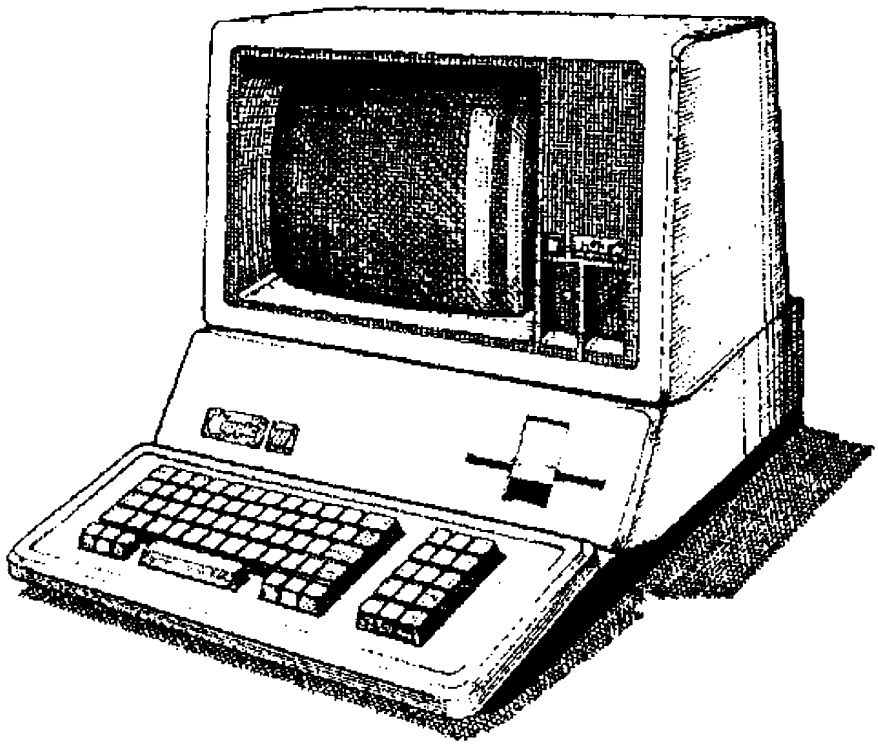
Apple /// Computer Information

Apple /// Service Reference Manual



Section I of II • Theory of Operation

Chapter 1 • Introduction

Written by Apple Computer • 1982

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INTRODUCTION

GENERAL DESCRIPTION

The Apple /// is a personal computer for the professional. It has the capabilities to run very involved programs since it can have up to 256K of RAM. The overall unit has been designed to incorporate the best features and options that make it a complete personal computer. The Apple][emulation mode allows users to run most Apple][software. However, minor modifications may be required for some Apple][programs or other peripheral devices.

The base system has a full ASCII keyboard which includes a 13-key numeric key pad with two special function keys. There are four cursor control keys. The A/// has two special repeat features: 1) each key repeats when held depressed, and 2) a high-speed repeat is activated with the Solid Apple key. It's typewriter style keyboard is sculptured for maximum typing speed and accuracy.

The Apple /// has a built-in disk drive (140K bytes) and controller which is capable of supporting three additional external drives without additional interfacing. One interesting feature is that the two drives may be on at the same time. This increases the disk-to-disk transfer effectiveness. The Apple /// can also be used with "Profile"- Apple's 5 Megabyte hard disk for mass data storage.

A built-in RS-232 port, located on the back panel, allows you to connect the Apple /// to letter quality printers, high-speed data collection devices, modems, and other serial input/output devices using RS-232-C protrocol. The A/// has two joystick ports for games, sophisticated cursor control, or silentype operation.

The Apple /// has 8 different modes of video operation. B/W Text in 40 and 80 column, a 40 column 16 color text mode (where the foreground and background of each character can be defined). The Apple][graphics modes are duplicated and there are three more graphics modes: a super black and white Hi-Res, 16 color Hi-Res, and 16 color medium resolution graphics. The eigth mode is actually a utilizatin of the color text mode where the user defines the character image and builds video images with these "character sets". Since the video character generator is RAM, not ROM, as in the Apple][, it provides the user with the capability of defining character sets to display whatever the user wants. Three video outputs are provided at the back panel; these are black and white, NTSC color composite, and RGB video for exceptional color purity and resolution.

The Apple ///'s Central Processing Unit (CPU) can be "interrupted" by peripheral devices whenever they require CPU control. Alternatively the CPU can poll the devices to determine which needs attention, thereby minimizing the software required for peripheral control.

There are more features in the Apple /// such as, a built-in clock/calender, a hardware beeper to simplify programming, a six-level D/A converter for more

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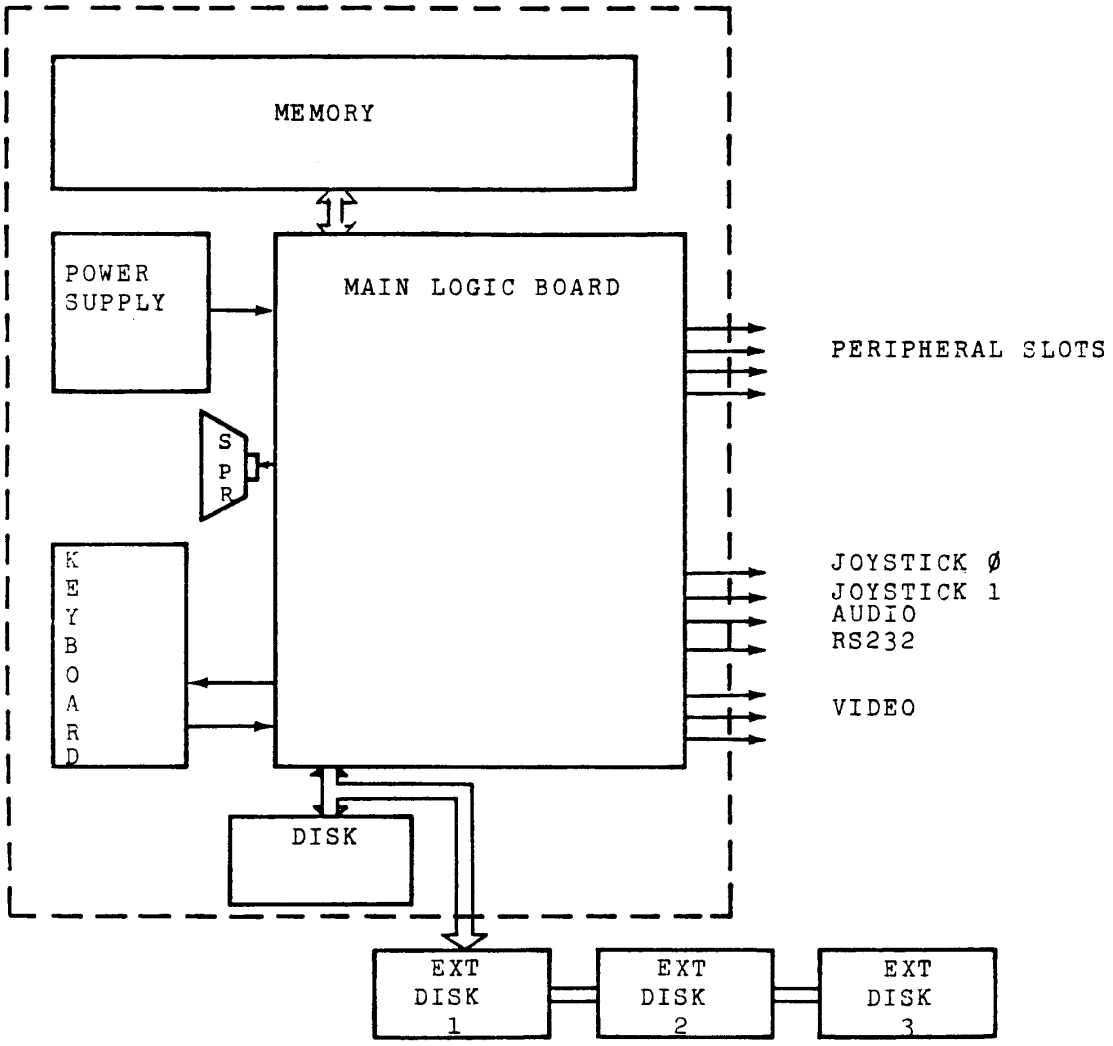
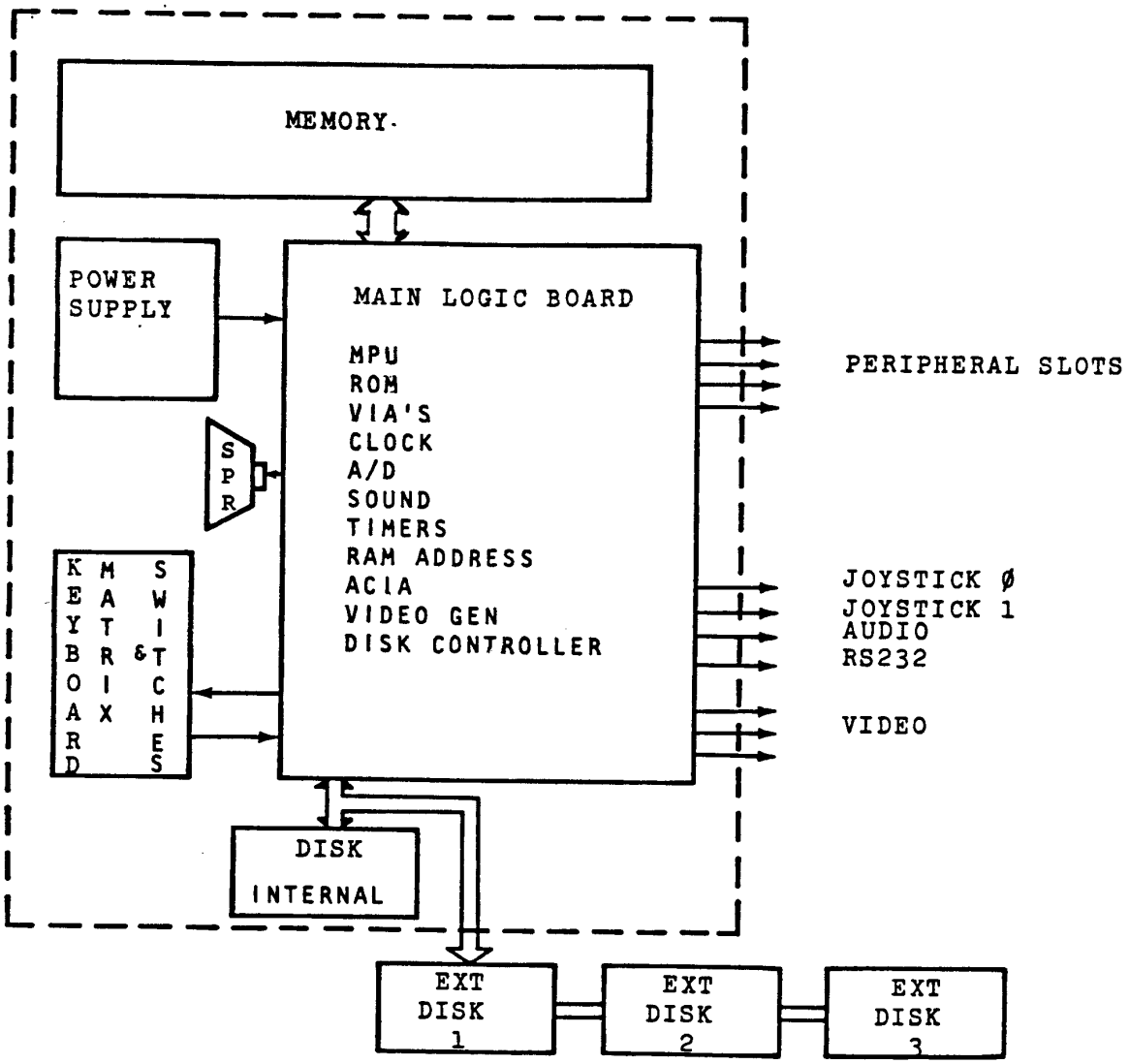
A III SYSTEM BLOCK DIAGRAM



1.2

A III SYSTEM BLOCK DIAGRAM



DEFINITIONS

MPU - MICROPROCESSOR
ROM - READ ONLY MEMORY
VIA - VERSATILE INTERFACE ADAPTER: A SPECIAL PURPOSE PROCESSOR
ACIA - ASYNCHRONOUS COMMUNICATIONS INTERFACE ADAPTER PROVIDES RS232 COMMUNICATIONS CAPABILITY.
A/D - ANALOG TO DIGITAL CONVERTER

FIG 1.1

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complex tone generation, and the duplication of the speaker function of the Apple][.

As you can see there are many onboard features that would fully load an Apple][, yet the Apple /// has four expansion slots for additional user interfacing. As you read this document and learn how it works, you will appreciate its capabilities, design, and usefulness.

SIMPLIFIED FUNCTIONAL DESCRIPTION

The Apple /// is not an easy machine to understand. It has been designed to emulate the Apple][and has done many operations in a different manner, while adding many enhancements which contribute to its complexity. To understand the system structure it is best to start building functional blocks and gain an understanding of each separately, and then comprehensively.

There are five major parts (modules) to the Apple ///. These parts are:

1) Main Logic PCB - this board functions primarily as a processor and device controller. Many functions are integrated into the board, including the disk controller.

2) Memory PCB - this board stores data/programs temporarily (until power is removed).

3) Keyboard PCB - this is the primary input device provided to the user.

4) Disk Drive - Mass storage device for storing data.

5) Power Supply - provides the voltages and regulation required to keep everything else working.

THE MAIN LOGIC BOARD

The Main Logic Board is easily identified by its large size and mass quantities of integrated circuits (IC's).

Referring to the block diagram of Figure 1.1 we encounter the microprocessor (MPU), Boot/Monitor ROM, address decode/select circuitry, the Versatile Interface (VIA) containing the bank switch register and the sound register, the VIA containing the environmental and zero page registers, the Asynchronous Communications Interface Adapter (ACIA), analog to digital circuit (joystick inputs), the expansion I/O slots, disk controller, keyboard encoder, video generator, RAM, RAM address circuits, and the system and video timing circuits. Whooo, now you see why it's so big!

Figure 1.1 shows the Apple /// in it's simplest form and presents its expanded I/O capability. On the other hand, the System Functional Block Diagram displays the system in more detail and presents a sophisticated system using some highly unique designs. Some definitions have been provided for some of the terms used in the block diagram.

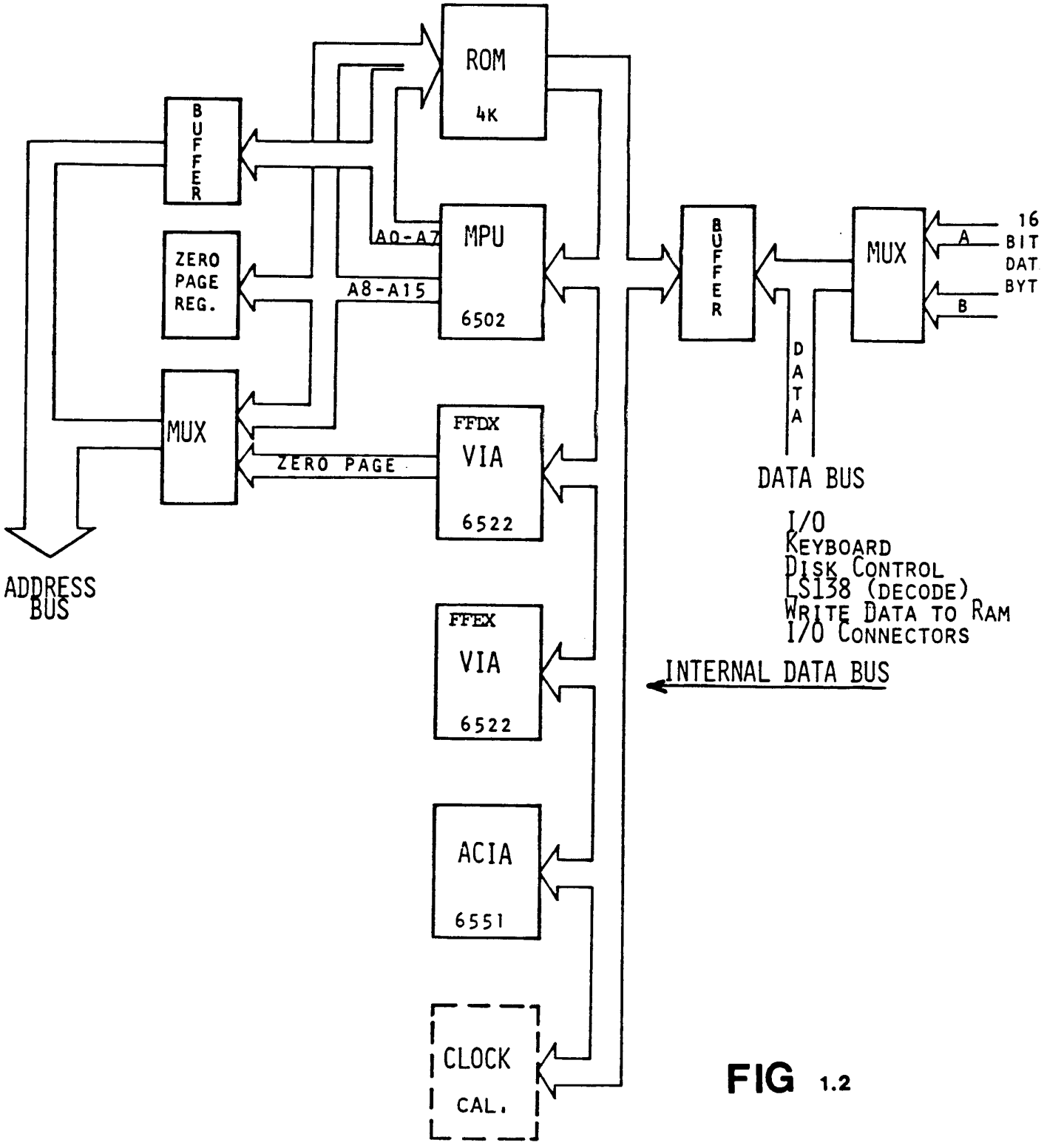
ROM
4K
BUFFER
MPU
6502
A0-A7
A8-A15
ZERO PAGE REG.
MUX
ZERO PAGE
FFDX
VIA
6522
FFEX
VIA
6522
ACIA
6551
CLOCK
CAL.
ADDRESS BUS
BUFFER
MUX
A
B
16 BIT DAT BYT
DATA
DATA BUS
I/O
KEYBOARD
DISK CONTROL
LS138 (DECODE)
WRITE DATA TO RAM
I/O CONNECTORS
INTERNAL DATA BUS

FIG 1.2

1.5

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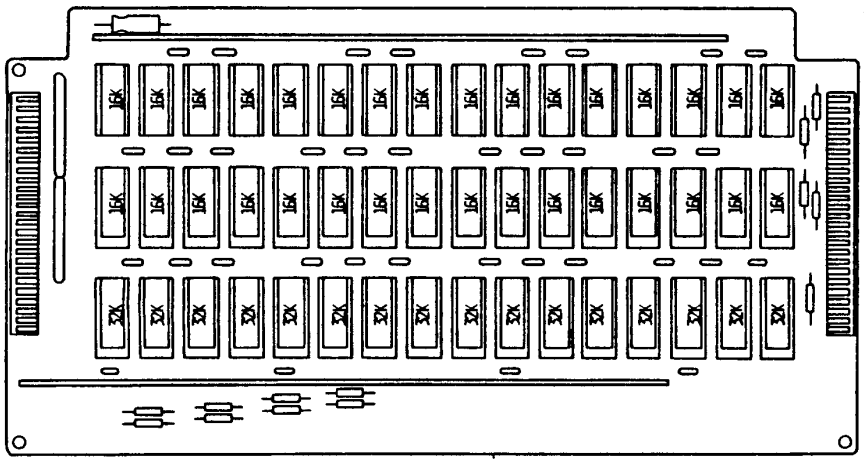
It is best to think of the Apple /// processor as more than just the MPU chip. The processor/controller is actually comprised of many components. The most significant of these are the MPU and the two VIA's. Because of the system's complexity and memory size, the MPU must have extended addressing. Extended addressing is accomplished thru bank switches, environmental register, and a zero page register.

The Apple /// system is interrupt driven. In order to efficienctly use processing time, only those devices that allow programs access to the processor are serviced. In fact the processor can even totally mask (disable) the reset key.

THE MEMORY BOARD

The other PCB in the Apple /// is the memory board. It is mounted on the Main Logic Board by two rows of pin connectors. There are two distinct types of memory boards. The early memory board version is commonly refered to as the 12V Memory Board. Below is an illustration of this board.

THE 12 VOLT MEMORY BOARD (128K CONFIGURATION)



With the correct Main Logic Board configuration, this board can have up to 128K RAM (without modification). The board uses 16K and 32K RAM chips.

The latest memory board version is called the 5 Volt Memory Board. This board, illustrated in the accompanying pages, can be configured for 128K or 256K RAM. The 5 Volt Memory Board, however, requires the correct Main Logic Board configuration.

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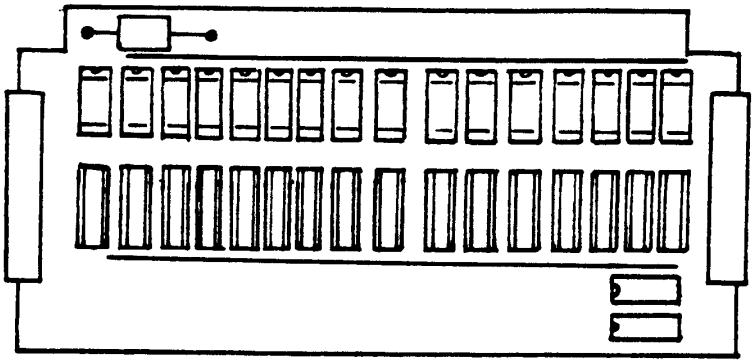
THE 5 VOLT MEMORY BOARD (128K CONFIGURATION)



THE KEYBOARD PCB

This has to be one of the nicest keyboards around. The sculptured keys are a delight to touch. The Apple /// does not have an on board keyboard encoder - the keyboard encoder is on the Main Logic Board. The keyboard is basically a matrix of switches. The keyboard is connected by means of a 26 pin ribbon cable to the Main Logic Board.

THE DISK DRIVE

The disk drive is similiar to the Disk][. The major difference between the Disk][and the Apple /// drive are the door, the bezel, and the Analog Card. Disk switch detection circuitry has been added to the Disk /// Analog Card. Through daisey-chaining you can have up to three (3) external disk drives.

THE APPLE /// POWER SUPPLY

The power supply, accessible from the bottom of the Apple ///, is housed in the casting. It is a "switching type" power supply that supplies the following voltages:

- o +5.0 VDC
- o +11.8 VDC
- o -5.0 VDC
- o -12.0 VDC

yet, it consumes less power than a 100 Watt light bulb. The power supply also has several protection features, ie. overvoltage protection.

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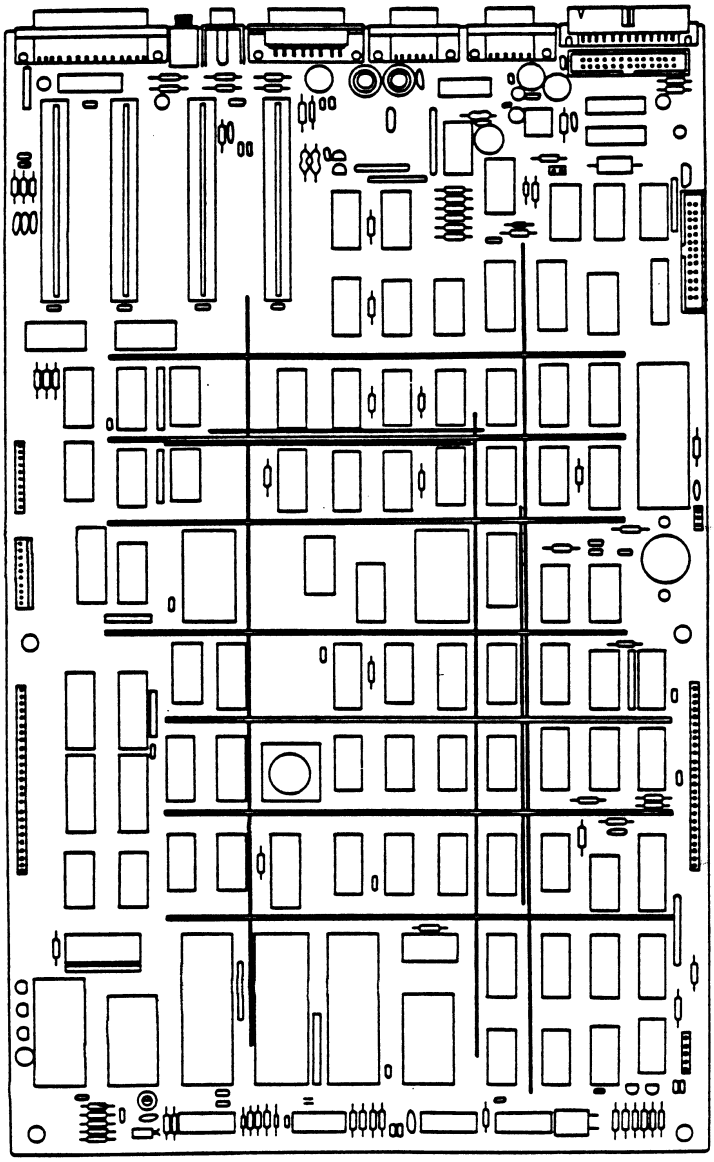
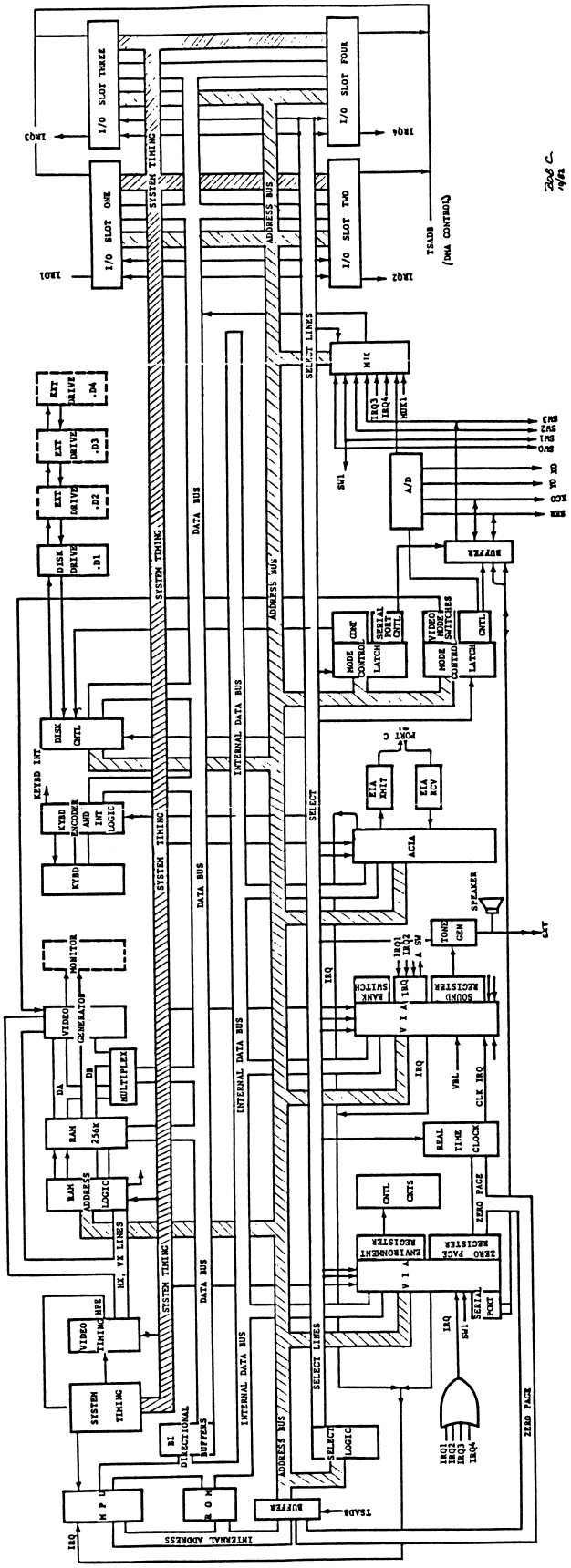
Now that we have taken a tour of the contents of the Apple /// let us begin to learn the inner workings.



THE APPLE /// MAIN LOGIC BOARD (MODULE)

1.8


I/O SLOT THREE
I/O SLOT FOUR
I/O SLOT ONE
I/O SLOT TWO
IRQ3
IRQ4
IRQ1
IRQ2
TSADB
(DMA CONTROL)
SYSTEM TIMING
ADDRESS BUS
DATA BUS
SELECT LINES
INTERNAL DATA BUS
MIX
A/D
BUFFER
DISK DRIVE .D1
DISK DRIVE .D2
DISK DRIVE .D3
DISK DRIVE .D4
DISK CNTL
KYBD
KYBD ENCODER AND INT LOGIC
KYBD INT
MODE CONTROL LATCH
SERIAL PORT CNTL
VIDEO MODE SWITCHES
EIA XMIT
EIA RCV
ACIA
SPEAKER
TONE GEN
EXT
MONITOR
VIDEO GENERATOR
MULTIPLEX
RAM 256K
RAM ADDRESS LOGIC
VT LINES
HS
BANK SWITCH
SOUND REGISTER
VIA
REAL TIME CLOCK
VBL
CLK IRQ
CNTL
CNTS
ZERO PAGE REGISTER
ENVIRONMENT REGISTER
ZERO PAGE
VIDEO TIMING
SYSTEM TIMING
BI DIRECTIONAL BUFFERS
SELECT LOGIC
M P U
R O M
INTERNAL ADDRESS
IRQ
TSADB