

The MicroLab I is shipped to you in a carton designed for maximum protection. Be sure to save the original carton in case you need to repack and ship the MicroLab I in the future.

Each personality card is packaged separately, and you should save the carton in case you need to ship the personality card to another location.

If it becomes necessary to repackage the MicroLab I or a personality card, be sure to use all the padding supplied with the original carton.

Site Considerations

Since the MicroLab I is a portable device, selection of a proper work site may not always be practical. Therefore, we'll outline a few things to keep in mind when using the MicroLab I.

Power Consumption

The power required by the MicroLab I will vary slightly, depending on the personality card used. As noted on the bottom panel of the MicroLab I, the maximum power required will be 50 watts.

Don't operate the equipment from power sources where both current-carrying conductors are isolated or above ground potential (such as phase-to-phase on a multiphase system, or across the legs of a 100-220 volt single-phase, three-wire system).

Power Sources

CAUTION

The MicroLab I is designed to be operated from a single-phase power source. The neutral leg should be at ground (earth) potential. Only one side of the line has over-current (fuse) protection within the unit.

Don't operate the equipment from power sources where both current-carrying conductors are isolated or above ground potential (such as phase-to-phase on a multiphase system, or across the legs of a 110-220 volt single-phase, three-wire system).

The MicroLab I is designed to operate from a 115-230 volt nominal line voltage that has a frequency of 50-60 Hz. The operating line voltage is selected with a switch located on the MicroLab I power supply circuit board.

NOTE

The line voltage switch is not *directly accessible from the exterior of the MicroLab I. Section 6 of this manual tells how to select the line voltage.*

Fuses

The fuse requirements for the MicroLab I are shown in Table 4-1.

Table 4-1
MicroLab I Fuse Requirements

	Amps	Voltage
Primary (115 volt operation)	1A	250 V fast blow
(230 volt operation)	0.5A	250 V fast blow
5 Vdc Secondary	5A	250 V fast blow
12 Vdc Secondary	3A	250 V fast blow
-12 Vdc Secondary	3A	250 V fast blow

Other Considerations

Be sure to observe these basic safety precautions with the power cord:

- Keep the power cord off the floor.
- Dress the power cord to the rear of the MicroLab I.
- Don't set other equipment on top of the power cord.

Personality Card Installation

CAUTION

Each personality card contains devices that are static-sensitive. In order to prevent damage to a static-sensitive part, handle the personality cards only in a static-free environment. Personality cards must be stored in pink polyethylene bags, or laid on conductive work surfaces only. See Section 7 of this manual for more information on handling static sensitive parts.

The personality card is always mounted so that the zero-insertion-force (ZIF) socket is facing upward, as shown in Fig. 4-1. The personality card slides into the MicroLab I through the front panel. The card is guided along two rails until the card's edge connector fits snugly into the MicroLab I edge connector socket.

To mount the personality card, perform the following steps:

1. Make sure that primary power to the MicroLab I is OFF.
2. Swing the plastic dust cover upward, until it rests in the vertical position.
3. At this point, make sure that any jumpers on your personality card have been set properly.
4. Slide the personality card (ZIF socket up) partway into the guide rails.
5. Positioning your hands as shown in Fig. 4-1, press the personality card with your thumbs until the card is seated.
6. Make sure that the ZIF socket lever is in the downward position; then close the dust cover. The cover will snap into place.

To remove a personality card, perform the following steps:

1. Make sure that primary power to the MicroLab I is OFF.
2. Swing the plastic dust cover upward, until it rests in the vertical position.
3. Grasping the two white ejector levers, pull the levers until the personality card comes free of the MicroLab I.
4. After removing the personality card, place the card into the spare slot in the MicroLab I, or on a conductive surface such as pink polyethylene or conductive foam.

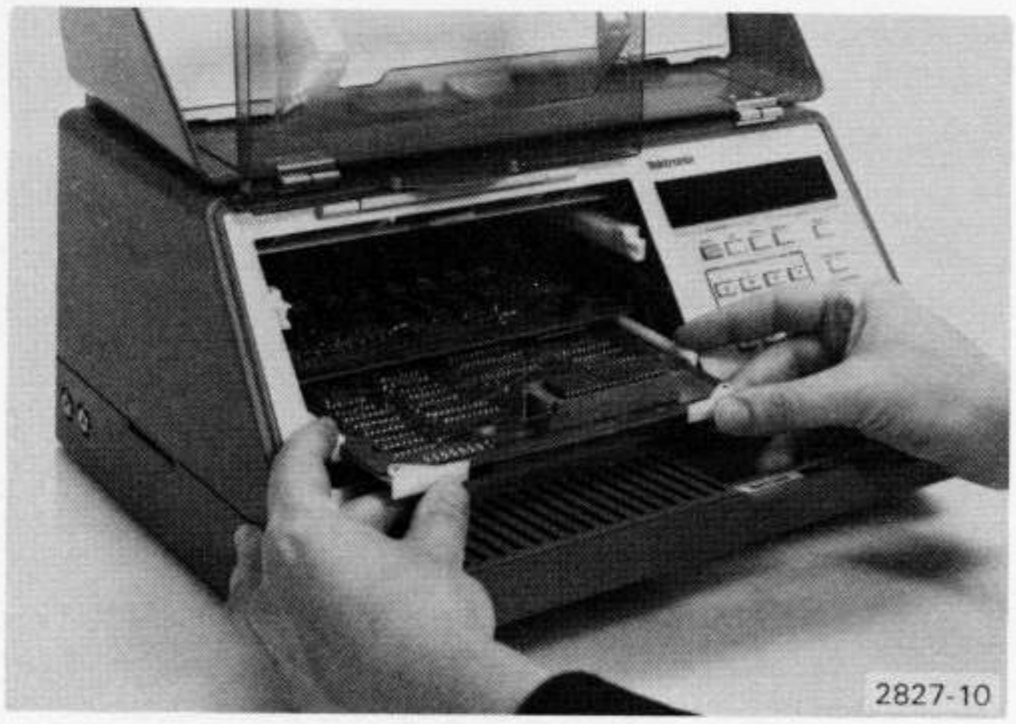

Fig. 4-1. Installing A Personality Card.
The personality card is always installed with the ZIF socket facing upward. Push the card firmly into the MicroLab I with both thumbs.

Checking Out The MicroLab I

Once you've unpacked the MicroLab I and installed a personality card, refer back to Section 2 of this manual and perform the self-test function described there. If the MicroLab I fails any of the tests, contact your nearest Tektronix Service Center.

After performing the self-test functions, set the MicroLab I baud rates, as described in the following paragraphs.

Setting The MicroLab I Baud Rate

The MicroLab I can communicate with an optional terminal through an RS-232-C port located on the side of the MicroLab I chassis. The rate at which data can be transmitted or received is selectable. Open the plastic lid on the front of the MicroLab I, and notice a row of square pins, as shown in Fig. 4-2. These square pins select the transmit/receive baud rates for the terminal RS-232-C port and for the modem RS-232-C port.

The row of square pins labeled J1080 select the baud rate for the terminal RS-232-C port (the upper connector on the side of the MicroLab I). The row of square pins labeled J1070 select the baud rate for the modem RS-232-C port (the lower connector on the side of the MicroLab I).

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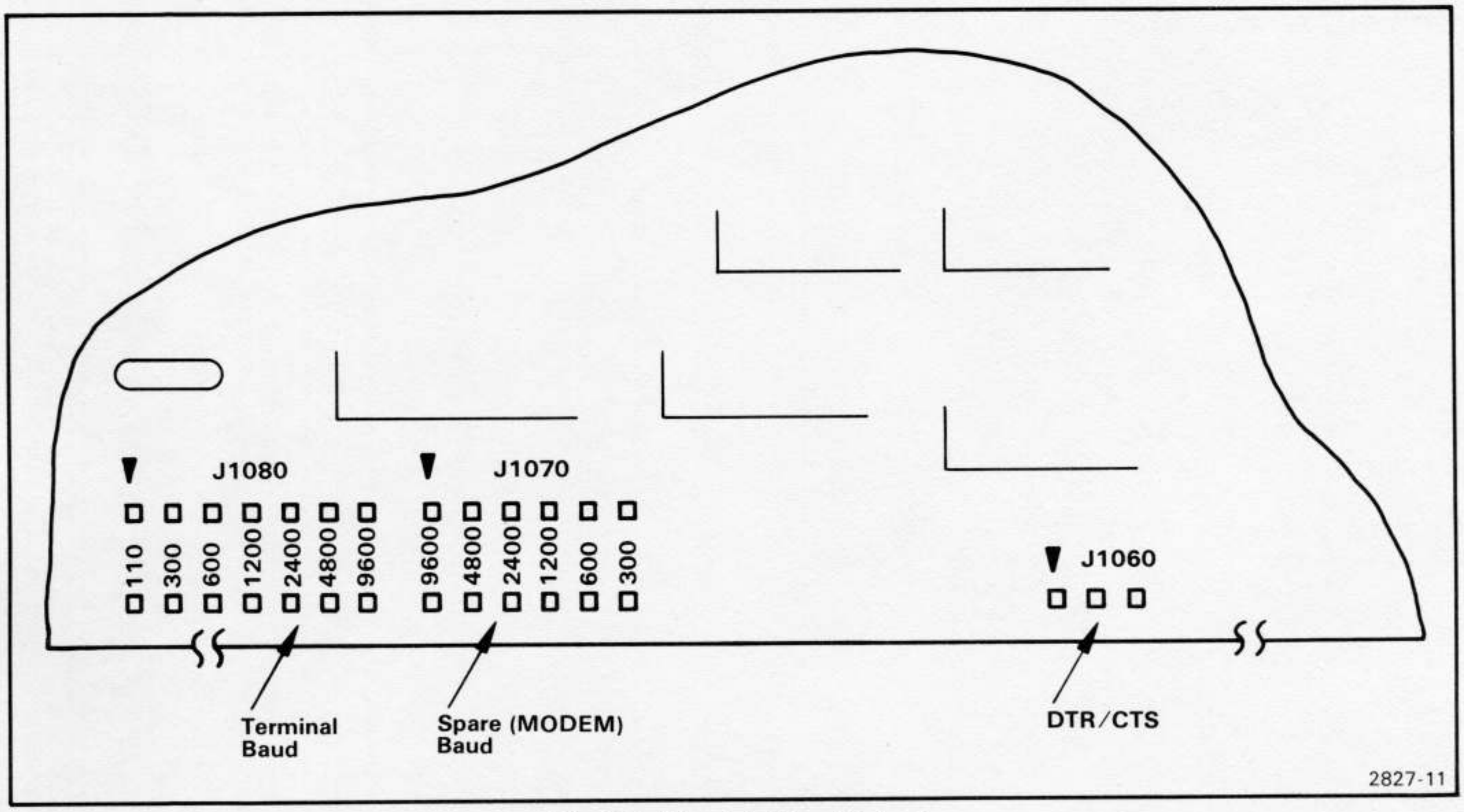

Fig. 4-2. MicroLab I Baud Selection.

Both of the MicroLab I RS-232-C ports have a selectable baud rate. J1080 (the square pins on the left in this illustration) selects the baud rate for the terminal connector. J1070 (on the right) selects the baud rate for the modem connector. The square pins labeled J1060 allow the modem connector to act as either a DTR or a CTS device.

Connecting a Cassette Recorder

The lid of the MicroLab I contains two cables that terminate in audio plugs. Connect one cable to the OUT jack on the MicroLab I, and the other cable to the IN jack.

Connect the free end of the OUT cable to the recorder's earphone jack, and the IN cable to the recorder's AUX jack.

If there is no AUX jack on the recorder, you should connect a l00-ohm, 1/4-Watt resistor either across C7089 inside the MicroLab I, or across the plug (signal to ground) that connects MicroLab I to the recorder; then connect the IN cable to the recorder's microphone input jack. Addition of this shunt resistance is necessary to prevent overdriving the cassette recorder's microphone input.

Section 5

MICROLAB I THEORY OF OPERATION

Introduction

In Section 2 of this manual, we talked about the MicroLab I from an operator's point of view. In this section, we'll explore the inner workings of the MicroLab I. First, we'll look at an overview of the MicroLab I, including a discussion of how the hardware and firmware work together. Then we'll get into the detailed operation of the MicroLab I hardware.

Schematics

Throughout this section, references are made to the schematics at the rear of this manual. Notice that each of the schematic pages is divided into operational areas by a grey tint. Generally, the discussions within this section follow this pattern. The block diagram located in this section is laid out into the same operational areas as the schematics.

In this section, each major heading has alongside it a schematic number and a grid, as shown in Fig. 5-1.

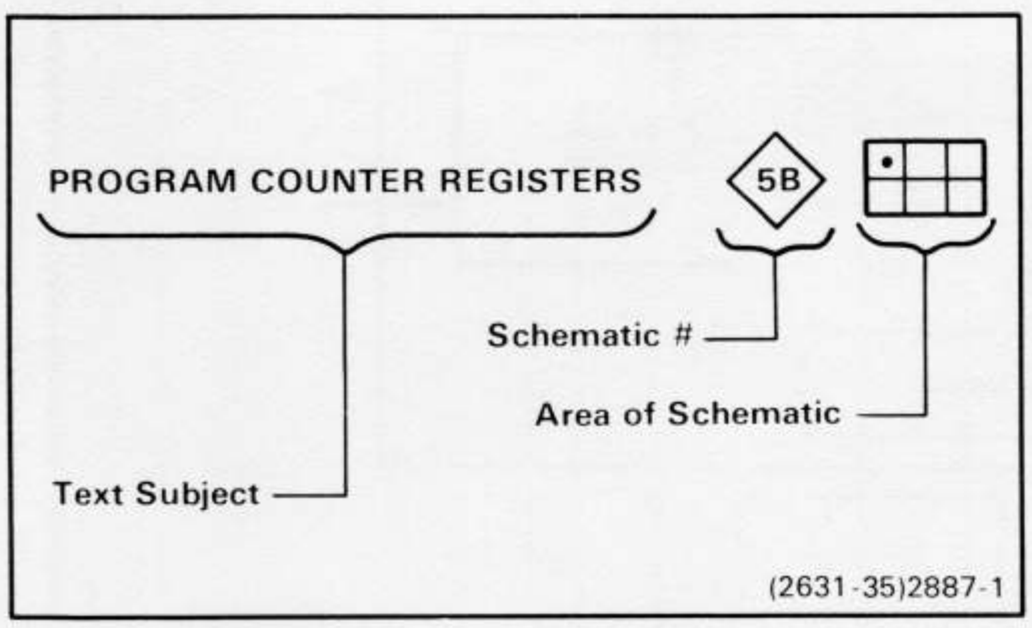

Fig. 5-1. Example Of Text Heading.

This example shows us that the subject of the text is the program counter registers, that the registers are shown on schematic 5, and that the registers are located in the upper left portion of schematic 5.

Personality Cards

The detailed theory of operation for a given personality card is contained in the Instruction Manual supplement for that personality card. Insert the service portion of each Personality Card Supplement in Section 11, at the rear of this manual.

Overview

The MicroLab I (with a personality card installed) can be divided into three major blocks: keypad/display logic; the MicroLab I mainframe; and the personality card. All three of these divisions are shown in Fig. 5-2.

Figure 5-2 also shows how these blocks communicate with one another. An address bus and a data bus connect each of the major sections of the MicroLab I. These buses allow the microprocessor in the personality card to control the actions of the MicroLab I.

Power-up

In order to explore how the MicroLab I operates, let's look at its operation at power-up. Recall that the operating system monitor resides within PROM on the personality card. (Some personality cards require that the monitor be an emulator processor's program memory. We'll only discuss the PROM-based monitor in this example.) The monitor tells the microprocessor what to do during keypad entry, self-test routines, and other operations.

When power is first applied to the MicroLab I, the microprocessor on the personality card is reset. The reset causes the microprocessor to begin execution of a reset routine located in PROM. As described in the operator's portion of this manual, a reset causes the display to be cleared and replaced with a greeting message. The greeting message is also sent to the terminal RS-232-C port for display on an optional terminal. And, at reset, the software relocatable RAM is positioned to its default base address.

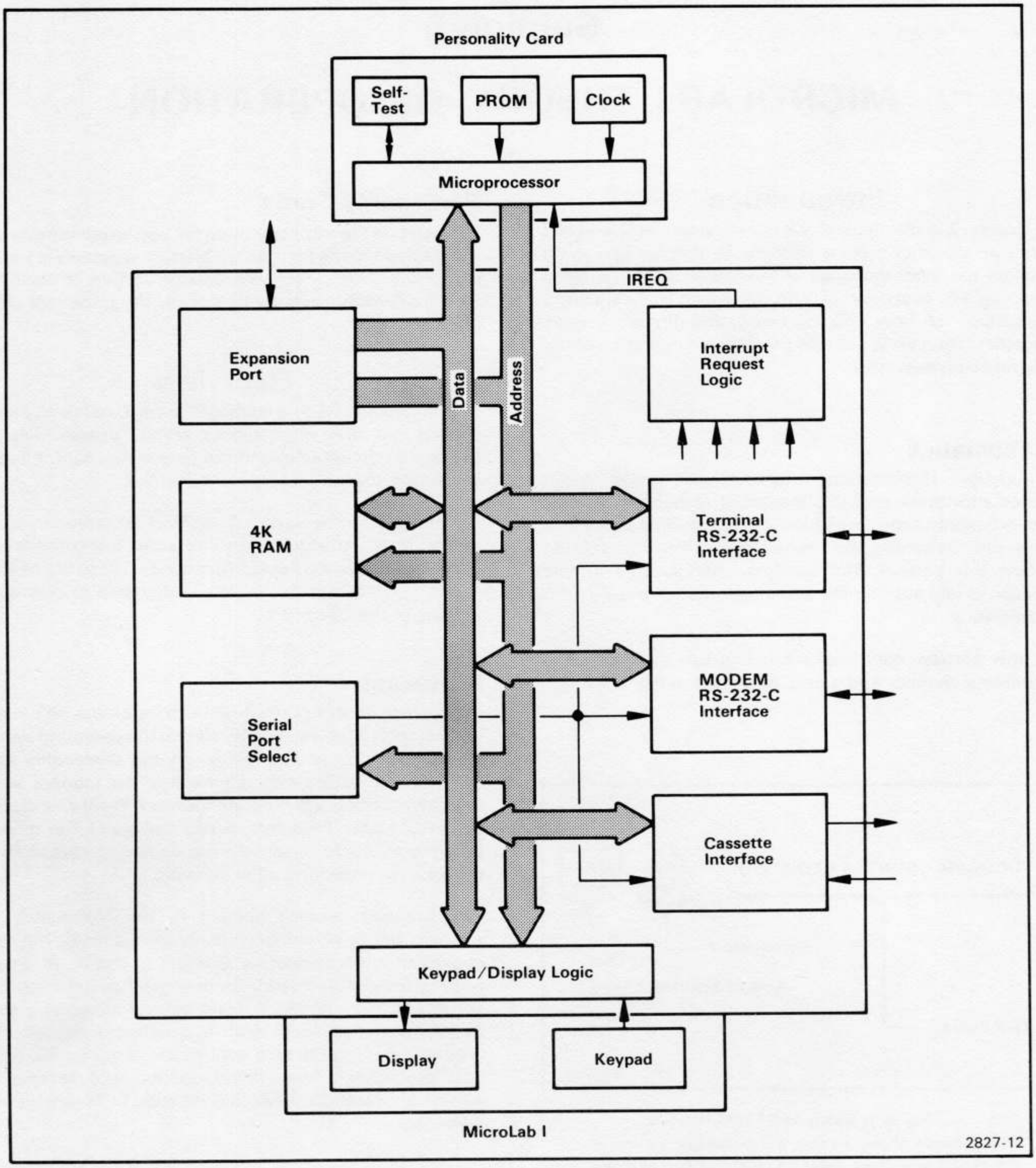

Fig. 5-2. MicroLab I Block Diagram.

The MicroLab I is divided into three major operational divisions: the personality card; the mainframe logic; and the keypad/display logic.

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For this example, let's follow what happens to the display at power-up. Refer to the block diagram in Fig. 5-3 while you read the following text.

The display logic works on the basis of having binary values (representing every character and every display position) stored in display RAM. This value is fed through a character PROM which converts the binary value into signals that can be used by a 7-segment LED display. Whenever the value in display RAM is changed, the 7-segment readout is changed. The display logic is self-refreshing — that is, it doesn't require any external signal to display a character. Whatever is in the display RAM is shown on the LEDs. In order to place a new character on the display, a new binary value must be written into the display RAM.

At power-up, there is no way of knowing the contents of the display RAM. Therefore, the first thing the MicroLab I monitor must do is fill the display with blanks, by writing a binary value that stands for "blank" to each display RAM location.

To the microprocessor, the display logic exists as an I/O address. So, the microprocessor places the I/O address of the display on the address bus. The microprocessor then places the value for "blank" on the data bus. This action is repeated for each display memory location. The result — the display is blanked.

To place the greeting message ("HELLO") on the display, the microprocessor goes through the same routine as it did to blank the display. The microprocessor places the display I/O address on the address bus, and then writes the characters into display RAM.

Every operation within the MicroLab I works in essentially the same way. If the microprocessor needs to get information out one of the serial ports, the port I/O address is placed on the address bus, and information is passed to the port on the data bus. As you can see in Fig. 5-2, the MicroLab I bus is central to all other logic.

Next, we'll discuss in detail each block of logic within the MicroLab I.

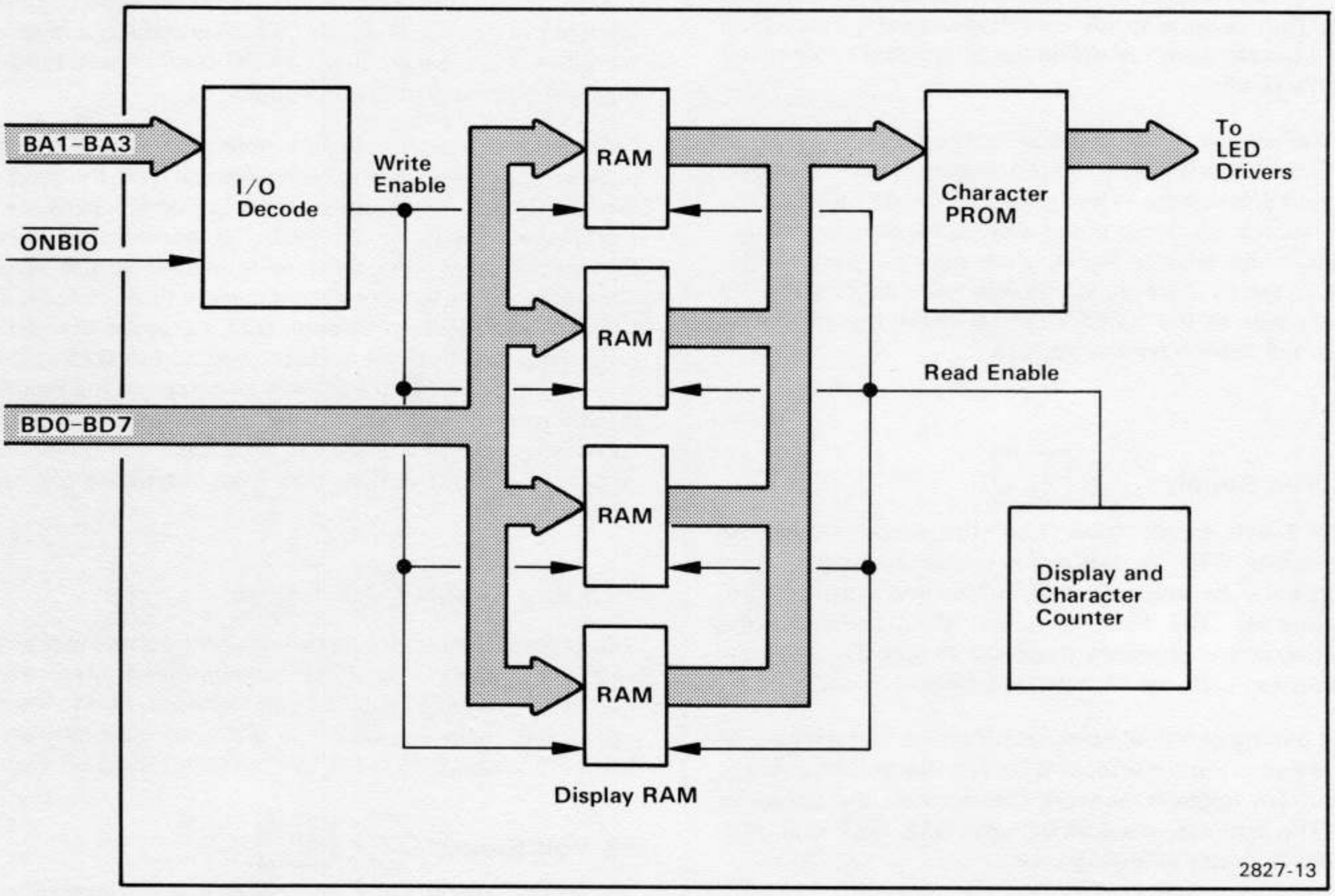


Fig. 5-3. Keypad/Display Block Diagram.

This diagram shows the logic found within the keypad/display block of Fig. 5-2.

Power Supply

The MicroLab I power supply transforms the input ac line voltage into dc voltages that are used by the other boards in the MicroLab I. The following voltages are supplied: +5 Vdc, +12 Vdc, and -12 Vdc. Some personality cards require a -5 volt supply. The -5 Vdc regulator is mounted on the MicroLab I main interconnect circuit board. The voltages supplied by the power supply are current-limited to prevent damage if a circuit board fails.

The MicroLab I power supply may require calibration. See Section 6 for the calibration procedure. Section 6 also tells how to disassemble the MicroLab I to get at the power supply.

Circuitry

Switches And Transformer

The MicroLab I is protected from overheating by a thermal switch (S100) located on the transformer core. The thermal switch is in series with the line voltage power cord, and will open if the temperature inside the MicroLab I exceeds the switch's rating.

The line voltage is fed to the primary side of transformer T80. One switch (S96) connected to the primary side allows the input line voltage to be either 120 Vac or 240 Vac. The other switch on the primary side (S94) allows the line voltage to be slightly higher than normal. Switch S94, when in the HI position, adds a few more windings to the primary side of the transformer, allowing the secondary side to maintain a normal voltage.

-12 Volt Supply

The -12 volt supply starts from the secondary tap on transformer T80. A full-wave bridge rectifier (CR50) rectifies the ac from the transformer and converts it to pulsating dc. The filter capacitor (C10) smoothes the pulsating dc and produces about -22 volts dc. The -22 volts is applied to Q39, which acts as a series regulator.

In the bottom center of schematic 7 notice that the base of Q39 is tied to the collector of Q18. Transistor Q18 is part of the current foldback network that controls the output of Q39. The complete network includes Q18, Q27, and Q28, and works in the following way.

When power is applied, the base of Q18 is at about 0.6 volts, which allows Q39 to come on. Transistors Q27 and Q28 create a voltage comparator. Notice that the base of Q27 is connected to a 3 volt zener diode. This zener regulates the amount of current flowing through Q27. Q28, on the other hand, is biased by a resistor network. Let's assume that the power supply is turned on, and that no load is present on the output. If the base of Q28 is adjusted with R13 to equal the voltage at the base of Q27, the current through both transistors is equal. Now, if we load the -12 volt supply, a proportionally larger voltage change will occur at the base of Q27 than at the base of Q28, because of the 3 volt zener diode. The diode tries to maintain the voltage differential between the base and emitter of Q27.

For this reason, Q27 begins to draw more current than Q28. The current drain through Q27 results in a greater voltage drop across R26, thus increasing the collector current in Q18. And when you increase Q18's collector current, you also increase the collector current through Q39.

The RC combination of R7 and C7 on the base of Q18 is used to prevent the regulator, which is actually a feedback amplifier, from oscillating. The RC combination tends to dampen any rapid voltage changes.

Transistor Q6 is the current-limiting device. When the power supply is operating with a normal load, the base-to-emitter voltage is not sufficient to turn on Q6. However, if the power supply is shorted, Q6 comes into action. Remember that when the load is increased, the voltage comparator tries to increase the current through Q27. And the increased current through Q27 increases the voltage drop across R26. If the voltage drop across R26 is great enough, the collector of Q6 will be forced in the negative direction far enough to turn the transistor on. When Q6 turns on, it keeps the base of Q18 from going any more negative, thus preventing Q39 from outputting any more current.

+12 Volt Supply

The +12 volt regulator works in much the same way as the -12 volt regulator. The +12 volt comparator is referenced to the -3 volts used by the -12 volt regulator, and to the -12 volts itself. Transistor Q35 acts as the current controller for Q49. Transistor Q36 is the overcurrent protection device.

+5 Volt Supply

The +5 volt supply is also referenced to the -12 volt supply. It functions in exactly the same way as the +12 volt regulator.

The Main Interconnect Board

The main interconnect board contains most of the operating logic for the MicroLab I. In this part of the manual, we'll talk about the following parts of the main interconnect board:

- communications between the main interconnect board and the other circuitry
- memory
- breakpoint circuitry
- serial I/O ports
- keypad and display logic

As with the rest of this section, the text refers to the schematics located at the rear of this manual. You'll find it helpful to refer to the schematics while you read the text.

Communications ◇1

The main interconnect board communicates with the personality card, the keypad/display board, I/O ports, and whatever may be attached to the expansion connector at the rear of the MicroLab I. All lines to and from the personality card (J8060) are buffered. The lines to the expansion connector (J9060) are buffered wherever possible. However, the device attached to the expansion connector should provide buffering in both directions.

Data Flow

Notice in the bottom left corner of schematic 1 that the data lines coming from the personality card are attached to the input lines of latch U7050. Data coming from the microprocessor is latched through U7050 for timing purposes. Data going to the microprocessor from the main interconnect board does *not* pass through U7050, but instead passes through tristate buffer U6050. To summarize, data comes from J8060, through U7050, and onto BD0–BD7. The main interconnect board sends data from BD0–BD7 through U6050, and out to J8060.

As you can see, pin 11 of U7050 is tied, through an inverter, to the $\overline{E}$ line from the personality card. The $\overline{E}$ line is the master enable line. The microprocessor on the personality card brings $\overline{E}$ low after all other control and data lines are stable.

Data is read from the main interconnect board with a combination of signals. The microprocessor forces its R/$\overline{W}$ line high, which is connected to pin 5 of U5030. Pin 12 of U5030 goes high any time $\overline{RAMC1}$, $\overline{RAMC0}$, or $\overline{ONBDIO}$ from the personality card goes low. Once this combination of signals comes together, buffer U6050 places the data from BD0–BD7 onto the D0–D7 lines.

Address Flow

In the top left corner of schematic 1, you can see the address bus coming from the personality card. Address lines A0–A9 are buffered by U8040 and U1080. Because of the MicroLab I's limited RAM space, only address lines A0–A9 are needed to address the full range of RAM. A0–A9 are fed through U8040 and U1080 onto internal address lines BA0–BA9. Notice that address lines A10–A15 are not buffered. They are instead sent to the breakpoint logic, where they require no buffering. We'll discuss the breakpoint logic later on in this section.

Reset Circuitry ◇1

While we're looking at schematic 1, let's examine the reset circuitry. The MicroLab I can be reset by one of two means: you can press the reset button, or you can turn the MicroLab I power off and then on again.

The RESET key from the MicroLab I keypad is attached to pin 16 of P3010 (at the bottom left of schematic 1). When the RESET key is pressed, pin 16 of P3010 goes to ground. Grounding pin 16 causes transistor Q1014 to shut off. When Q1014 shuts off, the base of Q2012 goes toward +5 volts, turning on Q2012. This causes the $\overline{RESET}$ line to the personality card and main interconnect board to go low. Notice a 100-ohm resistor (R3011) in line with pin 16. This resistor limits the amount of current that can flow through the RESET switch and prevents the switch contact from being welded closed.

When MicroLab I power is turned on, capacitor C3012 begins to charge through R2012. This action forces the base of Q1014 low, and also causes a reset. Diode CR2013 forces the capacitor to discharge faster when the power is shut off.

Memory ◇2

There are several things to remember when dealing with the MicroLab I RAM: the RAM is configured as 4K-byte memory when using 8-bit personality cards; RAM is automatically reconfigured into 2K-word memory when using 16-bit personality cards; and, a 1K-byte segment of RAM is software relocatable.

8-bit Operation

Notice on schematic 2 that there are eight memory devices. Also notice that the devices are connected in pairs. U6040 and U4040 make up a 1K x 8-bit pair, U5040 and U3040 make up another pair, U4060 and U4050 make up a third, and U3060 and U3050 make up the fourth pair. Each pair is controlled by a RAMC line from the personality card as shown in Fig. 5-4.

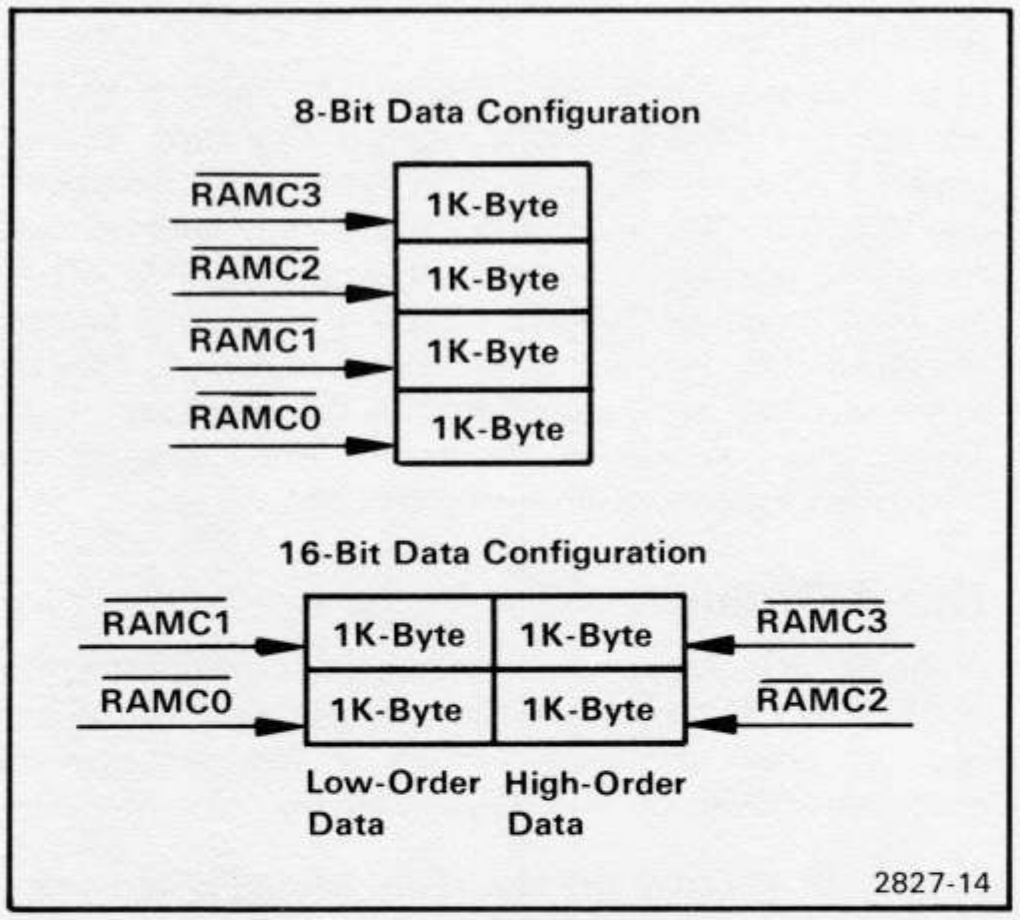


Fig. 5-4. MicroLab I Memory Configuration.

Each 1K block of RAM is controlled by a RAMC line from the personality card.

The blocks of RAM controlled by $\overline{\text{RAMC0}}$ and $\overline{\text{RAMC1}}$ always represent the low-order 2K bytes of memory, even when used with a 16-bit personality card. However, the RAM controlled by $\overline{\text{RAMC2}}$ and $\overline{\text{RAMC3}}$ are used either as the upper 2K bytes of an 8-bit memory, or the high-order 2K bytes of a 16-bit memory.

8-bit Read. If the personality card is going to read one of the two lower 1K-byte memories (U6040/U4040 or U5040/U3040) a fairly straightforward operation takes place. The personality card places the address on BA0—BA9 and forces the BR/$\overline{\text{W}}$ line high, indicating a read. The personality card also indicates which 1K memory pair is to be read by asserting either $\overline{\text{RAMC0}}$ or $\overline{\text{RAMC1}}$.

During a read operation to the upper 2K RAM (U4060/U4050 and U3060/U3050), the address is placed on BA0–BA9, the BR/$\overline{\text{W}}$ line (upper left side of schematic 2) is high, and $\overline{\text{WD ACCESS}}$ (in the lower left corner of schematic 2) is high. Now, the personality card will force either $\overline{\text{RAMC2}}$ or $\overline{\text{RAMC3}}$ low to eanble a device pair. If $\overline{\text{RAMC2}}$ is forced low, $\overline{\text{RAMC2}}$ and $\overline{\text{BE}}$ create a low at the output of U2060D, which in turn causes the output of NOR gate U4032D to go high. The output of U4032D is brought together with $\overline{\text{WD ACCESS}}$ and BR/$\overline{\text{W}}$ at NAND gate U5030, forcing U5030's output low. The low out of U5030 enables buffer U5060, and allows data to be transferred from H0–H7 to the D0–D7 data lines, and on to the personality card. Exactly the same thing happens if $\overline{\text{RAMC3}}$ is asserted.

8-bit Write. For a write operation to the lower 2K, essentially the same steps take place. The BR/$\overline{\text{W}}$ line is forced low, the write address is placed on the address bus, and a memory pair is selected by $\overline{\text{RAMC0}}$ or $\overline{\text{RAMC1}}$. Then, when $\overline{\text{BE}}$ is asserted, an 8-bit write occurs.

Something different happens when the upper 2K is written to. When writing to the upper 2K, the personality card forces the BR/$\overline{\text{W}}$ line low, and presents the address on BA0–BA9. Next, the personality card presents the data on D0–D7, and then forces the BE line high. BE causes U5050 to latch the data from D0–D7. Then the personality card forces the BW/$\overline{\text{R}}$ line high at pin 2 of U4032A. This high, along with the high at pin 1 (remember, the $\overline{\text{WD ACCESS}}$ line is high), forces the output enable pin (OE) of U5050 low, placing the data on H0–H7. At this same time, the BR/$\overline{\text{W}}$ line is low, allowing the upper RAM to store the data.

16-bit Operation

If a 16-bit personality card is used in the MicroLab I, the $\overline{\text{WD ACCESS}}$ line is forced low. You'll notice that $\overline{\text{WD ACCESS}}$ is fed through an inverter (U2050C) and appears as a high on pin 4 of U4032B. And, $\overline{\text{WD ACCESS}}$ appears as a low on pin 11 of U5030. Let's examine a read operation with a 16-bit personality card.

16-bit Read. When the personality card wants to read 16-bit memory, buffer U6060 is put to use. Notice that the low from $\overline{\text{WD ACCESS}}$ is fed through U5030 to disable buffer U5060. When the personality card is ready to read (all other control lines are set and stable), it asserts $\overline{\text{BE}}$. $\overline{\text{BE}}$ is fed to pin 12 of U2060D, and to pin 10 of U2060C. This means that each time the personality card asserts $\overline{\text{RAMC2}}$ or $\overline{\text{RAMC3}}$, the output of NOR gate U4032D goes high. This high is fed to pin 9 of U4032C. When the BR/$\overline{\text{W}}$ line goes high (indicating a read), the high is NANDed with the high from U4032D at U4032C. Those highs force the enabling pins of U6060 low, allowing data to pass from the memory devices onto D8–D15 of the data bus. At the same time, the low-order data is placed on BD0–BD7 whenever $\overline{\text{RAMC0}}$ or $\overline{\text{RAMC1}}$ is asserted.

16-bit Write. About the same thing happens when a 16-bit personality card writes to MicroLab I RAM. High-order data is latched into U7060 when the personality card forces BE high. Remember that $\overline{\text{WD ACCESS}}$ is low, appearing as a high on pin 4 of U4032B. When the BW/$\overline{\text{R}}$ line goes high (indicating a write), the output of U4032B goes low, clocking the data onto the H0–H7 data lines. Then, the high-order RAM pair is selected by $\overline{\text{RAMC2}}$ or $\overline{\text{RAMC3}}$, and data is stored in RAM.

Breakpoint Logic ⟨5⟩

The MicroLab I contains breakpoint circuitry that is used by some personality cards during the self-test and the processor-tests. The breakpoint circuitry generates an interrupt when certain specific conditions are met. There are two separate types of conditions that will trigger a breakpoint interrupt:

- When a 16-bit address generated by the personality card matches an address stored in breakpoint circuitry. Additionally, the breakpoint circuitry can detect whether the address is a memory or I/O address, and whether the address is being written to or read from.
- When a pattern of six of the 21 available processor-dependent lines from the personality card matches a pattern stored in breakpoint circuitry.

These two types of breakpoints can also be used to qualify one another. A breakpoint signal can be generated by ANDing or ORing the processor-dependent and address breakpoints, or either breakpoint can be selected independent of the other.

The interrupts generated by a break condition can be sent either to the interrupt handling logic on the main interconnect board, or to the SPECIAL line on the personality card. The use of the SPECIAL line is entirely software controlled.

Overview

Refer to Fig. 5-5 for a visual representation of how the breakpoint logic works.

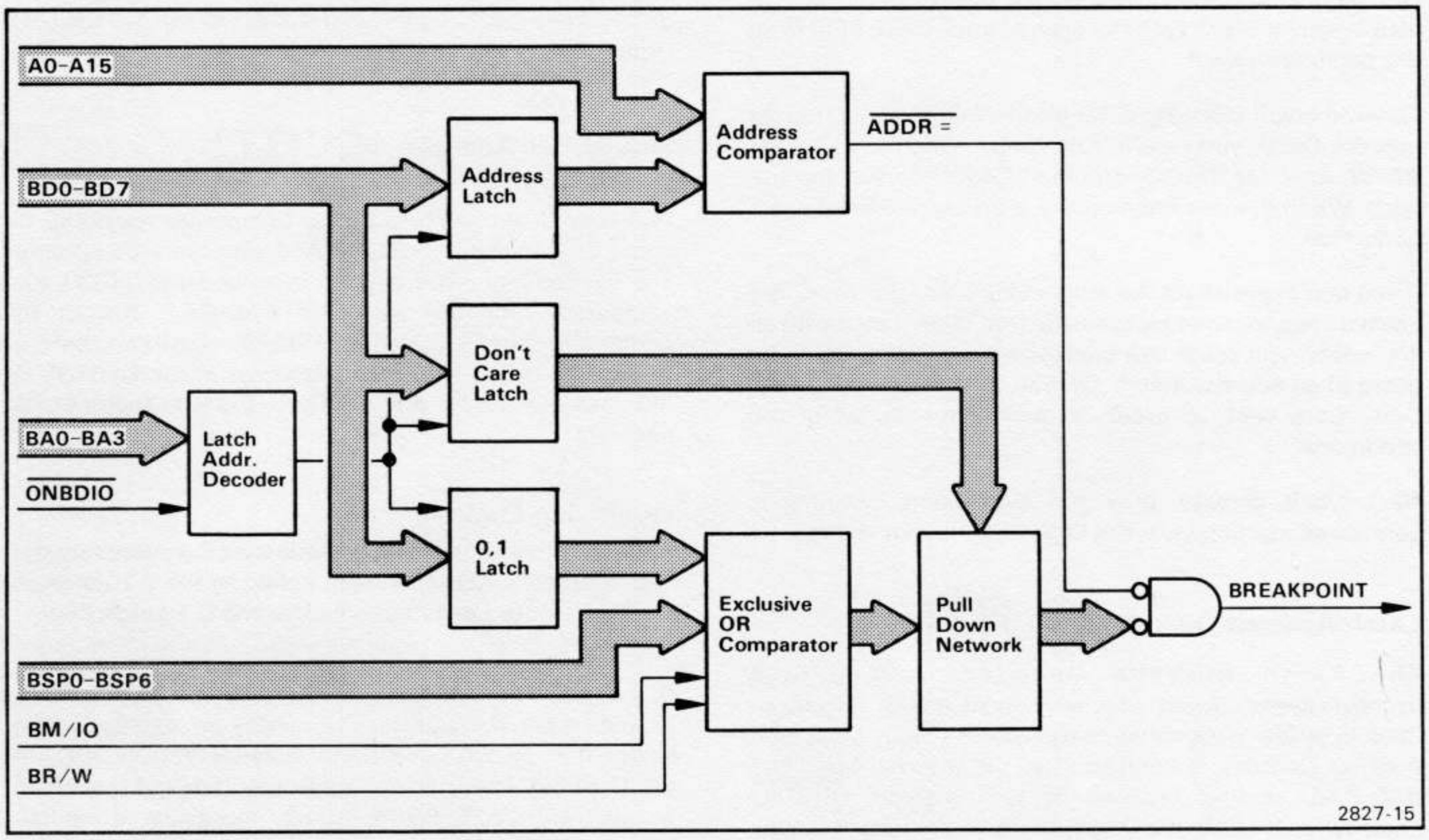


Fig. 5-5. Breakpoint Logic Block Diagram.

The breakpoint logic is used during execution of self-test and processor-test routines by the personality card.

What happens is basically this: If you want to break on a specific address, you first must store the address in the breakpoint address latch. An I/O address is sent to the Latch Address Decoder. The decoder enables the address latch to store the low-order eight bits and high-order eight bits of the address from data bus lines BD0–BD7. The stored address values are then constantly compared with the address present on A0–A15 from the personality card. If a match occurs, the comparator issues the $\overline{\text{ADDR}}$ = signal.

To further qualify the match, you can set up an exclusive OR comparator to detect whether the address was an I/O or memory access, and if a read or write was performed. This is done by loading a 0,1 latch with the specific values that will tell you if the BR/$\overline{\text{W}}$ line is high or low, and if the B$\overline{\text{M}}$/IO line is high or low. The latched states are then compared with the real states of the control lines. You can also qualify a break with the special lines (SP0–SP5) from the personality card.

For example, if you want to break on a read to an I/O port at address C400, you would load the 0,1 Latch with a 0 for BR/$\overline{\text{W}}$, an 1 for B$\overline{\text{M}}$/IO, and load C400 into the address latch. When this condition occurs, a breakpoint interrupt is generated.

If you don't care about the states of BR/$\overline{\text{W}}$, B$\overline{\text{M}}$/IO, or the special lines, you can program the Don't Care Latch with all 1's, which will cause the breakpoint to occur only on the event of an address match. Or, you can selectively set the Don't Care latch to break on some, but not all of the conditions.

Next, we'll discuss how the Breakpoint circuitry is controlled, starting with the Latch Address Decoder.

Latch Address Decoder

The Latch Address Decoder is a 3-to-8 decoder/demultiplexer that will cause one of its output lines to go low, depending on the address input. The Latch Address Decoder is connected to the internal bus lines BA0–BA3, and is enabled by two signals: $\overline{\text{ONBDIO}}$ (indicating an internal I/O operation), and $\overline{\text{BE}}$ (bus enable). BA3 is also used as an enabling signal.

When the personality card asserts $\overline{\text{BE}}$ and indicates an internal I/O operation by forcing $\overline{\text{ONBDIO}}$ low, the address at BA0–BA2 is enabled into U6010. Depending on the states of BA0–BA2, one of the five outputs of U6010 will go low. These outputs control:

- the High-Order Address Latch (at address 0B)
- the Low-Order Address Latch (at address 0A)
- the 0,1 Latch (at address 0C)
- the Don't Care Latch (at address 0D)
- the Breakpoint Control Latch (at address 0E)

As the breakpoint logic is set up, each of these latches is in turn enabled.

High-Order Address Latch/Comparator

The High-Order Address Latch (U9030) is clocked by the rising edge of U6010's pin 12. At that time, the data on BD0–BD7 is latched into U9030 and presented to the 'B' inputs of comparator U9040. BA8 and BA9, and A10–A15 are brought to the 'A' inputs of the comparator. When a match occurs between the 'A' and 'B' inputs, pin 19 of U9040 goes low. This low is fed to the $\overline{\text{EI}}$ input of the Low-Order comparator.

Low-Order Address Latch/Comparator

The Low-Order Address Latch/Comparator works in the same way as the High-Order Address Latch/Comparator. The desired low-order address is latched into U7030, then compared with the states of BA0–BA7. But in this comparator, the $\overline{\text{EI}}$ input (from U9040) must be low before a match can occur. When a match does occur, U7040's $\overline{\text{EO}}$ pin goes low, and this low is fed to the Breakpoint Enable circuitry.

Qualifying Logic

Now, let's look at the logic that qualifies the address match. The address match may be qualified by the 0,1 Latch and the Don't Care Latch. Let's look at the 0,1 Latch first.

0,1 Latch. The 0,1 Latch works in combination with the Exclusive OR Comparators to qualify an address match. Notice that U5070 has outputs labled R/WC, M/IOC, and SP0C–SP5C. These lines decide the states of the BR/$\overline{\text{W}}$, B$\overline{\text{M}}$/IO, and BSP0–BSP6 signals necessary to aquire a breakpoint. For example, if you wanted to break on an I/O address, you would place a 1 on pin 4 of U5070, then latch that 1 onto output pin 5. Pin 5 of U5070 is tied to pin 12 of Exclusive OR Comparator U6070 (at the bottom center of schematic 5). In this case, you would get a low out of pin 11 of the comparator only if the B$\overline{\text{M}}$/IO line went to a 1 state (indicating an I/O operation). The low out of pin 11 of U6070 is tied to pin 10 of U6080B of the Breakpoint Enable logic. (We'll talk about U6080B later.)

On the other hand, if you wanted to break on a memory operation, you'd place a 0 on pin 5 of U5070. Then, the output of U6070 would go low only if the B$\overline{\text{M}}$/IO line went low (indicating a memory access).

The same rules stand true for BR/$\overline{\text{W}}$ and the BSP0–BSP5 lines. To match a low state, a 0 is placed into the appropriate location in U5070. To match a high state, a 1 is placed into the appropriate location.

Don't Care Latch. Notice that there are eight lines coming out of the Exclusive OR Comparators (U4070, U6070). There may be situations where you'll want to qualify an address breakpoint with only a few of these eight lines. The Don't Care Latch is used to override some or all of the comparator outputs by forcing them low.

Suppose you wanted to break only if the BSP4 line from the personality card was high. First of all, you would place a 1 on pin 17 of U5070, then latch the 1 through to pin 12 of comparator U4070. That would assure that every time the BSP4 line went high, output pin 11 of the comparator would go low. Next, to mask out all other comparisons, except the address match of course, you would place a 0 into pin 14 of U5080 (the Don't Care Latch). All other inputs to U5080 would be 1's. When these signals are latched through U5080, they are fed to inverters U4080 and U6090. (Notice that the outputs of the Exclusive OR Comparators are all tied to the outputs of the inverters. The comparators have open-collector outputs, and their output states can be overridden by the inverter outputs.)

At this point, the inverters have forced all of the comparator lines low, except the SP4 output. When the BSP4 line from the personality card goes high, pin 11 of U4070 will go low. If this occurs at the same time an address comparison is made, a breakpoint occurs. The Breakpoint Enable circuitry takes over, and a breakpoint interrupt is issued.

Breakpoint Enable ⟨5⟩

The Breakpoint Enable logic collects signals from several different places, and determines if a valid breakpoint has been reached. The Breakpoint Enable logic is primarily divided into two sections: a section that determines if an address and control line match has occurred, and a section that determines if a special line match has occured. Notice that NAND gate U6080A (near the top of the Breakpoint Enable logic) is connected to five of the $\overline{\text{SP}}$ outputs from the Exclusive OR Comparators. If $\overline{\text{SP0-SP4}}$ from the comparators are low, the output of U6080A goes high, indicating a match. Now, look at U6080B. You can see that U6080B is connected to the $\overline{\text{ADDR=}}$ line, and to the $\overline{\text{M/IO}}$ and $\overline{\text{R/W}}$ lines from the Exclusive OR Comparators. In addition, U6080B is connected to the $\overline{\text{BE}}$ line from the personality card, and to the output of the Breakpoint Delay Counter (U1070). We'll discuss the Breakpoint Delay Counter later.

The Breakpoint Enable logic can issue a break if the output of U6080A and the output of U6080B are high, *OR* if either of their outputs is high. Selection between the two functions is controlled by the ORE signal from the Breakpoint Control register (U2070). When the ORE line is high, either U6080B or the U6080A/U2030C combination can cause a breakpoint. When the ORE line is low, an AND combination must exist to cause a breakpoint. Let's look at how this works.

OR. The key devices in this circuit are U3080D, and U4090(A, B, and C). Let's assume that the ORE line from the Breakpoint Control register is high, indicating that either U6080A/U2030C or U6080B can cause a breakpoint to occur. Let's further assume that the breakpoint will come from U6080A and U2030C. And finally, we'll assume that the RCO output from the Breakpoint Delay Counter (U1070) is low, but will go high later. (U1070 is used to delay the generation of a breakpoint interrupt. We'll talk more about U1070 later.)

NOTE

It might be helpful at this point to pull out schematic 5 and write down the states of the various gates we'll talk about.

ORE places a high on pin 1 of U4090A. A match from U6080A puts a high on pin 9 of U2022C. The output of U2030C is still low because RCO is low. If you follow the high out of U2022C pin 8, you'll find that it causes pins 4 and 5 of U3030B to be high. (Keep in mind that the output of U6080B is low.) Because RCO is low, and is fed to pin 9 of U4090C, pin 3 of U3030B is high. All the inputs to U3030B are now high, causing its output to be low.

Next, RCO will go to a high. RCO is inverted and placed on pin 11 of U2030C, allowing pin 8 to go high. Now we have a high on both input pins of U2022C. These highs force U2022C pin 8 low. The low from U2022C pin 8 and the high from U6030H pin 3 are combined at U4090B. The resulting high on pin 6 of U4090B is NANDed with the high ORE line to cause a low on input pin 5 of U3030B.

This low causes the output of U3030B to go high. The high at the output of U3030B is tied back to pin 10 of U4090C. Remember that RCO is high. The output of U4090C ($\overline{\text{BREAKPOINT}}$) goes low. Notice that $\overline{\text{BREAKPOINT}}$ is tied to the inputs of U2030A and U3080C. Now, depending on the states of the $\overline{\text{IRE}}$ and $\overline{\text{SPE}}$ lines, either a breakpoint interrupt (BINT) will be sent to the personality card, or a special key interrupt ($\overline{\text{BSP}}$) will be sent to the personality card.

Much the same thing would happen if the match occurred at U6080B. The output of U6080B would go high, be inverted to a low at pin 5 of U4090B and pin 12 of U3080D. But this time, a high would be present at the output of U2022C. Again, a low would be forced into pin 5 of U3030B, and a high output would result. This high is NANDed with RCO at U4090C, and a breakpoint occurs. Now let's look at what happens when the ORE line is low.

AND. We'll make some of the same assumptions as before. We'll assume that a match was made by U6080B, and that as soon as RCO goes high, the output of U6080B will go high. In order to demonstrate the AND operation, and prove that a breakpoint won't occur unless there are two matches, we'll assume that a match was *not* found by U6080A, and its output is low.

Until RCO is set high, the outputs of U6080B, U2030C, and U6080A are all low. As before, this places all highs at the inputs to U3030B, forcing the $\overline{\text{BREAKPOINT}}$ line high. Now, when RCO goes high, the output of U6080B goes high. This high is inverted and fed to pin 5 of U4090B and pin 12 of U3080D. The output of U2022C is high (remember, U6080A didn't make a match), forcing a high at pin 4 of U4090B and pin 13 of U3080D. So, we have a high and a low at the inputs of U4090B. This combination keeps the output high. At U4090A, the high from U4090B and the low ORE line are NANDed, keeping pin 5 of U3030B high. Remember, we need a low at one of U3030B's inputs to create a breakpoint. Let's see if we can find another way. At U3080D, pin 13 is high, and pin 12 is low. This combination forces a high to input pin 4 of U3030B. And since we can't force pin 3 low until one of the other input pins goes low, no breakpoint occurs. No breakpoint is possible because two matches weren't found. In other words, an AND situation didn't occur.

What would happen if the outputs of U6080A, U2030C, and U6080B were all high when RCO went high? First of all, a low would exist at output pin 8 of U2022C. That low is passed on to pin 13 of U3080D. Pin 6 of U6080B is high, so another low exists at input pin 12 of U3080D. These two lows are combined to create a low at pin 4 of U3030B. As soon as pin 4 goes low, pin 6 goes high. The high is fed back to pin 10 of U4090C and NANDed with the high RCO line to force the $\overline{\text{BREAKPOINT}}$ line low and enable either BINT or $\overline{\text{BSP}}$.

To Summarize, when the ORE line is high, either U6080B or the U6080A/U2030C combination can cause a breakpoint. When the ORE line is low, an AND combination must exist to cause a breakpoint. Next, we'll look at where the RCO line comes from.

Breakpoint Delay Counter ⟨5⟩

The Breakpoint Delay Counter is a presettable ripple counter. A binary value is loaded into the A, B, C, and D inputs by the Control Register (U2070). The counter is then clocked by the BE line from the personality card. As soon as the internal binary value has reached "1,1,1,1", the RCO (ripple carry out) line goes high. The delay, then, is the time it takes to count from the value entered to the maximum value possible. Because the comparator circuitry is asynchronous, a comparator match will remain stable until a new set of match values are stored in the latches. This gives the counter time to count out, and then enable the interrupts.

Breakpoint Status And Control Registers ⟨5⟩

The Breakpoint Status register (U3070) indicates to the personality card whether a breakpoint has occurred, and indicates the states of BSP0–BSP6. The contents of the Status register are placed on BD0–BD7 each time a breakpoint occurs. When an interrupt occurs, the personality card can poll the Breakpoint Status byte to see if the interrupt was a breakpoint interrupt.

The Breakpoint Control register allows the personality card to determine whether two portions of the Breakpoint Enable logic will be ANDed or ORed together. The Control register also determines where the breakpoint interrupt will go — that is, whether a breakpoint interrupt will be sent to the personality card, or whether the interrupt will be sent to the SPECIAL key circuitry. The Control register's third function is to permit the personality card to delay a breakpoint interrupt, by loading a count value into the Breakpoint Delay Counter.

The Serial I/O Ports ⟨3⟩

The MicroLab I has three serial I/O ports: a terminal RS-232-C port, a MODEM RS-232-C port, and a cassette port. You'll find the logic for all three ports shown on schematic 3. First, however, we'll cover the Baud and Clock Generator circuit shown at the top of the schematic 3. This circuitry serves all three I/O ports.

Baud And Clock Generator ⟨3⟩

The Baud and Clock Generator starts with the crystal-controlled oscillator at the top left of schematic 3. The oscillator frequency of 2.4576 MHz is fed to the clock input of U1010, where it's divided by 2 to create a 1.2288 MHz clock. The 1.2288 MHz clock is then fed to U2080. U2080 is a 12-stage ripple counter that divides the input frequency into six different frequencies. Each output frequency is equal to 16 times the corresponding baud rate. For example, the 1200 baud clock output from pin 2 of U2080 runs at a frequency of 19.36 KHz (16 X 1200). This division is necessary because each of the asynchronous communications interface adapters (ACIAs) is set up to accept a clock frequency 16 times that of the selected baud rate. Notice that the 1200 baud clock is also fed to U3090. U3090 is a divide-by-11 counter that produces the required frequency to operate at 110 baud (110 baud x 11 x 16 equals 19.36 KHz).

U2080 is a CMOS device, and each output line is buffered to prevent static damage when a rate jumper is moved.

Terminal Port ⟨3⟩

The Terminal Port is made up of U9020 and buffer U9010. U9020 is an ACIA that takes serial data from connector J101 and converts it to parallel data, and vice versa. You'll notice on schematic 3 that the incoming portion of J101 is shown on the left side of the page, while the output portion of J101 is shown on the right side of the page.

U9020 is enabled by the $\overline{\text{TSEL}}$ line coming from the I/O Decoding logic on schematic 4. (We'll discuss schematic 4 later.) The receive and transmit clocks (RXC and TXC) come from the Baud and Clock Generator. The position of jumper J1080 selects the operating frequency for U9020.

Data from J101 is accepted through pin 2 of U9020 when the $\overline{\text{DCD}}$ (data-carrier-detect) input is low. The data is then read from BD0–BD7 by the personality card.

When the personality card wants to transmit data to the terminal, U9020 forces its $\overline{\text{RTS}}$ (ready-to-send) line low, then waits for the $\overline{\text{CTS}}$ (clear-to-send) input from the terminal. When $\overline{\text{CTS}}$ is received, U9020 begins to transmit the data, in serial form, from BD0–BD7 to J101.

U9020 automatically adds any parity or stop bits when transmitting data, and checks for parity and stop bits when receiving data.

MODEM Port ⟨3⟩

The MODEM Port works the same way as the Terminal Port. The only difference is that connector J102 is designed to plug into a MODEM. U7020 is enabled by the $\overline{\text{SSEL}}$ line from the I/O Decode logic on schematic 4.

Cassette Port ⟨3⟩

The MicroLab I can store data on, and retrieve data from, a cassette tape recorder. Since cassette recorders are basically audio devices, the MicroLab I Cassette Port converts serial data into audio tones in a format called the "Kansas City Standard." Parallel data is converted to serial data by U2040. The serial data is then modulated to create the 1200/2400 Hz tones, and sent to the tape recorder. When data is received from the recorder, it's demodulated, then converted back to parallel data and placed on BD0–BD7.

The Kansas City Standard involves turning 1's and 0's into 2400 Hz and 1200 Hz tones. A logic "1" is represented by a 2400 Hz tone. A logic "0" is represented by a 1200 Hz tone. Figure 5-6 shows a representative timing diagram of the way in which the Kansas City Standard works.

The Modulator. Notice in the upper right corner of schematic 3 that there are two J-K flip-flops, U7090A and U7090B. These two flip-flops make up the Cassette Port modulator. Notice also that each flip-flop's clock input comes from the 300 baud clock line (4800 Hz). U7090B's J and K inputs are connected, through an inverter, to the TXD (transmit data) output of U2040. When the TXD output of U2040 is high, indicating a "1" state, the J-K flip-flop pair act as a divide-by-two counter. Because the "1" holds the set input of U7090B high, a high appears on the J-K inputs of U7090A, causing it to act as a divide-by-two counter. The 4800 Hz signal from the Baud and Clock Generator is divided by two, and the output of U7090A will be a 2400 Hz signal.

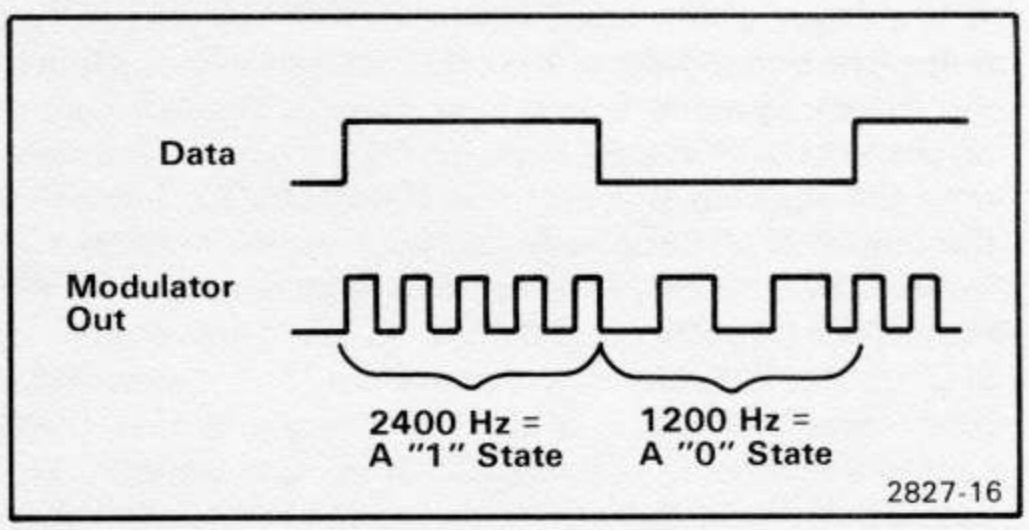


Fig. 5-6. Timing Diagram For The "Kansas City Standard".

A logic "0" is represented by a 1200 Hz tone, and a logic "1" by a 2400 Hz tone.

When the TXD output of U2040 is low, a "0" state, the J-K flip-flop pair act as a divide-by-four counter. U7090B will output a 2400 Hz square wave. The output of U7090A will be 1200 Hz. The data that entered the modulator as a series of "1's" and "0's" has been transformed into square-wave signals alternating between 1200 Hz and 2400 Hz.

The capacitor and resistor at the output of U7090A round off the corners the square waves, making the signal more acceptable to a tape recorder. Resistor R8092 also protects U7090A from accidental shorting at P8098.

The Demodulator. The Cassette Demodulator does the reverse of the modulator. The Demodulator receives the 1200 Hz and 2400 Hz tones and converts them to "0's" and "1's".

As the signal comes in from the recorder, C8097 removes any dc component that may exist. The two diodes connected to the incoming line limit the signal swing to a positive voltage less than +5 volts.

U2090A and its surrounding circuitry act as an amplifier with a gain of 10. Capacitor C2097 is a high frequency roll-off capacitor that prevents the amplifier from breaking into oscillation.

The amplifier's output centers around +2.5 volts, which is about a volt too high for the input to U2050B. C2084 and R2079 solve this problem. C2084 removes the dc component from the output of U2090A. Then R2079 works in combination with a 20K-ohm resistor within U2050B to create a voltage divider. The voltage divider lowers the center voltage to about +1.2 volts. U2050B cleans up the incoming signal to make a sharp-cornered square wave.

The next stage of the Demodulator is made up of U1050B, U2050D, and U1050C. These devices act as an edge-triggered one-shot multivibrator at both the rising and falling edges of the input from U2050B that generates a pulse. The output frequency of U1050C will be twice that of the input frequency. This is how it works: When the input on pin 4 of U1050B goes high, pin 6 goes high. At the same time, the input signal is fed to pin 10 of U2050D. Notice that the output of U1050B is fed through an RC network and inverted by U2050D. These components tend to delay the signal from U1050B pin 6 slightly, so that it arrives at pin 9 of U2050D a little after the signal at pin 10. Because of this delay, every transition of the input to pin 4 of U1050B causes a low-going output pulse at pin 8 of U1050C. The output pulse has a duration of about 5 microseconds. When a 1200 Hz signal is received, a pulse is produced about every 416 microseconds. When a 2400 Hz signal is received, the pulse is produced about every 208 microseconds.

The low-going pulse output at pin 8 of U1050C does two things: the pulse is turned into data by U1040; and, the pulse is used by U1020 and U1030 to create the receive clock used by U2040. Let's talk about the receive clock first.

Remember that the pulse frequency is twice the frequency coming from the tape recorder. Also remember that the time between pulses will vary with the incoming signal frequency.

Now notice that the pulse is fed to the reset input of U1020, which is a 4-bit binary counter. The clock input for U1020 is from the 2400 baud clock, and operates at a frequency of 38.4 KHz. The period of the clock input is 26 microseconds. As you can see, all the load inputs to U1020 are tied to ground, and so the counter counts from "0000" to "1111", then starts at "0000" again. The A, B, C, and D outputs of the counter are fed to U1030, which is a demultiplexer. When the output of U1020 equals "1010" (a decimal 10), the Y2 output of U1030 goes low. When the output of U1020 equals "1011" (a decimal 11), the Y3 output of U1030 goes low. So, the time from a "0000" output to either a Y2 or a Y3 can be calculated by multiplying the input clock period by 10 or 11. From the time U1020 is reset until the time it reaches a Y2 output is 260 microseconds. The time it takes to reach a Y3 output is 286 microseconds. Now, let's put all these numbers together and see what happens.

Let's say we get a low-going pulse out of U1050C at "time 0". This pulse resets U1020, and the counter begins counting. Now, if the signal we're getting from the tape recorder is at 2400 Hz (a "1"), another pulse will come along in 208 microseconds. So at "time 0" plus 208 microseconds, the PULSE line goes low at pin 12 of U1050D. Pin 13 is high because our counter hasn't reached a "1010" state, and the Y2 output of U1030 is high. At "time 0" plus 213 microseconds, the PULSE line goes low again, and the output of U1050D goes high. The high clocks the RXC input to U2040. At the same time, the negative-going edge of PULSE resets U1020, and the counter starts counting again. As long as a 2400 Hz signal is being received, the PULSE line will always beat the counter to U1050 and create an RXC clock. An remember, the 2400 Hz signal from the recorder is doubled by U1050, so the frequency fed to the RXC input ot U2040 is 4800 Hz — exactly the clock frequency required by U2040 to communicate at 300 baud.

What happens if the incoming signal from the tape recorder is 1200 Hz? Much the same thing. Recall that at 1200 Hz, the PULSE line will go low once every 416 microseconds. This rate is not fast enough to provide 4800 Hz clock input to U2040. But, the counter takes care of that. Remember that the counter only requires 260 microseconds to force the Y2 output of U1030 low. When we had a 2400 Hz input, the PULSE line went high before Y2 went low. With a 1200 Hz input, counter U1020 will reach the "1010" count before the next PULSE. When Y2 goes low, then high again at "1011", the RXC input to U2040 is toggled. It's toggled again when PULSE does go high. In effect, the incoming frequency has been doubled. When the incoming signal is only 1200 Hz, the counter injects a signal between each rising edge of PULSE, thus creating a 4800 Hz baud clock.

If you placed an oscilloscope probe on the RXC input to U2040, you wouldn't see a symmetrical square wave, nor would it seem very stable. Because this clock is actually generated by the signal from a tape recorder, all of the recorder's wow and flutter is passed through to the RXC input. However, the signal is stable enough to clock the ACIA.

Now let's talk about how the incoming signals are transformed to data.

The thing to remember in this discussion is that when a 2400 Hz signal is being received, we need to present a "1" to the RXD input of U2040 when U2040 receives a clock pulse. And, we need a "0" when 1200 Hz is being received. At the bottom of schematic 3, you can see that the PULSE line is tied to one input of U1050A. U1050A acts as an inverter. When PULSE is low, the output of U1050A will be high, and when PULSE is high, the output of U1050A will be low. This signal and PULSE are connected to the positive-edge clock inputs of U1040A and U1040B. As you can see, U1040A and B are set up much like the Cassette Modulator J-K pair. Notice that the set input of U1040B is connected back to the Y3 output of U1030. We'll discuss this connection later.

Let's assume that we're receiving a 2400 Hz signal, and that PULSE goes high at "time 0". Because J and K are tied low, that high causes the Q output of U1040B to go low, as shown in Fig. 5-7. Five microseconds later, when the clock input to U1040B goes high (remember, this is the inverse of the PULSE line), the Q output of U1040A goes high, indicating a "1" data to U2040. And as long as the incoming frequency is 2400 Hz, the states of U1040B and U1040A will remain this way. Each time U2040 receives a clock pulse, it will read a "1" on its RXD input.

Now let's look at what happens if the incoming signal is 1200 Hz. Refer to Fig. 5-8 while you read the following paragraphs.

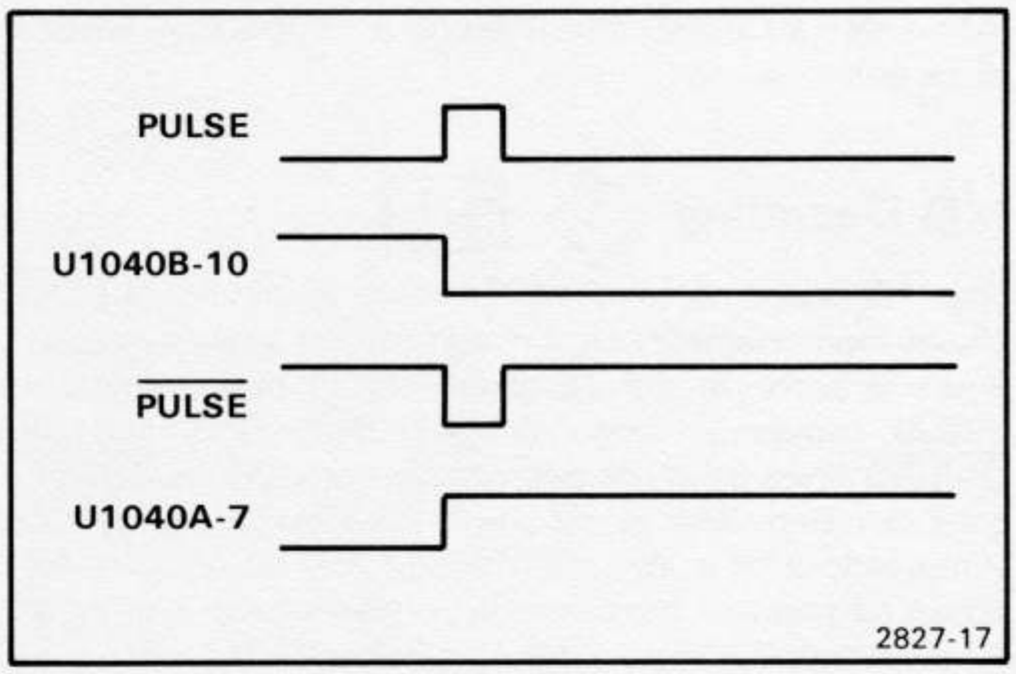


Fig. 5-7. 2400 Hz ("1") Timing.

As before, counter U1020 comes into use when reading 1200 Hz data. Notice in Fig. 5-8 that it takes one complete PULSE transition to set up the RXD line. The next clock (RXC) pulse will be generated by counter U1020. Recall that the Y2 output of U1030 goes low every 260 microseconds, and that the Y3 output follows by 26 microseconds. The Y3 output is connected back to the set input of U1040B. Look at Fig. 5-8, and you'll see that the timing of the set pulse forces the output of U1040A low just before the RXC clock created by the counter (the second RXC pulse in Fig. 5-8) goes high. The next time PULSE goes high, the whole thing starts over again.

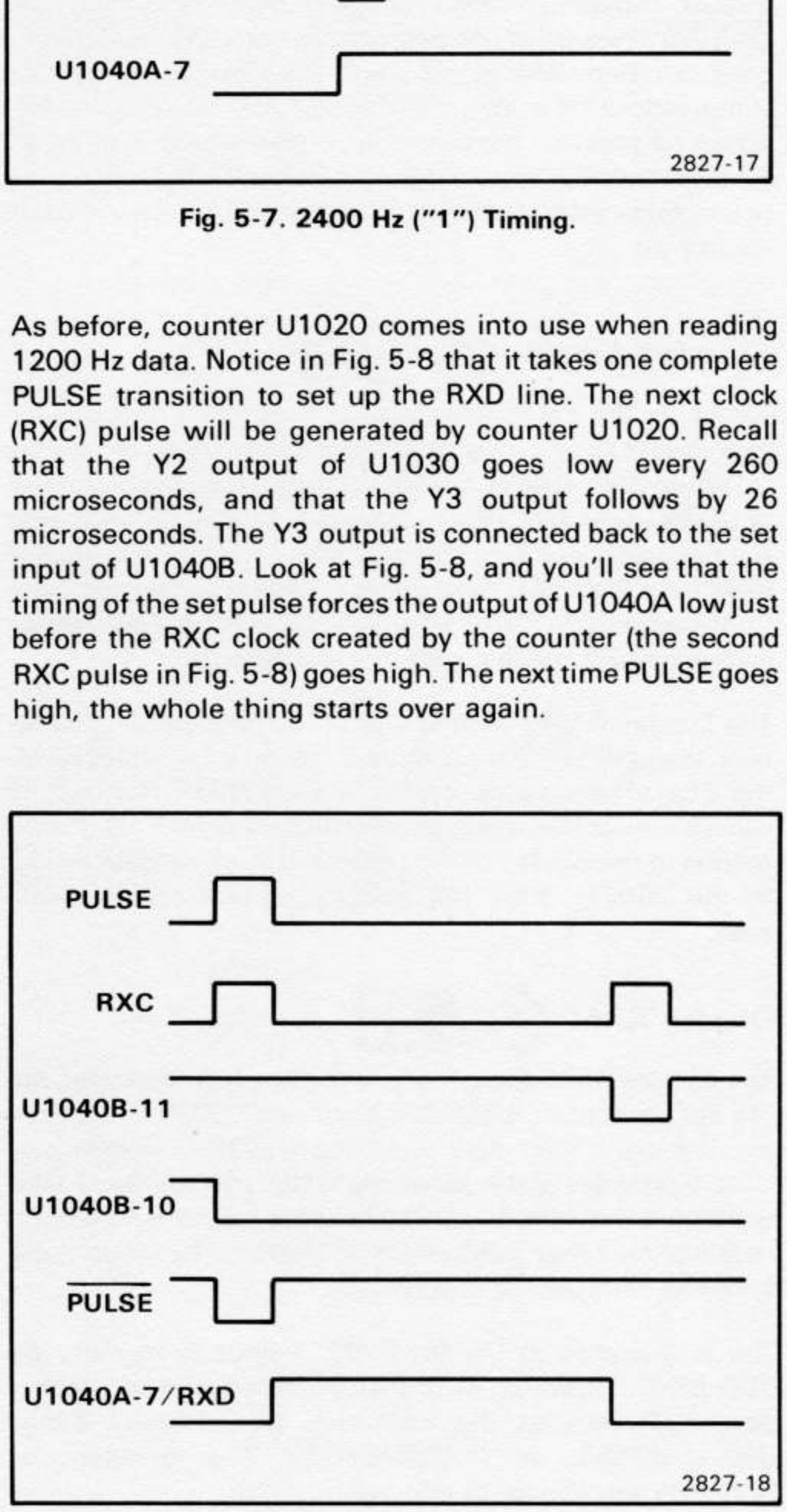


Fig. 5-8. 1200 Hz ("0") Timing.

In this way, a 1200 Hz tone presents a "0" to U2040 when a clock pulse occurs.

I/O Decoding

The I/O Decoding logic on the main interconnect board allows the personality card to address the keypad, display, and I/O ports. In the upper left corner of schematic 4, U8030 constantly looks at BA1, BA2, BA3, and the ONBDIO lines from the personality card. When ONBDIO goes low, BA1–BA3 select one of the Y outputs of U8030. When output Y4 is low, the MODEM Port ACIA is enabled. When Y3 goes low, the Cassette Port is enabled. And, when Y2 goes low, the Terminal Port is selected. The remaining two outputs select the display and keypad, which we'll talk about next.

Display Logic

As far as the personality card is concerned, the Display logic exists as an I/O port that the personality card writes to. When BA1–BA3 and ONBDIO are all low, the Y0 output of U8030 goes low. This low signals the Display logic that the personality card is going to write a value into Display RAM from BD0–BD7. This value in RAM is converted by the Character PROM into a set of signals that turn on specific segments of a specific LED in the display.

The Display RAM contains eight 5-bit data words, one for each display LED. Once a value is loaded into Display RAM, the Character Counter cycles through RAM, reading the values over and over again into the Character PROM. This results in the display being refreshed at a rate determined by the counter. We'll talk about each of these elements next.

Display RAM

The Display RAM devices are actually 4 X 4 registers, and are set up in pairs (U6020/U3020 and U5020/U4020) to provide eight 5-bit data words to U5010. For example, U6020 provides four 4-bit words to U5010. Four more 1-bit words are provided by U3020, so that U6020 and U3020 together feed four 5-bit words to U5010. The same thing happens with U5020 and U4020.

The data stored in Display RAM is sent to memory on BD0–BD4. In addition, BD5 and BD6 provide the addressing bits. BD7 acts as the switching bit to select either U6020/U3020, or U5020/U4020. The contents of BD0–BD7 are shown in Fig. 5-9.

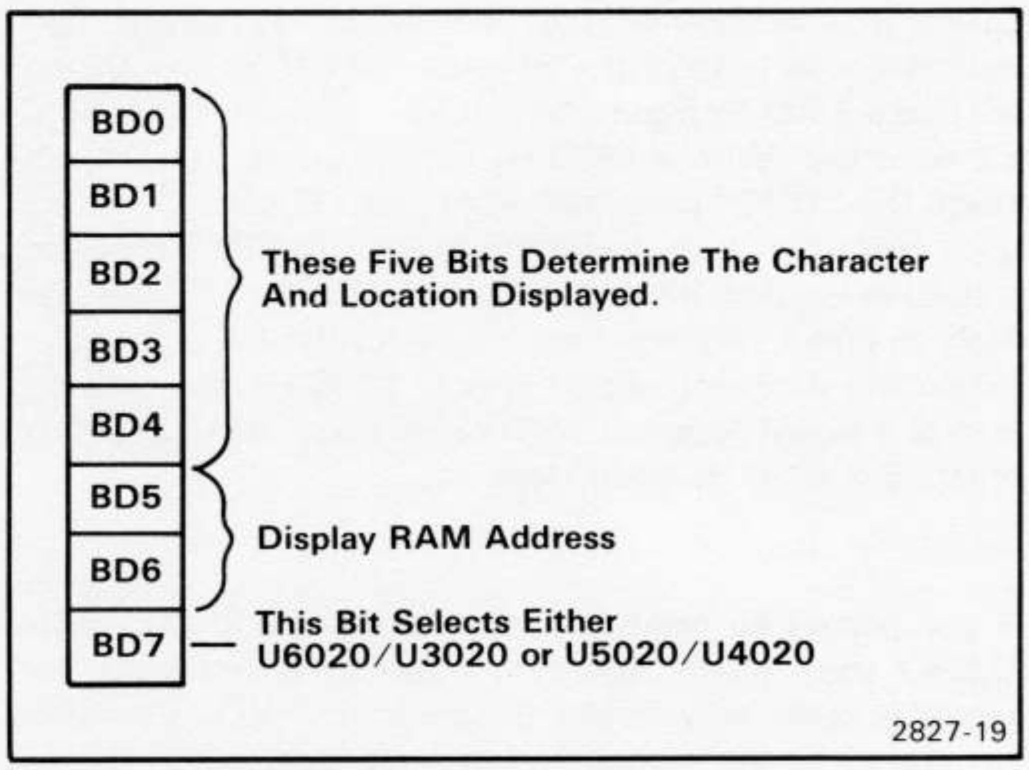


Fig. 5-9. The Display RAM Bit Format.
The data byte written to the display I/O location selects the character, character position, RAM location, and RAM devices.

The bit pattern of BD0–BD4 is determined by adding the value of the character you want to display to the value of the display location. Section 2 of this manual tells how to program the display. Now, let's discuss how BD5–BD7 address and control the Display RAM.

Display Enable

The Display logic is accessed by an I/O read or write to 00 on BA1–BA3. Let's look at what happens when the personality card wants to write to Display RAM.

Writing to the Display RAM. When Y0 of U8030 goes low, the very next "0 to 1" transition of BE will clock a high to output pin 9. Then, if BD7 is low, two highs will appear on the input of NAND gate U4030D. The resulting low write-enables U6020 and U3020. If BD7 is high, the output of U4030C will go low, enabling U5020 and U4020. But notice the set input of U1060B. If the BW/R line is low, indicating a read operation, pin 9 of U1060B is forced low, disabling the write-enable inputs to Display RAM. The Display RAM can never be read by the personality card.

When the BD7 line enables the GW input to a RAM pair, BD5 and BD6 select which of the four 4-bit registers in each RAM is to be written to. Remember that U3020 and U4020 use only the least significant bit of each register.

Reading the Display RAM. As we said before, the personality card cannot read what is written into Display RAM. What does read Display RAM is the Character PROM. Of course, this isn't exactly true — PROM certainly can't read RAM. But the result is about the same. The Display RAM contents are fed to the address inputs of the Character PROM, where they are converted into information suitable for 7-segment LEDs. There are eight 7-segment LED's in the MicroLab I display. Since the Character PROM can only put information on its output lines for one character at a time, another device must turn on the anode of each LED in the proper sequence. That device is the Character Counter, U3010. Let's look at how the 5-bit segment word gets to the LEDs. Refer to Fig. 5-10 and schematics 4 and 6.

Character Counter 4

Once data is stored in the Display RAM, the MicroLab I display LEDs are automatically selected and refreshed by the Character Counter.

The Character Counter is a simple binary up-counter whose outputs are clocked from a "0000" state through to a "1111" state by SCLK. The outputs of U3010 are the synchronizing elements in the Display logic. Notice that output pin 13 (S0) is connected to the RA (read address A) inputs of both U5020 and U4020. S0 is also connected to the RB (read address B) inputs of U6020 and U3020. The S1 output of U3010 is connected to the RB inputs of U5020 and U4020, and the RA inputs of U6020 and U3020. In other words, S0 and S1 provide the read addresses for the Display RAM. The Display RAM is read-enabled by a third output of U3010 called S2. So what we have at this point is a RAM address on S0 and S1, and a read-enable signal from S2. When S2 is high, only devices U5020 and U4020 will place data on the A0–A4 lines to the Character PROM. When S2 is low, only U6020 and U3020 feed addresses to the Character PROM.

Let's assume that S0, S1, and S2 are all high. When S2 goes high, U5020 and U4020 place data on their output pins. That data is fed over A0–A4 to the Character PROM. The Character PROM converts the RAM output to 7-segment display code. The code is fed through a biasing resistor network to transistor pack U4010. U4010 drives the display LED anodes low in the proper fashion to create a displayable character. But which LED is selected? That's taken care of by the Character Counter. Notice that the S0, S1, and S2 outputs of the counter are fed through P3010 to the keypad/display board on schematic 6.

Scan Decoder 6

The Scan Decoder (on schematic 6) is a demultiplexer/decoder that decodes a binary input to force one of eight outputs low. Each output of the Scan Decoder is connected to the cathode of an LED. So we have the segment pattern coming in at the upper right of schematic 6, and the LED selection lines coming in from the left side of the schematic. In this particular situation, S0–S2 high forces pin 4 of U3060 low, turning on DS1081.

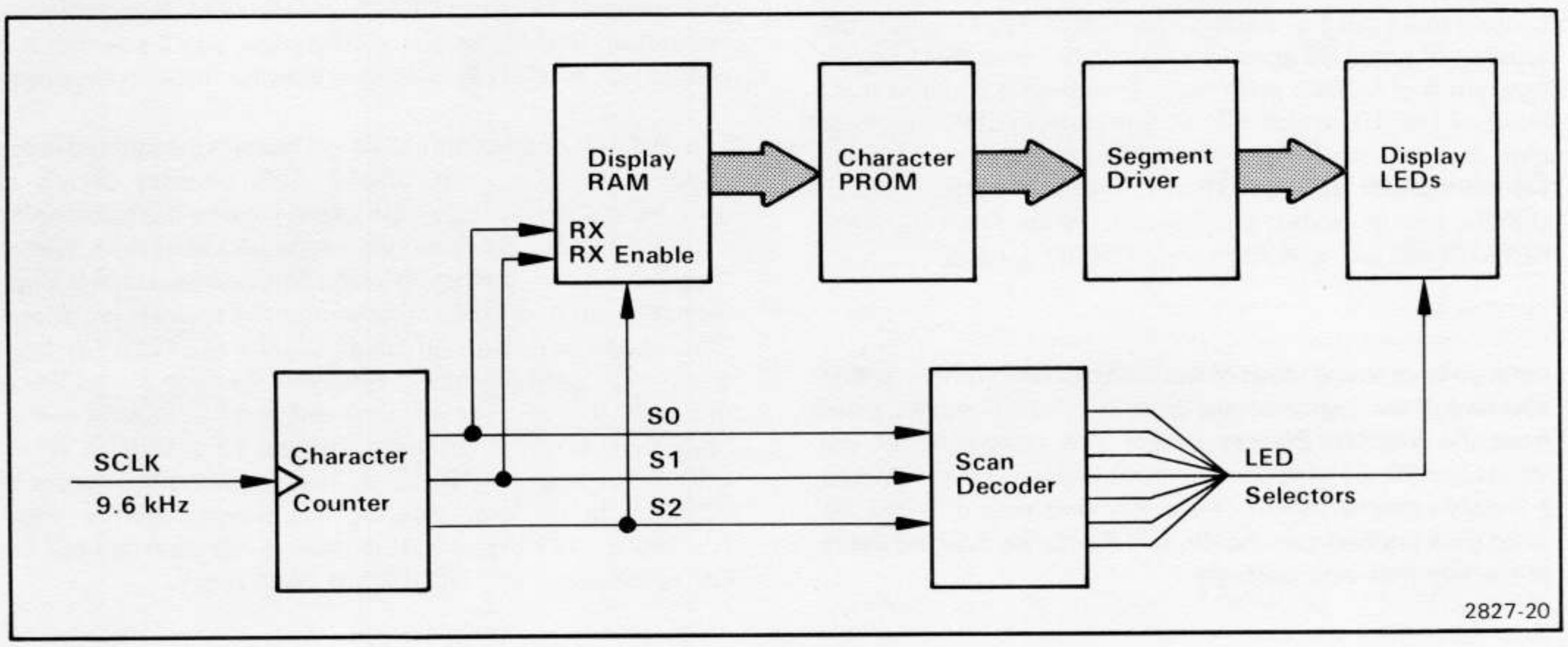


Fig. 5-10. MicroLab I Display Block Diagram.

To summarize, one location in Display RAM is dedicated to each LED in the display. The Character Counter constantly cycles through Display RAM, reading RAM contents out to the Character PROM, while sequentially turning on each LED in the display.

Keypad Encoding ⟨6⟩

If you'll turn to schematic 6, you'll see that the same S0–S2 lines that were used to turn on the LEDs are also used to scan the keypad. The Scan Decoder constantly forces its outputs low, one at a time. If a key is pressed while one of the Scan Decoder lines is low, a low appears on either the $\overline{KA}$, $\overline{KB}$, or $\overline{KC}$ lines fed back to the Main Interconnect board. For example, if pin 11 of U3060 low, and the A key (S3048) on the keypad is pressed, the $\overline{KB}$ line goes low. The speed at which the keys are scanned by the Scan Decoder is such that a key could not be pressed fast enough to escape forcing one of the "K" lines low.

Turn back to schematic 4 and you'll see the $\overline{KB}$ line coming in at the lower left corner of the schematic. Let's follow $\overline{KB}$ to U3030C. When $\overline{KB}$ goes low, the output of U3030C goes high. The pin 14 output of U3010 is NANDed with the output of U3030C to create a low out of U2022B. (During the time $\overline{KB}$ is low, the pin 14 output of U3010 will have gone high at least once.) The low output of U2022B does a number of things.

First, let's discuss U2012. U2012 is a dual 4-bit counter. It debounces all keystrokes, and it detects when someone is holding a key down. Notice that the output of U2022B is fed to clock input pin 1 of U2012. This half of U2012 counts the number of times $\overline{KB}$ goes low. The eighth time that $\overline{KB}$ goes low, pin 6 of U2012 goes high. That high is fed into the J input of U5010, which allows pin 12 (KEYSTROBE) to go high the next time $\overline{KB}$ goes low. This is the debounce action we mentioned. The KEYSTROBE line is fed back to pin 2 of U2020, and it clocks the Keypad Status latch (U2010). KEYSTROBE will stay high until U5010 is reset.

Let's go back to the input of the Keypad Status latch. Notice that two of the inputs to the latch are the $\overline{KB}$ and $\overline{KC}$ lines from the Keypad/Display board. The remainder of the inputs are S0, S1, and S2. The combination of these lines is a binary representation of the key that was pressed. So what gets latched into the Keypad Status latch is the value of the key that was pressed.

To summarize what has happened up to this point: The "A" key has been pressed on the keypad, forcing the $\overline{KB}$ line low. This low has clocked U2012 until its pin 6 output went high, allowing the next pulse from $\overline{KB}$ to force the KEYSTROBE line high. KEYSTROBE latched the value of the key pressed into U2010, the Keypad Status latch.

Notice that when KEYSTROBE went high, it forced pin 5 of OR gate U2030B high. This caused the output of U2030B to go low, which in turn, forced the $\overline{IREQ}$ line low. The $\overline{IREQ}$ line goes to the personality card, where it interrupts the microprocessor. The microprocessor stops what it was doing, and begins looking for where the interrupt came from. The MicroLab I handles interrupts on a polling basis. That is, the personality card reads all the MicroLab I status registers until it finds one that has its interrupt bit high. When the personality card gets to the keypad I/O address, the Y1 output of U8030 (in the upper left corner of schematic 4) goes low. This low is inverted, and NANDed with the BR/$\overline{W}$ line to produce a low at pin 3 of U4030A. The output of U4030A enables the information from the Keypad Status latch onto bus lines BD0–BD7. The personality card then checks BD7 to see if the interrupt bit was set. And it was, by the KEYSTROBE line.

To the personality card, the interrupt bit means that the data contained on BD0–BD6 is valid keypad data. The MicroLab I operating monitor then causes the personality card to write to the Keypad I/O port, again sending the Y1 output of U8030 low. If you'll look at U2022D, you'll see that its inputs are tied to the BE line and the BW/$\overline{R}$ line. During a write operation, both these lines are high. The output of U2022 goes low, is inverted, and is NANDed with the inverted low from U8030 and U4030B. If you'll follow the output of U4030B across the page, you'll see that this output resets U5010, making it ready for the next key press.

The one part of this circuit that we haven't mentioned is the upper half of counter U2012. This counter serves to prevent the wrong data from being read by the personality card if a key is held down for a long period of time. Notice that this counter is clocked by the S1 line from U3010. Each time the output of U2022B goes low, the counter is cleared. This action prevents pin 8 of U2012 ($\overline{KEYDOWN}$) from going high until the key is released. As soon as the key is released, the counter will time out and $\overline{KEYDOWN}$ will go high. $\overline{KEYDOWN}$ is NANDed with pin 13 of U5010. When U5010 is reset, pin 13 will go high, causing the output of U2022A to go low, clearing the Keypad Status latch. Therefore, the Keypad Status latch is not cleared until the key is released, and U5010 has been reset.

SPECIAL Key Debounce

In the lower right corner of schematic 4, you'll find the SPECIAL Key Debounce circuitry. On schematic 5, you can see that the $\overline{\text{SPECIAL}}$ key is connected with its own line to the Main Interconnect board. When the SPECIAL key is pressed, the SPECIAL line goes low, and the J-K inputs to U1060A are forced low. The KCLK clock input to U1060A originates from the Baud and Clock Generator circuitry. As soon as KCLK goes high, pin 7 of U1060A goes high, forcing the SPECIAL line to the personality card low. What the personality card does with the $\overline{\text{SPECIAL}}$ line is entirely dependent on the personality card.

U1060A is reset by the $\overline{\text{BSP}}$ line from the Breakpoint Enable logic on schematic 5.

Interrupt Gating

All the interrupts that can be generated on the Main Interconnect board (keypad interrupt, serial I/O port interrupt, etc.) all come together at the Interrupt Gating logic. All the interrupt lines are ORed together by U3030A and U2030B to generate an $\overline{\text{IREQ}}$ pulse that is sent to the personality card. When the personality card receives the interrupt, it begins polling all the device status registers on the Main Interconnect board to find the interrupting device.

–5 Volt Regulator And +5 Volt Crowbar

In the upper right corner of schematic 5 is the –5 volt regulator. U8084 is the regulating device. Some personality cards require –5 volts for proper operation.

Above the regulator is the +5 volt overvoltage crowbar circuit. If the +5 volt line approaches +6 volts, zener diode VR8096 pulls the gate input of Q9096 high enough to turn the SCR on. When the SCR comes on, it shorts the +5 volt power supply and blows the +5 volt supply fuse.

Section 6

CALIBRATION

Introduction

The MicroLab I is primarily a digital instrument, and therefore requires little calibration. The power supply is the only element of the MicroLab I that needs occasional calibration. In this section, you'll find instructions on disassembling the MicroLab I, and calibrating the power supply.

MicroLab I Disassembly

Separating The Cabinet Halves

Before you begin to take apart the MicroLab I, unplug the power cord and any other cabling, and remove any personality cards that are plugged into the chassis.

1. Close the clear plastic cover and turn the MicroLab over on its top, as shown in Fig. 6-1.
2. Remove the six screws shown in Fig. 6-1 with a long-tipped Phillips screwdriver.
3. Carefully hold the top and bottom parts of the MicroLab I together, and turn the MicroLab I back onto its base.
4. Slowly lift the top of the MicroLab I; be careful to move the top so that it clears the personality card guide rails. As the top of the cabinet clears the Main Interconnect circuit board, rotate the top to the right, exposing two cables that connect the Keypad/Display board and the Main Interconnect board.
5. Unplug the two cables at the Main Interconnect board.
6. Set the MicroLab I cabinet top aside.

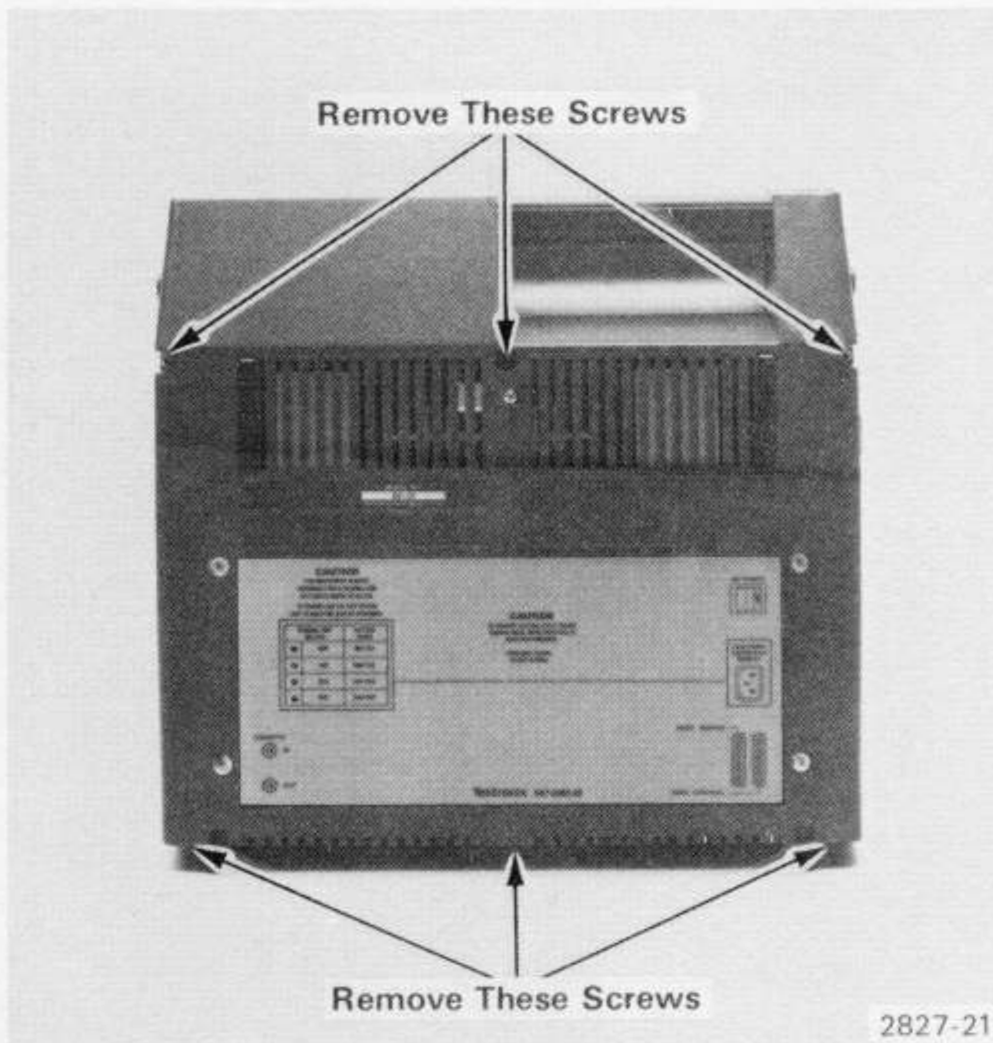


Fig. 6-1. Looking At The Bottom Of The MicroLab I.

Removing The Main Interconnect Board

The Main Interconnect board is fastened to the MicroLab I chassis with six screws. Two RS-232-C cables, the Cassette Port cables, and the fan power lines are also connected to the Main Interconnect board. Use the following procedure when removing the Main Interconnect board.

1. Remove the cables connected to the Main Interconnect board at the locations shown in Fig. 6-2.
2. Remove the six screws shown in Fig. 6-2.
3. Set the Main Interconnect board aside on a conductive surface, such as pink polyethylene.

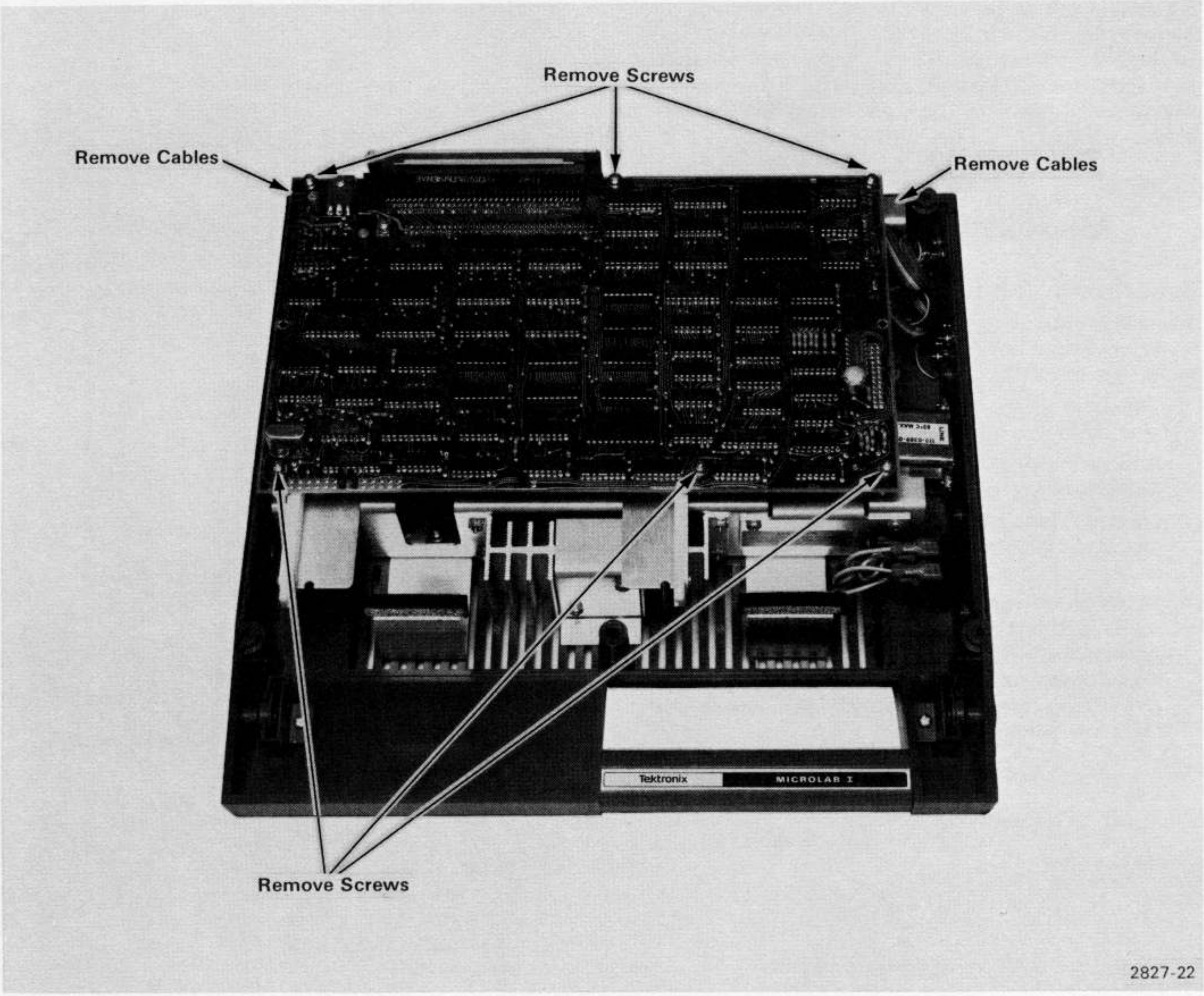


Fig. 6-2. Main Interconnect Board Cable Locations.

Each cable shown must be disconnected before you remove the Main Interconnect board.

Gaining Access To The Power Supply

To calibrate the MicroLab I power supply, the personality card guide rails and high voltage protective cover must be removed.

1. Loosen the two screws at the top of the personality card guide rails, as shown in Fig. 6-3.
2. Remove the screw holding the bottom of each guide rail.
3. Set aside the guide rails.
4. Remove the two screws at the front of the high voltage protective cover and set the cover aside.

To reassemble the MicroLab I, repeat all the previous steps in the reverse order.

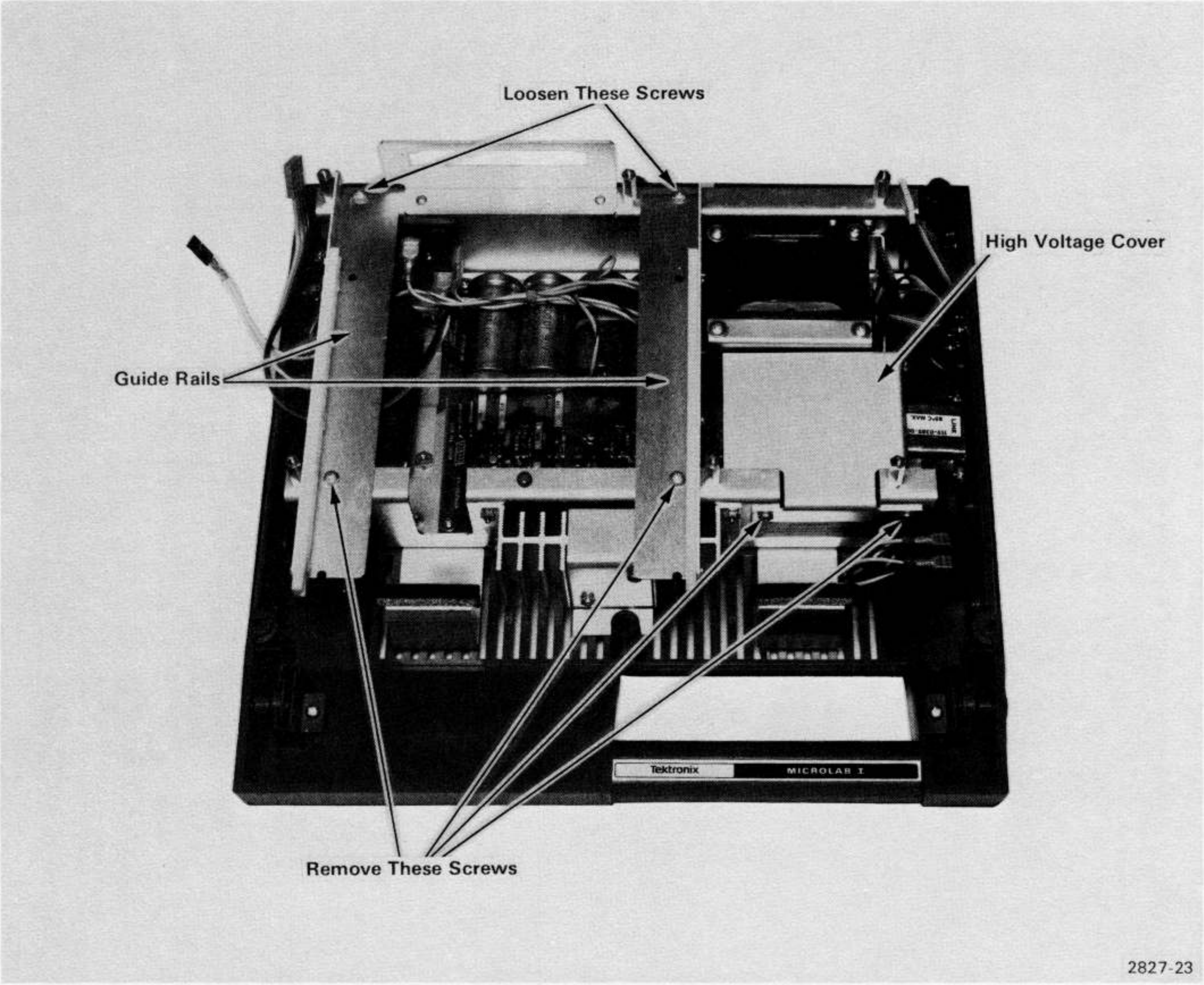


Fig. 6-3. Personality Card Guide Rails And High Voltage Protective Cover.
The guide rails and high voltage protective cover must be removed to expose the power supply.

Removing The Keypad/Display Board

The Keypad/Display board is located in the top of the MicroLab I cabinet. The Keypad/Display board is removed along with the MicroLab I front panel through the front of the cabinet. Use the following procedure when removing the Keypad/Display board.

1. Set the cabinet on its top, as shown in Fig. 6-4.
2. There are four screws that mount the Keypad/Display circuit board to the MicroLab I chassis. Remove these four screws.
3. The MicroLab I front panel is held to the chassis by six screws. Remove the front panel screws; be careful that the front panel doesn't drop to the bench surface.

NOTE

Unless you are careful when removing the front panel and Keypad/Display board, the key caps will fall free. Hold the front panel and circuit board together until you can set the Keypad/Display board upright and remove the front panel.

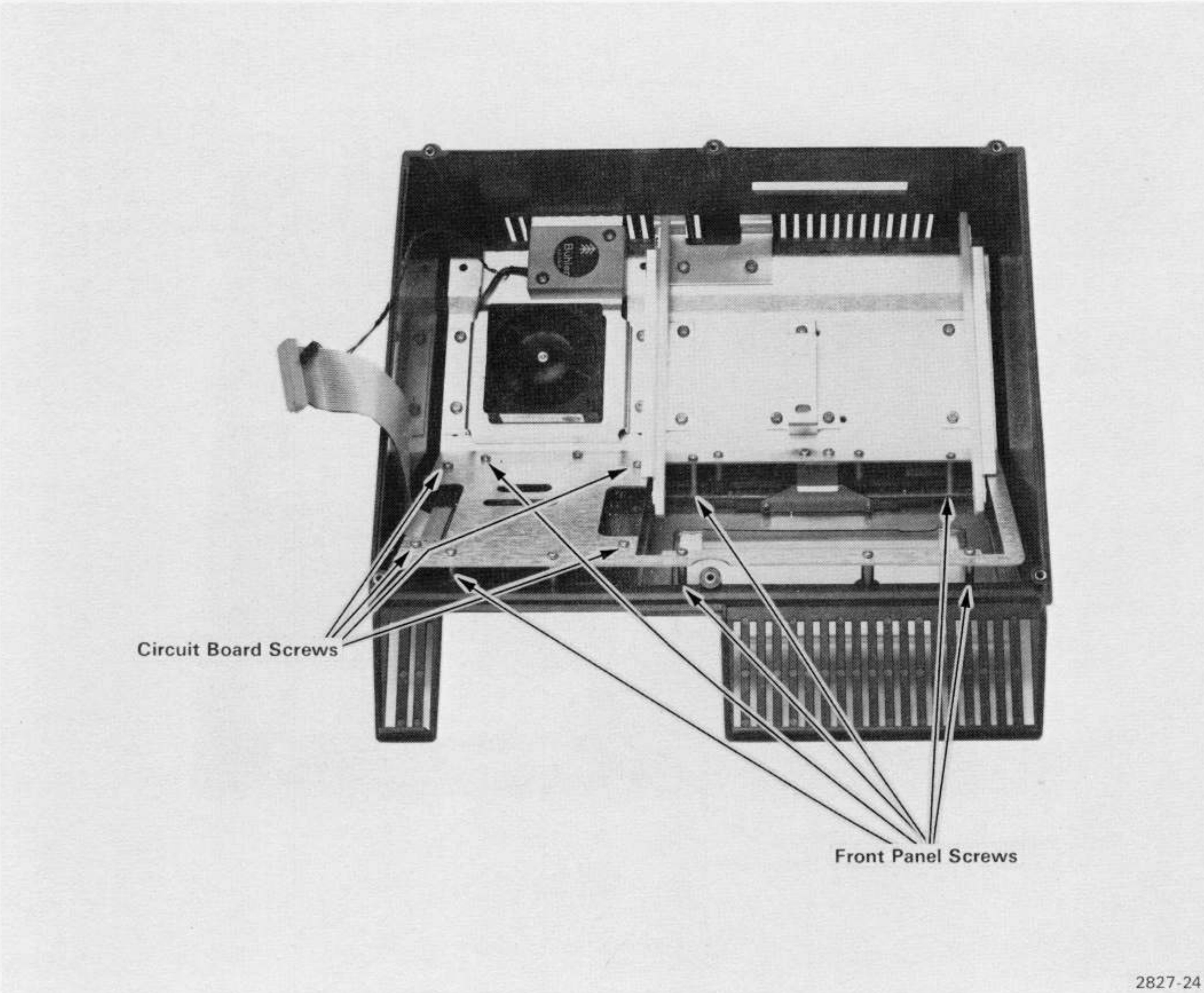


Fig. 6-4. The Cabinet Top Containing The Keypad/Display Board.

The Keypad/Display board is removed through the MicroLab I front panel.

4. Set the front panel and Keypad/Display board on a flat surface, circuit board down. Slowly lift the front panel away from the circuit board, then place the front panel on a soft surface to prevent scratching.

Power Supply Calibration

The following equipment is required to calibrate the MicroLab I power supply.

- a digital voltmeter — TEKTRONIX DM502 or equivalent
- an oscilloscope — TEKTRONIX 465 or equivalent
- a variable voltage source that has an output capacity of at least 1 A at 110 or 120 Vac (+ or −10%), or at least 0.5 A at 220 or 240 Vac (+ or − 10%).
- a common screwdriver, with a 1/8 inch flat blade, non-conductive, and at least 10 inches in length.

−12 Volt Adjustment

NOTE

The following procedure is used to calibrate the −12 volt portion of the MicroLab I power supply. In order for you to properly perform this procedure, the MicroLab I power supply must be connected to the Main Interconnect board. Connect the +5, +12, and −12 volt power leads to the square pins in the upper left corner of the Main Interconnect board. Tip the Main Interconnect board away from you as you face the MicroLab I, so that it rests well clear of the MicroLab I chassis.

CAUTION

Do not let the Main Interconnect board touch the MicroLab I chassis during any of these calibration procedures.

1. Make sure all power switches are in the OFF position. Connect the MicroLab I power cord to the MicroLab I power receptacle and the ac power supply.
2. Set the variable ac power supply voltage to 120 volts.
3. Set the HIGH/LOW line voltage switch on the MicroLab I power supply board (shown in Fig. 6-5) to the HIGH position.

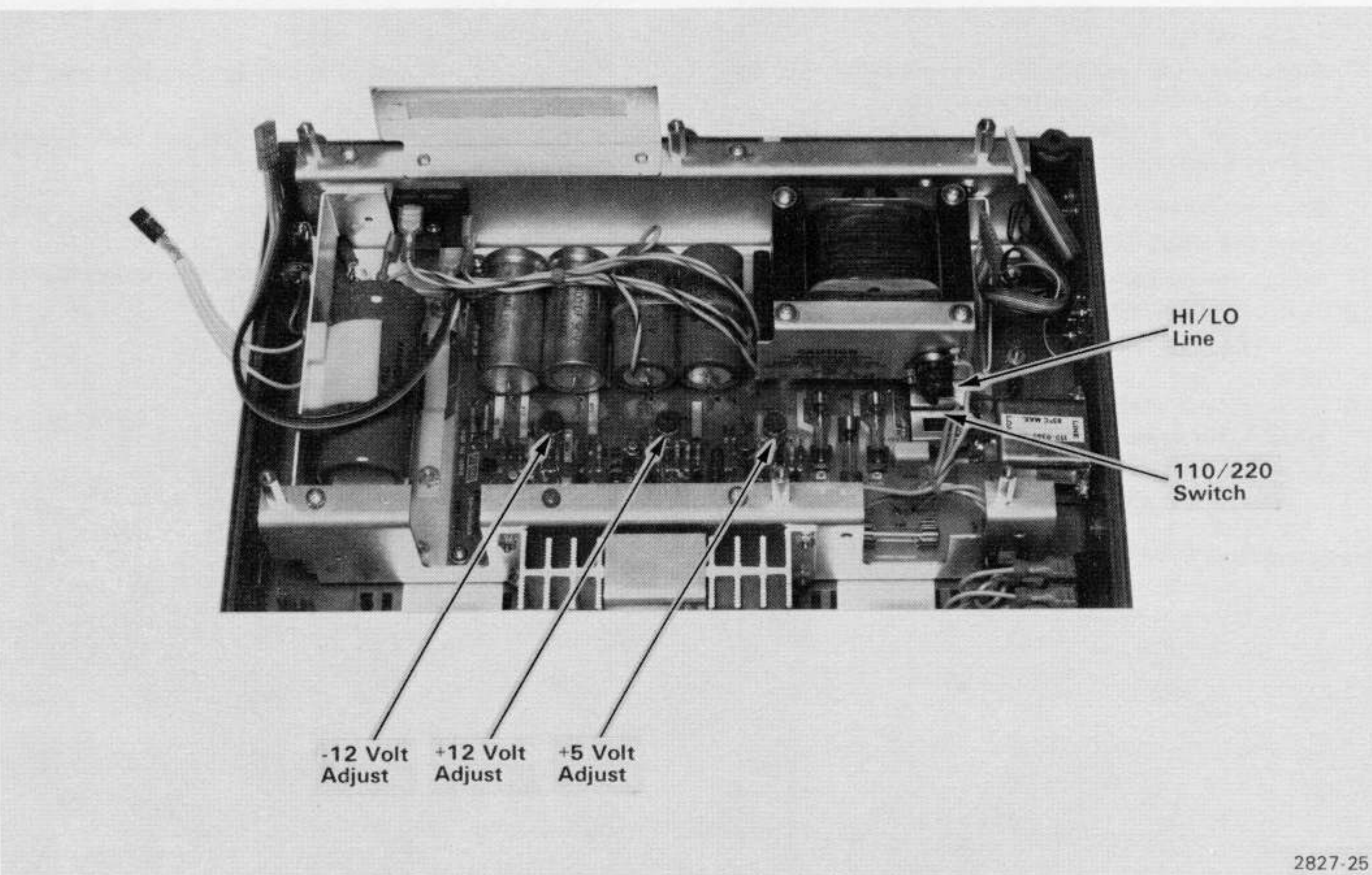


Fig. 6-5. MicroLab I Power Supply Adjustment Points.

4. Set the 120/220 volt switch on the MicroLab I power supply board to the 120 volt position.
5. Adjust the oscilloscope to the following settings:
   - 2 microseconds per division
   - 50 millivolts per division
   - ac input
6. Connect the black lead of the voltmeter to a point on the aluminum chassis.
7. Connect the red lead of the voltmeter to the NEGATIVE lead of capacitor C5.

CAUTION

If you are not using a digital voltmeter with an automatic polarity feature, reverse the placement of the red and black leads. (The first voltage measured is - 12 Vdc.)

8. Turn on the variable ac power supply.
9. By turning R13 (labeled -15 ADJ on the circuit board), adjust the -12 volt supply until the voltmeter reads -12.0 volts.
10. Disconnect the voltmeter from capacitor C5 and connect the oscilloscope probe to C5.
11. Check the -12 volt supply for not more than 50 millivolts peak-to-peak ripple.
12. Shut the variable power supply off.
13. Move the HIGH/LOW switch to the LOW position.
14. Adjust the variable ac power supply to 108 volts.
15. Turn on the variable power supply and repeat steps 9, 10, and 11. Do not adjust the -12 volt regulator at this time.
16. Turn off the variable power supply and reset the HIGH/LOW switch to HIGH.
17. Reset the variable power supply to 120 volts and go on to the +12 volt adjustment.

This completes the -12 volt adjustment.

+12 Volt Adjustment

Perform the following procedure to adjust the +12 volt supply.

1. Place the red lead of the voltmeter on the positive lead of capacitor C6.
2. By turning R43 (labled +15 ADJ on the circuit board), adjust the power supply until the voltmeter reads +12.0 volts.
3. Disconnect the voltmeter lead and attach the oscilloscope probe to C6.
4. Check for not more than 50 millivolts peak-to-peak ripple.

This completes the +12 volt adjustment.

+5 Volt Adjustment

Perform the following procedure to adjust the +5 volt supply.

1. Place the red lead of the voltmeter on the positive lead of capacitor C1 (near the +5, +12, -12 volt output connector).
2. By turning R62, adjust the +5 volt supply until the voltmeter reads +5.0 volts.
3. Disconnect the red voltmeter lead and connect the oscilloscope probe to C1.
4. Check for not more than 50 millivolts peak-to-peak ripple.

This completes the power supply adjustment procedures. You may now reassemble the MicroLab I.

Section 7

MAINTENANCE AND TROUBLESHOOTING

Introduction

This section describes procedures for preventing or reducing equipment malfunction, and includes techniques and aids for troubleshooting. Preventive maintenance improves equipment reliability. Should the equipment fail to operate properly, corrective measures should be taken immediately; otherwise, additional problems may develop within the equipment.

Static-Sensitive Devices

1. Minimize the handling of static-sensitive parts.
2. Transport and store static-sensitive parts in their original containers, on a metal rail, or on conductive foam. Label any container having a static-sensitive assembly or device.
3. Discharge the static charge on yourself by using a wrist strap before handling these devices. It is recommended that servicing of static-sensitive assemblies or devices be performed only at a static-free work station by qualified personnel.
4. Do not allow anything capable of generating or holding a static charge onto the work station surface.
5. Keep the leads shorted together whenever possible.
6. Pick up the part by the body, never by the leads.
7. Do not subject the part to sliding movements over any surface.
8. Avoid handling parts in areas having a floor or work surface covering that contributes to the generation of a static charge.
9. Use a soldering iron that has a connection to earth ground.
10. Use a special anti-static suction-type desoldering tool, such as the Silverstat Soldapulit, or a wick-type desoldering aid.

Reducing Susceptibility To Static Discharge

The following safeguards have been provided to reduce the change of static discharge damage:

1. The ground (earth) wire of the primary power cable is connected to the chassis where the cable enters the unit.
2. The shields of interconnecting EIA cables are grounded to the chassis at the cable entrance or egress of each unit.
3. All interconnecting ribbon cables have a built-in ground plane which is grounded to the chassis at the cable entrance or egress of each unit.
4. Ground loops have been avoided by installing a common ground between all units. Grounding straps are utilized where necessary.

CAUTION

Violation or modification of the preceding safeguards can result in ground loops and/or static discharge problems.

Preventive Maintenance

Preventive maintenance consists of cleaning, visual inspection, and performance checks. The preventive maintenance schedule established for the equipment should be based on the amount of use, and on the environment in which the equipment is operated.

Cleaning

Clean the equipment often enough to prevent dust or dirt from accumulating in or on it. Dirt acts as a thermal insulator and prevents efficient heat dissipation. It also provides high-resistance electrical leakage paths between conductors or components in a humid environment.

Exterior

Clean the dust from the outside of the equipment by cleaning the surface with a soft cloth or brush. The brush will remove dust from around the front panel selector buttons. Hardened dirt may be removed with a cloth dampened in water that contains a mild detergent. Abrasive cleaners should not be used.

Interior

Clean the interior by loosening accumulated dust with a dry soft brush, then blow the loosened dirt away with low-pressure air. If the circuit board assemblies need cleaning, remove the circuit board and clean with a dry, soft brush. Hardened dirt or grease may be removed with a cotton-tipped applicator dampened with a solution of mild detergent and water. Abrasive cleaners should not be used.

After cleaning, allow the interior to dry thoroughly before applying power to the equipment.

CAUTION

Do not allow water to get inside any enclosed assembly or components, such as switch assemblies, memory capacitors, potentiometers, etc. Instructions for removing assemblies for maintenance are provided in the Corrective Maintenance part of this section. Do not clean any plastic materials with organic cleaning solvents (such as benzene, toluene, xylene, acetone, or similar compounds); they may damage the plastic.

Visual Inspection

After cleaning, carefully check the equipment for such defects as defective connections and damaged parts. The remedy for most visible defects is obvious. If heat-damaged parts are discovered, try to determine the cause of overheating before replacing the damaged part; otherwise, the damage may be repeated.

Troubleshooting

Your Tektronix Service Support Center is best suited to perform repairs on this unit. However, the following general troubleshooting procedures may aid you in tracing a problem to its source.

Before beginning any troubleshooting work, check your warranty or service agreement. To prevent voiding the warranty, all service must be performed by Tekronix, Inc. for the first 90 days following delivery.

Troubleshooting Aids

Diagrams

Circuit diagrams are given on foldout pages in the Diagrams section of the manual. The circuit number and electrical value of each component are shown on the diagram. (See the first tab page for definition of the symbols used to identify components in each circuit.) Components on circuit boards are assigned vertical and horizontal grid numbers which correspond to the location of the component on the circuit board. Refer to the Replaceable Electrical Parts List section for a complete description of each component and assembly. These portions of the circuit that are on circuit boards are enclosed with a black border line, with the name and assembly number shown on the border.

NOTE

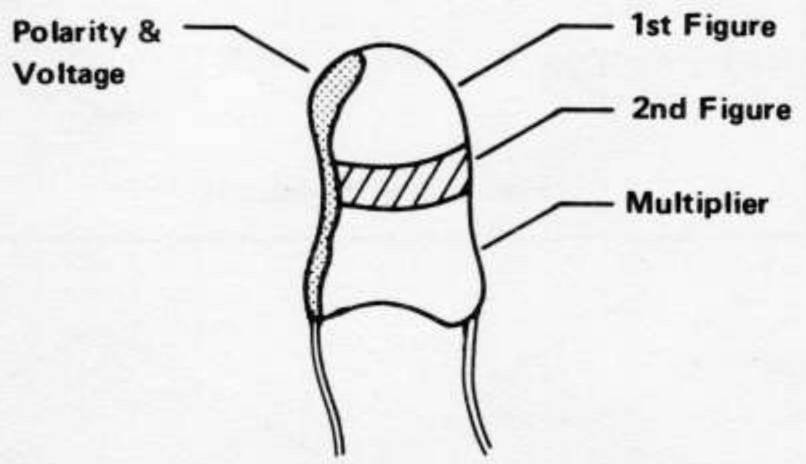
Corrections and modifications to the manual and equipment are described on inserts bound into the rear of the manual. Check this Change Information section for manual or instrument changes and corrections.

Circuit Board Illustrations

Electrical components, connectors, and test points are identified on circuit board illustrations located on the inside fold of the corresponding circuit diagram, or on the back of the preceding diagram. This allows cross-referencing between the diagram and the circuit board, and shows the physical location of components.

Capacitor Marking

The capacitance value of common disc capacitors and some electrolytics is marked in microfarads on the side of the component body. The white ceramic capacitors are color-coded in picofarads. Tantalum capacitors are color-coded as shown in Fig. 7-1.



DIPPED TANTALUM CAPACITOR MARKING

A AND B CASE

CAPACITANCE AND VOLTAGE COLOR CODE

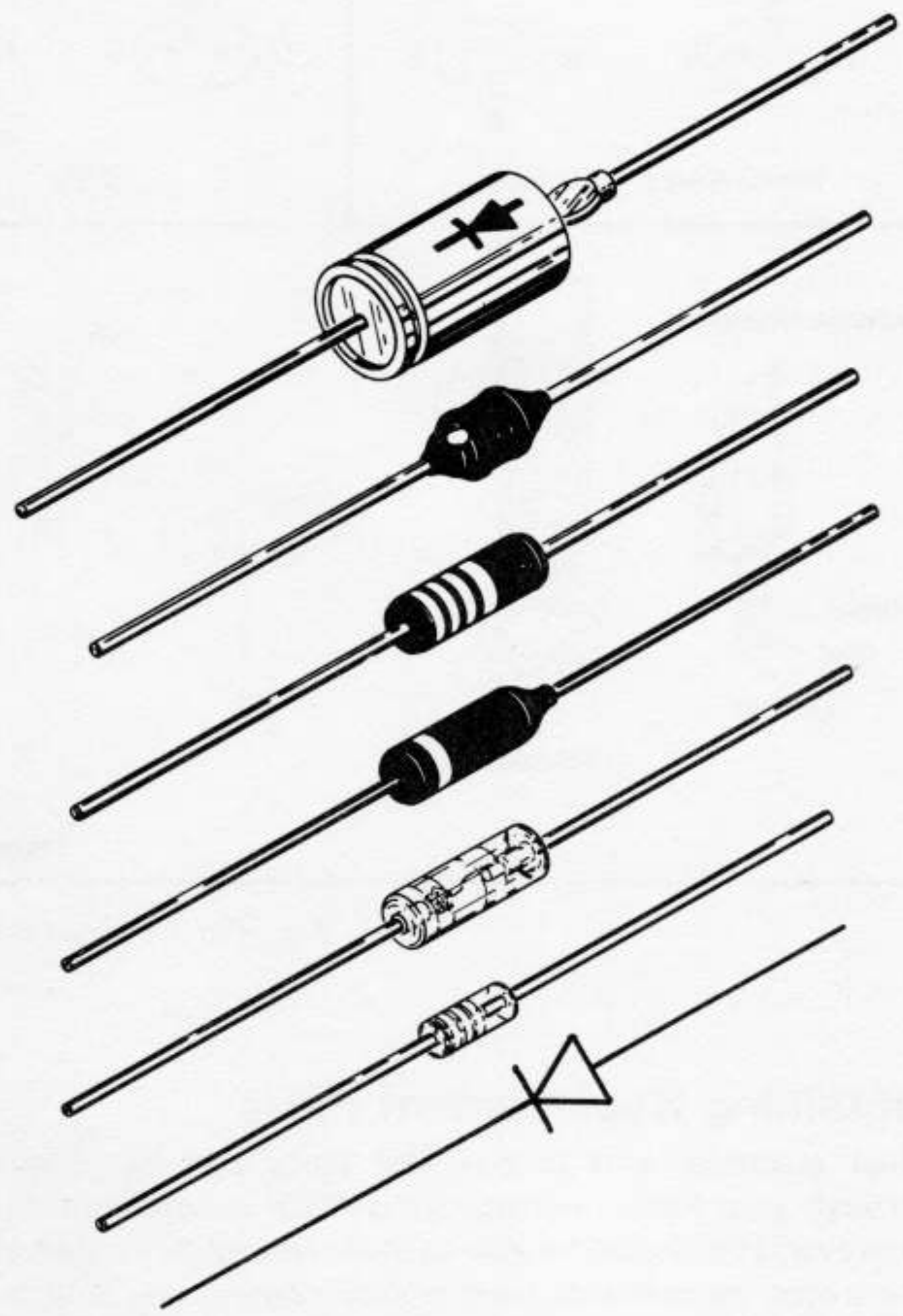
Rated Voltage VDC 25°C	Color	CODE FOR CAPACITANCE IN PICOFARADS		
		1st Figure	2nd Figure	Multiplier
3-4	Black	0	0	None
3-6	Brown	1	1	X10
3-10	Red	2	2	$X10^2$
3-15	Orange	3	3	$X10^3$
3-20	Yellow	4	4	$X10^4$
3-25	Green	5	5	$X10^5$
3-35	Blue	6	6	$X10^6$
3-50	Violet	7	7	$X10^7$
	Gray	8	8	
3	White	9	9	

(1733)2312-15

Fig. 7-1. Tantalum Capacitor Color Code.

Diode Code

The cathode of each glass-encased diode is indicated by a stripe, a series of stripes, or a dot. Some diodes have a diode symbol painted on one side. Fig. 7-2 illustrates diode types and polarity markings that are used in this equipment.



(1664)2312-16

Fig. 7-2. Diode Polarity Marking.

Transistor and Integrated Circuit Pin Configuration

Lead identification for the transistors is shown in Fig. 7-3. IC pin-out diagrams are shown, when necessary, on the back of the adjoining pullout schematic diagram.

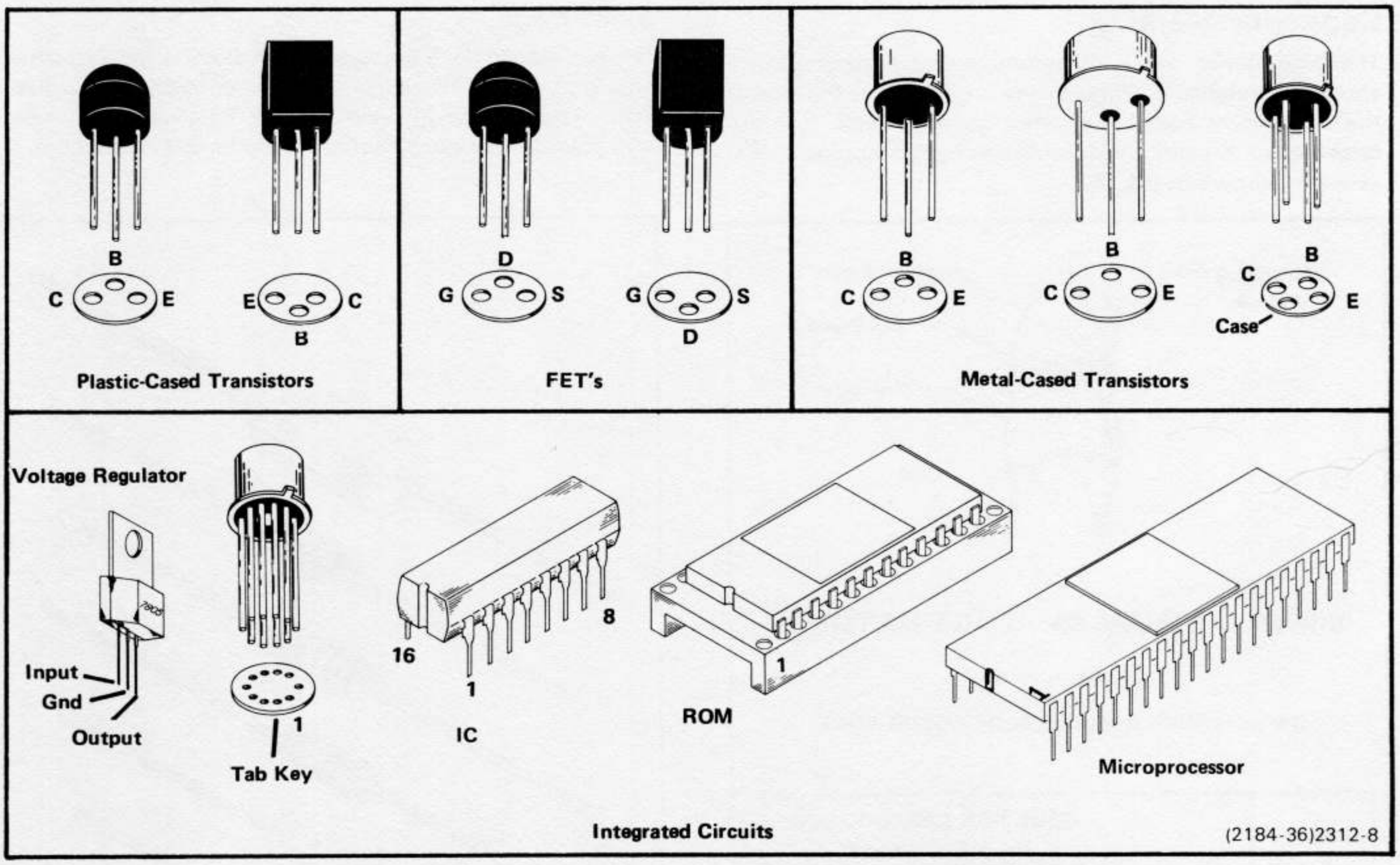


Fig. 7-3. Pin Configuration for Semiconductor Components.

Obtaining Replacement Parts

Most electrical and mechanical parts can be obtained through your local Tektronix field office or representative. However, you should be able to obtain many of the standard electronic components from a local commercial source in your area. Before you purchase or order a part from a source other than Tektronix, Inc., please check the Replaceable Electrical Parts list for the proper value, rating, tolerance and description. It is best to duplicate the original component as closely as possible. Parts orientation and lead dress should be duplicated, since orientation may affect circuit interaction.

If a component you have ordered has been replaced with a new or improved part, your local Field Office or representative will contact you concerning the change in the part number.

Parts Repair and Exchange Program

Tektronix service centers provide replacement or repair service on major assemblies, in addition to the unit itself. Contact your local service center for this service.

REPLACEABLE ELECTRICAL PARTS

PARTS ORDERING INFORMATION

Replacement parts are available from or through your local Tektronix, Inc. Field Office or representative.

Changes to Tektronix instruments are sometimes made to accommodate improved components as they become available, and to give you the benefit of the latest circuit improvements developed in our engineering department. It is therefore important, when ordering parts, to include the following information in your order: Part number, instrument type or number, serial number, and modification number if applicable.

If a part you have ordered has been replaced with a new or improved part, your local Tektronix, Inc. Field Office or representative will contact you concerning any change in part number.

Change information, if any, is located at the rear of this manual.

LIST OF ASSEMBLIES

A list of assemblies can be found at the beginning of the Electrical Parts List. The assemblies are listed in numerical order. When the complete component number of a part is known, this list will identify the assembly in which the part is located.

CROSS INDEX-MFR. CODE NUMBER TO MANUFACTURER

The Mfr. Code Number to Manufacturer index for the Electrical Parts List is located immediately after this page. The Cross Index provides codes, names and addresses of manufacturers of components listed in the Electrical Parts List.

ABBREVIATIONS

Abbreviations conform to American National Standard Y1.1.

COMPONENT NUMBER (column one of the Electrical Parts List)

A numbering method has been used to identify assemblies, subassemblies and parts. Examples of this numbering method and typical expansions are illustrated by the following:

Example a.

A23R1234 — component number: A23 (Assembly number) R1234 (Circuit number)

Read: Resistor 1234 of Assembly 23

Example b.

A23A2R1234 — component number: A23 (Assembly number) A2 (Subassembly number) R1234 (Circuit number)

Read: Resistor 1234 of Subassembly 2 of Assembly 23

Only the circuit number will appear on the diagrams and circuit board illustrations. Each diagram and circuit board illustration is clearly marked with the assembly number. Assembly numbers are also marked on the mechanical exploded views located in the Mechanical Parts List. The component number is obtained by adding the assembly number prefix to the circuit number.

The Electrical Parts List is divided and arranged by assemblies in numerical sequence (e.g., assembly A1 with its subassemblies and parts, precedes assembly A2 with its subassemblies and parts).

Chassis-mounted parts have no assembly number prefix and are located at the end of the Electrical Parts List.

TEKTRONIX PART NO. (column two of the Electrical Parts List)

Indicates part number to be used when ordering replacement part from Tektronix.

SERIAL/MODEL NO. (columns three and four of the Electrical Parts List)

Column three (3) indicates the serial number at which the part was first used. Column four (4) indicates the serial number at which the part was removed. No serial number entered indicates part is good for all serial numbers.

NAME & DESCRIPTION (column five of the Electrical Parts List)

In the Parts List, an Item Name is separated from the description by a colon (:). Because of space limitations, an Item Name may sometimes appear as incomplete. For further Item Name identification, the U.S. Federal Cataloging Handbook H6-1 can be utilized where possible.

MFR. CODE (column six of the Electrical Parts List)

Indicates the code number of the actual manufacturer of the part. (Code to name and address cross reference can be found immediately after this page.)

MFR. PART NUMBER (column seven of the Electrical Parts List)

Indicates actual manufacturers part number.

CROSS INDEX—MFR. CODE NUMBER TO MANUFACTURER

Mfr. Code	Manufacturer	Address	City, State, Zip
000LI	TOPTRON CORP		TOKYO, JAPAN
00779	AMP, INC.	P.O. BOX 3608	HARRISBURG, PA 17105
01121	ALLEN-BRADLEY COMPANY	1201 2ND STREET SOUTH	MILWAUKEE, WI 53204
01295	TEXAS INSTRUMENTS, INC.		
	SEMICONDUCTOR GROUP	P.O. BOX 5012	DALLAS, TX 75222
02735	RCA CORPORATION, SOLID STATE DIVISION	ROUTE 202	SOMERVILLE, NY 08876
02777	HOPKINS ENGINEERING COMPANY	12900 FOOTHILL BLVD.	SAN FERNANDO, CA 91342
04009	ARROW-HART, INC.	103 HAWTHORNE STREET	HARTFORD, CT 06106
04222	AVX CERAMICS, DIVISION OF AVX CORP.	P O BOX 867	MYRTLE BEACH, SC 29577
04713	MOTOROLA, INC., SEMICONDUCTOR PROD. DIV.	5005 E MCDOWELL RD,PO BOX 20923	PHOENIX, AZ 85036
05574	VIKING INDUSTRIES, INC.	21001 NORDHOFF STREET	CHATSWORTH, CA 91311
07263	FAIRCHILD SEMICONDUCTOR, A DIV. OF		
	FAIRCHILD CAMERA AND INSTRUMENT CORP.	464 ELLIS STREET	MOUNTAIN VIEW, CA 94042
09023	CORNELL-DUBILIER ELECTRONIC DIVISION		
	FEDERAL PACIFIC ELECTRIC CO.	2652 DALRYMPLE ST.	SANFORD, NC 27330
14433	ITT SEMICONDUCTORS	3301 ELECTRONICS WAY	
		P O BOX 3049	WEST PALM BEACH, FL 33402
14604	ELMWOOD SENSORS, INC.	1655 ELMWOOD AVENUE	CRANSTON, RI 02907
18324	SIGNETICS CORP.	811 E. ARQUES	SUNNYVALE, CA 94086
27014	NATIONAL SEMICONDUCTOR CORP.	2900 SEMICONDUCTOR DR.	SANTA CLARA, CA 95051
32997	BOURNS, INC., TRIMPOT PRODUCTS DIV.	1200 COLUMBIA AVE.	RIVERSIDE, CA 92507
34335	ADVANCED MICRO DEVICES	901 THOMPSON PL.	SUNNYVALE, CA 94086
34649	INTEL CORP.	3065 BOWERS AVE.	SANTA CLARA, CA 95051
51642	CENTRE ENGINEERING INC.	2820 E COLLEGE AVENUE	STATE COLLEGE, PA 16801
54473	MATSUSHITA ELECTRIC, CORP. OF AMERICA	1 PANASONIC WAY	SECAUCUS, NJ 07094
55680	NICHICON/AMERICA/CORP.	6435 N PROESEL AVENUE	CHICAGO, IL 60645
56289	SPRAGUE ELECTRIC CO.	87 MARSHALL ST.	NORTH ADAMS, MA 01247
57668	R-OHM CORP.	16931 MILLIKEN AVE.	IRVINE, CA 92713
58361	GENERAL INSTRUMENT CORP.		
	OPTO ELECTRONICS DIV.	3400 HILLVIEW AVE	PALO ALTO, CA 94304
59660	TUSONIX INC.	2155 N FORBES BLVD	TUCSON, AZ 85705
59821	CENTRALAB INC	7158 MERCHANT AVE	EL PASO, TX 79915
	SUB NORTH AMERICAN PHILIPS CORP		
71400	BUSSMAN MFG., DIVISION OF MCGRAW-		
	EDISON CO.	2536 W. UNIVERSITY ST.	ST. LOUIS, MO 63107
72982	ERIE TECHNOLOGICAL PRODUCTS, INC.	644 W. 12TH ST.	ERIE, PA 16512
73138	BECKMAN INSTRUMENTS, INC., HELIPOT DIV.	2500 HARBOR BLVD.	FULLERTON, CA 92634
75042	TRW ELECTRONIC COMPONENTS, IRC FIXED		
	RESISTORS, PHILADELPHIA DIVISION	401 N. BROAD ST.	PHILADELPHIA, PA 19108
75378	CTS KNIGHTS, INC.	400 REIMANN AVE.	SANDWICH, IL 60548
80009	TEKTRONIX, INC.	P O BOX 500	BEAVERTON, OR 97077
82389	SWITCHCRAFT, INC.	5555 N. ELSTON AVE.	CHICAGO, IL 60630
91637	DALE ELECTRONICS, INC.	P. O. BOX 609	COLUMBUS, NE 68601
96733	SAN FERNANDO ELECTRIC MFG CO	1501 FIRST ST	SAN FERNANDO, CA 91341

Component No.	Tektronix Part No.	Serial/Model No. Eff	Dscont	Name & Description	Mfr Code	Mfr Part Number
A5	670-6029-00			CKT BOARD ASSY:MAIN INTERCONNECT	80009	670-6029-00
A15	670-6037-00			CKT BOARD ASSY:KEYBOARD/DISPLAY	80009	670-6037-00
A20	670-4552-03			CKT BOARD ASSY:POWER SUPPLY	80009	670-4552-03
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A5	----- -----			CKT BOARD ASSY:MAIN INTERCONNECT		
A5C1016	281-0775-00			CAP.,FXD,CER DI:0.1UF,20%,50V	04222	MA205E104MAA
A5C1021	281-0775-00			CAP.,FXD,CER DI:0.1UF,20%,50V	04222	MA205E104MAA
A5C1051	281-0775-00			CAP.,FXD,CER DI:0.1UF,20%,50V	04222	MA205E104MAA
A5C1069	281-0775-00			CAP.,FXD,CER DI:0.1UF,20%,50V	04222	MA205E104MAA
A5C1091	281-0759-00			CAP.,FXD,CER DI:22PF,10%,100V	96733	R2735
A5C2056	283-0027-00			CAP.,FXD,CER DI:0.02UF,20%,50V	56289	1C20X5R203M050B
A5C2062	281-0775-00			CAP.,FXD,CER DI:0.1UF,20%,50V	04222	MA205E104MAA
A5C2081	281-0775-00			CAP.,FXD,CER DI:0.1UF,20%,50V	04222	MA205E104MAA
A5C2084	283-0198-00			CAP.,FXD,CER DI:0.22UF,20%,50V	56289	1C10Z5U223M050B
A5C2097	283-0185-00			CAP.,FXD,CER DI:2.5PF,5%,50V	72982	8101B057C0K0295B
A5C3012	290-0848-00			CAP.,FXD,ELCTLT:47UF,-20+100%,16 WVDC	54473	ECE-A16N47U
A5C3031	281-0775-00			CAP.,FXD,CER DI:0.1UF,20%,50V	04222	MA205E104MAA
A5C3041	281-0775-00			CAP.,FXD,CER DI:0.1UF,20%,50V	04222	MA205E104MAA
A5C3061	281-0775-00			CAP.,FXD,CER DI:0.1UF,20%,50V	04222	MA205E104MAA
A5C3089	281-0758-00			CAP.,FXD,CER DI:15PF,20%,100V	04222	CG101A150M150M
A5C4031	281-0775-00			CAP.,FXD,CER DI:0.1UF,20%,50V	04222	MA205E104MAA
A5C4041	281-0775-00			CAP.,FXD,CER DI:0.1UF,20%,50V	04222	MA205E104MAA
A5C4079	281-0775-00			CAP.,FXD,CER DI:0.1UF,20%,50V	04222	MA205E104MAA
A5C4091	281-0775-00			CAP.,FXD,CER DI:0.1UF,20%,50V	04222	MA205E104MAA
A5C5011	281-0775-00			CAP.,FXD,CER DI:0.1UF,20%,50V	04222	MA205E104MAA
A5C5031	281-0775-00			CAP.,FXD,CER DI:0.1UF,20%,50V	04222	MA205E104MAA
A5C5051	281-0775-00			CAP.,FXD,CER DI:0.1UF,20%,50V	04222	MA205E104MAA
A5C5071	281-0775-00			CAP.,FXD,CER DI:0.1UF,20%,50V	04222	MA205E104MAA
A5C6011	281-0775-00			CAP.,FXD,CER DI:0.1UF,20%,50V	04222	MA205E104MAA
A5C6051	281-0775-00			CAP.,FXD,CER DI:0.1UF,20%,50V	04222	MA205E104MAA
A5C6071	281-0775-00			CAP.,FXD,CER DI:0.1UF,20%,50V	04222	MA205E104MAA
A5C6091	281-0775-00			CAP.,FXD,CER DI:0.1UF,20%,50V	04222	MA205E104MAA
A5C7049	283-0789-00			CAP.,FXD,MICA D:600PF,1%,500V	09023	CD15FC601F03
A5C7062	281-0775-00			CAP.,FXD,CER DI:0.1UF,20%,50V	04222	MA205E104MAA
A5C7088	290-0782-00			CAP.,FXD,ELCTLT:4.7UF,+75-10%,35V	55680	ULA1V4R7TEA
A5C7089	283-0003-00			CAP.,FXD,CER DI:0.01UF,+80-20%,150V	59821	2DDH66J103Z
A5C8011	281-0775-00			CAP.,FXD,CER DI:0.1UF,20%,50V	04222	MA205E104MAA
A5C8031	281-0775-00			CAP.,FXD,CER DI:0.1UF,20%,50V	04222	MA205E104MAA
A5C8085	281-0775-00			CAP.,FXD,CER DI:0.1UF,20%,50V	04222	MA205E104MAA
A5C8091	281-0775-00			CAP.,FXD,CER DI:0.1UF,20%,50V	04222	MA205E104MAA
A5C8097	281-0775-00			CAP.,FXD,CER DI:0.1UF,20%,50V	04222	MA205E104MAA
A5C9041	281-0775-00			CAP.,FXD,CER DI:0.1UF,20%,50V	04222	MA205E104MAA
A5C9094	290-0782-00			CAP.,FXD,ELCTLT:4.7UF,+75-10%,35V	55680	ULA1V4R7TEA
A5C9099	281-0775-00			CAP.,FXD,CER DI:0.1UF,20%,50V	04222	MA205E104MAA
A5CR2013	152-0075-00			SEMICOND DEVICE:SW,GE,22V,40MA	14433	G866
A5CR8093	152-0141-02			SEMICOND DEVICE:SILICON,30V,150MA	01295	1N4152R
A5CR8095	152-0141-02			SEMICOND DEVICE:SILICON,30V,150MA	01295	1N4152R
A5J1060	131-0993-00			BUS,CONDUCTOR:2 WIRE BLACK	00779	850100-01
A5J1070	131-0993-00			BUS,CONDUCTOR:2 WIRE BLACK	00779	850100-01
A5J1080	131-0993-00			BUS,CONDUCTOR:2 WIRE BLACK	00779	850100-01
A5J8060	131-2143-00			CONN,RCPT,ELEC:CKT CD,72 CONT,RIGHT ANGLE	05574	000231-3939
A5J9060	131-2143-00			CONN,RCPT,ELEC:CKT CD,72 CONT,RIGHT ANGLE	05574	000231-3939
A5Q1014	151-0341-00			TRANSISTOR:SILICON,NPN	07263	S040065

Component No.	Tektronix Part No.	Serial/Model No. Eff	Dscont	Name & Description	Mfr Code	Mfr Part Number
A5Q2012	151-0341-00			TRANSISTOR:SILICON,NPN	07263	S040065
A5Q9096	151-0515-01			SCR:SILICON	04713	SCR1256K
A5R2012	315-0103-00			RES.,FXD,CMPSN:10K OHM,5%,0.25W	01121	CB1035
A5R2014	315-0104-00			RES.,FXD,CMPSN:100K OHM,5%,0.25W	01121	CB1045
A5R2015	315-0103-00			RES.,FXD,CMPSN:10K OHM,5%,0.25W	01121	CB1035
A5R2016	315-0102-00			RES.,FXD,CMPSN:1K OHM,5%,0.25W	01121	CB1025
A5R2017	315-0102-00			RES.,FXD,CMPSN:1K OHM,5%,0.25W	01121	CB1025
A5R2020	315-0302-00			RES.,FXD,CMPSN:3K OHM,5%,0.25W	01121	CB3025
A5R2040	315-0302-00			RES.,FXD,CMPSN:3K OHM,5%,0.25W	01121	CB3025
A5R2061	315-0681-00			RES.,FXD,CMPSN:680 OHM,5%,0.25W	01121	CB6815
A5R2079	315-0622-00			RES.,FXD,CMPSN:6.2K OHM,5%,0.25W	01121	CB6225
A5R2089	315-0105-00			RES.,FXD,CMPSN:1M OHM,5%,0.25W	01121	CB1055
A5R2096	315-0105-00			RES.,FXD,CMPSN:1M OHM,5%,0.25W	01121	CB1055
A5R3011	315-0101-00			RES.,FXD,CMPSN:100 OHM,5%,0.25W	01121	CB1015
A5R3091	315-0182-00			RES.,FXD,CMPSN:1.8K OHM,5%,0.25W	01121	CB1825
A5R3099	315-0182-00			RES.,FXD,CMPSN:1.8K OHM,5%,0.25W	01121	CB1825
A5R4010	307-0648-00			RES,NTWK,FXD,FI:8,100 OHM,2%,0.125W	01121	316B101
A5R4012	315-0222-00			RES.,FXD,CMPSN:2.2K OHM,5%,0.25W	01121	CB2225
A5R4013	315-0222-00			RES.,FXD,CMPSN:2.2K OHM,5%,0.25W	01121	CB2225
A5R4014	315-0222-00			RES.,FXD,CMPSN:2.2K OHM,5%,0.25W	01121	CB2225
A5R4015	315-0222-00			RES.,FXD,CMPSN:2.2K OHM,5%,0.25W	01121	CB2225
A5R4016	315-0222-00			RES.,FXD,CMPSN:2.2K OHM,5%,0.25W	01121	CB2225
A5R4017	315-0222-00			RES.,FXD,CMPSN:2.2K OHM,5%,0.25W	01121	CB2225
A5R4018	315-0222-00			RES.,FXD,CMPSN:2.2K OHM,5%,0.25W	01121	CB2225
A5R6051	307-0650-00			RES NTWK,FXD,FI:9,2.7K OHM,5%,0.150W	32997	4310R-101-272
A5R6052	307-0650-00			RES NTWK,FXD,FI:9,2.7K OHM,5%,0.150W	32997	4310R-101-272
A5R6061	307-0650-00			RES NTWK,FXD,FI:9,2.7K OHM,5%,0.150W	32997	4310R-101-272
A5R6062	307-0650-00			RES NTWK,FXD,FI:9,2.7K OHM,5%,0.150W	32997	4310R-101-272
A5R6081	307-0502-00			RES NTWK,FXD,FI:(9) 1.8K OHM,20%,0.125W	91637	MSP10A01-182M
A5R6096	315-0182-00			RES.,FXD,CMPSN:1.8K OHM,5%,0.25W	01121	CB1825
A5R7011	301-0222-00			RES.,FXD,CMPSN:2.2K OHM,5%,0.50W	01121	EB2225
A5R7051	307-0502-00			RES NTWK,FXD,FI:(9) 1.8K OHM,20%,0.125W	91637	MSP10A01-182M
A5R7052	321-0071-00			RES.,FXD,FILM:53.6 OHM,1%,0.125W	91637	MFF1816G53R60F
A5R7061	307-0502-00			RES NTWK,FXD,FI:(9) 1.8K OHM,20%,0.125W	91637	MSP10A01-182M
A5R7091	315-0103-00			RES.,FXD,CMPSN:10K OHM,5%,0.25W	01121	CB1035
A5R8038	315-0222-00			RES.,FXD,CMPSN:2.2K OHM,5%,0.25W	01121	CB2225
A5R8092	315-0103-00			RES.,FXD,CMPSN:10K OHM,5%,0.25W	01121	CB1035
A5R8094	315-0104-00			RES.,FXD,CMPSN:100K OHM,5%,0.25W	01121	CB1045
A5R8096	315-0471-00			RES.,FXD,CMPSN:470 OHM,5%,0.25W	01121	CB4715
A5R9011	301-0222-00			RES.,FXD,CMPSN:2.2K OHM,5%,0.50W	01121	EB2225
A5R9020	315-0302-00			RES.,FXD,CMPSN:3K OHM,5%,0.25W	01121	CB3025
A5R9082	315-0182-00			RES.,FXD,CMPSN:1.8K OHM,5%,0.25W	01121	CB1825
A5R9083	315-0182-00			RES.,FXD,CMPSN:1.8K OHM,5%,0.25W	01121	CB1825
A5U1010	156-0387-02			MICROCIRCUIT,DI:DUAL J-K FF,BURN IN	01295	SN74LS73
A5U1020	156-0844-02			MICROCIRCUIT,DI:SYN 4 BIT CNTR,SCRN	01295	SN74LS161A
A5U1030	156-0469-02			MICROCIRCUIT,DI:3/8 LINE DCDR	01295	SN74LS138NP3
A5U1040	156-1059-01			MICROCIRCUIT,DI:DUAL J-K EDGE TRIGGERED	01295	SN74LS109A
A5U1050	156-0381-02			MICROCIRCUIT,DI:QUAD 2-INP EXCL OR GATE	01295	SN74LS86
A5U1060	156-1061-02			MICROCIRCUIT,DI:DUAL JK FF,SCREENED	07263	SL81712
A5U1070	156-0844-02			MICROCIRCUIT,DI:SYN 4 BIT CNTR,SCRN	01295	SN74LS161A
A5U1080	156-0956-02			MICROCIRCUIT,DI:OCTAL BFR W/3 STATE OUT	01295	SN74LS244NP3
A5U2010	156-0391-02			MICROCIRCUIT,DI:HEX LATCH W/CLEAR	01295	SN74LS174
A5U2012	156-1172-01			MICROCIRCUIT,DI:DUAL 4 BIT CNTR	01295	SN74LS393
A5U2020	156-0956-02			MICROCIRCUIT,DI:OCTAL BFR W/3 STATE OUT	01295	SN74LS244NP3

Component No.	Tektronix Part No.	Serial/Model No. Eff	Dscont	Name & Description	Mfr Code	Mfr Part Number
A5U2022	156-0382-02			MICROCIRCUIT,DI:QUAD 2-INP NAND GATE	01295	SN74LS00
A5U2030	156-0718-03			MICROCIRCUIT,DI:TRIPLE 3-INP NOR GATE	01295	SN74LS27
A5U2040	156-1206-00			MICROCIRCUIT,DI:N-CHANNEL	04713	MC68B50P OR L
A5U2050	156-0645-00			MICROCIRCUIT,DI:EX INV ST NAND GATES,SCRN	01295	SN741LS14(NP3)
A5U2060	156-0479-02			MICROCIRCUIT,DI:QUAD 2-INP OR GATE	01295	SN74LS32NP3
A5U2070	156-0865-02			MICROCIRCUIT,DI:OCTAL D-TYPE FF W/CLEAR	01295	SN74LS273NP3
A5U2080	156-0545-01			MICROCIRCUIT,DI:12 BIT BINARY CNTR,SCRN	04713	MC14040BCLD
A5U2090	156-0745-01			MICROCIRCUIT,DI:HEX INVERTER,BURN-IN	02735	CD4069UBFX
A5U3010	156-0844-02			MICROCIRCUIT,DI:SYN 4 BIT CNTR,SCRN	01295	SN74LS161A
A5U3020	156-0989-02			MICROCIRCUIT,DI:4 X 4 RGTR FILE,BURN-IN	04713	SN74LS670NDS
A5U3030	156-0386-02			MICROCIRCUIT,DI:TRIPLE 3-INP NAND GATE	27014	DM74LS10N
A5U3040	156-1281-00			MICROCIRCUIT,DI:1024 X 4 STATIC RAM	34649	P2114AL-4/S7129
A5U3050	156-1281-00			MICROCIRCUIT,DI:1024 X 4 STATIC RAM	34649	P2114AL-4/S7129
A5U3060	156-1281-00			MICROCIRCUIT,DI:1024 X 4 STATIC RAM	34649	P2114AL-4/S7129
A5U3070	156-1065-01			MICROCIRCUIT,DI:OCTAL D TYPE TRANS LATCHES	34335	AM74LS373
A5U3080	156-0479-02			MICROCIRCUIT,DI:QUAD 2-INP OR GATE	01295	SN74LS32NP3
A5U3090	156-0844-02			MICROCIRCUIT,DI:SYN 4 BIT CNTR,SCRN	01295	SN74LS161A
A5U4010	156-0355-00			MICROCIRCUIT,LI:7-XSTR,COMMON EMITTER	02735	CA3081
A5U4020	156-0989-02			MICROCIRCUIT,DI:4 X 4 RGTR FILE,BURN-IN	04713	SN74LS670NDS
A5U4030	156-0180-04			MICROCIRCUIT,DI:QUAD 2-INPUT NAND GATE	01295	SN74S00NP3
A5U4032	156-0382-02			MICROCIRCUIT,DI:QUAD 2-INP NAND GATE	01295	SN74LS00
A5U4040	156-1281-00			MICROCIRCUIT,DI:1024 X 4 STATIC RAM	34649	P2114AL-4/S7129
A5U4050	156-1281-00			MICROCIRCUIT,DI:1024 X 4 STATIC RAM	34649	P2114AL-4/S7129
A5U4060	156-1281-00			MICROCIRCUIT,DI:1024 X 4 STATIC RAM	34649	P2114AL-4/S7129
A5U4070	156-0990-01			MICROCIRCUIT,DI:QUADR Z-INPUT EXCL OR GATE	80009	156-0990-01
A5U4080	156-0724-02			MICROCIRCUIT,DI:HEX INV W/OC OUT,BURN-IN	01295	SN74LS05
A5U4090	156-0382-02			MICROCIRCUIT,DI:QUAD 2-INP NAND GATE	01295	SN74LS00
A5U5010	160-0223-00			MICROCIRCUIT,DI:256 BIT PROM W/3 STATE	80009	160-0223-00
A5U5020	156-0989-02			MICROCIRCUIT,DI:4 X 4 RGTR FILE,BURN-IN	04713	SN74LS670NDS
A5U5030	156-0386-02			MICROCIRCUIT,DI:TRIPLE 3-INP NAND GATE	27014	DM74LS10N
A5U5040	156-1281-00			MICROCIRCUIT,DI:1024 X 4 STATIC RAM	34649	P2114AL-4/S7129
A5U5050	156-1065-01			MICROCIRCUIT,DI:OCTAL D TYPE TRANS LATCHES	34335	AM74LS373
A5U5060	156-0956-02			MICROCIRCUIT,DI:OCTAL BFR W/3 STATE OUT	01295	SN74LS244NP3
A5U5070	156-0865-02			MICROCIRCUIT,DI:OCTAL D-TYPE FF W/CLEAR	01295	SN74LS273NP3
A5U5080	156-0865-02			MICROCIRCUIT,DI:OCTAL D-TYPE FF W/CLEAR	01295	SN74LS273NP3
A5U6010	156-0694-02			MICROCIRCUIT,DI:DCDR/3 LINE TO 8 LINE,SCRN	07263	74S138DCQR
A5U6020	156-0989-02			MICROCIRCUIT,DI:4 X 4 RGTR FILE,BURN-IN	04713	SN74LS670NDS
A5U6030	156-1058-00			MICROCIRCUIT,DI:OCTAL SCHMITT TRIGGER BFR	01295	SN74S240J
A5U6040	156-1281-00			MICROCIRCUIT,DI:1024 X 4 STATIC RAM	34649	P2114AL-4/S7129
A5U6050	156-0956-02			MICROCIRCUIT,DI:OCTAL BFR W/3 STATE OUT	01295	SN74LS244NP3
A5U6060	156-0956-02			MICROCIRCUIT,DI:OCTAL BFR W/3 STATE OUT	01295	SN74LS244NP3
A5U6070	156-0990-01			MICROCIRCUIT,DI:QUADR Z-INPUT EXCL OR GATE	80009	156-0990-01
A5U6080	156-0985-01			MICROCIRCUIT,DI:DUAL 5 INPUT NOR GATE,SCRN	04713	SN74LS260
A5U6090	156-0724-02			MICROCIRCUIT,DI:HEX INV W/OC OUT,BURN-IN	01295	SN74LS05
A5U7010	156-0878-01			MICROCIRCUIT,DI:QUAD LINE RCVR,SCRN	80009	156-0878-01
A5U7020	156-1206-00			MICROCIRCUIT,DI:N-CHANNEL	04713	MC68B50P OR L
A5U7030	156-0865-02			MICROCIRCUIT,DI:OCTAL D-TYPE FF W/CLEAR	01295	SN74LS273NP3
A5U7040	156-1273-01			MICROCIRCUIT,DI:8 BIT EQUAL TO COMPTR,SCRN	80009	156-1273-01
A5U7050	156-1065-01			MICROCIRCUIT,DI:OCTAL D TYPE TRANS LATCHES	34335	AM74LS373
A5U7060	156-1065-01			MICROCIRCUIT,DI:OCTAL D TYPE TRANS LATCHES	34335	AM74LS373
A5U7070	156-0956-02			MICROCIRCUIT,DI:OCTAL BFR W/3 STATE OUT	01295	SN74LS244NP3
A5U7090	156-0525-03			MICROCIRCUIT,DI:DUAL J-K MASTER SLAVE FF	80009	156-0525-03
A5U8010	156-0879-01			MICROCIRCUIT,DI:QUAD LINE DRIVER,SCRN	80009	156-0879-01
A5U8030	156-0694-02			MICROCIRCUIT,DI:DCDR/3 LINE TO 8 LINE,SCRN	07263	74S138DCQR

Component No.	Tektronix Part No.	Serial/Model No. Eff	Dscont	Name & Description	Mfr Code	Mfr Part Number
A5U8040	156-0956-02			MICROCIRCUIT,DI:OCTAL BFR W/3 STATE OUT	01295	SN74LS244NP3
A5U8084	156-0846-00			MICROCIRCUIT,LI:VOLTAGE REGULATOR	04713	MC7905CT
A5U9010	156-0878-01			MICROCIRCUIT,DI:QUAD LINE RCVR,SCRN	80009	156-0878-01
A5U9020	156-1206-00			MICROCIRCUIT,DI:N-CHANNEL	04713	MC68B50P OR L
A5U9030	156-0865-02			MICROCIRCUIT,DI:OCTAL D-TYPE FF W/CLEAR	01295	SN74LS273NP3
A5U9040	156-1273-01			MICROCIRCUIT,DI:8 BIT EQUAL TO COMPTR,SCRN	80009	156-1273-01
A5VR8096	152-0279-00			SEMICOND DEVICE:ZENER,0.4W,5.1V,5%	04713	SZG35010RL
A5Y1090	158-0124-00			XTAL UNIT,QTZ:2.4576 MHZ,0.05% PARALLEL	75378	MP-024

Component No.	Tektronix Part No.	Serial/Model No. Eff	Dscont	Name & Description	Mfr Code	Mfr Part Number
A15	----- -----			CKT BOARD ASSY:KEYBOARD/DISPLAY		
A15C2068	283-0111-00			CAP.,FXD,CER DI:0.1UF,20%,50V	56289	273C11
A15DS1015	150-1022-00			LAMP,LED,RDOUT:7 SEG NUMERIC,LH DEC ORANGE	58361	MAN72A
A15DS1022	150-1022-00			LAMP,LED,RDOUT:7 SEG NUMERIC,LH DEC ORANGE	58361	MAN72A
A15DS1031	150-1022-00			LAMP,LED,RDOUT:7 SEG NUMERIC,LH DEC ORANGE	58361	MAN72A
A15DS1041	150-1022-00			LAMP,LED,RDOUT:7 SEG NUMERIC,LH DEC ORANGE	58361	MAN72A
A15DS1051	150-1022-00			LAMP,LED,RDOUT:7 SEG NUMERIC,LH DEC ORANGE	58361	MAN72A
A15DS1061	150-1022-00			LAMP,LED,RDOUT:7 SEG NUMERIC,LH DEC ORANGE	58361	MAN72A
A15DS1071	150-1022-00			LAMP,LED,RDOUT:7 SEG NUMERIC,LH DEC ORANGE	58361	MAN72A
A15DS1081	150-1022-00			LAMP,LED,RDOUT:7 SEG NUMERIC,LH DEC ORANGE	58361	MAN72A
A15Q2019	151-0342-00			TRANSISTOR:SILICON,PNP	07263	S035928
A15Q2028	151-0342-00			TRANSISTOR:SILICON,PNP	07263	S035928
A15Q2035	151-0342-00			TRANSISTOR:SILICON,PNP	07263	S035928
A15Q2045	151-0342-00			TRANSISTOR:SILICON,PNP	07263	S035928
A15Q2055	151-0342-00			TRANSISTOR:SILICON,PNP	07263	S035928
A15Q2062	151-0342-00			TRANSISTOR:SILICON,PNP	07263	S035928
A15Q2070	151-0342-00			TRANSISTOR:SILICON,PNP	07263	S035928
A15Q2075	151-0342-00			TRANSISTOR:SILICON,PNP	07263	S035928
A15R2017	315-0102-00			RES.,FXD,CMPSN:1K OHM,5%,0.25W	01121	CB1025
A15R2018	315-0102-00			RES.,FXD,CMPSN:1K OHM,5%,0.25W	01121	CB1025
A15R2020	315-0102-00			RES.,FXD,CMPSN:1K OHM,5%,0.25W	01121	CB1025
A15R2041	315-0102-00			RES.,FXD,CMPSN:1K OHM,5%,0.25W	01121	CB1025
A15R2051	315-0102-00			RES.,FXD,CMPSN:1K OHM,5%,0.25W	01121	CB1025
A15R2065	315-0102-00			RES.,FXD,CMPSN:1K OHM,5%,0.25W	01121	CB1025
A15R2066	307-0502-00			RES NTWK,FXD,FI:(9) 1.8K OHM,20%,0.125W	91637	MSP10A01-182M
A15R2068	315-0102-00			RES.,FXD,CMPSN:1K OHM,5%,0.25W	01121	CB1025
A15R2085	315-0102-00			RES.,FXD,CMPSN:1K OHM,5%,0.25W	01121	CB1025
A15R4079	315-0182-00			RES.,FXD,CMPSN:1.8K OHM,5%,0.25W	01121	CB1825
A15R5066	315-0182-00			RES.,FXD,CMPSN:1.8K OHM,5%,0.25W	01121	CB1825
A15R5079	315-0182-00			RES.,FXD,CMPSN:1.8K OHM,5%,0.25W	01121	CB1825
A15S2023	263-0019-09			SWITCH PB ASSY:MOMENTARY	80009	263-0019-09
A15S2035	263-0019-09			SWITCH PB ASSY:MOMENTARY	80009	263-0019-09
A15S2046	263-0019-09			SWITCH PB ASSY:MOMENTARY	80009	263-0019-09
A15S2061	263-0019-09			SWITCH PB ASSY:MOMENTARY	80009	263-0019-09
A15S2081	263-0019-09			SWITCH PB ASSY:MOMENTARY	80009	263-0019-09
A15S3023	263-0019-09			SWITCH PB ASSY:MOMENTARY	80009	263-0019-09
A15S3025	263-0019-09			SWITCH PB ASSY:MOMENTARY	80009	263-0019-09
A15S3035	263-0019-09			SWITCH PB ASSY:MOMENTARY	80009	263-0019-09
A15S3037	263-0019-09			SWITCH PB ASSY:MOMENTARY	80009	263-0019-09
A15S3046	263-0019-09			SWITCH PB ASSY:MOMENTARY	80009	263-0019-09
A15S3048	263-0019-09			SWITCH PB ASSY:MOMENTARY	80009	263-0019-09
A15S3062	263-0019-09			SWITCH PB ASSY:MOMENTARY	80009	263-0019-09
A15S3064	263-0019-09			SWITCH PB ASSY:MOMENTARY	80009	263-0019-09
A15S3081	263-0019-09			SWITCH PB ASSY:MOMENTARY	80009	263-0019-09
A15S3084	263-0019-09			SWITCH PB ASSY:MOMENTARY	80009	263-0019-09
A15S4023	263-0019-09			SWITCH PB ASSY:MOMENTARY	80009	263-0019-09
A15S4025	263-0019-09			SWITCH PB ASSY:MOMENTARY	80009	263-0019-09
A15S4035	263-0019-09			SWITCH PB ASSY:MOMENTARY	80009	263-0019-09
A15S4037	263-0019-09			SWITCH PB ASSY:MOMENTARY	80009	263-0019-09
A15S4046	263-0019-09			SWITCH PB ASSY:MOMENTARY	80009	263-0019-09
A15S4048	263-0019-09			SWITCH PB ASSY:MOMENTARY	80009	263-0019-09
A15S4062	263-0019-09			SWITCH PB ASSY:MOMENTARY	80009	263-0019-09
A15S4064	263-0019-09			SWITCH PB ASSY:MOMENTARY	80009	263-0019-09
A15S4081	263-0019-09			SWITCH PB ASSY:MOMENTARY	80009	263-0019-09
A15S4084	263-0019-09			SWITCH PB ASSY:MOMENTARY	80009	263-0019-09
A15U3060	156-0141-02			MICROCIRCUIT,DI:DUAL 2 TO 4 LINE DCDR/DEMX	18324	N74156(NB OR FB)

Component No.	Tektronix Part No.	Serial/Model No. Eff	Dscont	Name & Description	Mfr Code	Mfr Part Number
A20	----- -----			CKT BOARD ASSY:POWER SUPPLY		
A20C1	290-0135-00			CAP.,FXD,ELCTLT:15UF,20%,20V	56289	150D156X0020B2
A20C5	290-0135-00			CAP.,FXD,ELCTLT:15UF,20%,20V	56289	150D156X0020B2
A20C6	290-0135-00			CAP.,FXD,ELCTLT:15UF,20%,20V	56289	150D156X0020B2
A20C7	283-0003-00			CAP.,FXD,CER DI:0.01UF,+80-20%,150V	59821	2DDH66J103Z
A20C10	290-0633-00			CAP.,FXD,ELCTLT:2400UF,+75-10%,30V	56289	39D360
A20C18	283-0000-00			CAP.,FXD,CER DI:0.001UF,+100-0%,500V	59660	831610Y5U0102P
A20C20	290-0633-00			CAP.,FXD,ELCTLT:2400UF,+75-10%,30V	56289	39D360
A20C27	283-0004-00			CAP.,FXD,CER DI:0.02UF,+80-20%,150V	59821	SDDH69J203Z
A20C30	290-0632-00			CAP.,FXD,ELCTLT:6200UF,+75-10%,15V	56289	39D357
A20C35	283-0000-00			CAP.,FXD,CER DI:0.001UF,+100-0%,500V	59660	831610Y5U0102P
A20C38	283-0003-00			CAP.,FXD,CER DI:0.01UF,+80-20%,150V	59821	2DDH66J103Z
A20C39	283-0059-00			CAP.,FXD,CER DI:1UF,+80-20%,50V	51642	400050Z5U105Z
A20C48	283-0004-00			CAP.,FXD,CER DI:0.02UF,+80-20%,150V	59821	SDDH69J203Z
A20C50	290-0632-00			CAP.,FXD,ELCTLT:6200UF,+75-10%,15V	56289	39D357
A20C56	283-0000-00			CAP.,FXD,CER DI:0.001UF,+100-0%,500V	59660	831610Y5U0102P
A20C57	283-0004-00			CAP.,FXD,CER DI:0.02UF,+80-20%,150V	59821	SDDH69J203Z
A20C58	283-0003-00			CAP.,FXD,CER DI:0.01UF,+80-20%,150V	59821	2DDH66J103Z
A20C65	283-0010-00			CAP.,FXD,CER DI:0.05UF,+100-20%,50V	56289	1C10Z5U503Z050B
A20CR50	152-0488-00			SEMICOND DEVICE:SILICON,200V,1500MA	04713	SDA317
A20CR51	152-0488-00			SEMICOND DEVICE:SILICON,200V,1500MA	04713	SDA317
A20DS86	150-0035-00			LAMP,GLOW:90V,0.3MA,AID-T,WIRE LD	000LI	JH005/3011JA
A20F75	159-0015-00			FUSE,CARTRIDGE:3AG,3A,250V,0.65 SEC	71400	AGC 3
A20F76	159-0013-00			FUSE,CARTRIDGE:3AG,6A,125V,7 SEC	71400	MTH6
A20F85	159-0015-00			FUSE,CARTRIDGE:3AG,3A,250V,0.65 SEC	71400	AGC 3
A20F89	159-0022-00			FUSE,CARTRIDGE:3AG,1A,250V,FAST-BLOW	71400	AGC 1
A20Q6	151-0188-00			TRANSISTOR:SILICON,PNP	04713	SPS6868K
A20Q18	151-0301-00			TRANSISTOR:SILICON,PNP	27014	2N2907A
A20Q27	151-0190-00			TRANSISTOR:SILICON,NPN	07263	S032677
A20Q28	151-0190-00			TRANSISTOR:SILICON,NPN	07263	S032677
A20Q35	151-0301-00			TRANSISTOR:SILICON,PNP	27014	2N2907A
A20Q36	151-0188-00			TRANSISTOR:SILICON,PNP	04713	SPS6868K
A20Q37	151-0190-00			TRANSISTOR:SILICON,NPN	07263	S032677
A20Q48	151-0190-00			TRANSISTOR:SILICON,NPN	07263	S032677
A20Q56	151-0208-02			TRANSISTOR:SILICON,PNP	80009	151-0208-02
A20Q57	151-0188-00			TRANSISTOR:SILICON,PNP	04713	SPS6868K
A20Q58	151-0190-00			TRANSISTOR:SILICON,NPN	07263	S032677
A20Q68	151-0190-00			TRANSISTOR:SILICON,NPN	07263	S032677
A20R7	315-0101-00			RES.,FXD,CMPSN:100 OHM,5%,0.25W	01121	CB1015
A20R8	315-0301-00			RES.,FXD,CMPSN:300 OHM,5%,0.25W	01121	CB3015
A20R9	315-0331-00			RES.,FXD,CMPSN:330 OHM,5%,0.25W	01121	CB3315
A20R13	311-1559-00			RES.,VAR,NONWIR:10K OHM,20%,0.50W	73138	91-81-0
A20R14	315-0101-00			RES.,FXD,CMPSN:100 OHM,5%,0.25W	01121	CB1015
A20R15	308-0245-00			RES.,FXD,WW:0.6 OHM,5%,2W	91637	CW2B30 0.60HM 5%
A20R16	321-0172-00			RES.,FXD,FILM:604 OHM,1%,0.125W	91637	MFF1816G604R0F
A20R17	315-0472-00			RES.,FXD,CMPSN:4.7K OHM,5%,0.25W	01121	CB4725
A20R18	321-0173-00			RES.,FXD,FILM:619 OHM,1%,0.125W	91637	MFF1816G619R0F
A20R25	321-0222-00			RES.,FXD,FILM:2K OHM,1%,0.125W	91637	MFF1816G20000F
A20R26	315-0152-00			RES.,FXD,CMPSN:1.5K OHM,5%,0.25W	01121	CB1525
A20R27	315-0431-00			RES.,FXD,CMPSN:430 OHM,5%,0.25W	01121	CB4315
A20R28	315-0471-00			RES.,FXD,CMPSN:470 OHM,5%,0.25W	01121	CB4715
A20R34	315-0182-00			RES.,FXD,CMPSN:1.8K OHM,5%,0.25W	01121	CB1825
A20R35	321-0224-00			RES.,FXD,FILM:2.1K OHM,1%,0.125W	91637	MFF1816G21000F

Component No.	Tektronix Part No.	Serial/Model No. Eff	Dscont	Name & Description	Mfr Code	Mfr Part Number
A20R36	308-0755-00			RES.,FXD,WW:0.75 OHM,5%,2W	75042	BWH-R7500J
A20R37	315-0101-00			RES.,FXD,CMPSN:100 OHM,5%,0.25W	01121	CB1015
A20R38	315-0301-00			RES.,FXD,CMPSN:300 OHM,5%,0.25W	01121	CB3015
A20R39	315-0682-00			RES.,FXD,CMPSN:6.8K OHM,5%,0.25W	01121	CB6825
A20R43	311-1559-00			RES.,VAR,NONWIR:10K OHM,20%,0.50W	73138	91-81-0
A20R44	315-0472-00			RES.,FXD,CMPSN:4.7K OHM,5%,0.25W	01121	CB4725
A20R45	321-0189-00			RES.,FXD,FILM:909 OHM,1%,0.125W	91637	MFF1816G909R0F
A20R46	315-0431-00			RES.,FXD,CMPSN:430 OHM,5%,0.25W	01121	CB4315
A20R47	315-0101-00			RES.,FXD,CMPSN:100 OHM,5%,0.25W	01121	CB1015
A20R48	315-0471-00			RES.,FXD,CMPSN:470 OHM,5%,0.25W	01121	CB4715
A20R49	315-0101-00			RES.,FXD,CMPSN:100 OHM,5%,0.25W	01121	CB1015
A20R53	308-0643-00			RES.,FXD,WW:0.1 OHM,3%,3W	91637	RS2B-ER1000H TR
A20R56	315-0751-00			RES.,FXD,CMPSN:750 OHM,5%,0.25W	01121	CB7515
A20R57	315-0102-00			RES.,FXD,CMPSN:1K OHM,5%,0.25W	01121	CB1025
A20R58	315-0101-00			RES.,FXD,CMPSN:100 OHM,5%,0.25W	01121	CB1015
A20R62	311-1559-00			RES.,VAR,NONWIR:10K OHM,20%,0.50W	73138	91-81-0
A20R63	321-0197-00			RES.,FXD,FILM:1.1K OHM,1%,0.125W	91637	MFF1816G11000F
A20R64	315-0752-00			RES.,FXD,CMPSN:7.5K OHM,5%,0.25W	01121	CB7525
A20R65	321-0201-00			RES.,FXD,FILM:1.21K OHM,1%,0.125W	91637	MFF1816G12100F
A20R66	315-0431-00			RES.,FXD,CMPSN:430 OHM,5%,0.25W	01121	CB4315
A20R67	315-0101-00			RES.,FXD,CMPSN:100 OHM,5%,0.25W	01121	CB1015
A20R68	315-0471-00			RES.,FXD,CMPSN:470 OHM,5%,0.25W	01121	CB4715
A20R69	131-0566-00			BUS CONDUCTOR:DUMMY RES,2.375,22 AWG	57668	JWW-0200E0
A20R96	315-0304-00			RES.,FXD,CMPSN:300K OHM,5%,0.25W	01121	CB3045
A20R100	308-0499-00			RES.,FXD,WW:0.5 OHM,10%,2.5W AXIAL	91637	CW2B-R500K-TR
A20S94	260-1776-00			SWITCH,SLIDE:DPDT,3A,125VAC	82389	11A-1497A
A20S96	260-1776-00			SWITCH,SLIDE:DPDT,3A,125VAC	82389	11A-1497A
A20T80	120-1072-00			XFMR,PWR,STPDN:	80009	120-1072-00
A20VR28	152-0212-00			SEMICOND DEVICE:ZENER,0.5W,9V,5%	04713	SZ50646RL

Component No.	Tektronix Part No.	Serial/Model No. Eff	Dscont	Name & Description	Mfr Code	Mfr Part Number
				CHASSIS PARTS		
B100	119-0830-03			FAN,TUBEAXIAL:12VDC,2.4W	80009	119-0830-03
C100	290-0508-00			CAP.,FXD,ELCTLT:18,000UF,+100-10%,15V	56289	68D10444
CR52	152-0535-00			SEMICOND DEVICE:	80009	152-0535-00
FL100	119-0389-00			FILTER,RAD INTE:115/230V,3A	02777	F11935-3
J103	136-0094-00			JACK,TELEPHONE:MINIATURE,SHUNT TYPE	80009	136-0094-00
J104	136-0094-00			JACK,TELEPHONE:MINIATURE,SHUNT TYPE	80009	136-0094-00
Q39	151-0262-00			TRANSISTOR:SILICON,NPN	02735	62396
Q49	151-0262-00			TRANSISTOR:SILICON,NPN	02735	62396
Q59	151-0275-00			TRANSISTOR:SILICON,NPN	04713	SJ6847
S98	260-1842-00			SWITCH,ROCKER:DPST,16A,250VAC	04009	2600-11E 718
S100	260-1663-00			SWITCH,THRMSTC:C,OPEN 100,CL 88,8A,250V	14604	3450-21-418

DIAGRAMS AND CIRCUIT BOARD ILLUSTRATIONS

Symbols

Graphic symbols and class designation letters are based on ANSI Standard Y32.2-1975.

Logic symbology is based on ANSI Y32.14-1973 in terms of positive logic. Logic symbols depict the logic function performed and may differ from the manufacturer's data.

The overline on a signal name indicates that the signal performs its intended function when it is in the low state.

Abbreviations are based on ANSI Y1.1-1972.

Other ANSI standards that are used in the preparation of diagrams by Tektronix, Inc. are:

Y14.15, 1966	Drafting Practices.
Y14.2, 1973	Line Conventions and Lettering.
Y10.5, 1968	Letter Symbols for Quantities Used in Electrical Science and Electrical Engineering.

American National Standard Institute
1430 Broadway
New York, New York 10018

Component Values

Electrical components shown on the diagrams are in the following units unless noted otherwise:

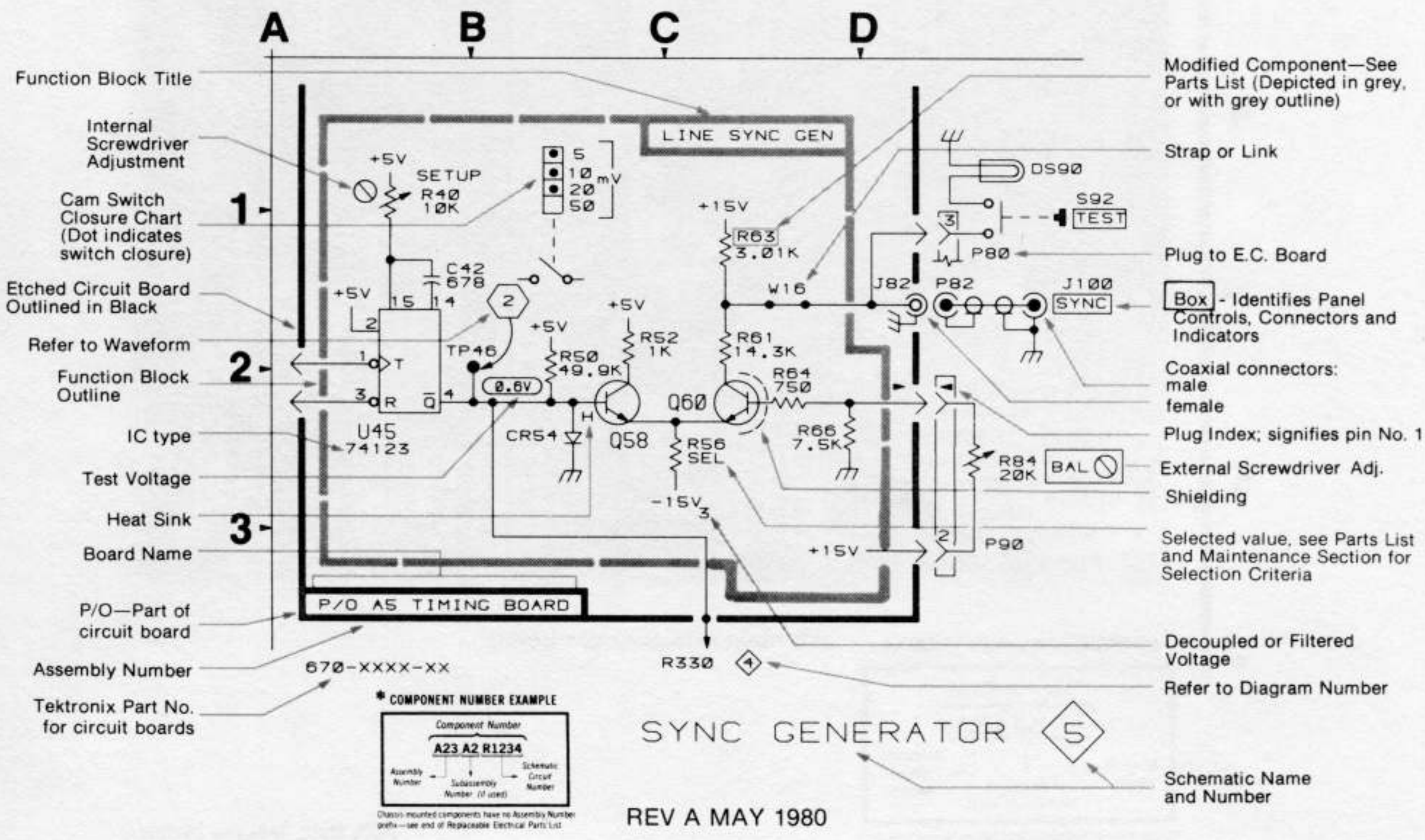
Capacitors = Values one or greater are in picofarads (pF). Values less than one are in microfarads (μF).
Resistors = Ohms (Ω).

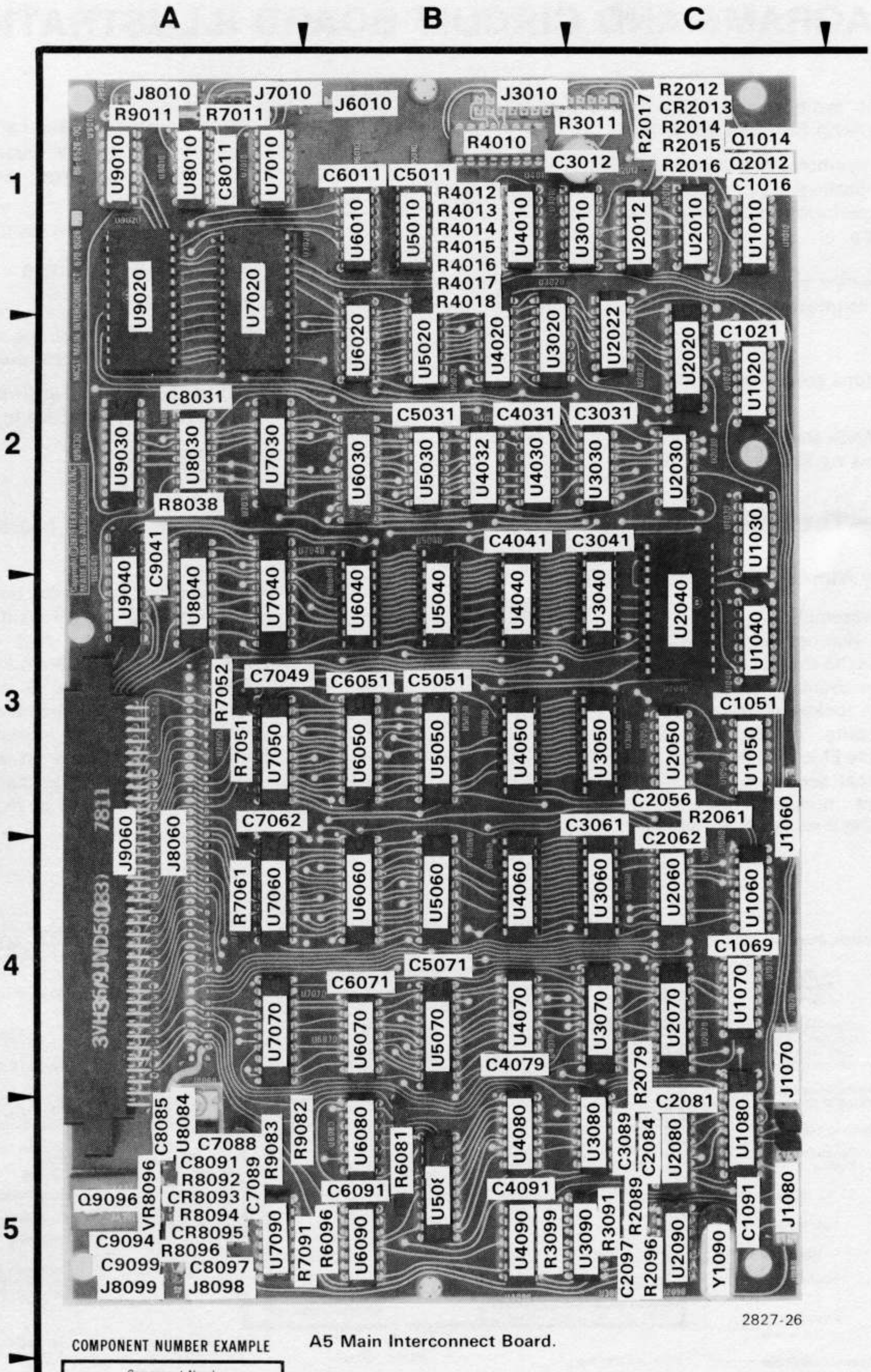
The information and special symbols below may appear in this manual.

Assembly Numbers and Grid Coordinates

Each assembly in the instrument is assigned an assembly number (e.g., A20). The assembly number appears on the circuit board outline on the diagram, in the title for the circuit board component location illustration, and in the lookup table for the schematic diagram and corresponding component locator illustration. The Replaceable Electrical Parts list is arranged by assemblies in numerical sequence; the components are listed by component number *(see following illustration for constructing a component number).

The schematic diagram and circuit board component location illustration have grids. A lookup table with the grid coordinates is provided for ease of locating the component. Only the components illustrated on the facing diagram are listed in the lookup table. When more than one schematic diagram is used to illustrate the circuitry on a circuit board, the circuit board illustration may only appear opposite the first diagram on which it was illustrated; the lookup table will list the diagram number of other diagrams that the circuitry of the circuit board appears on.

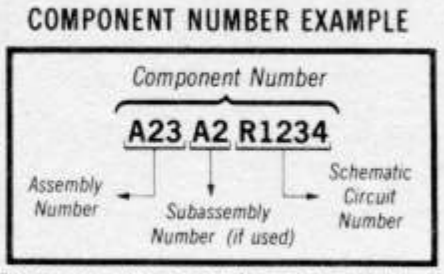




2827-26

A5 Main Interconnect Board.

COMPONENT NUMBER EXAMPLE



Chassis-mounted components have no Assembly Number prefix—see end of Replaceable Electrical Parts List.

Static Sensitive Devices
See Maintenance Section

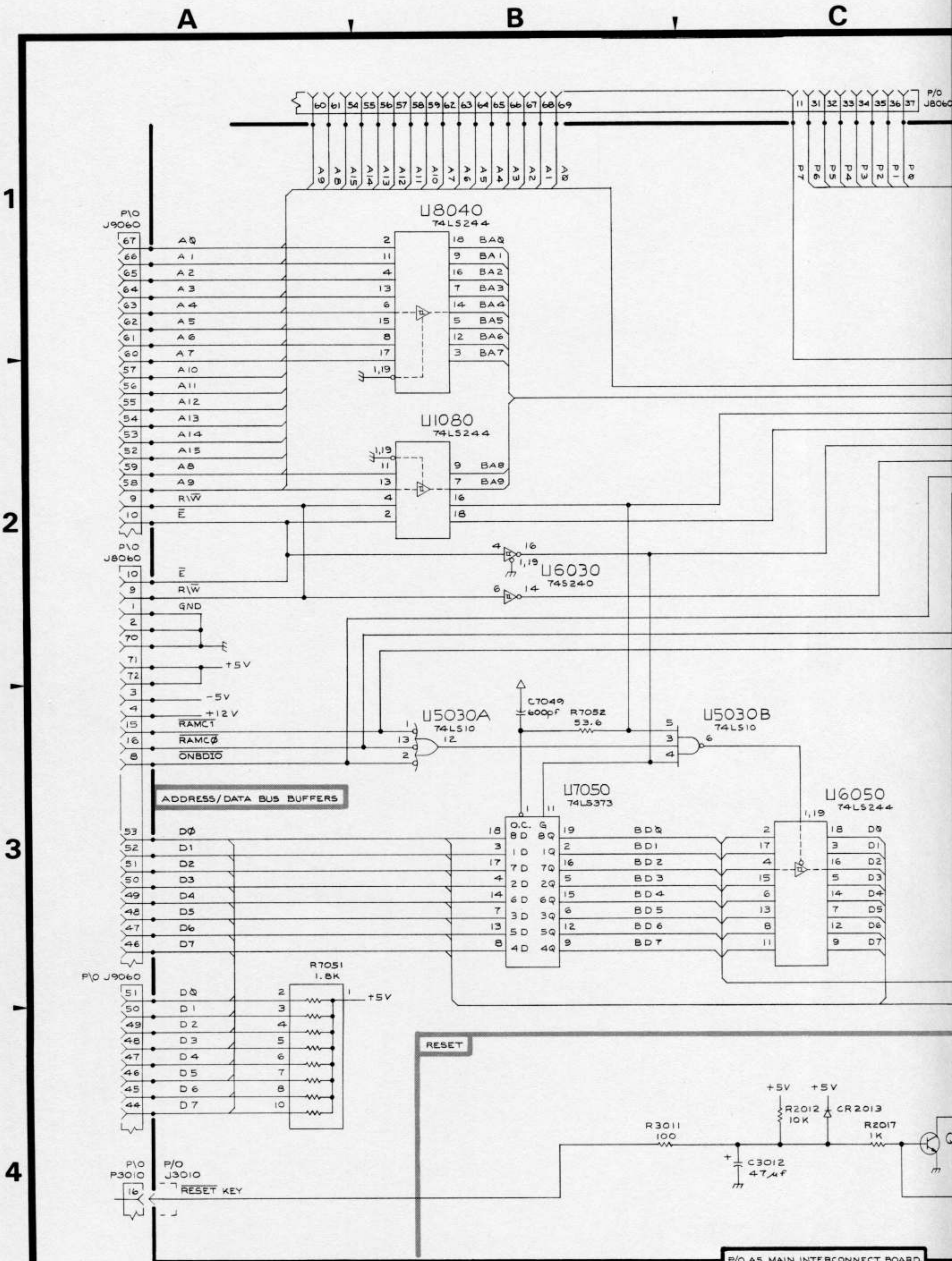
TABLE 9-1
IC PIN INFORMATION

DEVICE	VCC	GND	DEVICE	VCC	GND
2114	18	9	74LS136	14	7
25LS2521	20	10	74S138	16	8
4027	16	8	74156	16	8
4040B	16	8	74LS161	16	8
4069UB	14	7	74LS174	16	8
68B50	1	12	74S240	20	10
74LS00(S)	14	7	74LS244	20	10
74LS05	14	7	74LS260	14	7
74LS10	14	7	74LS273	20	10
74LS14	14	7	74LS373	20	10
74LS27	14	7	74LS393	14	7
74LS32	14	7	74LS670	16	8
74LS73	4	11	IM5610	16	8
74LS86	14	7	MC1488	14	7
74LS109	16	8	MC1489	14	7

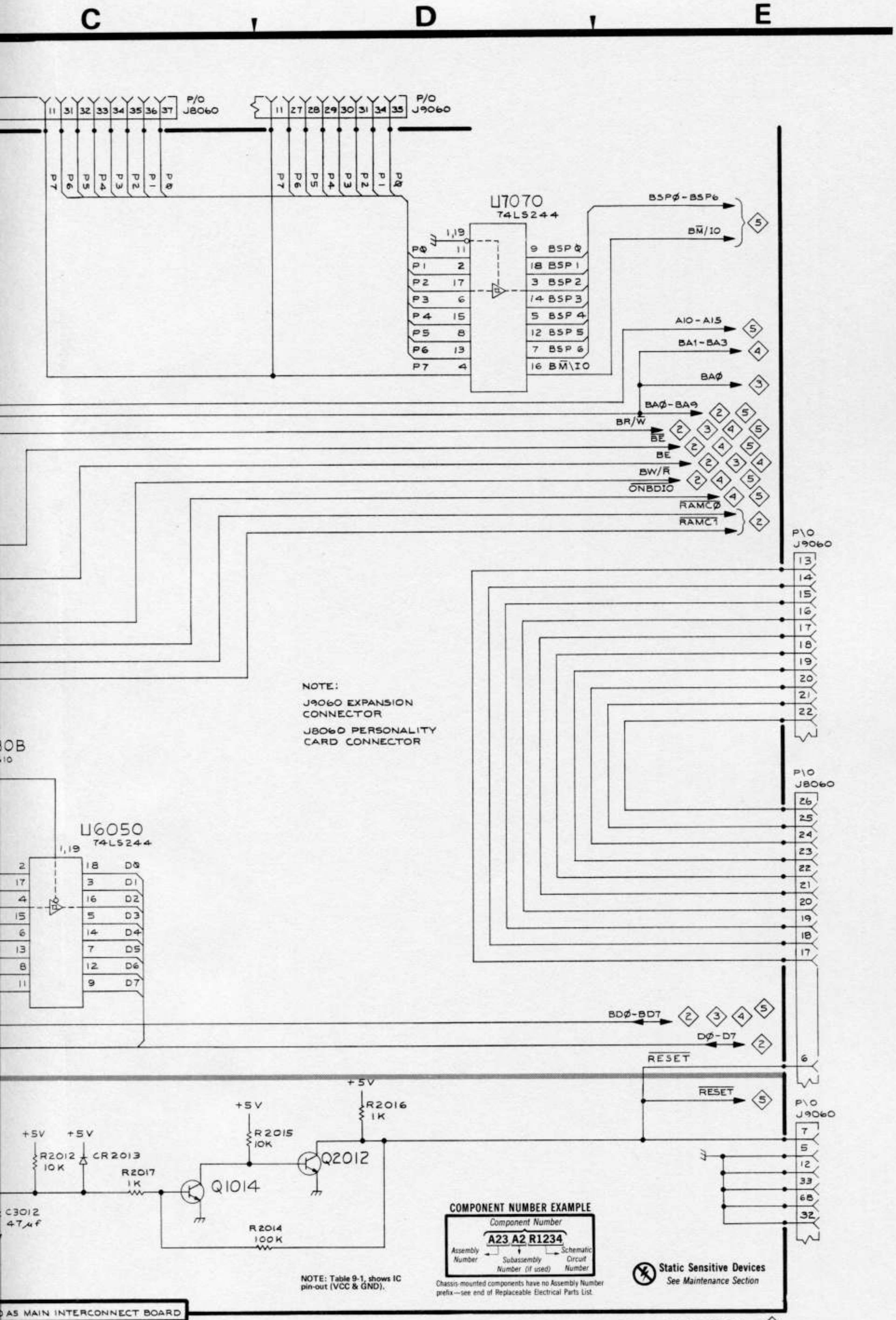
TABLE 9-2
BUS BUFFERS DIAGRAM ⟨1⟩

PARTIAL A5 ASSY					
CIRCUIT NUMBER	SCHEM LOCATION	BOARD LOCATION	CIRCUIT NUMBER	SCHEM LOCATION	BOARD LOCATION
C3012	C4	C1	R2012	C4	C1
C7049	B3	A3	R2014	D4	C1
			R2015	C4	C1
CR2013	C4	C1	R2016	D4	C1
			R2017	C4	C1
J3010	A4	B1	R3011	B4	C1
J8060	A2	A4	R7051	A4	A3
J8060	C1	A4	R7052	B3	A3
J8060	E3	A4			
J9060	A1	A4	U1080	B2	C5
J9060	A4	A4	U5030A	B3	B2
J9060	D1	A4	U5030B	C3	B2
J9060	E2	A4	U6030	B2	B2
J9060	E4	A4	U6050	C3	B3
			U7050	B3	A3
Q1014	C4	C1	U7070	D1	A4
Q2012	D4	C1	U8040	B1	A3

Partial A5 ASSY also shown on diagrams 2, 3, 4 and 5.



MICROLAB I INSTRUCTION



REV A MAY 1980

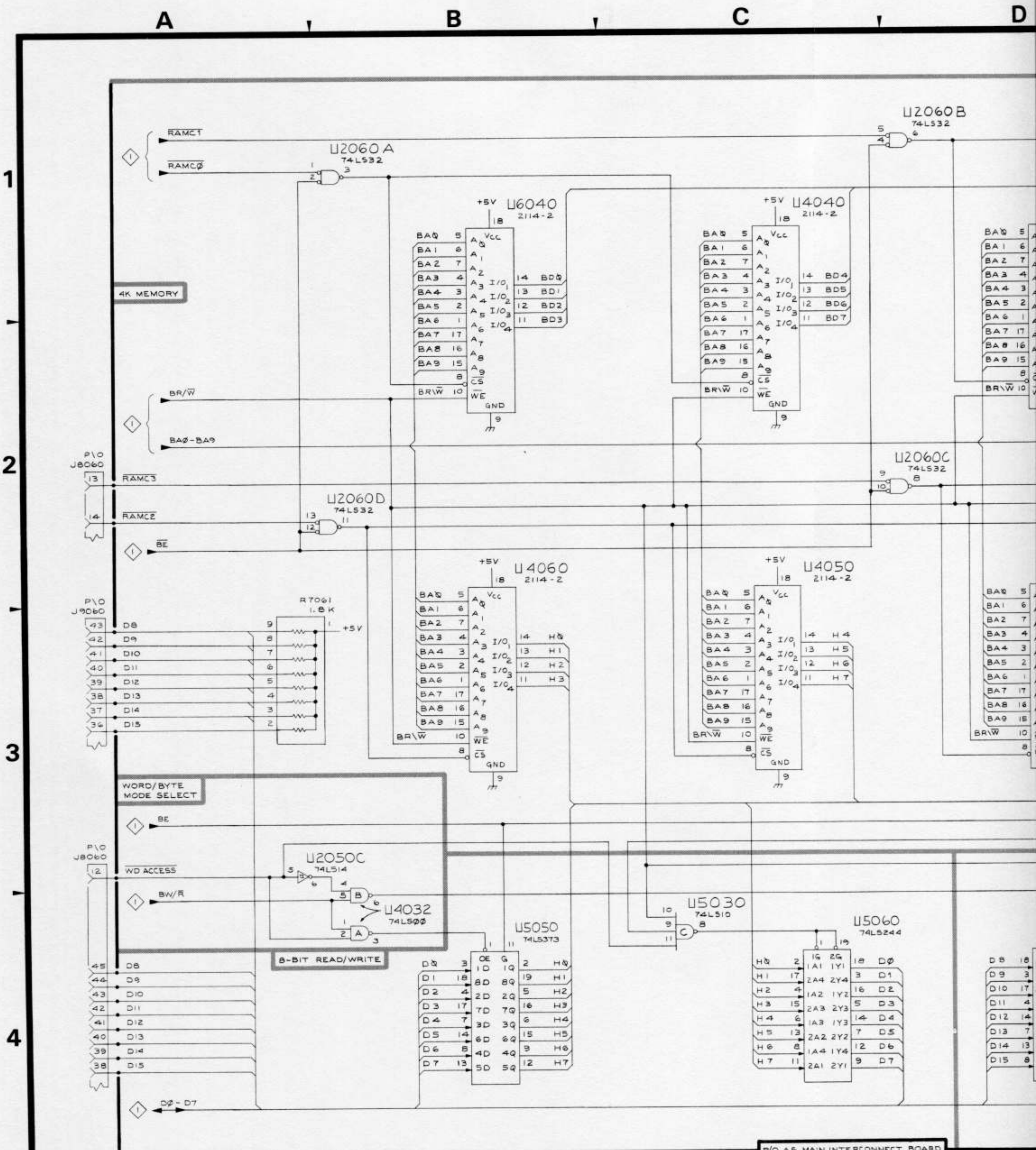
2827-29

TABLE 9-3
MEMORY DIAGRAM ⟨2⟩

PARTIAL A5 ASSY					
CIRCUIT NUMBER	SCHEM LOCATION	BOARD LOCATION	CIRCUIT NUMBER	SCHEM LOCATION	BOARD LOCATION
J8060	A2	A4	U4032	B4	B2
J8060	A4	A4	U4032C	E4	B2
J9060	A3	A4	U4032D	E2	B2
			U4040	C1	B3
R7061	A3	A4	U4050	C3	B3
			U4060	B3	B4
U2050C	A3	C3	U5030C	C4	B2
U2060A	B1	C4	U5040	D1	B3
U2060B	D1	C4	U5050	B4	B3
U2060C	D2	C4	U5060	C4	B4
U2060D	B2	C4	U6040	B1	B3
U3040	E1	C3	U6060	E4	B4
U3050	E3	C3	U7060	D4	A4
U3060	D3	C4			

Partial A5 ASSY also shown on diagrams 1, 3, 4 and 5.

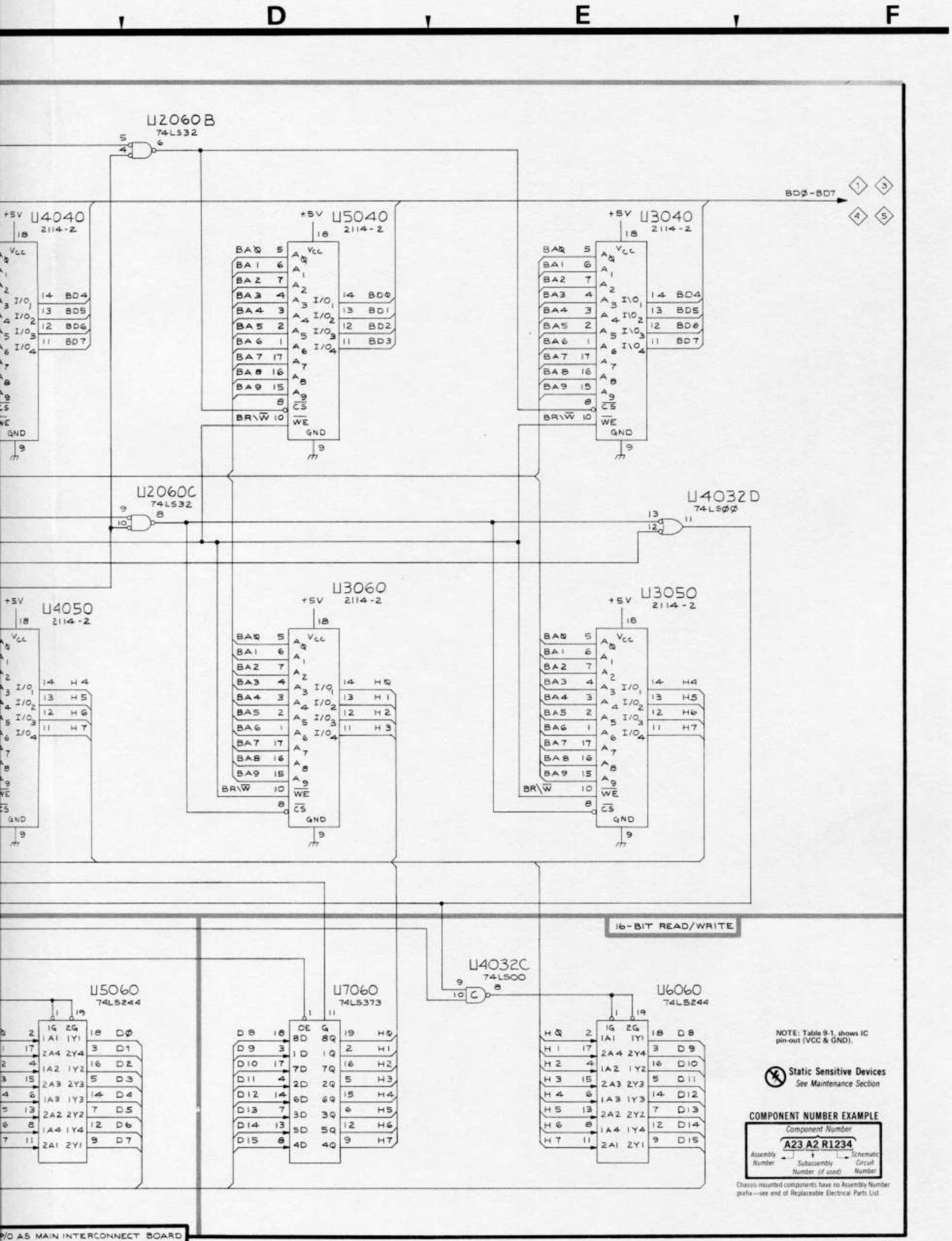
A5 ASSY component locations shown opposite of diagram 1.



MICROLAB I INSTRUCTION

REV A MAY 1980

2827 - 30



REV A MAY 1980
2827-30

TABLE 9-4
I/O PORTS DIAGRAM ◇3

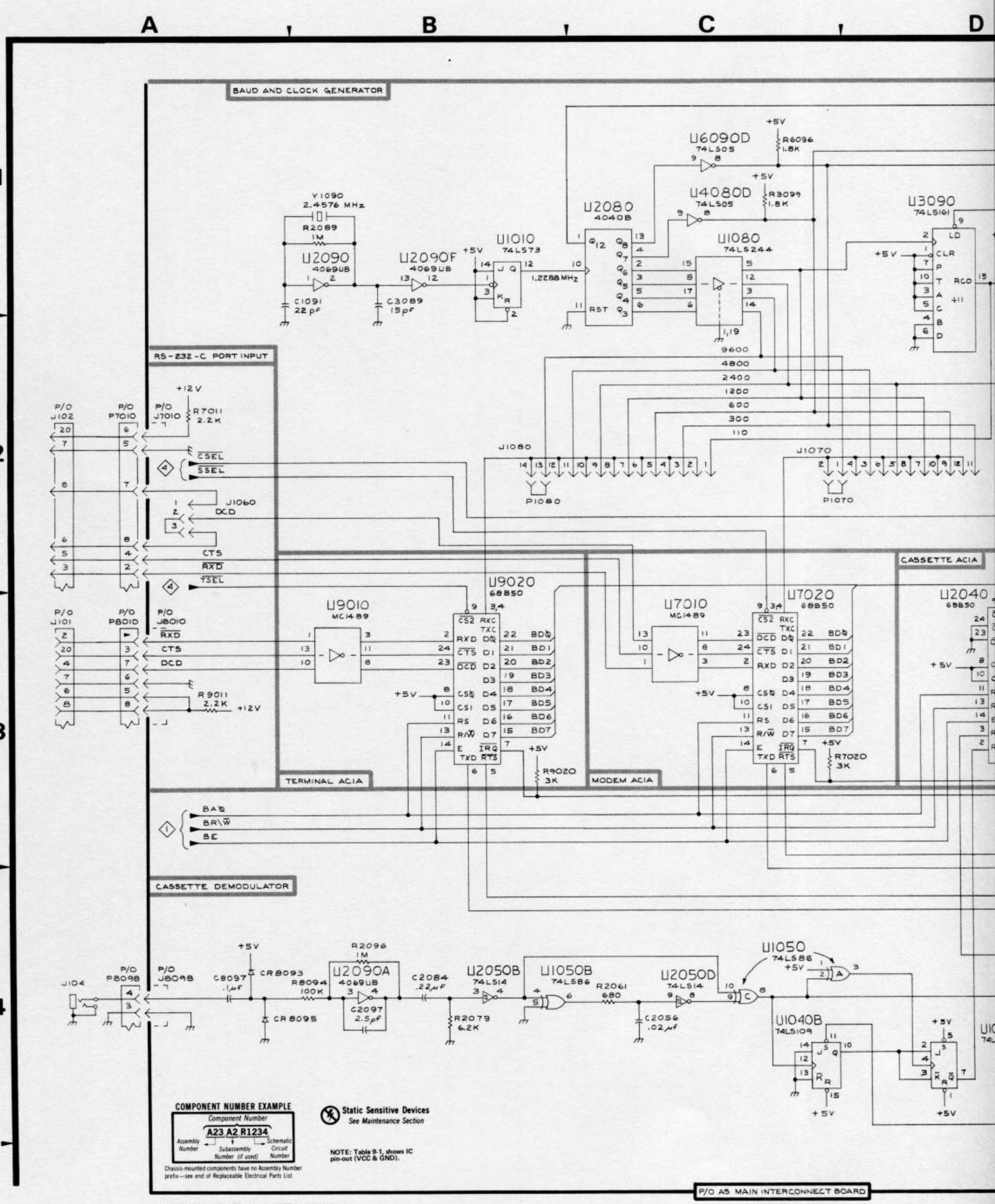
PARTIAL A5 ASSY					
CIRCUIT NUMBER	SCHEM LOCATION	BOARD LOCATION	CIRCUIT NUMBER	SCHEM LOCATION	BOARD LOCATION
C1091	A1	C5	R8094	B4	A5
C2056	C4	C3	R9011	A3	A1
C2084	B4	C5	R9020	B3	C5 *
C2097	B4	C5			
C3089	B1	C5	U1010	B1	C1
C7089	E2	A5	U1020	E4	C2
C8097	A4	A5	U1030	E4	C2
			U1040	C4	C3
CR8093	A4	A5	U1050A	C4	C3
CR8095	A4	A5	U1050B	B4	C3
			U1050C	C4	C3
J1060	A2	C3	U1050D	E4	C3
J1070	C2	C4	U1080	C1	C5
J1080	B2	C5	U2040	D3	C3
J7010	A2	A1	U2050B	B4	C3
J7010	F3	A1	U2050D	C4	C3
J8010	A3	A1	U2080	C1	C5
J8010	F4	A1	U2090A	B4	C5
J8098	A4	A5	U2090C	E2	C5
J8098	F2	A5	U2090D	D1	C5
			U2090F	B1	C5
R2040	E3	C5 *	U3090	D1	C5
R2061	C4	C3	U4080D	C1	B5
R2079	B4	C5	U6090D	C1	B5
R2089	B1	C5	U7010	C3	A1
R2096	B4	C5	U7020	C3	A1
R3091	D1	C5	U7090	E2	A5
R3099	C1	B5	U8010	E4	A1
R6096	C1	B5	U9010	B3	A1
R7011	A2	A1	U9020	B3	A1
R7020	C3	C5 *			
R7091	E1	B5	Y1090	B1	C5
R8092	E2	A5			

Partial A5 ASSY also shown on diagrams 1, 2, 4 and 5.

A5 ASSY component locations shown opposite of diagram 1.

* on back of board

CHASSIS MOUNTED PARTS					
CIRCUIT NUMBER	SCHEM LOCATION	BOARD LOCATION	CIRCUIT NUMBER	SCHEM LOCATION	BOARD LOCATION
J101	A3	CHASSIS	J102	A2	CHASSIS
J101	F4	CHASSIS	J103	F2	CHASSIS
J102	F3	CHASSIS	J104	A4	CHASSIS


A
B
C
D
1
2
3
4
BAUD AND CLOCK GENERATOR
Y1090
2.4576 MHz
R2089
1M
U2090
4069UB
C1091
22 pF
U2090F
4069UB
C3089
15pF
U1010
74LS73
1.2288 MHz
U2080
4040B
U6090D
74LS05
R6096
1.8K
U4080D
74LS05
R3099
1.8K
U1080
74LS244
U3090
74LS161
LD
CLR
RCO
÷11
+5V
9600
4800
2400
1200
600
300
110
J1080
P1080
J1070
P1070
RS-232-C PORT INPUT
+12V
P/O J102
P/O P7010
P/O J7010
R7011
2.2K
CSEL
SSEL
J1060
DCD
CTS
RXD
TSEL
P/O J101
P/O P8010
P/O J8010
R9011
2.2K
TERMINAL ACIA
U9010
MC1489
U9020
68B50
R9020
3K
MODEM ACIA
U7010
MC1489
U7020
68B50
R7020
3K
CASSETTE ACIA
U2040
68B50
BAØ
BR\W
BE
CASSETTE DEMODULATOR
J104
P/O P8098
P/O J8098
C8097
.1µF
CR8093
CR8095
R8094
100K
R2096
1M
U2090A
4069UB
C2097
2.5pF
C2084
.22µF
U2050B
74LS14
R2079
6.2K
U1050B
74LS86
R2061
680
C2056
.02µF
U2050D
74LS14
U1050
74LS86
U1040B
74LS109
COMPONENT NUMBER EXAMPLE
Component Number
A23 A2 R1234
Assembly Number
Subassembly Number (if used)
Schematic Circuit Number
Chassis-mounted components have no Assembly Number prefix—see end of Replaceable Electrical Parts List
Static Sensitive Devices
See Maintenance Section
NOTE: Table 9-1, shows IC pin-out (VCC & GND).
P/O A5 MAIN INTERCONNECT BOARD

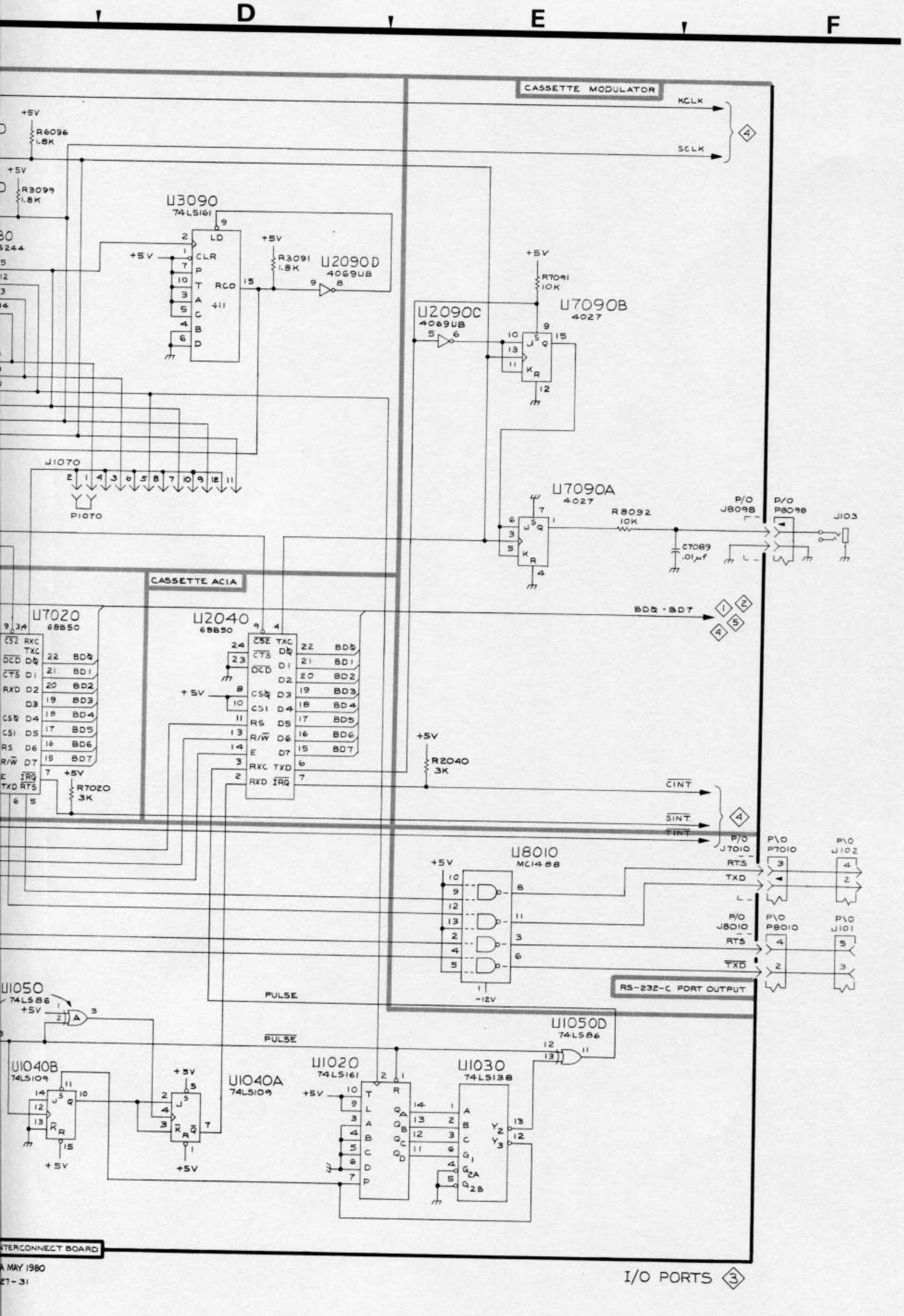

D
E
F
CASSETTE MODULATOR
KCLK
SCLK
+5V
R6096 1.8K
R3099 1.8K
U3090 74LS161
CLR
LD
RCO
+5V
R3091 1.8K
U2090D 4069UB
U2090C 4069UB
R7091 10K
U7090B 4027
J1070
P1070
U7090A 4027
R8092 10K
C7089 .01µf
P/O J8098
P/O P8098
J103
CASSETTE ACIA
U7020 68B50
U2040 68B50
BDØ - BD7
+5V
R7020 3K
R2040 3K
CINT
SINT
TINT
U8010 MC1488
P/O J7010
P\O P7010
P\O J102
RTS
TXD
P/O J8010
P\O P8010
P\O J101
-12V
RS-232-C PORT OUTPUT
U1050 74LS86
PULSE
U1050D 74LS86
U1040B 74LS109
U1040A 74LS109
U1020 74LS161
U1030 74LS138
INTERCONNECT BOARD
A MAY 1980
27-31

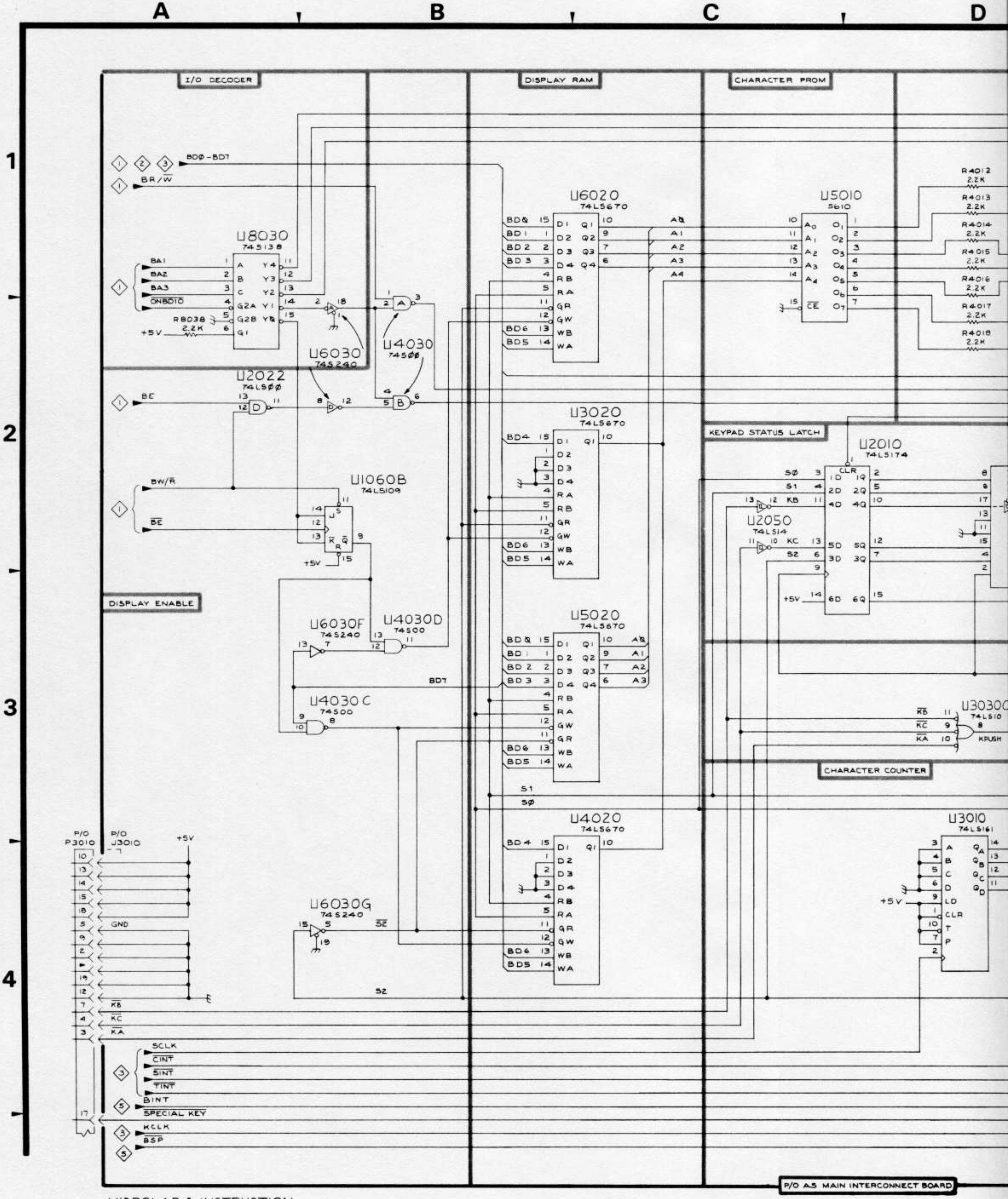
TABLE 9-5

KEYPAD/DISPLAY LOGIC DIAGRAM ⟨4⟩

PARTIAL A5 ASSY					
CIRCUIT NUMBER	SCHEM LOCATION	BOARD LOCATION	CIRCUIT NUMBER	SCHEM LOCATION	BOARD LOCATION
J3010	A4	B1	U2022D	A3	C2
J3010	F1	B1	U2030B	E4	C2
J8060	F4	A4	U2050	C2	C3
J9060	F4	A4	U2090E	E2	C5
			U3010	D4	C1
R4010	E1	B1	U3020	C2	B2
R4012	D1	B1	U3030A	E4	C2
R4013	D1	B1	U3030C	D3	C2
R4014	D1	B1	U4010	D1	B1
R4015	D1	B1	U4020	C4	B2
R4016	D1	B1	U4030A	B2	B2
R4017	D2	B1	U4030B	B2	B2
R4018	D2	B1	U4030C	B3	B2
R6081	E2	B5	U4030D	B3	B2
R8038	A2	A2	U4080F	F4	B5
R9082	F4	B5	U5010	D1	B1
R9083	F4	A5	U5020	C3	B2
			U6020	C1	B2
U1010	E3	C1	U6030A	B2	B2
U1060	E4	C4	U6030D	B2	B2
U1060B	B2	C4	U6030E	E4	B2
U2010	D2	C1	U6030F	B3	B2
U2012	E3	C1	U6030G	B4	B2
U2020	D2	C2	U6090A	F4	B5
U2022A	F2	C2	U8030	A1	A2
U2022B	D3	C2			

Partial A5 ASSY also shown on diagrams 1, 2, 3 and 5.

A5 ASSY component locations shown opposite of diagram 1.



MICROLAB I INSTRUCTION

REV APR 1984
2827-32

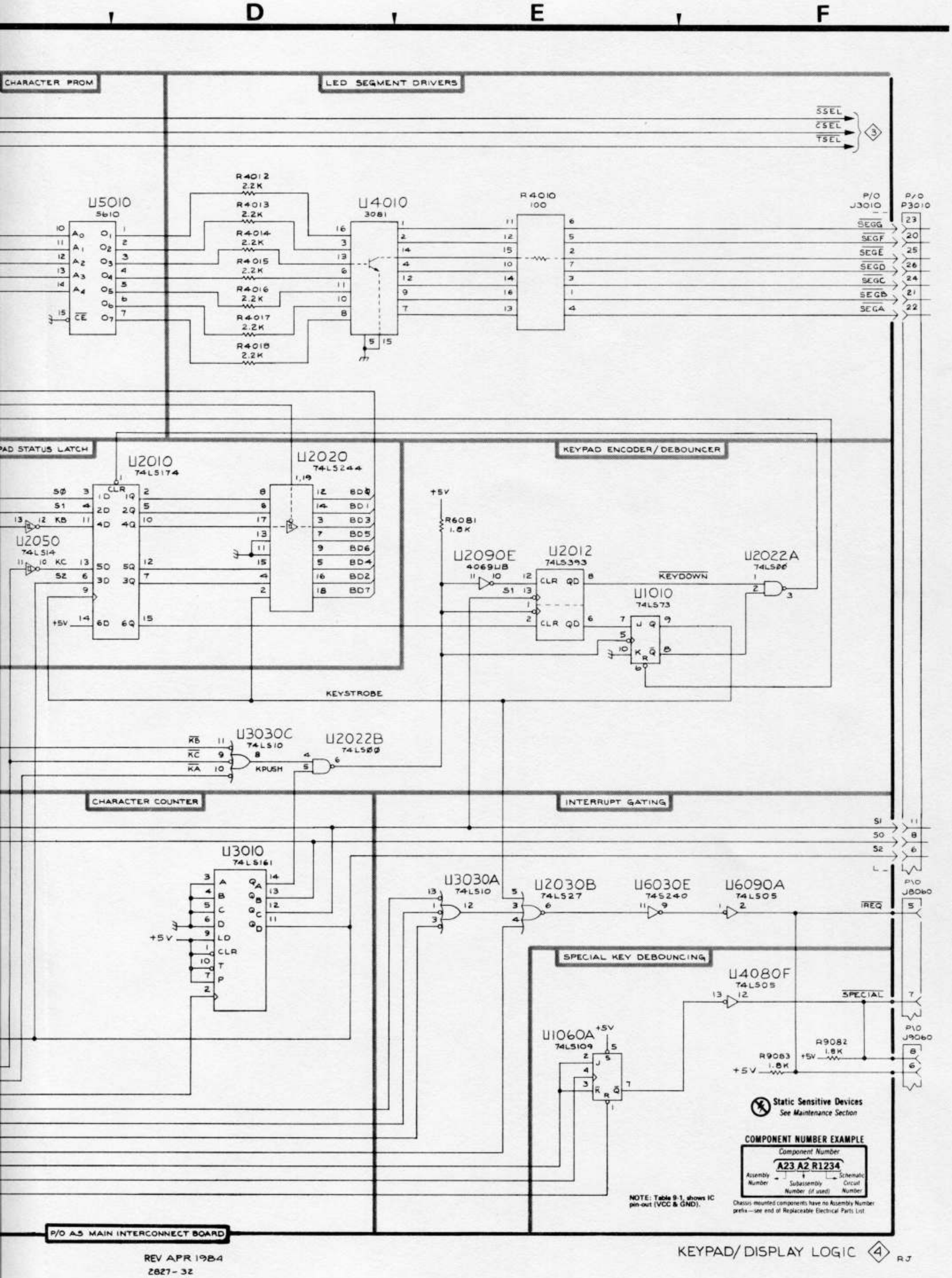

D
E
F
CHARACTER PROM
LED SEGMENT DRIVERS
U5010
5610
U4010
3081
R4010
100
R4012 2.2K
R4013 2.2K
R4014 2.2K
R4015 2.2K
R4016 2.2K
R4017 2.2K
R4018 2.2K
SSEL
CSEL
TSEL
3
P/O J3010
P/O P3010
SEGG
SEGF
SEGE
SEGD
SEGC
SEGB
SEGA
PAD STATUS LATCH
U2010
74LS174
U2020
74LS244
U2050
74LS14
KEYPAD ENCODER/DEBOUNCER
U2090E
4069UB
U2012
74LS393
U1010
74LS73
U2022A
74LS00
KEYDOWN
R6081 1.8K
KEYSTROBE
U3030C
74LS10
KPUSH
U2022B
74LS00
CHARACTER COUNTER
INTERRUPT GATING
U3010
74LS161
U3030A
74LS10
U2030B
74LS27
U6030E
74S240
U6090A
74LS05
P/O J8060
IREQ
SPECIAL KEY DEBOUNCING
U4080F
74LS05
SPECIAL
U1060A
74LS109
R9082 1.8K
R9083 1.8K
P/O J9060
Static Sensitive Devices
See Maintenance Section
COMPONENT NUMBER EXAMPLE
Component Number
A23 A2 R1234
Assembly Number
Subassembly Number (if used)
Schematic Circuit Number
Chassis-mounted components have no Assembly Number prefix—see end of Replaceable Electrical Parts List.
NOTE: Table 9-1 shows IC pin-out (VCC & GND).
P/O A5 MAIN INTERCONNECT BOARD

TABLE 9-6

BREAKPOINT CIRCUIT DIAGRAM ⟨5⟩

PARTIAL A5 ASSY

CIRCUIT NUMBER	SCHEM LOCATION	BOARD LOCATION	CIRCUIT NUMBER	SCHEM LOCATION	BOARD LOCATION
C1016	G1*	C1	R6081	E2	B5
C1021	G1*	C2	R8096	F1	A5
C1051	G1*	C3			
C1069	G1*	C4	U1070	C4	C4
C2062	G1*	C4	U2022C	F3	C2
C2081	G1*	C5	U2030A	F4	C2
C3031	G1*	C2	U2030C	E3	C2
C3041	G1*	C2	U2050A	E4	C3
C3061	G1*	C3	U2070	C4	C4
C4031	G1*	B2	U3030B	F3	C2
C4041	G1*	B2	U3070	B4	C4
C4079	G1*	B4	U3080A	A4	C5
C4091	G1*	B5	U3080B	A3	C5
C5011	G1*	B1	U3080C	F4	C5
C5031	G1*	B2	U3080D	F3	C5
C5051	G1*	B3	U4070	D1	B4
C5071	G1*	B4	U4080	D2	B5
C6011	G1*	B1	U4090A	F3	B5
C6051	G1*	B3	U4090B	F3	B5
C6071	G1*	B4	U4090C	E4	B5
C6091	G1*	B5	U5070	C1	B4
C7062	G1*	A3	U5080	C2	B5
C7088	F1	A5	U6010	A2	B1
C8011	G1*	A1	U6030H	F3	B2
C8031	G1*	A2	U6070	D4	B4
C8085	G1	A5	U6080A	E2	B5
C8091	G1	A5	U6080B	E3	B5
C9041	G1*	A2	U6090	D3	B5
C9094	F1	A5	U7030	B3	A2
C9099	G1*	A5	U7040	C2	A3
			U8084	F1	A5
J6010	G2	B1	U9030	B1	A2
J8060	G3	A4	U9040	C1	A3
J8099	G1	A5			
J9060	G2	A4	VR8096	F1	A5
Q9096	F1	A5			

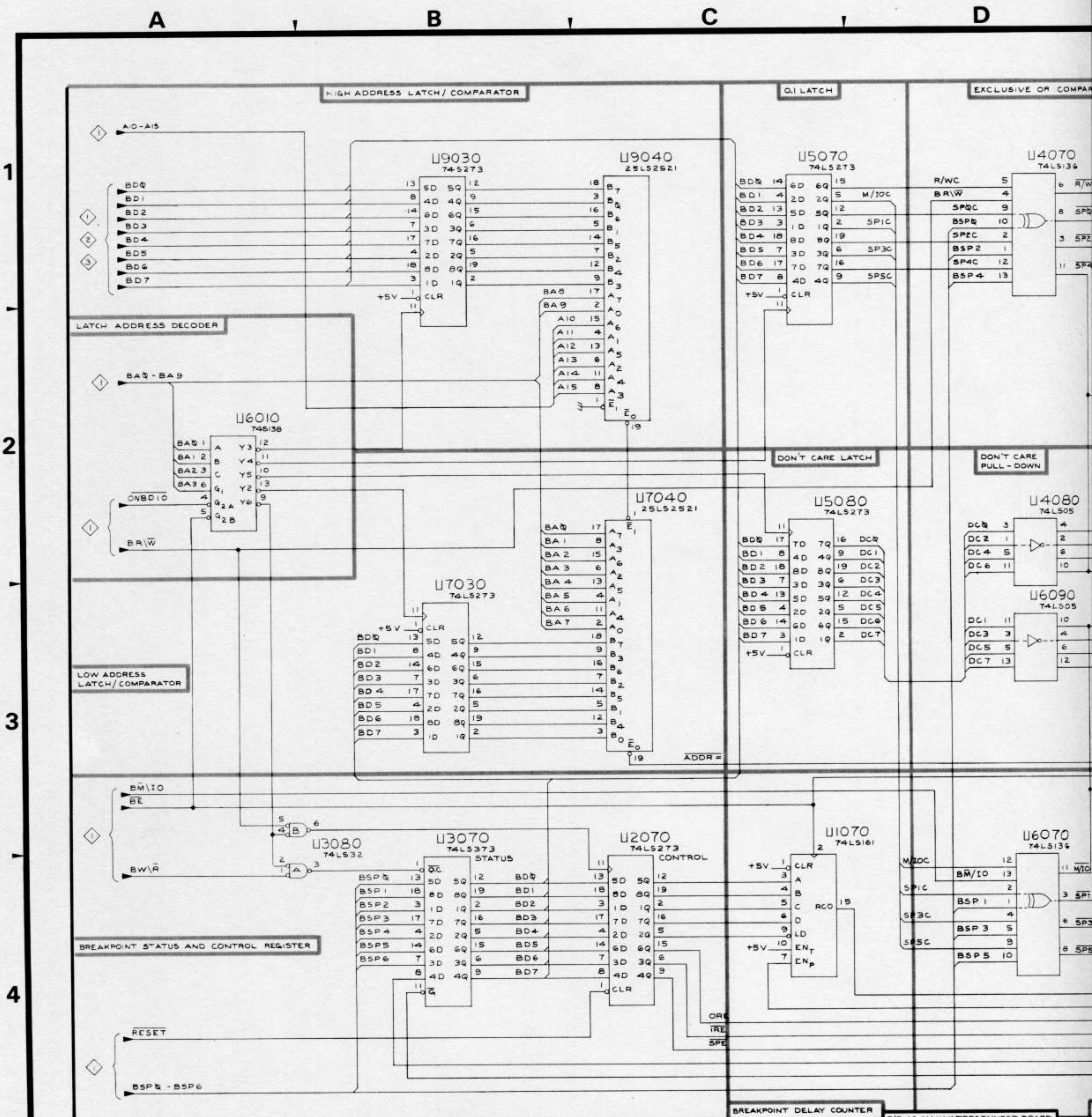
Partial A5 ASSY also shown on diagrams 1, 2, 3 and 4.

A5 ASSY component locations shown opposite of diagram 1.

*indicating decoupling capacitor, 0.1μF

CHASSIS MOUNTED PARTS

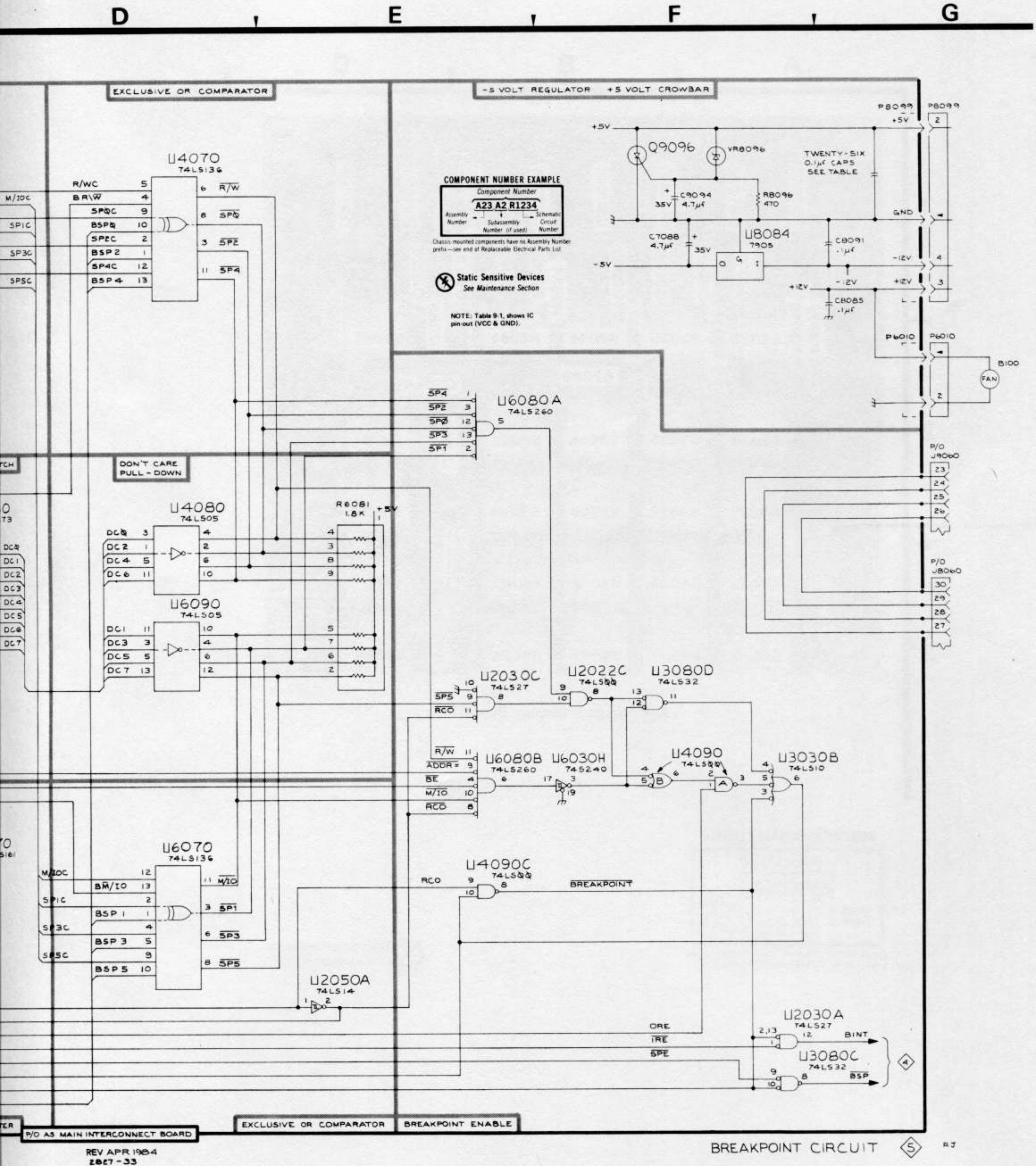
CIRCUIT NUMBER	SCHEM LOCATION	BOARD LOCATION	CIRCUIT NUMBER	SCHEM LOCATION	BOARD LOCATION
B100	G2	CHASSIS			



P/O A5 MAIN INTERCONNECT BOARD

REV APR 1984
2827-33

Appendix 1 Instruction



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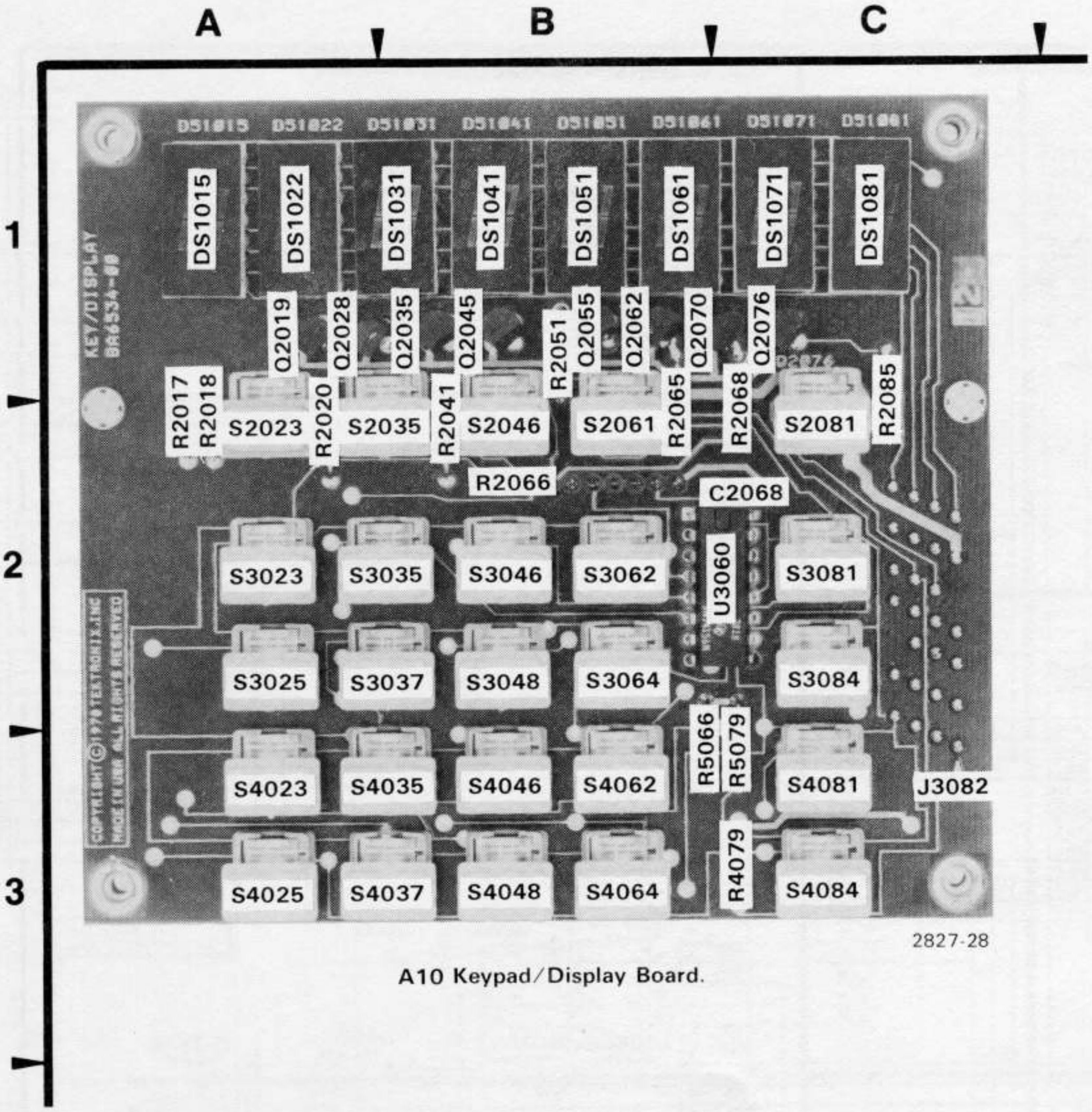
BREAKPOINT CIRCUIT—
MAIN INTERCONNECT

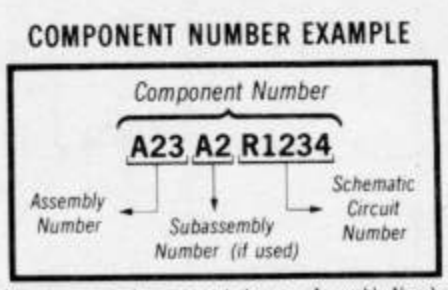
5

KEYPAD/DISPLAY BOARD
COMPONENT LOCATIONS



2827-28

A10 Keypad/Display Board.



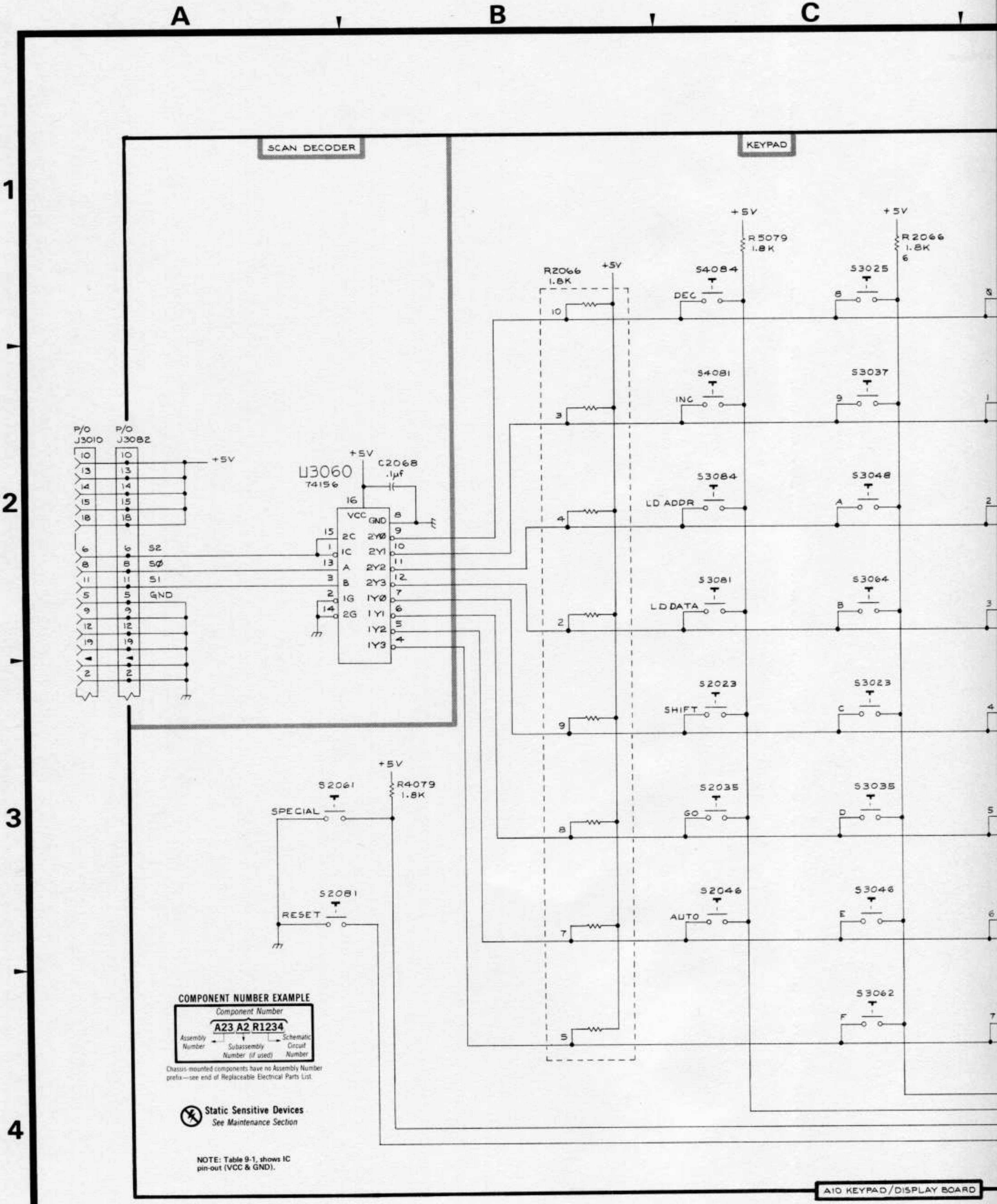
Chassis-mounted components have no Assembly Number prefix—see end of Replaceable Electrical Parts List.

Static Sensitive Devices
See Maintenance Section

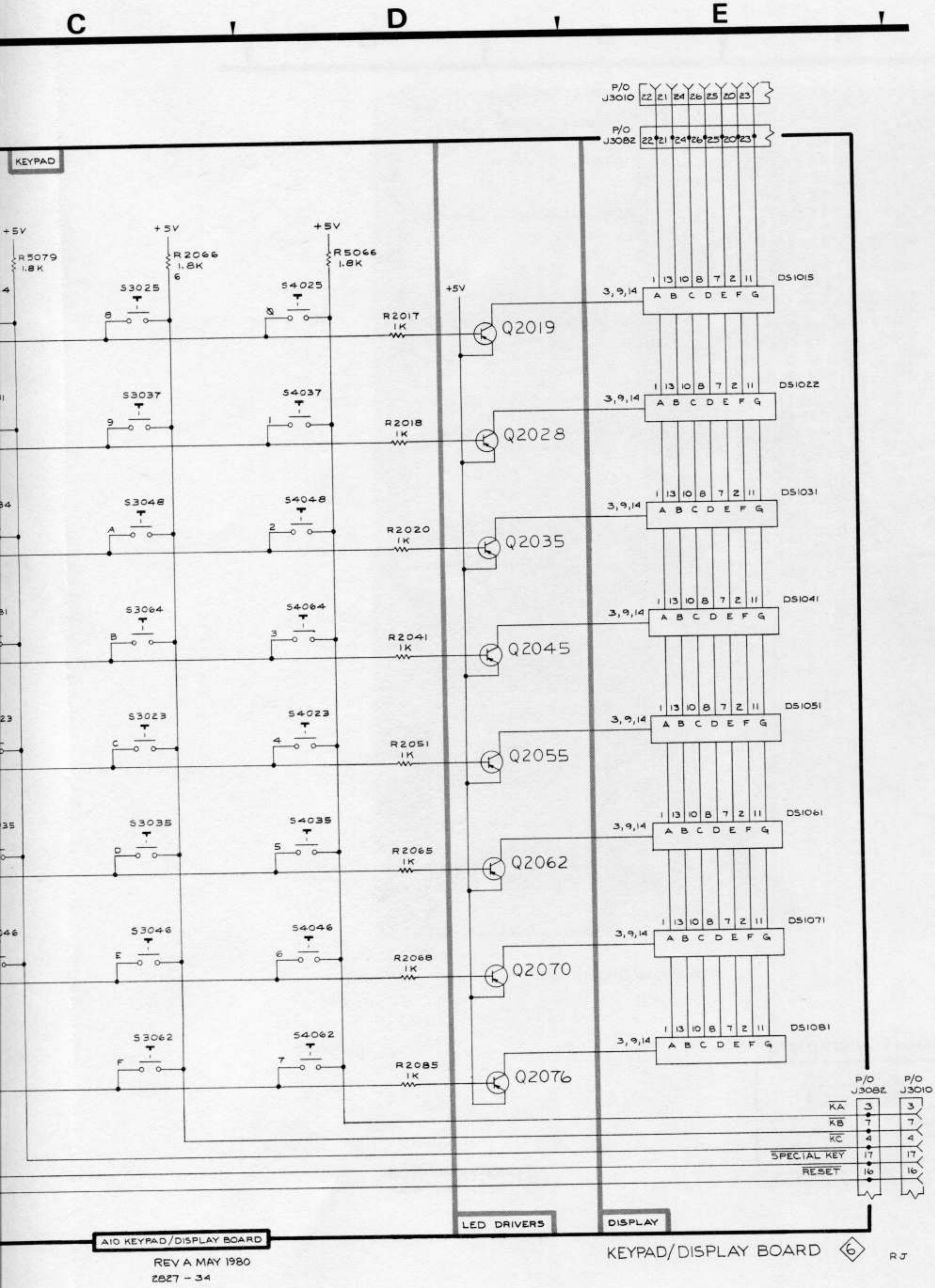
TABLE 9-7

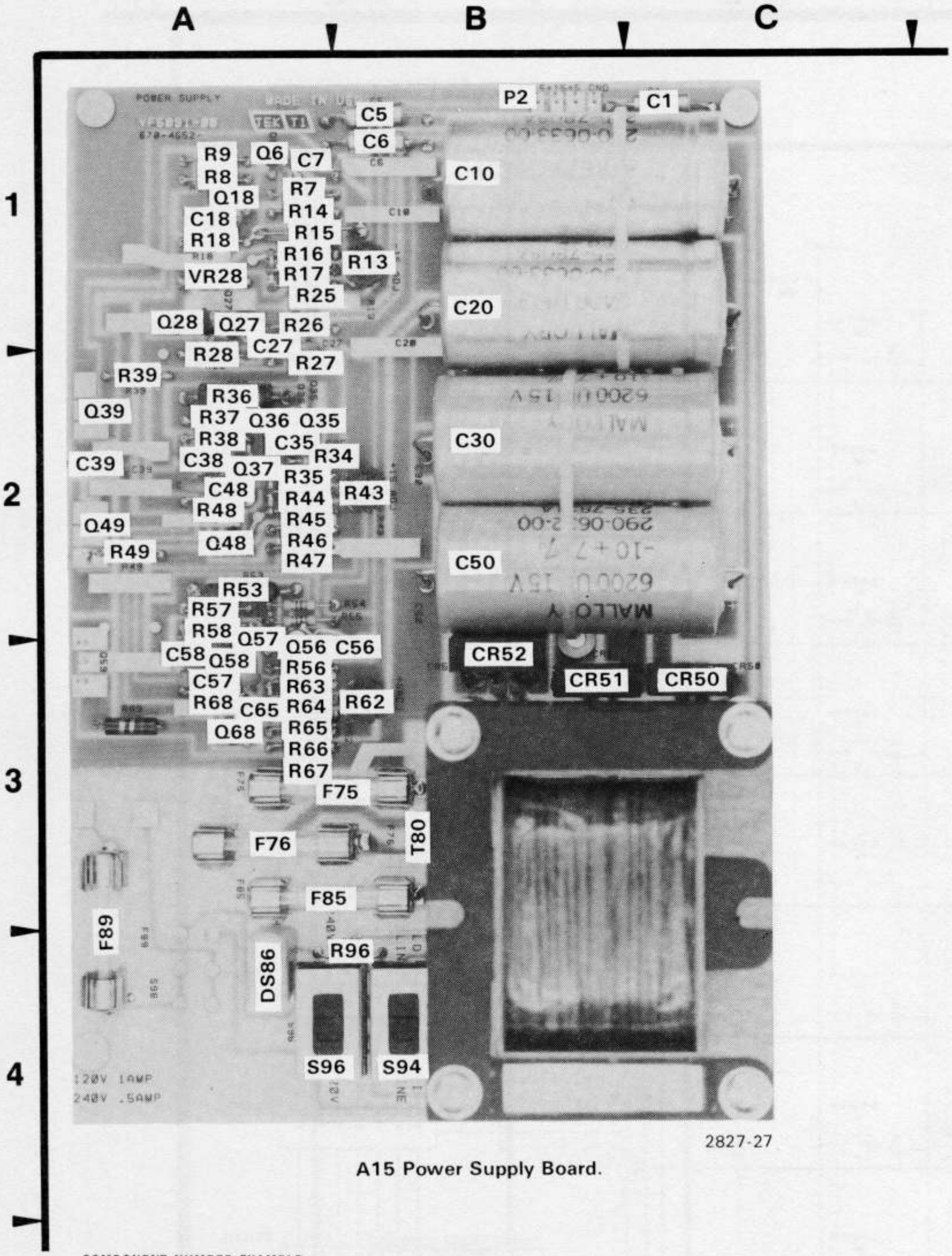
KEYPAD/DISPLAY DIAGRAM ⟨6⟩

A10 ASSY					
CIRCUIT NUMBER	SCHEM LOCATION	BOARD LOCATION	CIRCUIT NUMBER	SCHEM LOCATION	BOARD LOCATION
C2068	B2	C2	R2085	D4	C1
			R4079	B3	C3
DS1015	E1	A1	R5066	D1	B3
DS1022	E2	A1	R5079	C1	C3
DS1031	E2	B1			
DS1041	E2	B1	S2023	C3	A1
DS1051	E3	B1	S2035	C3	B2
DS1061	E3	B1	S2046	C3	B2
DS1071	E3	C1	S2061	A3	B2
DS1081	E4	C1	S2081	A3	C2
			S3023	C3	A2
J3082	A2	C3	S3025	C1	A2
J3082	E1	C3	S3035	C3	B2
J3082	E4	C3	S3037	C2	B2
			S3046	C3	B2
Q2019	D1	A1	S3048	C2	B2
Q2028	D2	A1	S3062	C4	B2
Q2035	D2	B1	S3064	C2	B2
Q2045	D2	B1	S3081	C2	C2
Q2055	D3	B1	S3084	C2	C2
Q2062	D3	B1	S4023	D3	A3
Q2070	D3	B1	S4025	D1	A3
Q2076	D4	C1	S4035	D3	B3
			S4037	D2	B3
R2017	D1	A2	S4046	D3	B3
R2018	D2	A2	S4048	D2	B3
R2020	D2	A2	S4062	D4	B3
R2041	D2	B2	S4064	D2	B3
R2051	D3	B1	S4081	C2	C3
R2065	D3	B2	S4084	C1	C3
R2066	B1	B2			
R2066	C1	B2	U3060	B2	C2
R2068	D3	C2			



SCAN DECODER
KEYPAD
P/O J3010
P/O J3082
+5V
U3060
74156
C2068
.1µf
VCC
GND
2C
1C
A
B
1G
2G
2YØ
2Y1
2Y2
2Y3
1YØ
1Y1
1Y2
1Y3
S2
SØ
S1
GND
R2066
1.8K
R5079
1.8K
S4084
DEC
S4081
INC
S3084
LD ADDR
S3081
LD DATA
S2023
SHIFT
S2035
GO
S2046
AUTO
S3025
S3037
S3048
S3064
S3023
S3035
S3046
S3062
S2061
SPECIAL
R4079
1.8K
S2081
RESET
COMPONENT NUMBER EXAMPLE
Component Number
A23 A2 R1234
Assembly Number
Subassembly Number (if used)
Schematic Circuit Number
Chassis-mounted components have no Assembly Number prefix—see end of Replaceable Electrical Parts List.
Static Sensitive Devices
See Maintenance Section
NOTE: Table 9-1, shows IC pin-out (VCC & GND).
A10 KEYPAD/DISPLAY BOARD

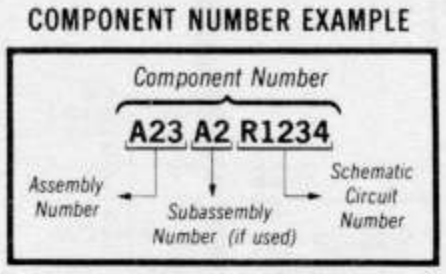

C
D
E
KEYPAD
P/O J3010
P/O J3082
+5V
R5079 1.8K
R2066 1.8K
R5066 1.8K
S3025
S4025
S3037
S4037
S3048
S4048
S3064
S4064
S3023
S4023
S3035
S4035
S3046
S4046
S3062
S4062
R2017 1K
R2018 1K
R2020 1K
R2041 1K
R2051 1K
R2065 1K
R2068 1K
R2085 1K
Q2019
Q2028
Q2035
Q2045
Q2055
Q2062
Q2070
Q2076
DS1015
DS1022
DS1031
DS1041
DS1051
DS1061
DS1071
DS1081
3,9,14
A B C D E F G
KA
KB
KC
SPECIAL KEY
RESET
LED DRIVERS
DISPLAY
A10 KEYPAD/DISPLAY BOARD
REV A MAY 1980
2827 – 34
KEYPAD/DISPLAY BOARD
RJ



A15 Power Supply Board.

POWER SUPPLY COMPONENT LOCATIONS

COMPONENT NUMBER EXAMPLE



Chassis-mounted components have no Assembly Number prefix—see end of Replaceable Electrical Parts List.

Static Sensitive Devices
See Maintenance Section

TABLE 9-8

POWER SUPPLY DIAGRAM ⟨7⟩

A15 ASSY

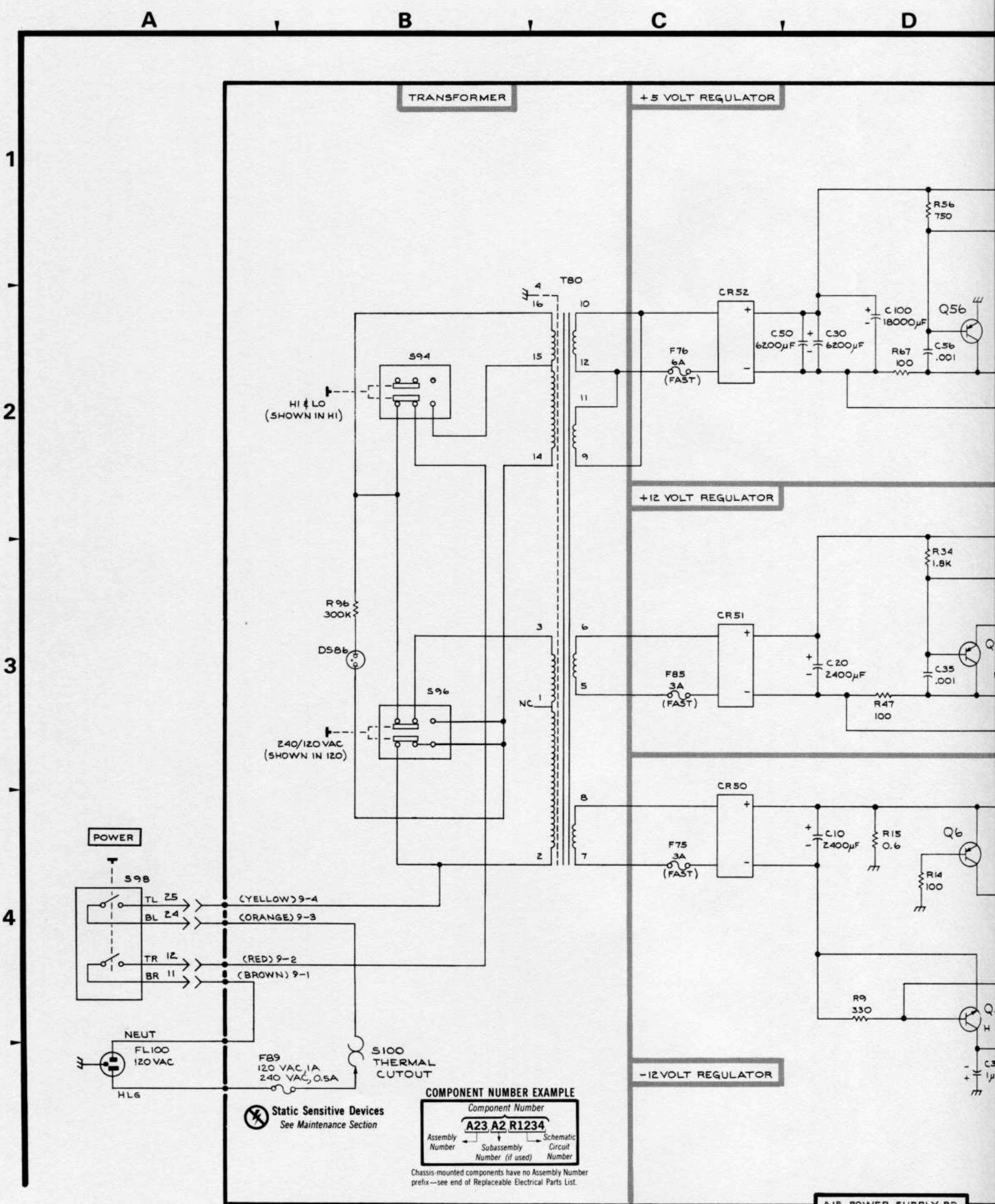
CIRCUIT NUMBER	SCHEM LOCATION	BOARD LOCATION	CIRCUIT NUMBER	SCHEM LOCATION	BOARD LOCATION	CIRCUIT NUMBER	SCHEM LOCATION	BOARD LOCATION
C1	G1	C1	Q6	D4	A1	R37	E3	A2
C5	G5	B1	Q18	E4	A1	R38	E3	A2
C6	G3	B1	Q27	F4	A1	R39	E4	A2
C7	E4	A1	Q28	F4	A1	R43	G3	B2
C10	D4	B1	Q35	D3	A2	R44	F3	A2
C18	E4	A1	Q36	E3	A2	R45	F3	A2
C20	D3	B1	Q37	F3	A2	R46	F3	A2
C27	F4	A2	Q39	D4	A2	R47	D3	A2
C30	D2	B2	Q48	F3	A2	R48	F3	A2
C35	D3	A2	Q49	E3	A2	R49	D3	A2
C38	E3	A2	Q56	D2	A3	R53	D2	A2
C39	D5	A2	Q57	E2	A3	R56	D1	A3
C48	F3	A2	Q58	F2	A3	R57	E2	A2
C50	D2	B2	Q68	F2	A3	R58	E2	A2
C56	B3	B3				R62	G2	B3
C57	F2	A3	R7	E4	A1	R63	F2	A3
C58	E2	A3	R8	E4	A1	R64	F2	A3
C65	F2	A3	R9	D4	A1	R65	F2	A3
			R13	G4	B1	R66	F2	A3
CR50	C4	C3	R15	D4	A1	R67	D2	A3
CR51	C3	B3	R15	D4	A1	R68	F2	A3
			R16	F4	A1	R96	B3	B4
			R17	F4	A1			
DS86	B3	A4	R18	E4	A1			
			R25	F4	A1	S94	B2	B4
F75	C4	A3	R26	E4	A1	S96	B3	B4
F76	C2	A3	R27	F4	A2			
F85	C3	A3	R28	E4	A2	T80	C2	B3
F89	B4	A4	R34	D3	A2			
			R35	F3	A2	VR28	E4	A1
P2	G1	B1	R36	E3	A2			

CHASSIS MOUNTED PARTS

CIRCUIT NUMBER	SCHEM LOCATION	BOARD LOCATION	CIRCUIT NUMBER	SCHEM LOCATION	BOARD LOCATION	CIRCUIT NUMBER	SCHEM LOCATION	BOARD LOCATION
C100	D2	CHASSIS	Q59	E2	CHASSIS	S98	A4	CHASSIS
						S100	B5	CHASSIS
FL100	A4	CHASSIS	R100	E2	CHASSIS	CR52	C2	CHASSIS

CHASSIS MOUNTED PARTS

CIRCUIT NUMBER	SCHEM NUMBER	SCHEM LOCATION	CIRCUIT NUMBER	SCHEM NUMBER	SCHEM LOCATION
B100	5	G2	J102	3	F3
			J103	3	F2
C100	7	D2	J104	3	A4
FL100	7	A4	Q59	7	E2
J101	3	A3	R100	7	E2
J101	3	F4			
J102	3	A2	S98	7	A4



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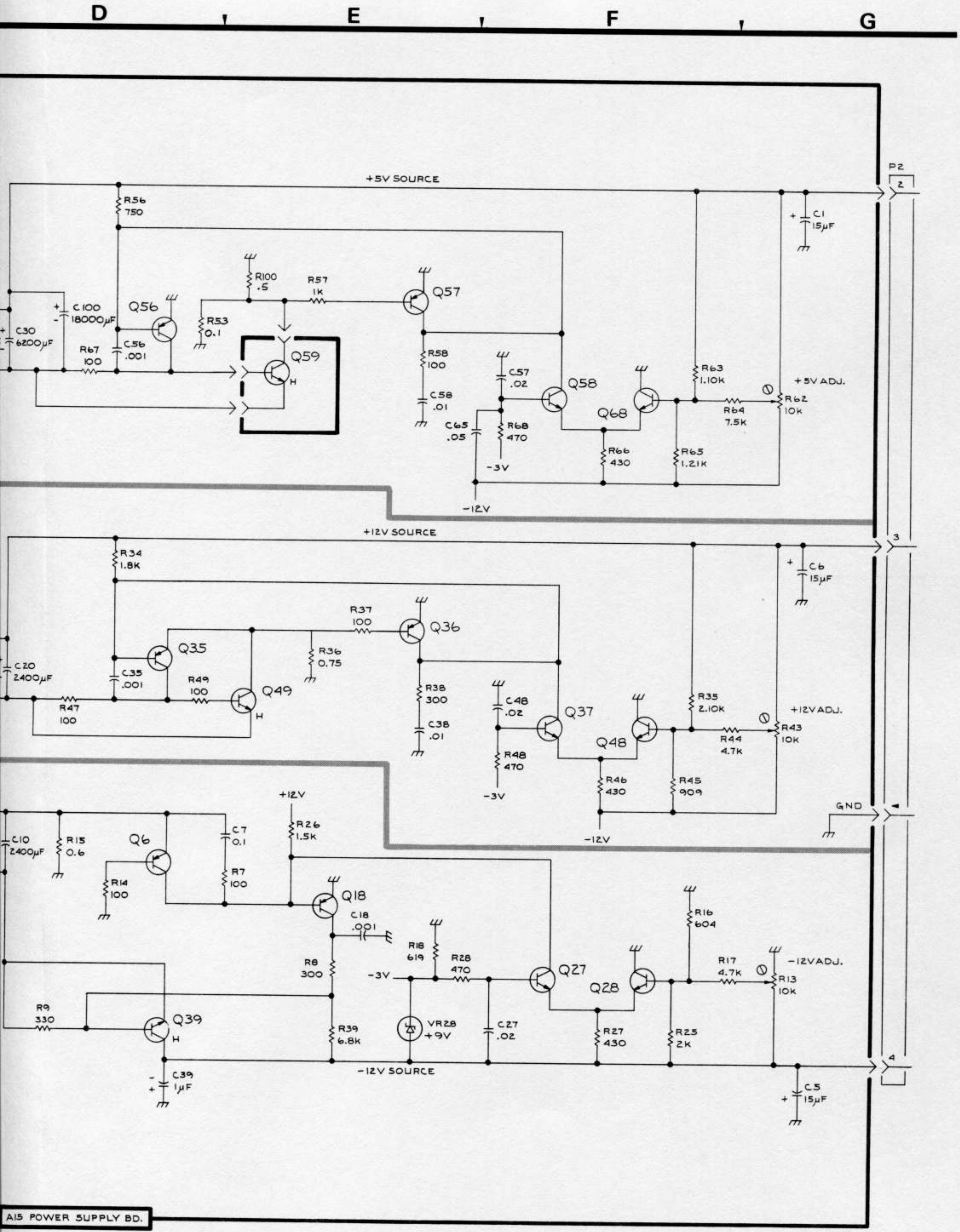

D
E
F
G
+5V SOURCE
P2
R56 750
C1 15µF
R100 .5
R57 1K
Q57
C100 18000µF
Q56
R53 0.1
C30 6200µF
R67 100
C56 .001
Q59
H
R58 100
C58 .01
C57 .02
Q58
Q68
R63 1.10K
+5V ADJ.
R62 10K
R64 7.5K
C65 .05
R68 470
-3V
R66 430
R65 1.21K
-12V
+12V SOURCE
R34 1.8K
C6 15µF
R37 100
Q36
Q35
R36 0.75
C20 2400µF
C35 .001
R49 100
Q49
R47 100
R38 300
C38 .01
C48 .02
Q37
Q48
R35 2.10K
+12V ADJ.
R43 10K
R44 4.7K
R48 470
R46 430
R45 909
GND
+12V
R26 1.5K
C7 0.1
C10 2400µF
R15 0.6
Q6
R7 100
R14 100
Q18
C18 .001
R16 604
R18 619
R28 470
R8 300
Q27
Q28
R17 4.7K
-12V ADJ.
R13 10K
R9 330
Q39
R39 6.8K
VR28 +9V
C27 .02
R27 430
R25 2K
-12V SOURCE
C39 1µF
C5 15µF
A15 POWER SUPPLY BD.

REPLACEABLE MECHANICAL PARTS

PARTS ORDERING INFORMATION

Replacement parts are available from or through your local Tektronix, Inc. Field Office or representative.

Changes to Tektronix instruments are sometimes made to accommodate improved components as they become available, and to give you the benefit of the latest circuit improvements developed in our engineering department. It is therefore important, when ordering parts, to include the following information in your order: Part number, instrument type or number, serial number, and modification number if applicable.

If a part you have ordered has been replaced with a new or improved part, your local Tektronix, Inc. Field Office or representative will contact you concerning any change in part number.

Change information, if any, is located at the rear of this manual.

SPECIAL NOTES AND SYMBOLS

X000	Part first added at this serial number
00X	Part removed after this serial number

FIGURE AND INDEX NUMBERS

Items in this section are referenced by figure and index numbers to the illustrations.

INDENTATION SYSTEM

This mechanical parts list is indented to indicate item relationships. Following is an example of the indentation system used in the description column.

1 2 3 4 5 Name & Description

Assembly and/or Component
Attaching parts for Assembly and/or Component
--- * ---

Detail Part of Assembly and/or Component
Attaching parts for Detail Part
--- * ---

Parts of Detail Part
Attaching parts for Parts of Detail Part
--- * ---

Attaching Parts always appear in the same indentation as the item it mounts, while the detail parts are indented to the right. Indented items are part of, and included with, the next higher indentation. The separation symbol --- * --- indicates the end of attaching parts.

Attaching parts must be purchased separately, unless otherwise specified.

ITEM NAME

In the Parts List, an Item Name is separated from the description by a colon (:). Because of space limitations, an Item Name may sometimes appear as incomplete. For further Item Name identification, the U.S. Federal Cataloging Handbook H6-1 can be utilized where possible.

ABBREVIATIONS

"	INCH	ELCTRN	ELECTRON	IN	INCH	SE	SINGLE END
#	NUMBER SIZE	ELEC	ELECTRICAL	INCAND	INCANDESCENT	SECT	SECTION
ACTR	ACTUATOR	ELCTLT	ELECTROLYTIC	INSUL	INSULATOR	SEMICOND	SEMICONDUCTOR
ADPTR	ADAPTER	ELEM	ELEMENT	INTL	INTERNAL	SHLD	SHIELD
ALIGN	ALIGNMENT	EPL	ELECTRICAL PARTS LIST	LPHLDR	LAMPHOLDER	SHLDR	SHOULDERED
AL	ALUMINUM	EQPT	EQUIPMENT	MACH	MACHINE	SKT	SOCKET
ASSEM	ASSEMBLED	EXT	EXTERNAL	MECH	MECHANICAL	SL	SLIDE
ASSY	ASSEMBLY	FIL	FILLISTER HEAD	MTG	MOUNTING	SLFLKG	SELF-LOCKING
ATTEN	ATTENUATOR	FLEX	FLEXIBLE	NIP	NIPPLE	SLVG	SLEEVING
AWG	AMERICAN WIRE GAGE	FLH	FLAT HEAD	NON WIRE	NOT WIRE WOUND	SPR	SPRING
BD	BOARD	FLTR	FILTER	OBD	ORDER BY DESCRIPTION	SQ	SQUARE
BRKT	BRACKET	FR	FRAME or FRONT	OD	OUTSIDE DIAMETER	SST	STAINLESS STEEL
BRS	BRASS	FSTNR	FASTENER	OVH	OVAL HEAD	STL	STEEL
BRZ	BRONZE	FT	FOOT	PH BRZ	PHOSPHOR BRONZE	SW	SWITCH
BSHG	BUSHING	FXD	FIXED	PL	PLAIN or PLATE	T	TUBE
CAB	CABINET	GSKT	GASKET	PLSTC	PLASTIC	TERM	TERMINAL
CAP	CAPACITOR	HDL	HANDLE	PN	PART NUMBER	THD	THREAD
CER	CERAMIC	HEX	HEXAGON	PNH	PAN HEAD	THK	THICK
CHAS	CHASSIS	HEX HD	HEXAGONAL HEAD	PWR	POWER	TNSN	TENSION
CKT	CIRCUIT	HEX SOC	HEXAGONAL SOCKET	RCPT	RECEPTACLE	TPG	TAPPING
COMP	COMPOSITION	HLCPS	HELICAL COMPRESSION	RES	RESISTOR	TRH	TRUSS HEAD
CONN	CONNECTOR	HLEXT	HELICAL EXTENSION	RGD	RIGID	V	VOLTAGE
COV	COVER	HV	HIGH VOLTAGE	RLF	RELIEF	VAR	VARIABLE
CPLG	COUPLING	IC	INTEGRATED CIRCUIT	RTNR	RETAINER	W/	WITH
CRT	CATHODE RAY TUBE	ID	INSIDE DIAMETER	SCH	SOCKET HEAD	WSHR	WASHER
DEG	DEGREE	IDENT	IDENTIFICATION	SCOPE	OSCILLOSCOPE	XFMR	TRANSFORMER
DWR	DRAWER	IMPLR	IMPELLER	SCR	SCREW	XSTR	TRANSISTOR

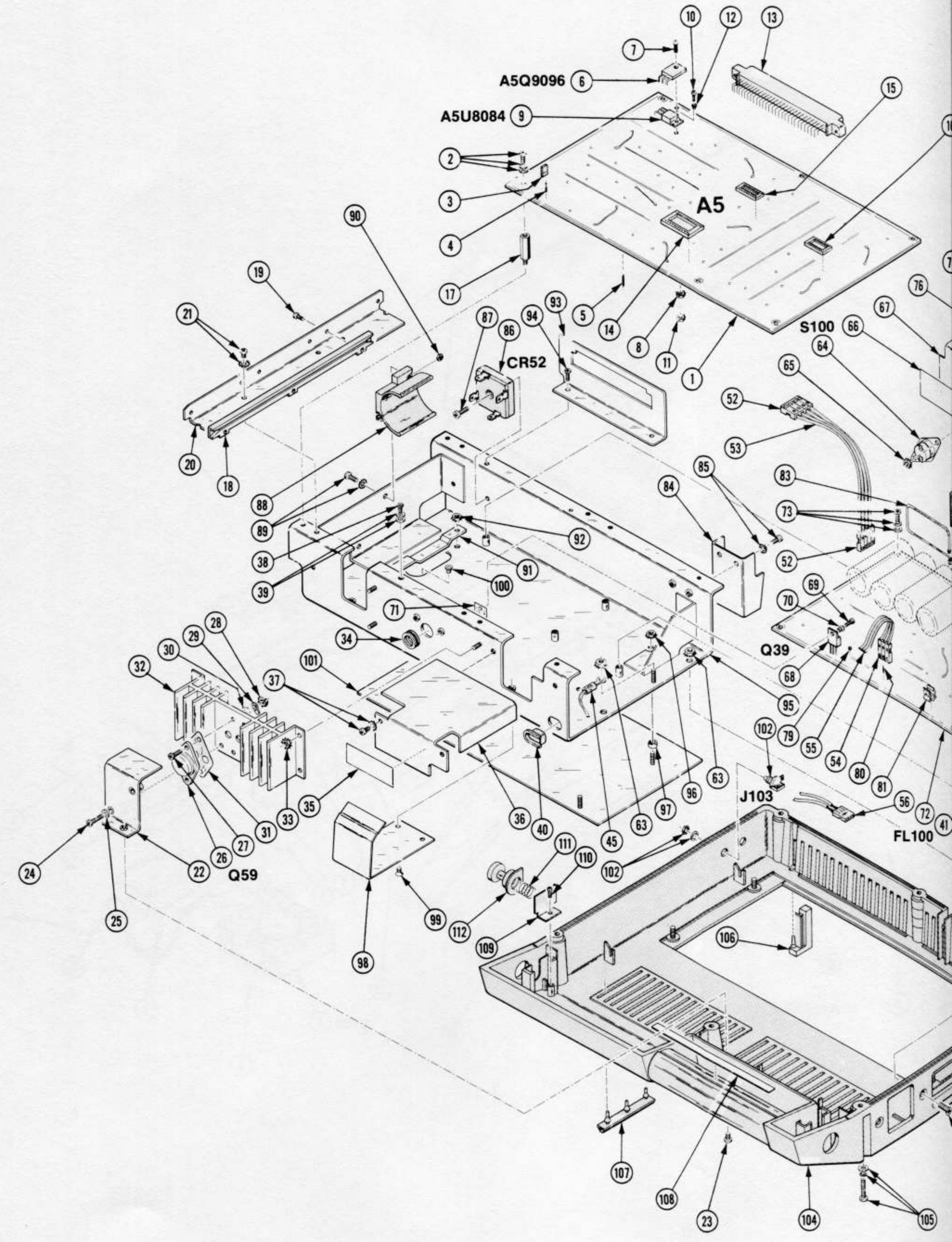
CROSS INDEX—MFR. CODE NUMBER TO MANUFACTURER

Mfr. Code	Manufacturer	Address	City, State, Zip
000AH	STANDARD PRESSED STEEL CO., UNBRAKO DIV.	8535 DICE ROAD	SANTA FE SPRINGS, CA 90670
000CV	ADVANCED ELECTRIC MFG.	1661 INDUSTRIAL WAY	BELMONT, CALIFORNIA 94002
000FU	WRIGHT ENGINEERED PLASTICS	10350 OLD REDWOOD HIGHWAY	WINDSOR, CA 95492
00779	AMP, INC.	P.O. BOX 3608	HARRISBURG, PA 17105
01295	TEXAS INSTRUMENTS, INC. SEMICONDUCTOR GROUP	P.O. BOX 5012	DALLAS, TX 75222
05574	VIKING INDUSTRIES, INC.	21001 NORDHOFF STREET	CHATSWORTH, CA 91311
06383	PANDUIT CORPORATION	17301 RIDGELAND	TINLEY PARK, IL 60477
08261	SPECTRA-STRIP CORP.	7100 LAMPSON AVE.	GARDEN GROVE, CA 92642
09922	BURNDY CORPORATION	RICHARDS AVENUE	NORWALK, CT 06852
12327	FREEWAY CORPORATION	9301 ALLEN DRIVE	CLEVELAND, OH 44125
22526	BERG ELECTRONICS, INC.	YOUK EXPRESSWAY	NEW CUMBERLAND, PA 17070
26365	GRIES REPRODUCER CO., DIV. OF COATS AND CLARK, INC.	125 BEECHWOOD AVE.	NEW ROCHELLE, NY 10802
28520	HEYMAN MFG. CO.	147 N. MICHIGAN AVE.	KENILWORTH, NJ 07033
49671	RCA CORPORATION	30 ROCKEFELLER PLAZA	NEW YORK, NY 10020
70485	ATLANTIC INDIA RUBBER WORKS, INC.	571 W. POLK ST.	CHICAGO, IL 60607
71400	BUSSMAN MFG., DIVISION OF MCGRAW-EDISON CO.	2536 W. UNIVERSITY ST.	ST. LOUIS, MO 63107
71468	ITT CANNON ELECTRIC	666 E. DYER RD.	SANTA ANA, CA 92702
71785	TRW, CINCH CONNECTORS	1501 MORSE AVENUE	ELK GROVE VILLAGE, IL 60007
73743	FISCHER SPECIAL MFG. CO.	446 MORGAN ST.	CINCINNATI, OH 45206
73803	TEXAS INSTRUMENTS, INC., METALLURGICAL MATERIALS DIV.	34 FOREST STREET	ATTLEBORO, MA 02703
75915	LITTELFUSE, INC.	800 E. NORTHWEST HWY	DES PLAINES, IL 60016
77250	PHEOLL MANUFACTURING CO., DIVISION OF ALLIED PRODUCTS CORP.	5700 W. ROOSEVELT RD.	CHICAGO, IL 60650
78189	ILLINOIS TOOL WORKS, INC. SHAKEPROOF DIVISION	ST. CHARLES ROAD	ELGIN, IL 60120
80009	TEKTRONIX, INC.	P O BOX 500	BEAVERTON, OR 97077
83309	ELECTRICAL SPECIALITY CO., SUBSIDIARY OF BELDEN CORP.	213 E. HARRIS AVE. SOUTH	SAN FRANCISCO, CA 94080
83385	CENTRAL SCREW CO.	2530 CRESCENT DR.	BROADVIEW, IL 60153
86928	SEASTROM MFG. COMPANY, INC.	701 SONORA AVENUE	GLENDALE, CA 91201
S3109	C/O PANEL COMPONENTS CORP.	P.O. BOX 6626	SANTA ROSA, CA 95406
T1105	J PHILLIP INDUSTRIES INC	5713 NORTHWEST HIGHWAY	CHICAGO, IL 60646
T1372	ELECTRI-CORD MFG CO INC	312 E. MAIN ST.	WESTFIELD, PA 16950

Fig. & Index No.	Tektronix Part No.	Serial/Model No. Eff	Dscont	Qty	1 2 3 4 5 Name & Description	Mfr Code	Mfr Part Number
1-1	----- -----			1	CKT BOARD ASSY:MAIN INTERCONN(SEE A5 REPL)		
					**************(ATTACHING PARTS)***********		
-2	211-0601-00			6	SCR,ASSEM WSHR:6-32 X 0.312,DOUBLE SEMS	83385	ORD BY DESCR
					************(END ATTACHING PARTS)*********		
	----- -----			-	.CKT BOARD ASSY INCLUDES:		
-3	131-0993-00			3	.BUS,CONDUCTOR:2 WIRE BLACK	00779	850100-01
-4	131-0608-00			77	.TERMINAL,PIN:0.365 L X 0.025 PH BRZ GOLD	22526	47357
-5	131-0589-00			4	.TERMINAL,PIN:0.46 L X 0.025 SQ	22526	48283-029
-6	----- -----			1	.TRANSISTOR:(SEE A5Q9096 REPL)		
					.*************(ATTACHING PARTS)***********		
-7	211-0097-00			1	.SCREW,MACHINE:4-40 X 0.312 INCH,PNH STL	83385	ORD BY DESCR
-8	210-0586-00			1	.NUT,PL,ASSEM WA:4-40 X 0.25,STL,CD PL	78189	211-041800-00
					.***********(END ATTACHING PARTS)*********		
-9	----- -----			1	.MICROCIRCUIT,DI:(SEE A5U8084 REPL)		
					.*************(ATTACHING PARTS)***********		
-10	211-0097-00			1	.SCREW,MACHINE:4-40 X 0.312 INCH,PNH STL	83385	ORD BY DESCR
-11	210-0586-00			1	.NUT,PL,ASSEM WA:4-40 X 0.25,STL,CD PL	78189	211-041800-00
-12	210-1178-00			1	.WASHER,SHLDR:U/W T0-220 TRANSISTOR	49671	DF137A
					.***********(END ATTACHING PARTS)*********		
-13	131-2143-00			2	.CONN,RCPT,ELEC:CKT CD,72 CONT,RIGHT ANGLE	05574	000231-3939
-14	136-0578-00	B010100	B010549	3	.SKT,PL-IN ELEK:MICROCKT,24 PIN,LOW PRFL	73803	C S9002-24
-15	136-0670-00	B010100	B010549	8	.SKT,PL-IN ELEK:MICROCKT,18 PIN,LOW PROFIL	73803	CS9002-18
-16	136-0260-02	B010100	B010549	1	.SKT,PL-IN ELEK:MICROCIRCUIT,16 DIP,LOW CL	71785	133-51-92-008
	136-0634-00	B010181	B010549	3	.SOCKET,PLUG-IN:20 LEAD DIP,CKT BD MTG	73803	CS9002-20
-17	129-0770-00			6	SPACER,POST:0.75 L,W/6-32 INT/EXT THD	80009	129-0770-00
	210-0921-00			6	WASHER,MICA:0.50 X 0.141 X0.005 INCH TH	80009	210-0921-00
-18	351-0179-00			2	GUIDE,CKT CARD:6.75 INCH LONG,PLASTIC	80009	351-0179-00
					**************(ATTACHING PARTS)***********		
-19	211-0008-00			6	SCREW,MACHINE:4-40 X 0.250,PNH,STL,POZ	83385	ORD BY DESCR
					************(END ATTACHING PARTS)*********		
-20	407-2325-00			2	BRACKET,ANGLE:CIRCUIT BOARD	80009	407-2325-00
					**************(ATTACHING PARTS)***********		
-21	211-0614-00			4	SCR,ASSEM WSHR:6-32 X 0.250 PNH,STL CD PL	83385	ORD BY DESCR
					************(END ATTACHING PARTS)*********		
-22	337-2677-00			1	SHIELD,ELEC:TRANSISTOR	80009	337-2677-00
					**************(ATTACHING PARTS)***********		
-23	211-0507-00			1	SCREW,MACHINE:6-32 X 0.312 INCH,PNH STL	83385	ORD BY DESCR
-24	211-0513-00			2	SCREW,MACHINE:6-32 X 0.625 INCH,PNH STL	83385	ORD BY DESCR
-25	210-0005-00			2	WASHER,LOCK:#6 EXT,0.02 THK,STL	78189	1106-00
					************(END ATTACHING PARTS)*********		
-26	----- -----			1	TRANSISTOR:(SEE Q59 REPL)		
					**************(ATTACHING PARTS)***********		
-27	211-0578-00			2	SCREW,MACHINE:6-32 X 0.438 1NCH,PNH STL	83385	ORD BY DESCR
-28	210-0457-00			2	NUT,PL,ASSEM WA:6-32 X 0.312,STL CD PL	83385	ORD BY DESCR
-29	210-0205-00			1	TERMINAL,LUG:SE #8	86928	5442-7
-30	210-0967-00			2	WASHER,SHLDR:0.156 ID X 0.094D X 0.375 O	86928	5607-82
					************(END ATTACHING PARTS)*********		
-31	386-0978-00			1	INSULATOR,PLATE:TRANSISTOR,MICA	80009	386-0978-00
-32	214-2888-00			1	HEAT SINK,XSTR:(1)TO-3,AL	80009	214-2888-00
					**************(ATTACHING PARTS)***********		
-33	210-0586-00			4	NUT,PL,ASSEM WA:4-40 X 0.25,STL,CD PL	78189	211-041800-00
					************(END ATTACHING PARTS)*********		
-34	348-0004-00			1	GROMMET,RUBBER:0.281 ID X 0.563 INCH OD	70485	763
-35	334-3621-00			1	MARKER,IDENT:MARKED DANGER,LINE VOLTAGE	80009	334-3621-00
-36	337-2676-00			1	SHIELD,ELEC:LINE FILTER	80009	337-2676-00
					**************(ATTACHING PARTS)***********		
-37	211-0614-00			2	SCR,ASSEM WSHR:6-32 X 0.250 PNH,STL CD PL	83385	ORD BY DESCR
					************(END ATTACHING PARTS)*********		
-38	211-0040-00			1	SCREW,MACHINE:4-40 X 0.25",BDGH PLSTC	26365	ORD BY DESCR
-39	210-1006-00			2	WASHER,FLAT:0.12 ID X 0.062 THK,AL,0.25	80009	210-1006-00
-40	358-0025-00			1	BSHG,STRAIN RLF:	28520	SR-6P-4
-41	----- -----			1	FILTER,RFI:(SEE FL100 REPL)		
					**************(ATTACHING PARTS)***********		
-42	210-0586-00			2	NUT,PL,ASSEM WA:4-40 X 0.25,STL,CD PL	78189	211-041800-00
-43	211-0198-00			2	SCREW,MACHINE:4-40 X 0.438 PNH,STL,POZ	77250	ORD BY DESCR
					************(END ATTACHING PARTS)*********		

Fig. & Index No.	Tektronix Part No.	Serial/Model No. Eff	Dscont	Qty	1 2 3 4 5 Name & Description	Mfr Code	Mfr Part Number
1-	198-4195-00	B010100	B010392	1	WIRE SET,ELEC:	80009	198-4195-00
	198-4195-01	B010393		1	WIRE SET,ELEC:	80009	198-4195-01
-44	131-2435-00			8	.TERM,QIK DISC:FEMALE,18-22 AWG	00779	2-520183-2
-45	210-0306-00			3	.TERMINAL,LUG:#10 RING,SOLDERLESS,CU TIN	09922	BA14E-10
-46	352-0166-09			1	.HLDR,TERM CONN:8 WIRE WHITE	80009	352-0166-09
-47	175-0831-00			FT	.WIRE,ELECTRICAL:8 WIRE RIBBON	08261	SS-0826-710610C
-48	352-0166-08			1	.CONN BODY,PL,EL:8 WIRE GRAY	80009	352-0166-08
-49	175-0831-00			FT	.WIRE,ELECTRICAL:8 WIRE RIBBON	08261	SS-0826-710610C
-50	131-1461-00			1	.CONN BODY,RCPT:25 FEMALE CONTACTS	00779	205207-1
-51	131-1316-00			1	.CONNECTOR BODY,:25 MALE-CONT POSITIONS	00779	208076-1
-52	352-0200-02			2	.CONN BODY,PL EL:4 WIRE RED	80009	352-0200-02
-53	175-1987-00			FT	.CABLE,SP,ELEC:4,18 AWG,STRD,PVC JKT	000CV	OBD
-54	352-0199-01			1	.HLDR,TERM CONN:3 WIRE BROWN	80009	352-0199-01
-55	175-5051-00			FT	.CA ASSY,SP,ELEC:3,18 AWG,PVC,8.5 INCH LON	000CV	OBD
-56	352-0162-00			1	.HLDR,TERM CONN:4 WIRE BLACK	80009	352-0162-00
	346-0128-00			3	STRAP,TIE DOWN:0.1W X 8.0" LONG,NYLON	06383	PLT2M
-57	210-0201-00			2	TERMINAL,LUG:0.12 ID,LOCKING,BRZ TIN PL	86928	ORD BY DESCR
-58	131-0890-00			2	LOCK,CONNECTOR:4-40 X 0.312 L	71468	D 20418-2
-59	----- -----			1	SWITCH,POWER:(SEE S98 REPL)		
-60	334-3379-01			1	MARKER,IDENT:MARKED GROUND SYMBOL	80009	334-3379-01
-61	407-2482-00			1	BRACKET,CMPNT:SW & CONN,ALUMINUM	80009	407-2482-00
					**************(ATTACHING PARTS)***********		
-62	212-0040-00			4	SCREW,MACHINE:8-32 X 0.375 100 DEG,FLH ST	83385	ORD BY DESCR
-63	220-0410-00			3	NUT,EXTENDED WA:10-32 X 0.375 INCH,STL	83385	ORD BY DESCR
					************(END ATTACHING PARTS)*********		
-64	----- -----			1	SWITCH,THERMO:(SEE S100 REPL)		
					**************(ATTACHING PARTS)***********		
-65	210-0586-00			2	NUT,PL,ASSEM WA:4-40 X 0.25,STL,CD PL	78189	211-041800-00
					************(END ATTACHING PARTS)*********		
-66	334-3855-00			1	MARKER,IDENT:MKD CAUTION	80009	334-3855-00
-67	407-2543-00			1	BRACKET,CMPNT:THERMO SWITCH,AL	80009	407-2543-00
-68	----- -----			2	TRANSISTOR:(SEE Q39,Q49 REPL)		
					**************(ATTACHING PARTS)***********		
-69	211-0008-00			2	SCREW,MACHINE:4-40 X 0.250,PNH,STL,POZ	83385	ORD BY DESCR
-70	210-1178-00			2	WASHER,SHLDR:U/W T0-220 TRANSISTOR	49671	DF137A
					************(END ATTACHING PARTS)*********		
-71	342-0202-00			2	INSULATOR,PLATE:TRANSISTOR	01295	10-21-023-106
-72	----- -----			1	CKT BOARD ASSY:POWER SUPPLY(SEE A20 REPL)		
					**************(ATTACHING PARTS)***********		
-73	211-0601-00			3	SCR,ASSEM WSHR:6-32 X 0.312,DOUBLE SEMS	83385	ORD BY DESCR
					************(END ATTACHING PARTS)*********		
	----- -----			-	.CKT BOARD ASSY INCLUDES:		
-74	----- -----			1	.TRANSFORMER:(SEE A20T80 REPL)		
					.*************(ATTACHING PARTS)***********		
-75	211-0594-00			4	.SCREW,MACHINE:	77250	ORD BY DESCR
-76	210-0803-00			4	.WASHER,FLAT:0.15 ID X 0.032 THK,STL CD	12327	ORD BY DESCR
	166-0226-00			4	.INS SLV,ELEC:1.125 INCHES LONG	80009	166-0226-00
-77	384-0539-00			4	.ROD,SPACER:0.375 X 0.750 INCH	80009	384-0539-00
-78	210-1011-00			4	.WASHER,NONMETAL:0.13 ID X 0.375 " OD,PLST	83309	ORD BY DESCR
	210-0457-00			4	.NUT,PL,ASSEM WA:6-32 X 0.312,STL CD PL	83385	ORD BY DESCR
					.***********(END ATTACHING PARTS)*********		
-79	136-0252-07			33	.SOCKET,PIN CONN:W/O DIMPLE	22526	75060-012
-80	131-0589-00			7	.TERMINAL,PIN:0.46 L X 0.025 SQ	22526	48283-029
-81	344-0286-00			8	.CLIP,ELECTRICAL:FOR 3AG FUSE,BRS	75915	102074
-82	352-0331-00			1	.LAMPHOLDER:	80009	352-0331-00
-83	346-0128-00			3	.STRAP,TIE DOWN:0.1W X 8.0" LONG,NYLON	06383	PLT2M
	195-1529-00			2	.LEAD,ELECTRICAL:16 AWG,2.5 L	80009	195-1529-00
-84	407-2479-00			1	BRACKET,DAMPING:ALUMINUM	80009	407-2479-00
					**************(ATTACHING PARTS)***********		
-85	211-0614-00			2	SCR,ASSEM WSHR:6-32 X 0.250 PNH,STL CD PL	83385	ORD BY DESCR
					************(END ATTACHING PARTS)*********		
-86	----- -----			1	RECTIFIER:(SEE CR52 REPL)		
					**************(ATTACHING PARTS)***********		
-87	211-0578-00			1	SCREW,MACHINE:6-32 X 0.438 1NCH,PNH STL	83385	ORD BY DESCR
					************(END ATTACHING PARTS)*********		

Fig. & Index No.	Tektronix Part No.	Serial/Model No. Eff	Dscont	Qty	1 2 3 4 5 Name & Description	Mfr Code	Mfr Part Number
1-88	352-0322-00			1	RETAINER,CAP:1.375 DIA,HORIZ MOUNT	80009	352-0322-00
					**************(ATTACHING PARTS)***********		
-89	211-0614-00			2	SCR,ASSEM WSHR:6-32 X 0.250 PNH,STL CD PL	83385	ORD BY DESCR
-90	210-0407-00			2	NUT,PLAIN,HEX.:6-32 X 0.25 INCH,BRS	73743	3038-0228-402
					************(END ATTACHING PARTS)*********		
-91	407-2340-00			1	BRACKET,LENS:ALUMINUM	80009	407-2340-00
					**************(ATTACHING PARTS)***********		
-92	220-0410-00			2	NUT,EXTENDED WA:10-32 X 0.375 INCH,STL	83385	ORD BY DESCR
					************(END ATTACHING PARTS)*********		
-93	407-2483-00			1	BRACKET,ANGLE:CONN GUIDE,AL	80009	407-2483-00
					**************(ATTACHING PARTS)***********		
-94	211-0008-00			2	SCREW,MACHINE:4-40 X 0.250,PNH,STL,POZ	83385	ORD BY DESCR
					************(END ATTACHING PARTS)*********		
-95	441-1478-01			1	CHAS,TEST FXTR:W/BRACKETS	80009	441-1478-01
					**************(ATTACHING PARTS)***********		
-96	210-0457-00			4	NUT,PL,ASSEM WA:6-32 X 0.312,STL CD PL	83385	ORD BY DESCR
					************(END ATTACHING PARTS)*********		
-97	166-0029-00			4	SPACER,SLEEVE:0.125 L X 0.18 ID,AL	80009	166-0029-00
-98	407-2480-00			2	BRACKET,ANGLE:GROUNDING,ALUMINUM	80009	407-2480-00
					**************(ATTACHING PARTS)***********		
-99	211-0105-00			4	SCREW,MACHINE:4-40 X 0.188,100 DEG,FLH ST	83385	ORD BY DESCR
					************(END ATTACHING PARTS)*********		
-100	378-0613-00			1	LENS,LIGHT:AMBER,0.25 DIA PLASTIC	80009	378-0613-00
-101	386-4118-00			1	PANEL,BOTTOM:ALUMINUM	80009	386-4118-00
-102	136-0094-00			2	JACK,TELEPHONE:MINIATURE,SHUNT TYPE	80009	136-0094-00
-103	334-3545-00			1	MARKER,IDENT:CAUTION	80009	334-3545-00
-104	202-0252-01			1	CASE,MICROCMPTR:BOTTOM,W/HARDWARE	80009	202-0252-01
					***************(ATTACHING PARTS)***********		
-105	211-0648-00			6	SCR ASSEM WSHR:6-32 X 0.625 INCH,PNH,STL	80009	211-0648-00
					************(END ATTACHING PARTS)*********		
	----- -----			-	.BOTTOM CASE INCLUDES:		
-106	348-0514-00			2	.FOOT,CABINET:POLYURETHANE,BLACK	80009	348-0514-00
-107	348-0089-00			3	.BUMPER,PLASTIC:BLACK VINYL	80009	348-0089-00
-108	334-3546-00			1	.MARKER,IDENT:TEKTRONIX	80009	334-3546-00
-109	407-1920-00			2	.BRACKET,COV LCH:ALUMINUM	80009	407-1920-00
					.*************(ATTACHING PARTS)***********		
-110	211-0504-00			2	.SCREW,MACHINE:6-32 X 0.25 INCH,PNH STL	83385	ORD BY DESCR
					.***********(END ATTACHING PARTS)*********		
-111	214-0428-00			2	.SPRING,HANDLE:0.375 OD X 0.4 L,CLOSED	80009	214-0428-00
-112	366-1724-00			2	.PUSH BUTTON:BLUE,0.72 SQ X 0.8 H	80009	366-1724-00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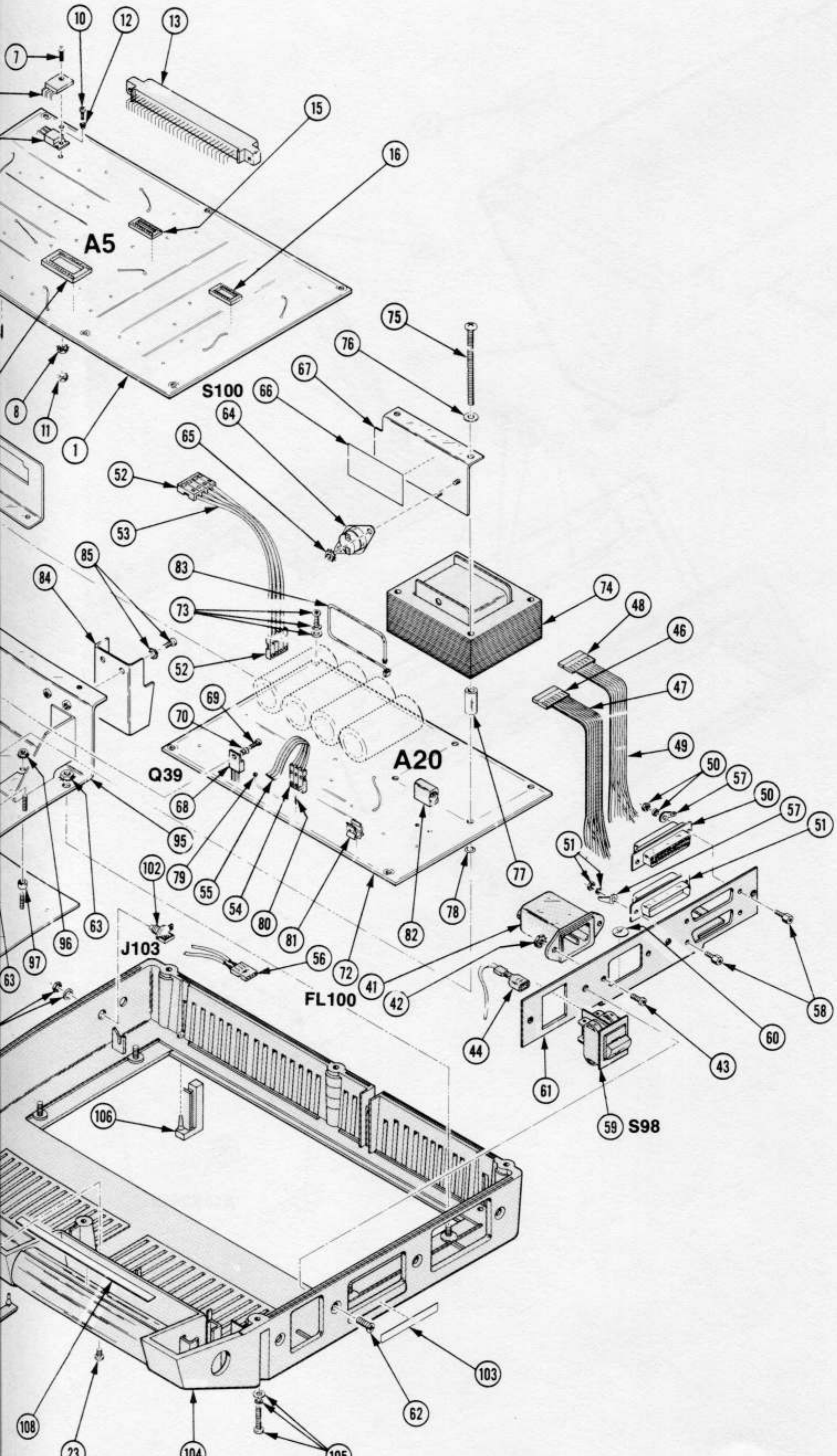
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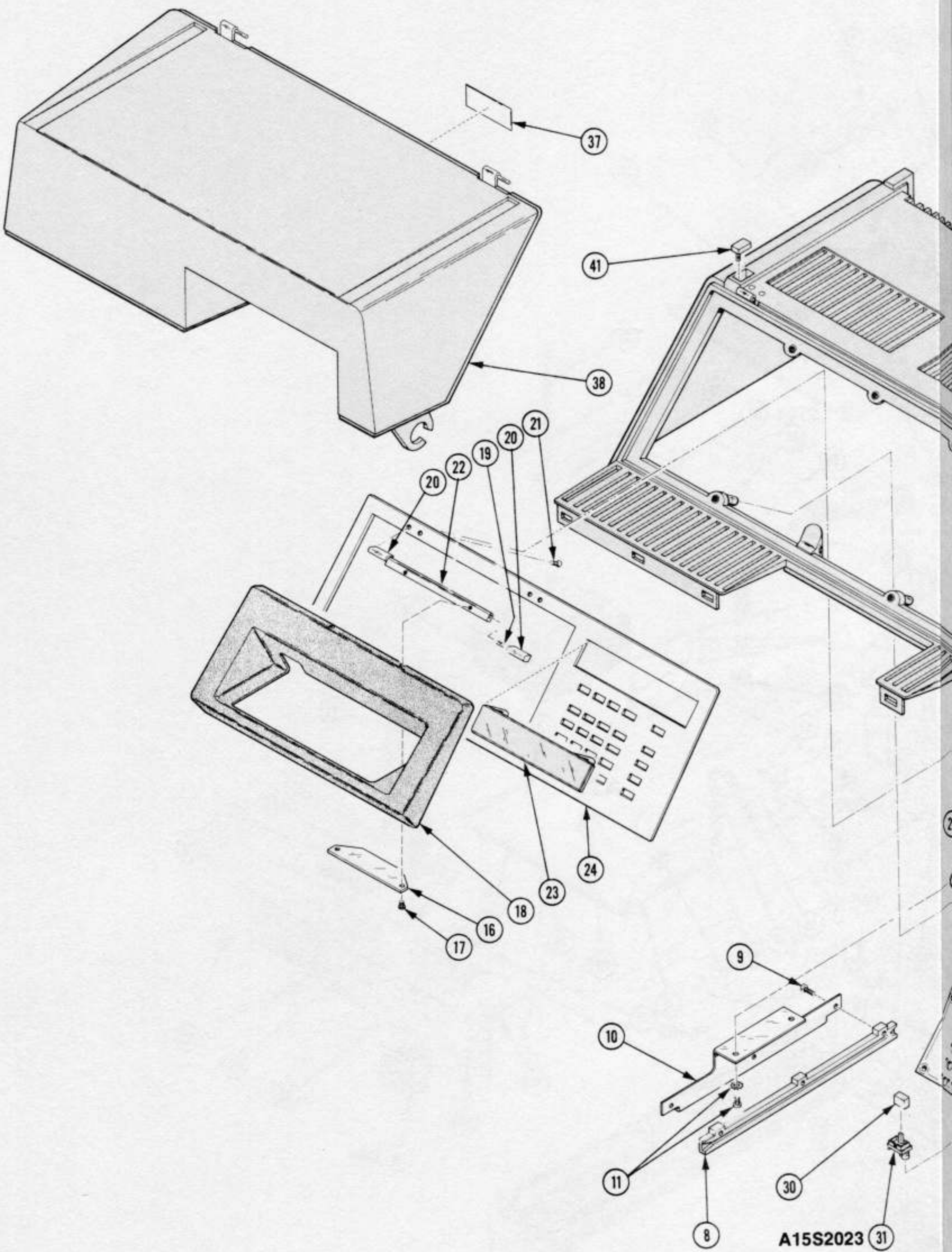

FIGURE 2 FRONT PANEL

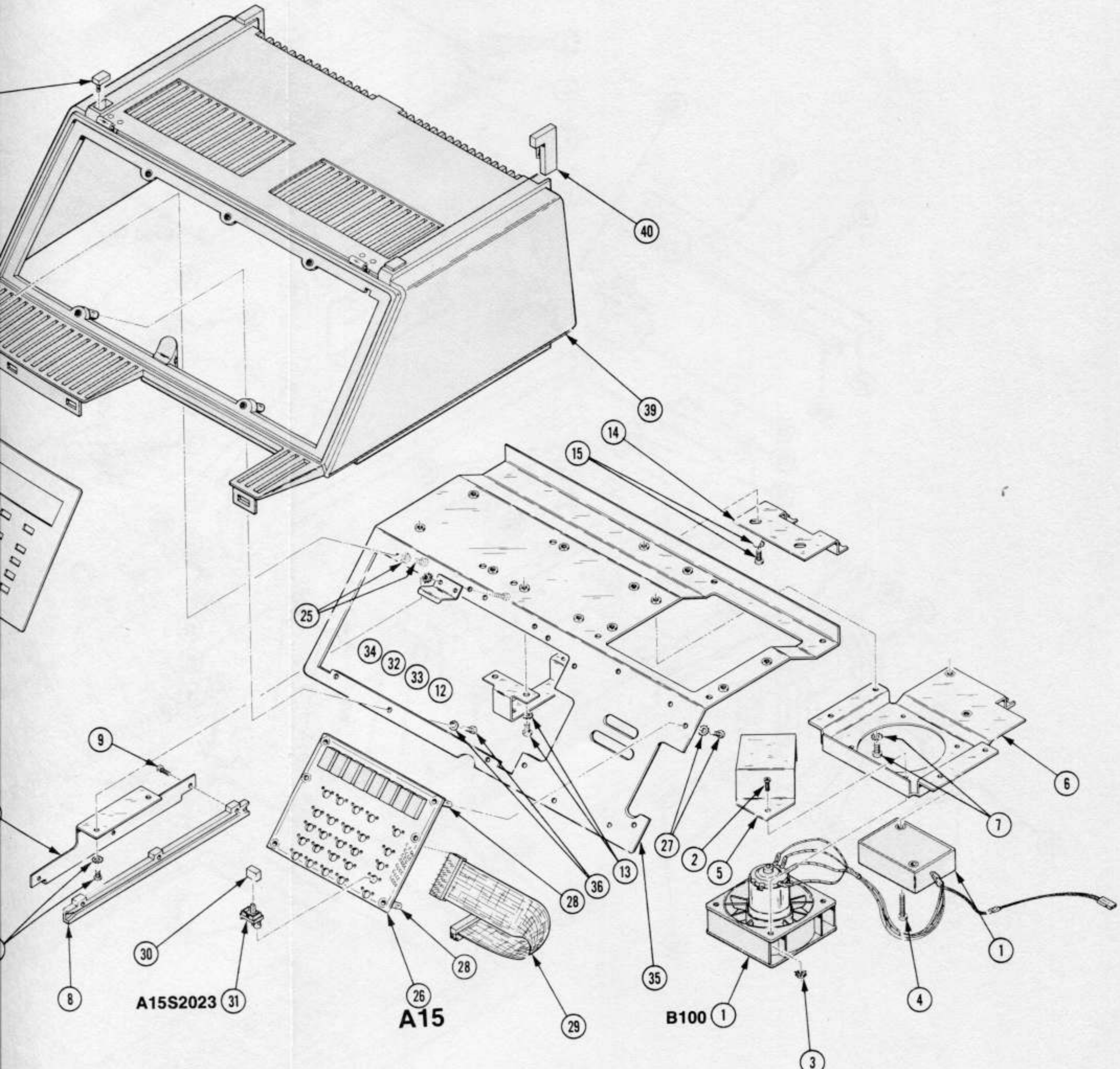

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Fig. & Index No.	Tektronix Part No.	Serial/Model No. Eff	Dscont	Qty	1 2 3 4 5 Name & Description	Mfr Code	Mfr Part Number
2-1	----- -----			1	FAN,DC:(SEE B100 REPL)		
					**************(ATTACHING PARTS)***********		
-2	211-0008-00			4	SCREW,MACHINE:4-40 X 0.250,PNH,STL,POZ	83385	ORD BY DESCR
-3	210-0586-00			4	NUT,PL,ASSEM WA:4-40 X 0.25,STL,CD PL	78189	211-041800-00
-4	211-0513-00			2	SCREW,MACHINE:6-32 X 0.625 INCH,PNH STL	83385	ORD BY DESCR
					************(END ATTACHING PARTS)*********		
-5	337-2767-00			1	SHIELD,ELEC:FAN,AL	80009	337-2767-00
-6	407-2539-00			1	BRACEKT,FAN:ALUMINUM	80009	407-2539-00
					**************(ATTACHING PARTS)***********		
-7	211-0614-00			4	SCR,ASSEM WSHR:6-32 X 0.250 PNH,STL CD PL	83385	ORD BY DESCR
					************(END ATTACHING PARTS)*********		
-8	351-0179-00			2	GUIDE,CKT CARD:6.75 INCH LONG,PLASTIC	80009	351-0179-00
					**************(ATTACHING PARTS)***********		
-9	211-0008-00			6	SCREW,MACHINE:4-40 X 0.250,PNH,STL,POZ	83385	ORD BY DESCR
					************(END ATTACHING PARTS)*********		
-10	407-2324-00			2	BRKT,DBL ANGLE:CIRCUIT BOARD	80009	407-2324-00
					**************(ATTACHING PARTS)***********		
-11	211-0614-00			4	SCR,ASSEM WSHR:6-32 X 0.250 PNH,STL CD PL	83385	ORD BY DESCR
					************(END ATTACHING PARTS)*********		
-12	407-2481-00			1	BRACKET,DETENT:ALUMINUM	80009	407-2481-00
					**************(ATTACHING PARTS)***********		
-13	211-0614-00			3	SCR,ASSEM WSHR:6-32 X 0.250 PNH,STL CD PL	83385	ORD BY DESCR
					************(END ATTACHING PARTS)*********		
-14	386-4302-00			1	SUPPORT,CHASS:TEST FIXTURE,TOP	80009	386-4302-00
					**************(ATTACHING PARTS)***********		
-15	211-0614-00			2	SCR,ASSEM WSHR:6-32 X 0.250 PNH,STL CD PL	83385	ORD BY DESCR
					************(END ATTACHING PARTS)*********		
-16	386-4230-00			1	PL,LATCH,STRIKE:ALUMINUM	80009	386-4230-00
					**************(ATTACHING PARTS)***********		
-17	211-0196-00			2	SCREW,MACHINE:4-40 X 0.188,SCH,HEX,STL	000AH	ORD BY DESCR
					************(END ATTACHING PARTS)*********		
-18	200-2326-00			1	COVER,CKT BOARD:POLYCARBONATE	80009	200-2326-00
-19	214-2146-00			2	PIN,STR,HDLS:0.062 OD X 0.60 INCH L,SST	80009	214-2146-00
-20	214-2873-00			2	HINGE HALF,COV:ALUMINUM	80009	214-2873-00
					**************(ATTACHING PARTS)***********		
-21	211-0105-00			4	SCREW,MACHINE:4-40 X 0.188,100 DEG,FLH ST	83385	ORD BY DESCR
					************(END ATTACHING PARTS)*********		
-22	214-2872-00			1	HINGE HALF,COV:ALUMINUM	80009	214-2872-00
-23	378-2026-00			1	FILTER,LIGHT:RED,0.99 W X 3.82 L,PLASTIC	80009	378-2026-00
-24	333-2532-00			1	PANEL,FRONT:	80009	333-2532-00
					**************(ATTACHING PARTS)***********		
-25	211-0033-00			6	SCR,ASSEM WSHR:4-40 X 0.312 PNH,STL,CD PL	83385	ORD BY DESCR
					************(END ATTACHING PARTS)*********		
-26	----- -----			1	CKT BOARD ASSY:KEYBOARD/DISPLAY(SEE A15 RE		
					**************(ATTACHING PARTS)***********		
-27	211-0033-00			4	SCR,ASSEM WSHR:4-40 X 0.312 PNH,STL,CD PL	83385	ORD BY DESCR
					************(END ATTACHING PARTS)*********		
	----- -----			-	.CKT BOARD ASSY INCLUDES:		
-28	129-0216-00			4	.SPACER,POST:0.187 OD,0.312 INCH LONG	80009	129-0216-00
-29	175-2878-00			1	.CA ASSY,SP,ELEC:26,28 AWG,7.0 L	22526	OBD
-30	366-1770-00			8	.PUSH BUTTON:GY,0.225 X 0.4 X 0.17	000FU	OBD
	366-1770-02			1	.PUSH BUTTON:GRAY,1	000FU	OBD
	366-1770-03			1	.PUSH BUTTON:GRAY,2	000FU	OBD
	366-1770-04			1	.PUSH BUTTON:GRAY,3	000FU	OBD
	366-1770-05			1	.PUSH BUTTON:GRAY,4	000FU	OBD
	366-1770-06			1	.PUSH BUTTON:GRAY,5	000FU	OBD
	366-1770-07			1	.PUSH BUTTON:GRAY,6	000FU	OBD
	366-1770-08			1	.PUSH BUTTON:GRAY,7	000FU	OBD
	366-1770-09			1	.PUSH BUTTON:GRAY,8	000FU	OBD
	366-1770-10			1	.PUSH BUTTON:GRAY,9	000FU	OBD
	366-1770-11			1	.PUSH BUTTON:GRAY,O	000FU	OBD
	366-1770-12			1	.PUSH BUTTON:GRAY,A	000FU	OBD
	366-1770-13			1	.PUSH BUTTON:GRAY,B	000FU	OBD

Fig. & Index No.	Tektronix Part No.	Serial/Model No. Eff	Dscont	Qty	1 2 3 4 5 Name & Description	Mfr Code	Mfr Part Number
2-	366-1770-14			1	.PUSH BUTTON:GRAY,C	000FU	OBD
	366-1770-15			1	.PUSH BUTTON:GRAY,D	000FU	OBD
	366-1770-16			1	.PUSH BUTTON:GRAY,E	000FU	OBD
	366-1770-17			1	.PUSH BUTTON:GRAY,F	000FU	OBD
	366-1791-00			1	.PUSH BUTTON:ORN,0.225 W X 0.4 L X 0.175 H	000FU	OBD
-31	----- -----			25	.SWITCH PB:(SEE A15S2023,2035,2046,2061,		
	----- -----			-	.2081,3023,3025,3035,3037,3046,3048,3062,		
	----- -----			-	.3064,3081,3084,4023,4025,4035,4037,4046,		
	----- -----			-	.4048,4062,4064,4081,4084 REPL)		
-32	105-0827-00			1	LATCH,COVER:COPPER BERYLLIUM	80009	105-0827-00
					**************(ATTACHING PARTS)***********		
-33	211-0504-00			2	SCREW,MACHINE:6-32 X 0.25 INCH,PNH STL	83385	ORD BY DESCR
-34	210-0457-00			2	NUT,PL,ASSEM WA:6-32 X 0.312,STL CD PL	83385	ORD BY DESCR
					************(END ATTACHING PARTS)*********		
-35	441-1477-00			1	CHAS,TEST FXTR:MAIN	80009	441-1477-00
					**************(ATTACHING PARTS)***********		
-36	211-0033-00			11	SCR,ASSEM WSHR:4-40 X 0.312 PNH,STL,CD PL	83385	ORD BY DESCR
					************(END ATTACHING PARTS)*********		
-37	334-3856-00			1	MARKER,IDENT:DO NOT BLOCK AIR FLOW	80009	334-3856-00
-38	200-2064-01			1	COVER,ACCESS:W/HARDWARE AND LID	80009	200-2064-00
	200-2102-00			1	.LID,SCOPE COVER:PLASTIC	80009	200-2102-00
-39	200-2462-01			1	COVER,DGTL TSTR:PLASTIC W/HARDWARE	80009	200-2462-01
-40	348-0514-00			2	.FOOT,CABINET:POLYURETHANE,BLACK	80009	348-0514-00
-41	348-0513-00			2	.FOOT,CABINET:POLYURETHANE,BLACK	80009	348-0513-00

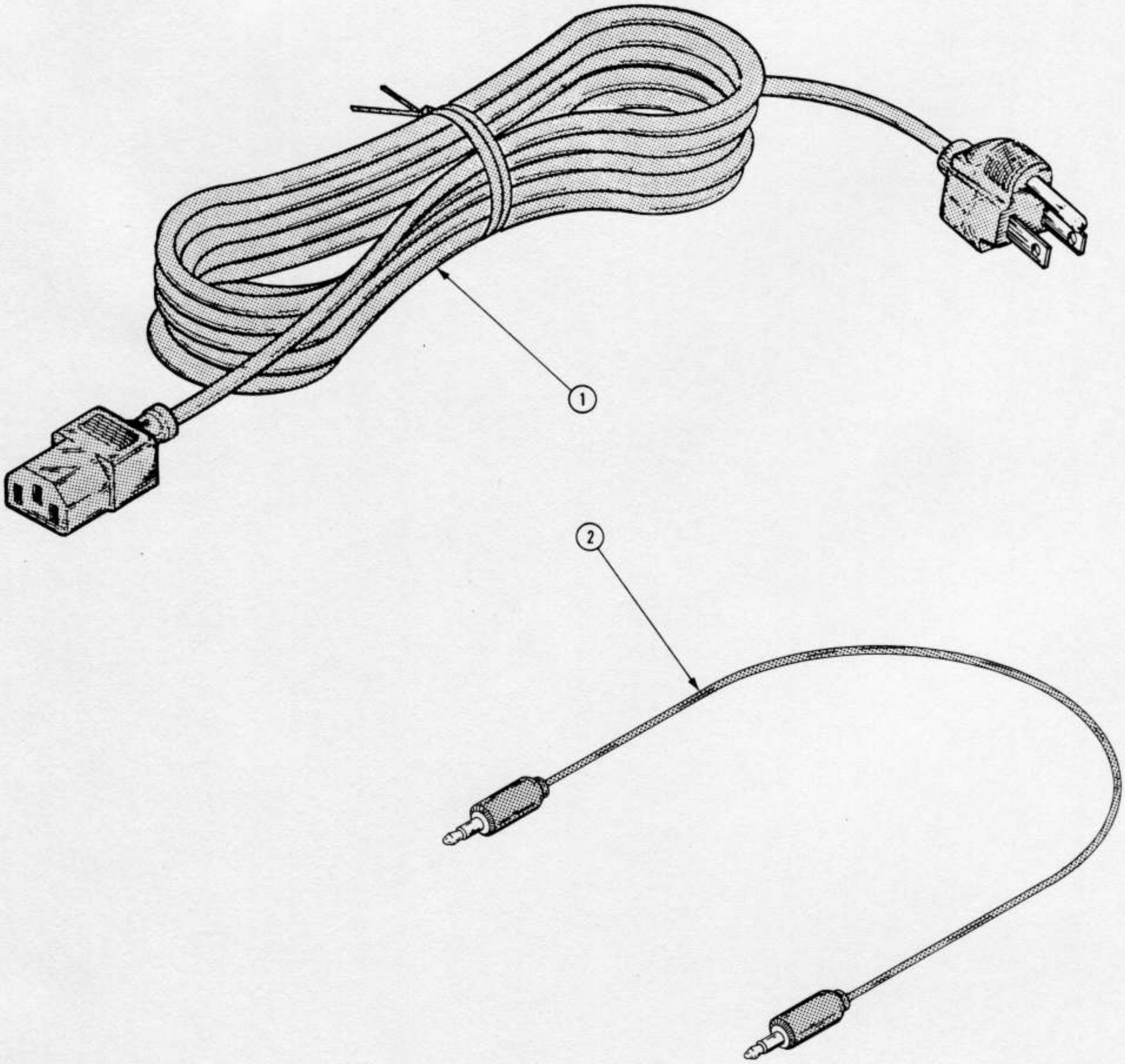

Fig. & Index No.	Tektronix Part No.	Serial/Model No. Eff	Dscont	Qty	1 2 3 4 5 Name & Description	Mfr Code	Mfr Part Number
3-1	161-0066-00			1	CABLE ASSY,PWR,:3 WIRE,98 INCH LONG	80009	161-0066-00
	----- -----			-	(067-0892-00 ONLY)		
	161-0066-09			1	CABLE ASSY,PWR:3,0.75MM SQ,220V,96.0 L	16428	OBD
	----- -----			-	(067-0892-01 ONLY)		
	161-0066-10			1	CABLE ASSY,PWR:3,0.75MM SQ,240V,96.0 L	80126	OBD
	----- -----			-	(067-0892-02 ONLY)		
	161-0066-11			1	CABLE ASSY,PWR:3,0.75MM SQ,240V,96.0 L	80126	OBD
	----- -----			-	(067-0892-03 ONLY)		
	161-0066-12			1	CABLE ASSY,PWR:3,18 AWG,240V,96.0 L	80126	OBD
	----- -----			-	(067-0892-04 ONLY)		
	159-0022-00			1	FUSE,CARTRIDGE:3AG,1A,250V,0.15SEC	75915	312001
	----- -----			-	(067-0892-00 ONLY)		
	159-0025-00			1	FUSE,CARTRIDGE:3AG,0.5A,250V,0.25SEC	75915	312.500
	----- -----			-	(067-0892-01,-02,-03,-04 ONLY)		
-2	175-5100-00			1	CA ASSY,SP,ELEC:2,26 AWG,24.0 L	80009	175-5100-00
	175-5101-00			1	CA ASSY,SP,ELEC:2,26 AWG,24.0 L	80009	175-5101-00
	070-2827-01			1	MANUAL,TECH:INSTRUCTION	80009	070-2827-01

Section 11

PERSONALITY CARD SERVICE

INTRODUCTION

This section is devoted to the service part of the personality card Instruction Manual supplements shipped with your personality cards. The supplements can be divided into two parts. The servicing information goes within this section.

MANUAL CHANGE INFORMATION

At Tektronix, we continually strive to keep up with latest electronic developments by adding circuit and component improvements to our instruments as soon as they are developed and tested.

Sometimes, due to printing and shipping requirements, we can't get these changes immediately into printed manuals. Hence, your manual may contain new change information on following pages.

A single change may affect several sections. Since the change information sheets are carried in the manual until all changes are permanently entered, some duplication may occur. If no such change pages appear following this page, your manual is correct as printed.