MICROMATION

DOUBLER

OPERATOR'S MANUAL

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MICROMATION

DOUBLER
FLOPPY DISK CONTROLLER

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1 INTRODUCTION

The DOUBLER is a high performance floppy disk controller designed for the S-1ØØ bus. Its proper installation in an S-1ØØ system will provide reliable operation at the highest speed and capacity currently possible with floppy disk technology. The controller is designed to interface directly with CP/M*, an operating system which has file management facilities and software utilities comparable to the most advanced computer systems. To ensure full utilization, the user of a DOUBLER system should be acquainted with the options available and its general method of operation.

1-1 HARDWARE INTERFACE

The DOUBLER will provide all the functions required for single or double density floppy diskette operation for S-1ØØ bus computer. It uses the IBM 374Ø format for single density recording (26 sectors of 128 bytes each). In double density, the DOUBLER uses a version of the IBM 2D format modified for 52 sectors of 128 bytes to maintain compatability with CP/M. The board uses the system processor to control drive functions. The transfer of disk data is done under program control in order to assure reliable operation. The board requires two thousand (2K) bytes of system address space: 1K is used by the 27Ø8 EPROM and the remainder is used for an on-board RAM scratchpad and memory-mapped I/O locations. All I/O operations are handled through memory locations in the board's address space, so no I/O mapped ports are required.

1-2 BUS INTERFACE

Detailed interface information is available by referring to the schematics included in appendix D. Address decoding for the board is accomplished by a 256 x 4 bipolar PROM. When the proper address appears on the bus, the appropriate strobes are generated. Further decoding of the strobes for input and output functions provides strobes for individual operations. A power-on-jump is accomplished by disabling the memory at location Ø after a reset with the phantom line. The on-board EPROM is then enabled and a jump instruction to the bootstrap routine is sent to the processor. The board synchronizes the disk drive with the processor by holding the system ready line low until the disk interface is ready for another byte of data. Circuitry on the board prevents the ready line from remaining low for a period of time longer than that required to transfer eight bytes of data from the disk.

* CP/M is a registered trademark of Digital Research, Inc.

1-3 DISK INTERFACE

Software routines in the EPROM direct the generation of signals necessary to control the disk drives. The output signals are latched in a latch/driver. The input signals are read by the system through an input port. Circuitry is included to cause the drive head to unload if there has been no disk access during eight revolutions of the diskette.

When reading data from the disk drive, the controller derives its data clock from the data on the diskette by generating a signal called PLO. This signal represents a phase lock oscillator and maintains synchronization with the disk data without being sensitive to the shift of individual bits. During write operations, the PLO is derived from the crystal clock and controls the data pulses written to the disk. During write operations in double density, the PLO signal is shifted under special conditions to cause the data written to the diskette to be "pre-compensated." Special circuitry prevents inadvertent writing to the diskette by unintentional memory accesses.

Error checking of all disk operations is done by computation of the sector's CRC. The CRC checking is done in hardware, so the system is capable of reading or writing consecutive sectors.

1-4 SPECIAL INTERFACE REQUIREMENTS

The DOUBLER and Micromation CP/M are currently configured to interface Shugart single-sided or Remex or YE Data double-sided drives. In addition, the controller can be factory configured for PerSci model 277 drives. Call Micromation for other drive types supported. This is especially important if you are thinking of upgrading your system with the DOUBLER.

FOUR-DRIVE SYSTEMS: The DOUBLER and associated CP/M are designed to support from 1 - 4 drives without modification. Each drive must be from the same manufacturer and be of the same type (single- or double-sided), however.

DRIVES REQUIRING ABOVE TRACK 43 CONTROL: Some floppy disk drives require a signal to indicate that the head is positioned above track 43. This signal is available from the controller and is generally connected to the disk interface connector on pin 8. Some drives require this signal on a different line, however, and the user should verify the operation with the particular drive being used.

2 CONTROLLER OPTIONS

The DOUBLER has several options to make it the most powerful controller available. Their functions and factory settings are reviewed below. Note that all the jumpers described below except the WAIT jumper are in the form of traces. To disable the function, the trace must be cut. (A header can be installed to facilitate re-enabling the jumper.)

POJ: Connection of this jumper (located near device 7C) enables the power-on-jump function of the DOUBLER. This feature operates by driving the "phantom" line on pin 67 of the S-100 bus low after a reset. This should disable the output buffers of the low memory. Check with your system technical manual of the memory used in this area to ensure that it supports the "phantom" line. If it does not, the controller's power-on-jump cannot be used, and another method of transferring control of the processor to the bootstrap routine must be used. When enabled, the DOUBLER's power-on-jump circuitry causes the system to jump to the cold bootstrap routine located in PROM on the controller board. The DOUBLER is shipped with the power-on-jump enabled. To disable it, remove the jumper between the pads marked "POJ".

PHANTOM: This jumper (located near device D4) connects the line used to disable RAM while the DOUBLER executes a power-on-jump. It ordinarily is connected to pin 67 of the S-100 bus, but can be jumpered to any other pin which the user's system supports. The reference manuals of the system should be checked to determine whether any other boards use pin 67. A few processor boards use this line to output the refresh signal from Z-80 processors. This should be disabled or disconnected if the DOUBLER's power-on-jump circuitry is utilized.

XRDY & PRDY: The DOUBLER uses the ready line to synchronize the processor with disk data. Different systems, depending on front panel or dynamic memory design, require that peripherals use XRDY and PRDY on the S-100 bus. The DOUBLER can use either line. It is shipped with jumpers (located near device D4) enabled to use both XRDY and PRDY. If either adversely affects the system operation, it may be disconnected by cutting the trace where marked.

WRITE: In order to prevent unintentional writing on a diskette, a write enable jumper (located near device 7A) is installed. This jumper must be in place in order to write on a diskette. If the floppy disk drives that are being used do not support write protect (all Micromation systems do), it is recommended that this jumper be removed until the system has been operated successfully and whenever the user wants to ensure that a diskette is not written upon.

HEAD: Standard Shugart-type drives support a signal named HEAD LOAD on the disk interface cable. This signal is used to load and unload the head of a selected drive, so the drive select buffers may remain enabled. Other drives, such as PerSci, use the drive select lines to unload the head. With these drives, the drive select lines must be disabled in order to unload the head. The DOUBLER unloads the head of a selected drive if a read or write operation has not occurred during the past eight revolutions of the diskette. Ordinarily this is done by disabling the HEAD LOAD line. If the controller is used with PerSci-type drives, the HEAD jumper (located near device 10A) must be switched to its alternate position. This will disable the drive select buffers to unload the head.

WAIT: To facilitate operations with Z-80 processors, a WAIT jumper (in the form of a header located near device D5) is available. This causes a wait state to be added only when the board is addressed. This is necessary to enable the on-board 2708 EPROM to be accessed and to allow time for the disk control circuitry to be properly set-up. This wait state will not affect overall system speed since during disk operations the speed of the system is controlled by the transfer speed of the disk data. The WAIT jumper must be connected when the DOUBLER is used with any 8080 system or when the DOUBLER is installed in a Z-80 based system operating at 4 MHz. If a 2 MHz Z-80 processor is used, WAIT should not be connected. The DOUBLER is shipped with the WAIT jumper installed. It should be removed only when operating with a 2 MHz Z-80 processor.

2-1 NECESSARY HARDWARE

Micromation DOUBLER floppy disk systems are designed to operate with all standard S-100 systems with 2 to 4 MHz 8080 or Z-80 processors. Since the controller performs a power-on-jump, it can be used in systems with or without a front panel. The operating system requires at least 16K bytes of RAM contiguously addressed in the lowest addresses of memory. The controller occupies 2K bytes of memory generally located at the top of the addressable memory range, from F800 to FFFF. The user should ensure that there are no memory address conflicts with other boards in the system. The DOUBLER may be addressed at locations C000, D000, E000 or F000 by obtaining special PROMs from Micromation.

2-2 CONSOLE DEVICE CONNECTION

A console device is necessary to communicate with the system. The DOUBLER includes a full function UART to communicate with RS-232 type terminals. The software provided with the system is programmed to use the UART on the controller to communciate with the console device. Optional software drivers for the Processor Technology SOL and NorthStar Horizon are also available from Micromation.

NOTE: The DOUBLER derives the clock input for the UART from the CLOCK signal on pin 49 of the S-100 bus. This must have a 2 MHz frequency for the UART to function. Check your system manual to ensure that pin 49 has a 2 MHz clock on it. If your system does not, install the necessary jumpers to provide the requisite signal.

CONSOLE DEVICE INSTALLATION: Installation of the hardware is straightforward. To initially bring up the system, the minimum amount of hardware should be used. This is just the disk controller, processor board, and, at least, 16K to 32K of memory in the lowest address of RAM. An RS-232 terminal should then be connected to the controller board. The controller has a 10 pin socket header with cable on the right side of the board. The pins are labelled to indicate their RS-232 function. The following table may be used to connect an RS-232 terminal. A ten foot cable with RS-232 connector is available from Micromation. Most RS-232 terminals require only three signals (ground, transmitter data, and receiver data) to be connected. The other signals are for terminals which require handshake operation.

DOUBLER HEADER PIN	SIGNAL NAME	TERMINAL RS-232 PIN
2	GND	7
1	TxD	3
3	RTS	20
5	DSR	4
9	RxD	2

GND The ground signal sets a common reference between the output and input devices.

TxD Transmitter Data is that data output from the CPU to the terminal.

RTS Request to Send informs the terminal that the CPU has some data to output. This signal is used only when handshaking is necessary.

DSR Data Set Ready active indicates that the terminal is ready to receive data. The terminal sends a signal called Data Terminal Ready (DTR) to this pin. The processor checks this bit before it sends the character. This, also, is only necessary with terminals that require handshaking.

RxD Receiver Data is that data output from the terminal to the processor.

3 DOUBLER INSTALLATION

3-1 PREPARATION

Before installing the DOUBLER in your system, clean off the S-100 edge connector fingers with alcohol on a cotton swab. This will remove any oxidation or finger prints. Do not use any other cleaning agents (e.g., a solvent, emory cloth, ink eraser, etc.), as these may damage the connector fingers.

3-2 BAUD RATE SELECTION

Any baud rate from 110 to 9600 can be selected with the proper jumper. The baud rate selection jumpers are in the upper right side of the DOUBLER, just to the right of the RS-232 connector. Do not confuse the two. The baud rate jumpers are in the form of a 16-pin connector; the RS-232 connector has 10 pins.

The selectable baud rates are labelled on the board. The DOUBLER is shipped with a jumper setting the rate at 2400. Before installing the board, remove the jumper and place it in the position that corresponds with the setting on your terminal. Most terminals also feature a selectable baud rate. Ensure that the setting on the DOUBLER matches the setting on your terminal. If you are in a quandary as to which setting to choose, 9600 BPS (bits per second) is a popular rate.

3-3 JUMPER OPTIONS

Read the **CONTROLLER OPTIONS** section above and install or remove the appropriate jumpers for your system.

3-4 BOARD INSERTION

- Turn off power to the computer and floppy drives.

- Install the DOUBLER in a slot in the S-100 mother board. Place the controller as close to the processor card as possible. Ensure that the card is pressed down into the edge connector all the way. Note that S-100 fingers are offset from the side preventing mis-orientation of the DOUBLER in the card cage.

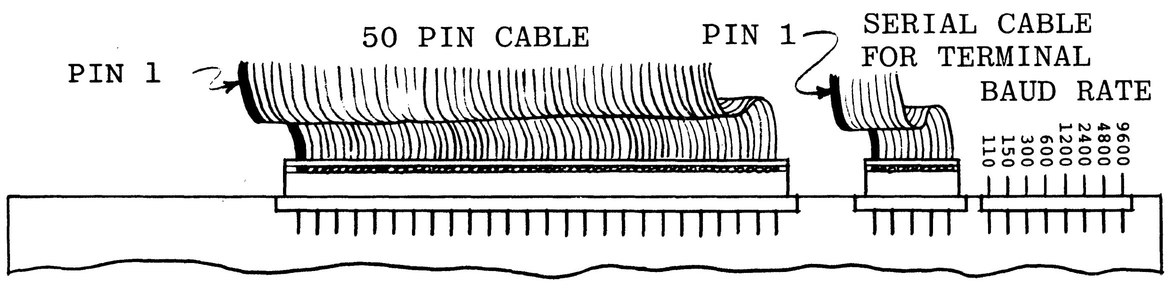
3-5 CABLE INSTALLATION

- Connect the 50 conductor ribbon cable from the floppy disk drives to the 50-pin connector on the DOUBLER. Pin 1, indicated by a red stripe on the edge of the cable, must be connected to header pin 1 on the left side (as viewed from the component side) of the board.

- Connect the RS-232 terminal to the controller. Again, pin 1 of the 1Ø-pin cable attaches to the left side of the DOUBLER connector.

NOTE: Pin 1 of this cable is typically indicated by a red stripe. If no such stripe is present on the cable, an arrow or indentation molded into the plastic cable connector also designates pin 1.

The figure below illustrates the top of the DOUBLER for use with cable installation and baud select



DOUBLER CABLES AND BAUD SELECT

3-6 BOOTING THE SYSTEM

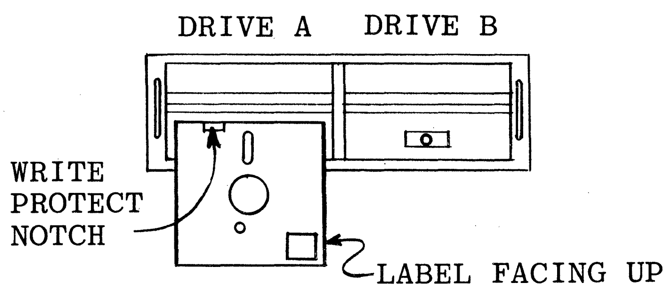
Before loading the operating system, read the CP/M Licensing Agreement and mail the registration card to Digital Research. Only registered owners are entitled to updates.

Of course, you should become familiar with the CP/M operating system as well. Begin with the booklet <u>An Introduction to CP/M Features and Facilities</u>. This should be followed with <u>CP/M 2.2 User's Guide for CP/M 1.4 Owners</u> for a discussion of the updates from the previous version included in the new release. The remainder of the documents shipped with the O/S (operating system) can be read when the need arises.

NOTE: CP/M version 2.2 is being shipped at the time of this writing. As new revisions are distributed by Digital Research, Micromation makes the necessary modifications and ships them with the units. To accommodate this flux, 2.x will be used as a descriptor in the examples that follow.

To boot the system,

- Turn on the power to the floppy drives and the terminal.
- Turn on the power to the computer and press the reset button.
- Ensure that the distribution diskette from Micromation is write protected. For systems with drives that check the write protect notch of the diskette, leave the notch **exposed.** (The figure below shows the location of the notch.) If your drives do not support this feature, remove the WRITE GATE jumper described above from the DOUBLER.
- Insert the distribution disk in drive A with the label facing up (see the illustration below) and close the door. In Micromation systems, drive A is the bottom drive where the drives are mounted vertically; the left drive in our systems with horizontal mounting.



DISKETTE ORIENTATION
(Horizonal Mounting)

- If the computer has a RUN/STOP switch, hit RUN. If the DOUBLER's power-on-jump is not being utilized, use a front panel or monitor to cause the system to execute the program at location F8ØØ (or at the base address of the controller if it is located at a different location).
- Drive A should home (go to track Ø), step twice, and within two or three seconds display

```
62k CP/M - Micromation ver 2.x
A>
```

  where the first line is the sign-on message and "A>" is the CP/M prompt. "A" indicates the current drive.

- To view the contents of the disk, type "DIR". This is the CP/M command to display the directory of the files on the diskette. The system responds with the names of the files.

This is the sequence for booting the system. It is referred to as a cold boot and need only be performed when the system is first turned on. Subsequently, a control-C can be used to load the system when necessary. This is called a warm boot and is only mandatory when diskettes are changed. In the event of a program crash, a cold boot may be necessary to get out of the program and back to the operating system.

The following chapeter discusses the utilities (called transient commands in the CP/M documents) provided on the distribution diskette and provides some exercises to demonstrate their use. We strongly recommend that the operator(s) perform(s) these exercises to get hands-on experience in the use of the computer system.

4 USE OF CP/M WITH THE DOUBLER

4-1 DISKETTE HANDLING AND FILE MAINTENANCE

There are some precautions that should be observed to ensure that your files aren't inadvertently lost due to operator error or the slings and arrows of outrageous fortune.

1) **Handle the diskettes with care.** Keep your fingers away from the exposed areas on both sides of the disk. Store diskettes in the paper sleeve whenever they are not in the computer (dust accumulates, otherwise, and shortens the life of the read/write head on the floppy drive). Since diskettes are a magnetic media, be sure to keep them away from magnets. You should also keep the diskette out of direct sunlight and away from extreme heat. Never remove the mylar disk from its protective paper enclosure nor abuse the disk by folding or bending it. When possible, write the label before applying it to the diskette. Subsequently, use only felt-tip pens for additional notes.

2) **ALWAYS make a back-up of your data files.** In many cases great time and effort is spent creating these files. It is much easier to make back-up copies on an on-going basis than to re-enter the whole thing over again. Make a back-up of any files changed **every time** they're changed. (After the program has terminated and the O/S prompt has re-appeared, of course.)

3) **NEVER power down the disk drives during program execution nor with a disk in a drive and the door closed.** Clear the drives of all diskettes before turning off the power to the drives (opening the drive door will do). Powering down during program execution will, at least, render the data files suspect or, worse, trash a couple of sectors rendering the whole file useless. Turning off power with a diskette in the drive (but not during program execution) may also trash a sector or two as the head responds to powering down.

4) **Write protect your important diskettes.** The little notch on the left side of the leading edge (see the figure above) causes write protect when exposed. Cover it with tape (or the silver squares frequently provided with this type of diskette) and the diskette can be written on. The CP/M system disk provided with the DOUBLER has the notch exposed so the disk cannot be written on or formatted (erased).

If these precautions are observed, very few problems will arise and those that do can be easily repaired with the back-up disks.

4-2 STANDARD CP/M UTILITIES

These two utilities will be used frequently. Diskettes used for program execution (and development) should contain these programs for diskette monitoring (with STAT) and file back-up (with PIP).

STAT.COM: This utility is used primarily to indicate the status of the disk space. It can indicate, for instance, the amount of space remaining for file storage, how much space a certain file takes up, how much space a group of files takes up, etc. Slightly different invocations display or change the current logical assignments of the peripheral devices.

PIP.COM: PIP is short for Peripheral Interchange Program. It is most frequently used to transfer files from one disk to another in multi-drive systems. It is also used to transfer files between devices (from disk to list device, from paper tape reader to disk, etc.).

The next three programs may be useful, depending upon the application of the your system.

ED.COM: This is the CP/M text editor for creating and altering files. Although ED can be used for word processing, it is not recommended. There are several word processing programs available that are much better suited to this application. Primarily, it is useful for creating and editing program files.

SUBMIT.COM: A limited form of batch processing is available with SUBMIT. This is most useful when a sequence of transient commands is frequently performed. A source file containing these commands is created with the editor for subsequent execution(s). There is no limit to the number of times this file is SUBMITed.

XSUB.COM: XSUB enhances SUBMIT by allowing line input to programs in addition to CCP input. Refer to the _CP/M 2.2 User's Guide for CP/M 1.4 Owners_ for a description of XSUB.

The following utilities are used to generate a new system and to transfer the system from one disk to another.

MOVCPM.COM: This utility is used to move the CP/M system from one location in memory to another. CP/M should be loaded into the uppermost part of memory allowed by the computer system unless a special application requires differently.

SYSGEN.COM: Primarily, this utility is useful for transferring the system image between different density disks (single to double, double to single). Additionally, SYSGEN is used when a new system image is created and recorded. An illustration of its primary use is given in **DISKETTE PREPARATION** below.

The next four utilities are pertinent to assembly language programming. Many end users will never need these programs.

ASM.COM: This is the CP/M 8080 assembler. A program of commands from the 8080 instruction set can be assembled rendering two files, x.HEX and x.PRN, where 'x' is name of the program file. The .PRN file contains the original program listing plus the machine code. The .HEX file contains only the 8080 machine code in the Intel "hex" format.

LOAD.COM: The LOAD command converts a .HEX file created by ASM to a COM file (which indicates that it contains machine executable code). Once an assembly language program has been LOADed, it can be invoked by merely typing the file name when the CP/M prompt is displayed on the console. That is, the program has the status of a CP/M utility.

DUMP.COM: The DUMP program displays the contents of the designated file on the console device in hexadecimal form.

DDT.COM: DDT, which stands for Dynamic Debugging Tool, allows interactive testing and debugging of programs. An assembly language program can be tested, altered, patched, executed and/or repaired "on the fly" under DDT.

4-3 MICROMATION UTILITIES

The utilities described below were developed by Micromation to reconcile CP/M with Micromation equipment and to make computer operation easier. Note that the following describes the utilities provided with the standard Micromation CP/M system.

FORMAT.COM: Before using them to store data, diskettes must be formatted. This procedure writes a code on the diskette identifying each track (77 concentric circles around the diskette) and sector (26 or 52, depending upon the density, sections within each track). Thus, each location on the diskette is uniquely identified and can be individually accessed. There are two formats for standard 8" diskettes: single and double density. The diskette shipped with the DOUBLER is recorded in single density and contains about 250 kilobytes (250K) of read/write space. Diskettes with a double density format have about 500K bytes of file space.

To format a diskette in drive B in double density enter:

FORMAT BD@

Where FORMAT indicates the program, B the drive containing the diskette and D the density.

To format a diskette in drive B in single density enter:

FORMAT BS@

Where S indicates single density.

The diskette in drive A can be formatted. However this will erase the diskette. Do not attempt to boot from the diskette in drive A after it has been formatted.

IMPORTANT: The format program should be used with care. When old diskettes that have information stored on them are formatted, **all data is erased as part of the process.** If a used diskette requires formatting (e.g., to make it double density from single density) be aware of this fact. There is no way to recover files erased by FORMAT.

SYSTFORM.COM: This program is like the format utility but formats the system tracks on the diskette only.

VERIFY.COM: This utility calculates cyclic redundancy check characters from all sectors and compares them to the CRCCs written on the diskette in the drive queried. If an error exists its location will be displayed, if not the prompt is returned.

DENSITY.COM: A program to determine and display the density of the diskette in the drive queried.

SDIR.COM: This utility displays an alphabetized disk directory when called.

COPY.COM: Often, it is easier or necessary to copy an entire diskette rather than transfer files one at a time. The COPY utility is provided for this purpose. Note that COPY will only transfer data between like-density formatted diskettes (single to single or double to double).

There are three forms of COPY, each for a different task.

COPY A (copy All system and data tracks)
COPY S (copy just the System area, tracks Ø,1)
COPY D (copy just the Data area, tracks 2 - 76)

Prompts are displayed by the program requesting the source disk (the master from which the copy is made) and the destination disk. Use of COPY is illustrated in DISTRIBUTION DISKETTE DUPLICATION below.

FILES.COM: The directory entries for a disk and the blocks used are indicated by this transient. The first three 8-digit groups of numbers are the file name and type; the fourth indicates the extent in the first two digits and the number of records used in the extent (in hex) in the last two digits (the middle 4 digits have no significance); and the remainder indicate the specific blocks used. Note that this utility can be invoked on the current disk only.

CPM62.COM: This is not a utility. It is a duplicate of the Micromation CP/M operating system set up for operation in 62K of RAM. It is provided as a convenience in new system generation. Refer to Appendix C for an example of its use.

RAMTEST.COM: This utility was written to check the RAM in Micromation systems. It may or may not run in non-Micromation systems. Refer to the listing (RAMTEST.ASM) on the distribution diskette to see if it has utility.

4-4 OTHER FILES

DISKDEF.LIB: DISKDEF is used with the Digital Research Macro assembler. It has no utility beyond its use with this program. Refer to the CP/M 2.2 Alteration Guide.

DEBLOCK.LIB: This file is supplied by Digital Research and conains sector blocking and deblocking algorithms. Refer to the CP/M Alteration Guide for a discussion of this feature.

CBIOS.LIB, BIOS.LIB, BOOT.LIB: These files are distributed by Digital Research as examples of the BIOS and BOOT programs. They are for reference only. To alter the system, use MM2BIOS.ASM and M2BOOT.ASM described below.

LIST.SUB, STEP.SUB: These files are used with the CP/M SUBMIT utility to change the IOBYTE and step time respectively. See Appendix C-2 for a description of their use.

The remainder of the files on the distribution diskette, with file type ASM, are the source files of the Micromation generated utilities. Many users will find these files immaterial for day to day operation. However, system builders may find these very useful, especially when developing dedicated application packages. Most of the ASM files have corresponding COM files, some don't. Those that don't are discussed below.

C2PROM.ASM: This file contains the code of the DOUBLER PROM at board location D4. It is provided for reference. As such it can be used to develop special application packages that require knowledge of and/or access to DOUBLER routines and their locations.

MM2BIOS.ASM: MM2BIOS is the source file of the BIOS portion of CP/M. Micromation has written this section to allow system alteration with a minimum of fuss. Refer to THE MICROMATION BIOS below for a description of the default characteristics.

M2BOOT.ASM: M2BOOT, like the custom BIOS, is another part of the CP/M O/S. Its role is to load the system. If you change the size parameter in MM2BIOS, a corresponding change must be made in M2BOOT. The two files must then be re-assembled and inserted in the system.

4-5 THE MICROMATION BIOS

The BIOS (Basic Input/Output System) portion of CP/M is custom tailored to accommodate the Micromation hardware. In addition, several parts are conditionally assembled to suit the user's application. "Conditionally assembled" means that portions of the program are not included during assembly unless a flag is set true. To reset them to alter the system configuration, see **New System Generation** below.

The system characteristics are established in BIOS and are as follows. (Your system may have slightly different characteristics if it was configured for a non-Micromation hardware environment.)

- a system size of 62K
- the serial port on the DOUBLER for console (CON:) device with an appropriate driver
- 3 parallel ports on the Multi I/O board assigned to the line printer (LPT:) option for LST: with a driver routine for a Centronics type dot matrix printer
- the serial port on the Multi I/O Board assigned to the TTY: option for LST: with a driver routine for a serial interface printer

The following table summarizes the relationship between logical and physical device assignments as established in BIOS at cold boot.

```
CON: = CRT: (through the DOUBLER serial port)
RDR: = TTY:
PUN: = TTY:
LST: = LPT: (Centronics 7Ø3/779 printer through Multi
             I/O board parallel ports)
```

Although RDR: and PUN: are assigned to TTY:, they are not supported in the BIOS. Attempts to output to PUN: or input from RDR: will not work.

The list device (LST:) is assigned to the line printer (LPT:) option. The BIOS currently contains a driver for a Centronics 7Ø3/779 printer to correspond with this assignment. This is a parallel input dot matrix printer connected through the parallel ports on the I/O board.

The next section has twofold significance. First, it presents the procedures for backing up the distribution diskette, for making a double master from the distribution diskette, and, finally, for making work disks for use in the day to day operation of your computer system. Second and equally as important, execution of these procedures provides hands-on experience in use of the utilities for the operator.

5 CP/M INTER-VERSION COMPATIBILITY

The operating system shipped with the DOUBLER is the latest version of the popular CP/M O/S from Digital Research. (As of this writing, the version number is 2.2. This is subject to change as new revisions are distributed.) In the single density recording format, there's complete compatibility between this and previous versions. In double density recording, there is an important difference. This difference will destroy the data stored in a file when transferring it from a diskette recorded under an earlier version to one recorded under version 2.2 (or later) or vice versa. Use the following procedure to move files from diskettes recorded in double density by previous versions to double density disks created under the new 2.2 system.

1) Put the old system master in drive A. Use your old FORMAT program to initialize enough disks in drive B to accommodate the files presently on your double density disks.

2) Using the old version of PIP, transfer the program and data files from the double density disks to the newly created single density disks. Do not transfer any utilities (also referred to as transient commands); the ones provided with your new system diskette will replace those from the previous version.

3) Place a single or double density CP/M version 2.2 (or later) disk in drive A and your single density disk created above in drive B. Use PIP from the new version to transfer the program and data files from B to A. Do not use the version of PIP from the earlier revision of CP/M.

Transfer all the files from your double density disks created under a previous CP/M version to the new one in this manner.

Do not use the Micromation COPY utility to make 2.2 duplicates of your 1.4 or earlier double density disks. This will render the files on the 2.2 disk unreadable.

Do not use any utilities from previous versions. Use only the ones provided on the distribution diskette.

SECTION 2

THEORY OF OPERATION

6 INTRODUCTION

The DOUBLER is a byte oriented floppy disk controller. It has an on board PROM that allows for bootstrap start, and holds primitives that control hardware systems on the board. Features include single and double density disk formats with automatic selection of the format on the disk, an RS-232 serial port with baud rate select, and a variety of control configurations for the S-1ØØ bus.

The disk controller transfers data under program control on a sector by sector basis. In CP/M compatible single density format there are 26 sectors per track with 128 bytes per sector transfered at a data bit rate of 25ØKHz (IBM 374Ø standard). In the double density format there are 52 sectors per track with 128 bytes per sector transfered at a data bit rate of 5ØØKHz.

The intent of this theory of operation is to describe the hardware systems on the DOUBLER. Since there are many references to the schematic diagrams, component parts are referenced by the page number of the schematic followed by the part number. The part numbers on the schematic also refer to the column and row that the package occupies on the board. After the part number, the part type is listed in parentheses. For instance 2IC1ØC (74LS374) refers to page 2 of the schematic, IC 1ØC (which is the IC in column 1Ø at row C), of the type 74LS374.

6-1 DISK SYSTEM OPERATION

When the disk system is to be accessed the intent of the operator is translated by CP/M into a sequence of events. The drive to be used, selection of read or write, and the file to be found, are provided, indirectly, by the operators actions. These parameters are then processed by the operating system to access the appropriate portion of the disk.

Disk I/O is performed by a sequence of calls to the disk access subroutines, and by hardware that performs the ongoing processes of encoding, decoding, and phase lock to the serial data stream. When a request for disk access is made, the operating system readies the file to be written to the disk or allocates memory space to accept the file read from the disk. The operating system must then select the drive to be accessed, load the read/write head and move it to the proper track on the disk, phase lock the controller to the serial data stream on the disk, locate the sector to be operated on, perform a read or write record operation, and determine if the transfer is completed. If the transfer is not complete the next record is selected, located, and written to or read from, until the transfer is completed.

The routines used to control the disk drive, and interface to the operating system are in BIOS and the C2-PROM (Appendix B is a listing of the C2-PROM). The routines in the C2-PROM are an extension of BIOS. They are closest to the DOUBLER hardware, while BIOS holds the more executive functions. A listing of the MICROMATION custom BIOS and C2-PROM can be found in the distribution diskette, and information on the standard model BIOS is included in the CP/M reference manuals.

The parameters used to access the sector on the disk are held in the scratch pad RAM. For example, TRACK, SECTOR, DMA (the address of a memory buffer used for the source or destination of data during transfers), and DENBYTE are registers in the RAM that pertain directly to sector read/write operations. A complete list of these registers is included in the C2-PROM listing.

When a disk is accessed for the first time after being inserted in the drive, it is logged and tested for density. Testing for density is executed by trying to read the SYNC FIELD HEADER on track 2 in single density. After 3Ø unsuccessful tries at single density, double density is tested. DENBYTE, in the scratch pad RAM, is set according to test results.

6-2 DISK READ/WRITE

During disk read and write operations the operating system loads the head, steps to the selected track, and tests DENBYTE for the density of the disk. A call to the SYNC subroutine then finds the sync field header (see Appendix A if unfamiliar with the sector format) in the ID FIELD and establishes the synchronization of PLO and the byte sync counter with the moving disk data. Once in sync, the operating system looks for the sector ID MARK. When it is found, the track intended is checked against the track read. If it is the correct track, a sector by sector search is executed until the selected sector is found. CRC is checked during these operations to ensure that the disk has been read correctly.

After the proper sector has been found, read or write of the DATA FIELD begins. When a read operation has been requested, the operating system looks for the DATA MARK, then reads the 128 bytes of data in the sector, and finally checks the CRC to confirm the accuracy of the data. When a write operation has been requested, the operating system writes a new SYNC FIELD HEADER and a DATA MARK in the data field, then writes 128 bytes of data followed by the CRC.

Read or write operations are a byte by byte transfer of a sector of data to or from the system memory area marked by the disk memory address, DMA, (not to be confused with direct memory access). After a sector has been read, the operating system takes the information in the memory area marked by DMA and uses it to build the file being read. The operating system then provides parameters on a new sector to be transfered, and transfers it, or ends the read operation. After a sector has been written, another sector of data is placed in the memory area marked by DMA, and transfered, or the write operation is ended.

7 THE S-1ØØ BUS INTERFACE

The DOUBLER's S-1ØØ bus interface has three sections; the control bus, the bidirectional data bus (DØ-D7), and the address bus (AØ-A15).

7-1 THE CONTROL BUS

The **control bus** is used to control data transfers between the processor and memory or peripherals. The DOUBLER uses the following signals:

PDBIN is used by the processor to indicate that a valid address is on the address bus and that it is reading data on data bus lines DØ-D7 from memory or an I/O port.

/PWR is used by the processor to indicate that a valid address is on the address bus and that it is outputting data on data bus lines DØ-D7 to memory or an I/O port.

SINP and **SOUT** are used by the processor to indicate input or output, respectively, to an I/O port. They are similar to the PDBIN and /PWR signals and are active when these signals are in coincidence with /IOREQ. These lines disable the DOUBLER when active.

SINTA indicates that the processor is in an interrupt mode. The DOUBLER is disabled when this signal is active.

/PHANTOM disables the RAM that occupies the same memory position as the DOUBLER. It is active whenever the DOUBLER is enabled.

PSYNC is a synchronizing signal used with a 4MHz CPU clock to synchronize wait state requests to the processor machine cycles.

/PRST (reset) is used on the DOUBLER board to generate a power on jump which accesses the jump to BOOT instruction in the resident firmware.

XRDY and **PRDY** are wait state inputs to the processor. One of these control lines (user option) is used by the DOUBLER floppy disk interface to make the CPU wait, on a byte by byte basis, during data transfers to and from the disk.

7-2 THE DATA BUS

The **bidirectional data bus** handles data transfers between the DOUBLER and the processor. It is isolated from the on board data bus by a bidirectional tri-state buffer, consisting of 1IC1ØD (74LS244) and 1IC11D (83Ø4).

This buffer writes data to the DOUBLER board whenever /PWR is active, and reads data to the bus when PDBIN is active and the board is enabled by the address decoder. When the DOUBLER is not enabled the data bus buffers are in a high impedance state.

7-3 THE ADDRESS BUS

The **address bus** is used to enable and select registers that comunicate with the disk system on the DOUBLER board, and to access the UART, scratch pad RAM, and the C2-PROM.

8 ADDRESS BUS DECODING

Decoding of the high order address bits takes place in the address decoder PROM 1IC9C (74S287). The low order bits are connected directly to the devices addressed or to the read/write control.

8-1 THE ADDRESS DECODER PROM

The address decoder generates the /RAM, I/O, PROM, and BD signals from address lines A9-A15. Decoding of these lines takes place in the bipolar PROM, 1IC9C (74S287). Note that address inputs to 1IC9C do not correspond to address bus lines. The A3 input to 1IC9C is set by the NOR of control bus signals SINP, SOUT, and SINTA. If any of these lines are active the decoder PROM output lines, and the board, are not enabled. BD is active whenever /RAM, I/O, or PROM are active. BD is used as the board enable, and inverted, it drives the /PHANTOM line.

The DOUBLER occupies the memory space from F8ØØH to FFFFH. This area is divided into three sections as follows.

C2-PROM	F8ØØH - FBFFH
Scratch pad RAM	FCØØH - FDFFH
I/O	FEØØH - FFFFH

8-2 THE C2-PROM

The C2-PROM, 6IC9D (27Ø8), is enabled by the PDBIN and PROM enable signals, accessed by address lines AØ-A9, and based at address F8ØØH. It holds the bootstrap loader and routines that control the DOUBLER. Refer to the C2PROM.ASM listing in Appendix B.

8-3 THE SCRATCH PAD RAM

The 64 byte scratch pad RAM, 6IC9A (4Ø36), is accessed by address lines AØ-A5. It is selected by the /RAM signal from the address decoder. RAM output enable and R/W are controlled by the /WR signal. This RAM is assigned the dedicated registers and the stack used by the routines in C2-PROM and BIOS.

8-4 READ AND WRITE CONTROL

The read/write control generates strobes that operate the read, write, control, and status latches on the DOUBLER's internal data bus. Its inputs are address lines AØ-A2, /WR, /PDBIN, and I/O. This circuit consists of two, eight wide data distributors, 1IC7D and 1IC6D (74LS138). Both of these are enabled by the I/O signal from the address decoder PROM. 1IC6D and 1IC7D are also enabled by /PDBIN and /WR, respectively, /PDBIN enables the read control; /WR enables the write control. Low active strobes generated by the read/write control memory map are listed in firmware as follows.

ADDRESS	/WR	/PDBIN
FEØØH	WRCONT	RDSTAT
FEØ1H	WRCLK	
FEØ2H	WRUART	RDUART
FEØ4H	WRMRKCRC	RDMRKRC
FEØ5H	WRMRK	RDMARK
FEØ6H	WRDATA	RDDATA
FEØ7H	WRCRC	SYNCPORT
FEØAH		UARTSTAT

These strobes and their corresponding latches perform the following functions.

WRCONT loads the drive control latch, 5IC1ØA (74S374), which operates the drive control lines.

RDSTAT reads the drive status latch, 5IC11A (74LS224), which contains the drive status lines.

WRCLK writes the clock pattern to the sync mark latch, 2IC12D (74LS273). This value is then compared with the clock pattern from the SYNC FIELD HEADER to synchronize with the moving disk data.

WRUART and **RDUART** write and read to the UART, 6IC13D (8251), used for the RS-232 serial interface.

WRMRK is a strobe that writes an ID or a DATA MARK to the disk (depending on the status of the MRKA signal).

RDMRK is a strobe that holds the processor until a MARK is read (or the timeout triggers) in order to synchronize the byte sync counter. It is also used to clear the head load counter.

WRMRKCRC and **RDMRKCRC** are strobes that perform the same functions as WRMRK and RDMRK, respectively, and also preset the cyclic redundancy check circuit.

WRDATA and **RDDATA** these strobes activate the DISKWR and /DISK READ signals respectively. Addressing these ports transfers data to or from the disk on a byte by byte basis.

WRCRC is a strobe used to gate the cyclic redundancy check character into the serial data stream.

SYNCPORT is a strobe used in the synchronization of the byte sync counter.

UARTSTAT accesses the control and status latches in the UART.

Address line A2 is used to enable the DISKWR and /DISKREAD signals. All strobes listed above in the address range of FEO4H - FEO7H also transfer data to or from the disk when active.

8-5 THE UART

The UART, 6IC13D (8251), is based at FEØ2H, and selected by the /RDUART and /WRUART signals from the READ/WRITE CONTROL. Address line A3 is connected to the UART C/D input, which accesses its control and status latch, based at FEØAH.

9 DISK DRIVE INTERFACE

The operating system controls and monitors the drives via the **drive control latch (WRCONT)**, which operates the drive control input lines, and the **drive status latch (RDSTAT)**, which contains the drive status outputs. These latches and their pin connection to the disk drive list as follows:

BIT	PIN	WRCONT	PIN	RDSTAT
DØ	36	/STEP	22	/RDY
D1	34	/DIR	1Ø	/SEEK DONE
D2		SD/DD	18	/HEAD
D3	32	/DRIVE D	2Ø	/INDEX
D4	3Ø	/DRIVE C	24	/SECTOR
D5	28	/DRIVE B	44	/WRITE PRT
D6	26	/DRIVE A	42	/TRACK ØØ
D7	12	/RESTORE		CRCSTAT

CRCSTAT and SD/DD are listed in the latches but do not connect to the drives. The other signal pin connections to the drives are:

PIN	FUNCTION
8	/ABOVE 43
38	/DISK WRITE DATA
40	/WRITE GATE
46	/RAW DATA

9-1 THE PHASE LOCK OSCILLATOR

The heart of the floppy disk system is the **phase lock oscillator, PLO,** which generates signals used to synchronize to the moving disk data. Phase lock is the process of synchronizing an oscillator to an external signal. In order to work, control of the output frequency of the oscillator and a system to detect the frequency differences between the external signal and the oscillator must exist. The final part of the phase lock system is a feedback loop that allows the detector to control the oscillator.

In the DOUBLER, control of the PLO output frequency is achieved by digitally dividing the signal from an oscillator with a frequency twenty times higher than the frequency to be generated. The divider (a preset counter string) can be set to divide by any integer in the domain of 1 to 45.

Detection of frequency difference is executed by latching the divider status when a transition of the external signal (raw disk data) occurs.

The feedback loop is completed by a PROM that is coded to use the divider status as an input to output a preset value that will correct the difference in frequency.

The DOUBLER's PLO consists of a 20 MHz crystal oscillator, 4 Y1 and 4IC4A (74S04), which drives a presetable counter string, 4IC2A (74LS163) and 4IC3A (74LS161-A). The nominal count for double density is 20D, which yields a 1 MHz clock rate which is approximately equal to the frequency of the serial stream from the disk. The nominal count for single density is 40D which yields 500KHz. Notice that these values are twice the data transfer rate. This is necessary to accommodate the interleaved data and clock bits.

Preset values are provided for the counter string by one of two PROMs, the R1, 4IC1B (74S471), for read and the WA, 4IC2B (74S471), for write. The counters are continuosly being incremented by the 20MHz clock. The logic conditioned raw data stream is used as a clock input to the latch, 4IC1A (74LS174). Data inputs to this latch are connected to the stage outputs of the counter string. When a pulse comes down the raw data stream the current count of the counter string is stored in the latch. Outputs of this latch connect to the address inputs of the R1 PROM. If there is an error in timing between the disk data stream and the PLO, the preset value of the counter string is changed by the contents of the PROM to correct the timing error.

Since data on the disk is frequency modulated, changes in timing caused by modulation must be ignored, so the R1 PROM is coded to compensate only the larger errors in timing. If there is no incoming pulse during the current PLO count cycle, (when reading a zero data bit for example), the latch is cleared. If the incoming pulse is on time, the latch stores zero. Either of these conditions set the counter string to the nominal value, and PLO remains synchronous to the disk data stream.

PLO is the clock input of the byte sync counter, and is also used to shift disk data into the shift register, 2IC11B and 2IC11C (74LS164), used for conversion of raw disk data to eight bit parallel bytes. PLO is locked to the signal from the disk any time information is read from the disk. (Write operations involve a read of the ID field to verify the track and locate the sector to be written to.) Since the frequency to be locked is known, phase lock can be achieved in a few cycles.

During write operations, after the sector has been located, PLO becomes a frequency synthesizer and is set to the nominal frequency. Data is brought from the data bus to the disk write data latch, 2IC10B (74LS165), and is shifted serially out by the PLO signal. This serial stream goes through the CRC, multiplexer, encoder, and precompensator, and then to the disk drive.

9-2 THE BYTE SYNC COUNTER

The **byte sync counter,** 3IC4B (74LS161), provides signals used to separate clock bits from data bits and define the beginning and end of bytes in moving disk data. Outputs from this counter are also sent to the multiplexer, 3IC3B (74LS157), to insert clock bits into the disk write data and provide information for write precompensation (see section 9-5).

The byte sync counter is clocked by the /DPLO signal. This signal is PLO delayed by 50Ns which is one cycle of the 20MHz oscillator. /DPLO is used so that circuits using PLO can settle before action is taken on their outputs.

The byte sync counter is set, if not in sync, when SYNCPLO is addressed by the operating system. The counter is set so that C/D is high with respect to data bits in the moving disk data, EOC is high during data bit 7 and EOW is high during clock bit 0.

The SYNCMARK signal is connected to the "B" load input of the counter. If SYNCPLO is addressed and the counter is not in sync the high on the "B" load input is loaded. This steps the counter toward byte synchronization.

Detection of SYNCMARK starts in the shift register, 2IC11C and 2IC11B (74LS164), which is used to separate clock bits from data bits, and convert moving disk data into parallel bytes. Alternating stages of this shift register are connected to the disk read data latch, 2IC10C (74LS374), and the SYNCMARK comparator, 2IC12B and 2IC12C (74LS266). The SYNCMARK comparator sees the clock bits from the shift register and codes loaded by the operating system into the sync mark latch, 2IC12D (74LS273). When the codes in the sync mark latch and the shift register match, the SYNCMARK signal goes low. This sets EOC from the byte sync counter, 3IC4B (74LS161), and loads the multiplexed data pattern, from the SYNC FIELD HEADER, into the disk read data latch, 2IC10C (74LS374). The operating system reads this latch and, if the proper code is found, verifies sync and continues the read or write sector operation.

9-3 WAIT STATES (XRDY or PRDY)

Data recovery from the disk is slower than the cycle time of the CPU. Consequently the XRDY or PRDY lines are held low to hold the processor in a wait state and allow the current byte of the disk read or write operation to be transfered. The byte sync counter output, EOC, marks the end of a byte. EOC is used to lift the wait state and transfer a complete data byte from the DOUBLER to the data bus, or from the data bus to the DOUBLER.

If for some reason the DOUBLER cannot complete the byte transfer, a timer, 1IC13A (4040), is used to prevent loss of dynamic RAM data. It lifts the wait state before the refresh timing limits of dynamic RAM are exceeded.

Wait states must also be generated when a 4MHz processor clock is used. PSYNC and BD (board enable) coincidences are detected in an AND gate 1IC5D (74LS00). When coincidence is detected XRDY and PRDY become active, generating one wait state per board access. This is needed to allow adequate access time for the C2-PROM. A jumper labeled "WAIT" can be found at location D-4 on the DOUBLER. It must be installed to operate at 4MHz.

9-4 THE CYCLIC REDUNDANCY CHECK

The **cyclic redundancy check**, CRC, is an on going process carried on by the CRC IC, 3IC8B (8506). During write operations a complex logic creates a unique code from the data sent to the sector, called the cyclic redundancy check character (CRCC), which is appended to the sector. During disk read operations the CRCC is read from the disk and compared with the character calculated from the data just read. If an error condition is found, the operating system attempts to read again. If subsequent retries fail, the operating system displays an error message.

9-5 ENCODING AND WRITE PRECOMPENSATION

The double density recording format pushes the recording medium to the limit. When two transitions of magnetic polarity are written adjacent to each other, they interact, causing a shift in timing. This shift makes the data stream unreadable. The solution is to write adjacent pulses shifted, so that their interaction yields the correct position in time along the disk serial data stream. This corrective shift of timing, prior to write, is called write precompensation. In the DOUBLER, compensation in write timing is achieved by moving the position of clock bits with respect to data bits. The mechanism for doing this is in the PLO. The PLO is a digitally controlled frequency synthesizer. During read, frequency control is used to achieve synchronization with the moving data stream on the disk. During write, clock pulses are offset in time by changing the count of the counter string, 4IC2A and 4IC3A (74LS161A), on a bit by bit basis.

During write, control of the PLO counter string is executed by the WA PROM, 4IC2B (74S471). The address inputs to this PROM represent a portion of the serial data stream mixed with clock. The data outputs of the PROM are connected to the preset inputs of the counter string. Coding in the PROM presets the counter string to provide write precompensation.

WA PROM output D7 is the serial data stream sent to the disk during write. Coding in the PROM also holds the algorithms for encoding disk data. Both single and double density codes are in the WA PROM. Write precompensation is not used in single density. So for single density write the counter string is always set to the nominal count, which yields a 5ØØKHz output frequency.

1Ø THE RS-232 SERIAL INTERFACE

The terminal interface consists of an RS-232 serial interface designed around the UART, 6IC13D (8251), on the DOUBLER. The UART clock is derived from system clock by counters, 6IC14D (74LS161), and 6IC14A (4Ø24). Baud rate is selectable via a jumper from the outputs of the counters. There is a provision for use of the on board 2ØMHz clock to generate the 2MHz UART clock via 6IC3C (74LS9Ø not provided), if the host system has a different clock frequency.

The following is a list of the RS-232 connections:

J2-1	TxD	transmitter data
J2-2	GND	ground
J2-3	/RTS	request to send
J2-5	/DSR	data set ready
J2-6	/DTR	data terminal ready
J2-7	/CTS	clear to send data
J2-9	/RxD	receiver data

To connect a video display terminal, signal ground, TxD, and /RxD are all that need be connected. The other signals are for handshake arrangements not usually necessary for terminals.

11 POWER ON JUMP

When power is first applied to the computer, or the reset button is pushed, a reset (/PRST) pulse is generated activating the power on jump circuit on the DOUBLER which generates a /POJ signal. With this signal active the C2-PRØM is enabled, and the JMP COLDBOOT instruction at address F8ØØH in the PROM is executed. Since the high order address bits are decoded by the address decoder, F8ØØH appears to be ØØØØH when /POJ is active.

COLDBOOT reads tracks "Ø" and "1" (the system tracks) of the diskette in drive "A" into memory locations ØØØØH-ØØ7FH, and then executes the transferred code by performing a jump to ØØØØH, to load the system into memory.

12 POWER SUPPLY

The DOUBLER runs on the S-1ØØ bus supply line voltage. On board regulation produces +5v, -5v, +12v, and -12v. The +5 volt line can draw more than an ampere, while the other lines draw less than 5Ø milli amperes.

Ceramic disk capacitors are distributed along the power rails, in accordance with good digital logic design, to reduce noise.

Appendix A:

THE DISK FORMAT

The MICROMATION DOUBLE DENSITY FORMAT divides the disk into tracks (numbered Ø - 76). Each track has 52 sectors. The position of the tracks is set by the position of the read/write head in the disk drive. Sectors are sequentially positioned within the track starting at the index.

Each sector is divided into two parts; the ID FIELD and the DATA FIELD. The ID FIELD is written when the disk is formatted and is used to find the sector to be read from or written to. This is called soft sectoring.

Gaps are inserted between the sectors, and between the ID and DATA fields. These allow the write current to be turned on without destruction to the information recorded on the disk. Gaps are recorded with the hex number 4E, which identifies them as gaps when the operating system is locating sectors.

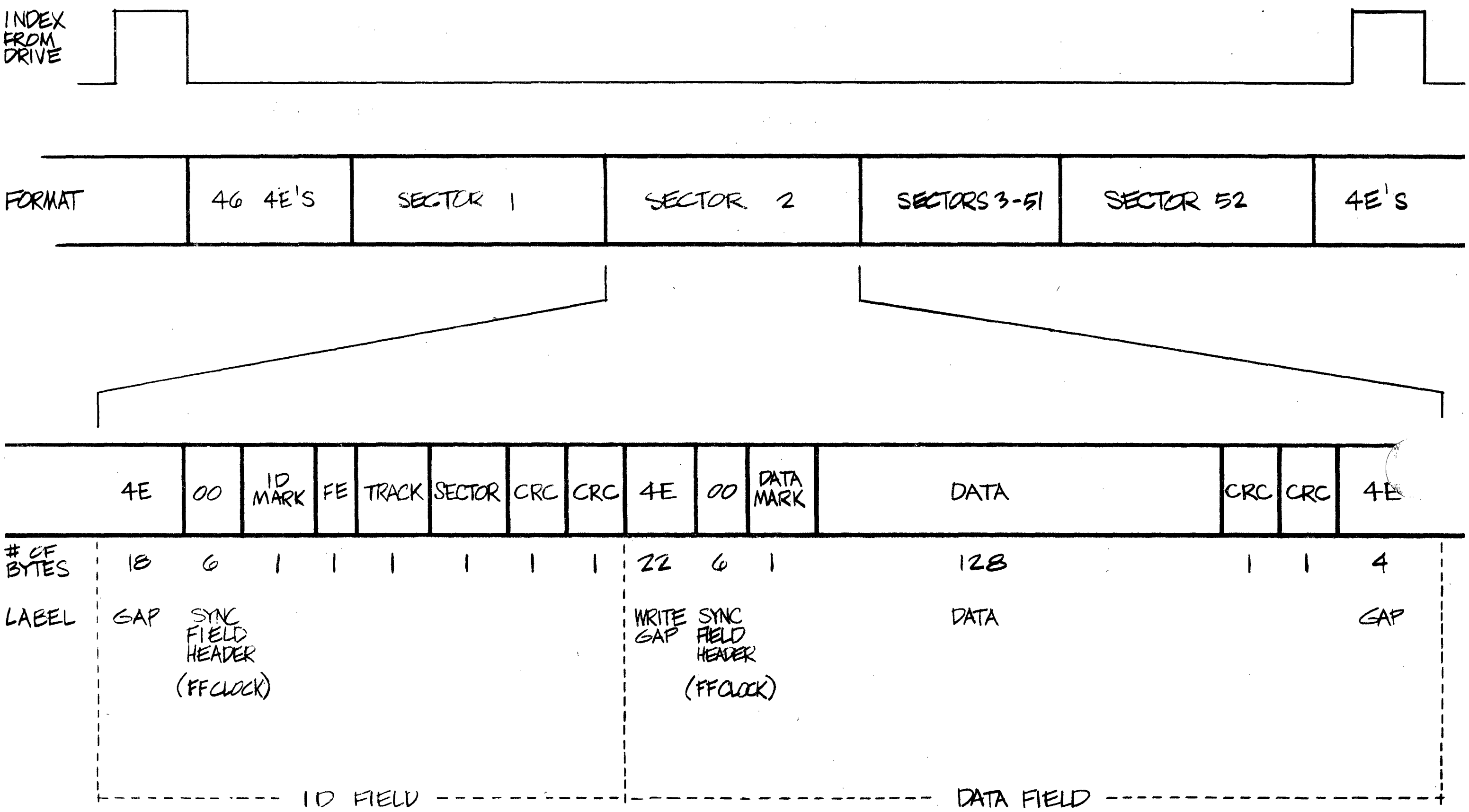
The ID field marks the start of a sector, identifies it and verifies the track. The first six bytes of the ID FIELD are the SYNC FIELD HEADER. These have an unique pattern written into the clock pulses and are therefore readily distinguished from the rest of the serial data stream. The SYNC FIELD HEADER is used to synchronize the hardware to the serial data stream. The next byte is the ID MARK. This verifies that the SYNC FIELD HEADER found is in an ID FIELD, and prepares the operating system to read the track and sector bytes. The ID MARK is followed by a byte written with the hex number FE, which ensures that an ID FIELD, not a gap, has been found. This is necessary since gaps are written with random information, that may mimic an ID FIELD, when the write current is turned on.

The DATA FIELD is used to store the 128 bytes of data recorded in a sector. There is a gap that separates it from the ID field. So the SYNC FIELD HEADER, and the DATA MARK, in the DATA FIELD are needed to synchronize the hardware again. When the disk is formatted, the SYNC FIELD HEADER and the DATA MARK are written, and the data area of the DATA FIELD is filled with the hex number E5.

When data is written to the disk, only the DATA FIELD is changed. A new SYNC FIELD HEADER and DATA MARK are written, followed by the data to be recorded in the sector.

CRC, cyclic redundancy check, bytes are appended to the fields in sectors. They are used by the hardware system to verify that the serial data was read without errors.

MICROMATION DOUBLE DENSITY FORMAT



ID & DATA MARKS = A1 DATA
0A CLOCK

APENDIX B:

C2-PROM LISTING

WARNING: This listing is provided for information only. It may not be the exact information for your DOUBLER. Refer to the listing provided in the distribution diskette for exact information.

```
;
;PROM ROUTINES FOR MICROMATION DOUBLER, VERSION C.2
;THE C.1 VERSION HAS NOPS IN SYNC ROUTINE TO ALLOW MORE FREQUENT
;REFRESH OF DYNAMIC RAMS
;IT ALSO SETS UP THE SIDE BIT EARLIER TO MEET SETUP TIME FOR Y-E
;DATA DRIVES
;THIS VERSION HAS THE FOLLOWING CHANGES FROM C.1:
;HAS FIX FOR C.1 BUG IN SETTING UP DENSITY
;DISABLES INTERRUPTS AFTER FINDING CORRECT SECTOR
;HAS SLOWER STEP AND SETTLE TIMES
;
;               FEB 11, 1980

BASE            ORG     0F800H
BUFF            EQU     BASE+400H          ;SCRATCHPAD RAM
        ;
        ;START OF HARDWARE PORT DEFINITIONS
        ;
WRCONT          EQU     BASE+600H
WRCLK           EQU     WRCONT+1
WRUART          EQU     WRCONT+2
WRMRKCRC        EQU     WRCONT+4
WRMRK           EQU     WRCONT+5
WRDATA          EQU     WRCONT+6
WRCRC           EQU     WRCONT+7
RDSTAT          EQU     WRCONT
RDUART          EQU     WRCONT+2
RDMRKCRC        EQU     WRCONT+4
RDMARK          EQU     WRCONT+5
RDDATA          EQU     WRCONT+6
SYNCPORT        EQU     WRCONT+7
        ;
        ;START OF RAM VARIABLE DEFINITIONS
        ;
ERRORBYTE       EQU     BUFF    ;NO. OF ERRORS DURING RETRIES
DENBYTE         EQU     BUFF+1  ;0 FOR SINGLE DENSITY
                                ;4 FOR DOUBLE DENSITY
READWRITE       EQU     BUFF+2  ;0  FOR READ
                                ;10H FOR WRITE
CONTROLBYTE     EQU     BUFF+3  ;RAM IMAGE OF RDSTAT OR WRCONT
```

```
TRACK           EQU     BUFF+4
PRESDISK        EQU     BUFF+5
LOGINTAB        EQU     BUFF+6  ;FOR EACH DRIVE
                                ;Ø IF DRIVE HAS NOT BEEN LOGGED IN
                                ;55H IF DRIVE HAS BEEN LOGGED IN
SECTOR          EQU     BUFF+ØAH
DMA             EQU     BUFF+ØBH ;DMA ADDRESS
DISK            EQU     BUFF+ØDH
TESTNEXT        EQU     BUFF+ØEH ;55H IF WANT TO TEST DENSITY
                                 ; OF NEXT TRACK
TWOSIDE         EQU     BUFF+ØFH
STEPTIME        EQU     BUFF+1ØH
ABOVE43         EQU     BUFF+11H ;1ØH IF (TRACK)<44D
                                 ; 5ØH OTHERWISE
TRACKTAB        EQU     BUFF+12H
DENMAP          EQU     BUFF+16H ;SAME CONVENTION AS DENBYTE
TRY1            EQU     BUFF+2ØH
RETRYCOUNT      EQU     BUFF+21H
CURRDRIVE       EQU     BUFF+22H
TESTMAX         EQU     BUFF+23H ;NO. RETRIES FOR DENSITY TEST

STEPSETTLE      EQU     15
HEADSETTLE      EQU     4Ø
STACK           EQU     BUFF+64D

        JMP     COLDBOOT
        JMP     HOME
        JMP     SELDSK
        JMP     SETTRK
        JMP     SETSEC
        JMP     SETDMA
        JMP     READ
        JMP     WRITE
        JMP     SKEW
        JMP     SETDEN

WRITEPROTECT:
        CALL    DISKREADY1          ;LOADS HEAD
                                    ;WAITS TILL DISK READY
                                    ;RETURNS (RDSTAT) IN B
        MOV     A,B
        ANI     Ø4                  ;WRITEPRT BIT FROM DRIVE
        RNZ
        LDA     RDMARK              ;RESETS HEAD LOAD COUNTER
        RET
READ:           ;ENTRY POINT FOR READ ROUTINE
        XRA     A                   ;(READWRITE)= ØØ FOR READ
        JMP     GO

WRITE:          ;ENTRY POINT FOR WRITE ROUTINE
        MVI     A,1ØH               ;(READWRITE)=1ØH FOR WRITE
```

```
GO      STA     READWRITE
        LHLD    DENBYTE             ;(L)=(DENBYTE)
        LDA     CONTROLBYTE
        CMA
        ANI     ØFBH                ;MASK OUT BIT 2 (SD/-DD = Ø)
        ORA     L
        CMA
        STA     WRCONT
        CALL    DISKREADY1
        LDA     SECTOR
        MOV     C,A                 ;(C)=(SECTOR)
        LDA     TRACK
        MOV     B,A                 ;(B)=(TRACK)
        XRA     A
        STA     ERRORBYTE           ;(ERRORBYTE)= Ø
        MOV     A,L
        ORA     A                   ;TEST FOR SINGLE DENSITY
        JZ      SD
READDD:         ;DOUBLE DENSITY READ OR WRITE
BLOOP   CALL    SYNC                ;SYNC ON HEADER
                                    ;FOUND HEADER
        MVI     M,ØAH               ;FIND OA CLOCK FOR ID MARK
        LDAX    D                   ;SYNC WITH -EOW
        LDA     RDMRKCRC
        CPI     ØA1H                ;DATA FOR ID MARK
        JNZ     BLOOP
                                    ;FOUND ID ADDRESS MARK
                                    ;
        LDAX    D                   ;BYTE AFTER ID MARK SHOULD BE FE
        CPI     ØFEH
        JNZ     BLOOP
                                    ;FOUND FE BYTE
                                    ;
        LDAX    D                   ;TRACK BYTE FROM DISK
        CMP     B                   ;(B)=(TRACK)
        JNZ     TERROR1             ;TRACK ERROR

        LDAX    D                   ;SECTOR BYTE FROM DISK
        CMP     C                   ;(C)=(SECTOR)
        JNZ     BLOOP               ;WRONG SECTOR.  TRY AGAIN

        LDAX    D
        DI                          ;DISABLE INTERRUPTS BEFORE
                                    ;CHECKING ID CRC
        LDAX    D
        LDAX    D                   ;READ 1 BYTE PAST ID CRC
        LDA     RDSTAT
        RAR                         ;CHECK ID CRC
        LDAX    D
        JC      ERROR               ;ID CRC ERROR
        LDAX    D
        LDA     ABOVE43
        MOV     B,A
        LDAX    D
```

```
        MOV     M,B             ;(WRCLK)=(ABOVE43)
        LDAX    D               ;NOW 5 BYTES INTO GAP
        MVI     B,9
GLOOP   LDAX    D
        DCR     B
        JNZ     GLOOP

        LDAX    D               ;NOW 15 BYTES INTO GAP
        LDA     READWRITE
        ORA     A               ;CHECK FOR WRITE
        LDAX    D               ;16 BYTES INTO GAP
        JNZ     WRITEDD
                                ;
                                ;DOUBLE DENSITY READ
                                ;
        LDAX    D
        LDAX    D
        MVI     M,ØFFH
        LDAX    D
        LDAX    D
        LDAX    D               ;21 BYTES INTO GAP
        INX     D               ;(D)=SYNCPORT
        LDAX    D               ;SYNC ON FF CLOCK PATTERN
        DCX     D               ;(D)=RDDATA
        MVI     M,ØAH           ;(WRCLK)=ØA
                                ;CLOCK PATTERN FOR DATA MARK
        LHLD    DMA
        LDAX    D               ;SYNC WITH -EOW
        LDA     RDMRKCRC        ;GET DATA PATTERN FOR DATA MARK
        CPI     ØA1H
        JNZ     ERROR           ;MISSING DATA MARK
                                ;
                                ;FOUND DATA MARK
                                ;START TRANSFERRING DATA
                                ;
RXFER   LDAX    D
        MOV     M,A
        INX     H
        MOV     B,D
        LDAX    D
        MOV     M,A
        INX     H
        MOV     C,E
        LDAX    B
        MOV     M,A
        INX     H
        MVI     E,ØE1H
        LDAX    B
        MOV     M,A             ;4 BYTES OF DATA
        INX     H
        LDAX    B
```

```
RLOOP   MOV     M,A
        LDAX    B
        INR     E
        INX     H
        MOV     M,A
        LDAX    B
        INX     H
        MOV     M,A
        LDAX    B
        INX     H
        MOV     M,A
        INX     H
        LDAX    B
        JNZ     RLOOP                ;HAVE TRANSFERRED 128 BYTES
                                     ;AND HAVE READ 129TH BYTE

        LDAX    B
        LDAX    B                    ;READ 1 BYTE PAST CRC
        LDA     RDSTAT
        RAR                          ;CHECK DATA CRC
        JC      ERROR                ;DATA CRC ERROR
                ;
                ;SUCCESSFUL SECTOR READ
                ;
        XRA     A                    ;RETURN ØØ IN ACCUMULATOR
        STA     WRCLK
        RET

ERROR:          ;ARRIVE HERE ON ANY OF FOLLOWING CONDITIONS
                ;       3ØH TRACK ERRORS
                ;       ID CRC ERROR
                ;       MISSING DATA MARK
                ;       DATA CRC ERROR

        MVI     A,ØEFH               ;RETURN EFH IN ACC
        ORA     A                    ;        (UNSUCCESSFUL READ)
        STA     WRCLK
        RET

TERROR:         ;ARRIVE HERE ON TRACK ERROR IN SINGLE DENSITY
        CALL    ERRORCOUNT           ;INCREMENT ERRORBYTE
        JNZ     ALOOP                ;TRY AGAIN IF LESS THAN 3ØH

NO      MVI     A,ØEFH               ;3ØH TRACK ERRORS
        ORA     A                    ;RETURN EFH IN ACC
        STC                          ;(UNSUCESSFUL DISK OPERATION)
        STA     WRCLK
        RET

TERROR1:        ;ARRIVE HERE ON TRACK ERROR IN DOUBLE DENSITY
        CALL    ERRORCOUNT           ;INCREMENT ERRORBYTE
        JNZ     BLOOP                ;TRY AGAIN IF LESS THAN 3ØH
        JMP     NO
```

```
ERRORCOUNT:
        LXI     H,ERRORBYTE
        INR     M                   ;INCREMENT ERRORBYTE
        MOV     A,M
        CPI     30H
        RET

WRITEDD:        ;DOUBLE DENSITY WRITE
                ;ARRIVE HERE 16 BYTES AFTER ID FIELD
        MVI     A,4EH
        STAX    D                   ;WRITE 4 BYTES OF 4E
        STAX    D
        STAX    D
        STAX    D
        XRA     A
        STAX    D                   ;WRITE 6 BYTES OF 00
        STAX    D
        LHLD    DMA
        STAX    D
        STAX    D
        LXI     B,WRMRKCRC
        STAX    D
        STAX    D
        MVI     A,0A1H
        STAX    B                   ;WRITE DATA MARK (A1)
        MVI     C,0E1H
                ;START WRITING DATA TO DISK FROM MEMORY
WXFER   MOV     A,M
WLOOP   STAX    D
        INX     H
        INR     C
        MOV     A,M
        STAX    D
        INX     H
        MOV     A,M
        STAX    D
        INX     H
        MOV     A,M
        INX     H
        STAX    D
        MOV     A,M
        JNZ     WLOOP
                ;WHEN WE ARRIVE HERE WE'VE WRITTEN
                ; 31*4=124 BYTES TO DISK
        STAX    D
        INX     H
        MOV     A,M
        STAX    D
        INX     H
        MOV     A,M
        INX     H
        STAX    D
        MOV     A,M
        STAX    D                   ;128TH BYTE TO DISK
```

```
        MVI     A,ØFFH
        STA     WRCRC               ;WRITE 2 BYTES OF DATA CRC
        STA     WRCRC
        STAX    D                   ;WRITE 3 BYTES OF FF
        STAX    D
        STAX    D
        XRA     A                   ;RETURN ØØ IN ACC
        STA     WRCLK               ;(SUCCESSFUL WRITE)
        RET
                ;SINGLE DENSITY ROUTINES
                ;ENTRY POINT IS SD  (BELOW)

WRITESD:        ;ARRIVE HERE 6 BYTES PAST ID FIELD
        MVI     A,ØFFH
        STAX    D                   ;WRITE 3 BYTES FF (BYTES 7,8,9)
        STAX    D
        STAX    D
        XRA     A
        STAX    D                   ;WRITE 6 BYTES OO (BYTES 1Ø-15)
        STAX    D
        LHLD    DMA
        STAX    D
        STAX    D
        STAX    D
        STAX    D                   ;BYTE 15 OF GAP
        MVI     A,ØFBH              ;WRITE DATA MARK FOR SINGLE DEN
        STA     WRMRKCRC
        MVI     C,ØE1H
        JMP     WXFER               ;JUMP TO COMMON WRITE ROUTINE

SYNC;           ;ROUTINE TO SYNC ON HEADER
        LXI     H,WRCLK
        MVI     M,ØFFH
        LXI     D,SYNCPORT
CLOOP   LDAX    D                   ;SYNC ON FF CLOCK IN HEADER
        ORA     A                   ;SHOULD HAVE ØØ DATA
                                    ;FOUND SYNC PATTERN
        NOP
        NOP
        DCX     D                   ;(D)=WRDATA=READDATA
        RZ
        JMP     SYNC

SD:             ;SINGLE DENSITY ENTRY POINT
ALOOP   CALL    SYNC
                                    ;FOUND HEADER
MLOOP   MVI     M,ØC7H              ;CLOCK PATTERN FOR ID MARK
LLOOP   LDA     RDMRKCRC
        ORA     A
        JZ      LLOOP
        CPI     ØFEH
        JZ      NLOOP
        MVI     M,ØFFH
        LDA     SYNCPORT
```

```
        ORA     A
        JZ      MLOOP
        JMP     ALOOP
NLOOP:                          ;FOUND DATA MARK
        LDAX    D               ;TRACK BYTE FROM DISK
        CMP     B
        JNZ     TERROR          ;TRACK ERROR
        LDAX    D               ;SIDE BYTE FROM DISK (IGNORE)
        LDAX    D               ;SECTOR BYTE FROM DISK
        CMP     C
        JNZ     ALOOP           ;WRONG SECTOR.  TRY AGAIN

                                ;FOUND CORRECT TRACK AND SECTOR
        DI                      ;DISABLE INTERRUPTS BEFORE
                                ;CHECKING ID CRC
        LDAX    D
        LDAX    D               ;CRC BYTE
        LDAX    D               ;CRC BYTE
        LDAX    D               ;GAP BYTE 1
        LDA     RDSTAT          ;CHECK ID CRC
        RAR
        LDAX    D               ;GAP BYTE 2
        LDAX    D               ;GAP BYTE 3
        JC      ERROR           ;ID CRC ERROR

        LDAX    D               ;GAP BYTE 4
        LDA     ABOVE43
        MOV     M,A
        LDAX    D               ;GAP BYTE 5
        LDA     READWRITE
        ORA     A               ;CHECK FOR WRITE
        LDAX    D               ;GAP BYTE 6
        JNZ     WRITESD
                ;SINGLE DENSITY READ
        LDAX    D               ;READ 6 BYTES OF GAP
        LDAX    D
        LDAX    D
        LDAX    D
        LDAX    D
        LDAX    D
        MVI     M,ØFFH          ;(WRCLK)=FF
        LXI     B,RDDATA
        LDAX    D               ;GAP BYTE 14
        INX     D               ;(D)=SYNCPORT
        LDAX    D
        MVI     M,ØC7H          ;CLOCK PATTERN FOR DATA MARK
        MVI     E,Ø4            ;(D)=RDMRKCRC
        LDAX    B               ;GAP BYTE 16
        LDAX    D               ;READ DATA MARK
        ANI     ØFCH
        CPI     ØF8H            ;DATA PATTERN FOR DATA MARK
        JNZ     ERROR           ;MISSING DATA MARK
                        ;FOUND SINGLE DENSITY DATA MARK
        MVI     E,ØEØH          ;32*4=128 BYTE TRANSFER
```

```
        LDAX    B
        LHLD    DMA
        JMP     RLOOP           ;JUMP TO MAIN READ ROUTINE


TEST:           ;TESTS DENSITY OF DISKETTE IN LOGGED-IN DRIVE
                ;RETURNS ØØ IN ACC IF DOUBLE DENSITY
                ;RETURNS ØF IN ACC IF SINGLE DENSITY
                ;RETURNS ØA IN ACC IF TEST FAILS
        XRA     A
        STA     TESTMAX         ;(TESTMAX)=Ø
TEST1   XRA     A
        STA     ERRORBYTE       ;(ERRORBYTE)=Ø
        CALL    DISKREADY       ;LOAD HEAD
        LXI     B,WRCONT
        LDA     CONTROLBYTE
        ORI     8ØH             ;SET CONTROLLER FOR SIDE Ø
        ANI     ØFBH            ;TRY DOUBLE DENSITY
        STAX    B
LOOP6:          ;DOUBLE DENSITY TEST
        LXI     H,WRCLK
        MVI     M,ØFFH
        LXI     D,SYNCPORT      ;SYNC ON FF CLOCK IN HEADER
LOOP7   LDAX    D               ;READ DATA PATTERN
        INR     L               ;ABORT AFTER 256 TRIES
        JZ      RETRY
        ORA     A               ;DATA SHOULD BE ØØ
        JNZ     LOOP7
                                ;FOUND HEADER
        DCX     D               ;(D)=READDATA
        MVI     L,Ø1            ;(H)=WRCLK
        MVI     M,ØAH
        LDAX    D               ;SYNC WITH -EOW
        LDA     RDMRKCRC        ;LOOK FOR ID MARK
        CPI     ØA1H
        JNZ     RETRY
                                ;FOUND ID MARK
        LDAX    D               ;FE BYTE
        LDAX    D               ;SECTOR BYTE
        LDAX    D               ;CRC BYTE
        LDAX    D               ;CRC BYTE
        LDAX    D               ;GAP BYTE 1
        LDAX    B
        RAR                     ;CHECK ID CRC
        JC      RETRY
                                ;ID CRC OK
        XRA     A               ;RETURN ØØ
        RET

RETRY   CALL    ERRORCOUNT
        JNZ     LOOP6

                ;SINGLE DENSITY TEST
                ;ARRIVE HERE AFTER 3ØH TRIES AT DOUBLE DENSITY
```

```
SDTEST  XRA     A
        STA     ERRORBYTE          ;(ERRORBYTE)=Ø
        LDA     CONTROLBYTE
        ORI     84H                ;SET UP SIDE Ø, SINGLE DENSITY
        STAX    B                  ;TO WRCONT
SDLOOP1 MVI     E,Ø7               ;(D)=SYNCPORT
        LXI     H,WRCLK
        MVI     M,ØFFH             ;SYNC ON FF CLOCK PATTERN
SDLOOP2 LDAX    D                  ;GET CORRESPONDING DATA
        INR     L                  ;ABORT AFTER 256 TRIES
        JZ      RETRY1
        ORA     A                  ;DATA SHOULD BE ØØ
        JNZ     SDLOOP2
                                   ;FOUND HEADER
        DCX     D                  ;(D)=READDATA
        MVI     L,Ø1               ;(H)=WRCLK
        MVI     M,ØC7H             ;LOOK FOR C7 CLOCK
        LDAX    D                  ;SYNC WITH -EOW
        LDA     RDMRKCRC
        CPI     ØFEH               ;DATA FOR ID MARK
        JNZ     RETRY1
                                   ;FOUND ID MARK
        LDAX    D                  ;TRACK BYTE
        LDAX    D                  ;SIDE
        LDAX    D                  ;SECTOR
        LDAX    D
        LDAX    D                  ;CRC BYTE
        LDAX    D                  ;CRC BYTE
        LDAX    D
        LDAX    B                  ;GET RDSTAT
        RAR                        ;CHECK ID CRC
        JC      RETRY1
                                   ;ID CRC OK
        ORI     ØFFH               ;RETURN FF
        RET

RETRY1  CALL    ERRORCOUNT
        JNZ     SDLOOP1

                ;FAILED BOTH DOUBLE AND SINGLE DENSITY
                ; TESTS 3ØH TIMES
        LXI     H,TESTMAX
        INR     M                  ;INCREMENT TESTMAX
        MOV     A,M
        CPI     1Ø
        JNZ     TEST1
                ;FAILED TEST 1Ø TIMES
        ORA     A                  ;RETURN ØA
        RET
```

```
SKEW:                   ;COMPUTES PHYSICAL SECTOR FROM LOGICAL SECTOR
                        ;SKEW FACTOR IS 8
                        ;INPUT AND OUTPUT ARE IN C REG
                        ;OUTPUT=(((INPUT) MOD 52)*8 - 7) MOD 52
                        ;IF INPUT>52, SELECTS SIDE 1
        LXI     H,Ø
        PUSH    H
        LDA     CONTROLBYTE
        ANI     7FH             ;SIDE 1
        MOV     E,A
        MOV     A,C
        SUI     52
        MOV     B,A             ;(B)=(C)-52
        MOV     A,E             ;(A)=(CONTROLBYTE)^7F
        JP      SKIPY
                                ;INPUT WAS LESS THAN 52
        ORI     8ØH             ;CHOOSE SIDE Ø
        MOV     B,C
SKIPY   STA     TWOSIDE
        MOV     A,B             ;(B)=(INPUT) MOD 52
        MOV     L,B
        POP     B
LOOP1Ø  INR     C
        SUI     13
        JP      LOOP1Ø
        DAD     H
        DAD     H
        DAD     H
        MOV     A,H
        ORA     A
        MOV     A,L
        CNZ     HIGH
LOOP11  CPI     52
        JC      SKIP12
        ADI     2Ø4
        JMP     LOOP11
SKIP12  ADD     C
        MOV     C,A
        RET
HIGH    ADI     48
        RET


SETDMA  MOV     H,B
        MOV     L,C
        SHLD    DMA             ;STORE DMA ADDRESS
        RET


SETSEC  MOV     A,C
        STA     SECTOR          ;STORE SECTOR NUMBER
        RET
```

```
SETTRK:             ;STEPS DRIVE TO TRACK (C)
        MOV     A,C
        CPI     44D             ;IF (C)<44
        MVI     A,1ØH           ;  THEN (ABOVE43)=1ØH
        JC      SKIP3
        MVI     A,5ØH           ;  ELSE (ABOVE43)=5ØH
SKIP3   STA     ABOVE43
        CALL    DISKREADY

STEPLOOP LXI    H,TRACK
        MOV     A,M             ;GET (TRACK)
        CMP     C               ;DONE?
        JZ      DONESTEP
        CALL    STEPHEAD        ;NO, STEP HEAD
        JMP     STEPLOOP        ;REPEAT

STEPHEAD JC     STEPIN          ;IF (TRACK)<(C) THEN STEP IN
STEPOUT LDA     CONTROLBYTE     ;ELSE STEP OUT
        DCR     M               ;(TRACK)=(TRACK)-1
        ORI     Ø2H             ;DIR=OUT
        JMP     DOSTEP

STEPIN  LDA     CONTROLBYTE
        INR     M               ;(TRACK)=(TRACK)+1
        ANI     ØFDH            ;DIR=IN

DOSTEP  STAX    D               ;STORE DIRECTION IN WRCONT
        DCR     A               ;-STEP=Ø
        STAX    D
        INR     A               ;-STEP=1
        STAX    D
        LDA     STEPTIME
        MOV     B,A             ;WAIT 8 MS FOR NEXT STEP
        JMP     DELAY           ;DELAY EXECUTES A RETURN

DONESTEP MVI    B,STEPSETTLE
        CALL    DELAY           ;WAIT 8 MS FOR STEP SETTLE
        MOV     A,C
        CPI     2               ;IF (TRACK)<2 THEN SET TESTNEXT
        JC      SETTN
        LDA     TESTNEXT
        ORA     A
        MVI     A,Ø
        STA     TESTNEXT
        STC
        JNZ     SETDEN          ;IF TESTNEXT=55 TEST DENSITY
        RET
SETDEN:                 ;TESTS DENSITY
                        ;UPDATES DENBYTE AND DENMAP
        CALL    TEST            ;TEST DENSITY
        MVI     A,4             ;IF Z IS SET (DOUBLE DENSITY)
        JZ      SKIP            ;  THEN (DENBYTE)=4
        MVI     A,Ø             ;  ELSE (DENBYTE)=Ø
```

```
SKIP    STA     DENBYTE
        LXI     H,DENMAP
        PUSH    PSW
        LDA     PRESDISK
        MOV     C,A
        MVI     B,Ø
        DAD     B
        POP     PSW                 ;SAVE FLAGS
        MOV     M,A                 ;(DENMAP(PRESDISK))=(DENBYTE)
        RET

SELDSK:         ;SELECTS DRIVE POINTED TO BY C REG
                ;LOADS HEAD OF SELECTED DRIVE
        LXI     H,MASKTABLE
        MVI     B,Ø
        DAD     B                   ;C CONTAINS DRIVE NUMBER
        MOV     A,M                 ;MASKTABLE CONTAINS Ø FOR
SELDSK1 STA     WRCONT              ; SELECTED DRIVE, 1'S ELSEWHERE
        STA     TWOSIDE
        STA     CONTROLBYTE
        LXI     H,TRACKTAB
        LDA     PRESDISK
        MOV     E,A
        MOV     D,B
        DAD     D
        LDA     TRACK
        MOV     M,A                 ;(TRACKTAB(PRESDISK))=(TRACK)
        MOV     A,C
        STA     PRESDISK            ;(PRESDISK)=(C)
        STA     DISK                ;(DISK)=(C)
        LXI     H,TRACKTAB
        DAD     B
        MOV     A,M
        STA     TRACK               ;(TRACK)=(TRACKTAB(C))
        LXI     H,LOGINTAB
        DAD     B
        MOV     A,M
        ORA     A                   ;HAS DRIVE BEEN LOGGED IN?
        JNZ     INOK
        MVI     A,55H               ;NO. MARK AS LOGGED IN
        MOV     M,A
        CALL    HOME                ;  AND HOME THE HEAD
INOK    CALL    DISKREADY           ;LOAD HEAD
        MVI     B,HEADSETTLE
        CALL    DELAY               ;WAIT FOR HEAD SETTLING
        LDA     TRACK
        CPI     Ø2
        JNC     SETDEN
SETTN   MVI     A,55H               ;ON TRACKS Ø AND 1, WE WANT
        STA     TESTNEXT            ; TO TEST DENSITY OF NEXT TRACK
        JMP     SETDEN              ;TEST DENSITY OF THIS TRACK
```

```
HEADLOAD LDAX   D                   ;ASSUMES (D)=RDSTAT
         ANI    20H                 ;HEAD ALREADY LOADED?
         LDA    RDMARK              ;RESET HEAD LOAD COUNTER
         MVI    B,HEADSETTLE
         CNZ    DELAY               ;IF HEAD WASN'T LOADED
         RET

DELAY:          ;DELAYS (B) MILLISECONDS
         PUSH   H                   ;SAVE HL
DELAY2   LDA    CONTROLBYTE
         ANI    4                   ;IF SINGLE DENSITY,
         MVI    L,31                ;       31 BYTES * 32 USEC = 1 MS
         JNZ    DELAY1
         MVI    L,63                ;IN DD, 63 BYTES * 16 USEC = 1 MS
DELAY1   LDA    RDDATA
         DCR    L
         JNZ    DELAY1
         DCR    B                   ;END 1 MS LOOP
         JNZ    DELAY2
         POP    H                   ;RESTORE HL
         RET

HOME     CALL   DISKREADY
         LXI    H,TRACK             ;FOR STEPIN AND STEPOUT
ATHOME   CALL   STEPIN              ;STEP TOWARD 76
         LDAX   D
         ANI    Ø2                  ;  UNTIL -TRKØ IS INACTIVE
         JZ     ATHOME
GOHOME   CALL   STEPOUT             ;THEN STEP TOWARD ØØ
         LDAX   D
         ANI    Ø2                  ;  UNTIL -TRKØ IS ACTIVE
         JNZ    GOHOME
         MVI    A,1ØH
         STA    ABOVE43             ;(ABOVE43)=1ØH
         STA    TESTNEXT            ;(TESTNEXT)=1ØH
         XRA    A
         STA    TRACK               ;(TRACK)=ØØ
         JMP    SETDEN              ;TEST DENSITY
DISKREADY1 LDA  RDSTAT
         MOV    B,A
         ANI    ØAØH                ;IF DRIVE READY AND HEAD LOADED
         RZ                         ;       THEN RETURN
DISKREADY PUSH  B
         LXI    D,WRCONT            ;(D)=WRCONT=RDSTAT
         CALL   HEADLOAD            ;LOAD HEAD
         POP    B
         LDAX   D
         RLC
         JC     DISKREADY           ;LOOP UNTIL DRIVE READY
         RET
```

```
COLDBOOT LXI      SP,STACK
         XRA      A
         LXI      B,BUFF
CBUFF    STAX     B                    ;ZERO OUT RAM BUFFER
         INR      C
         JNZ      CBUFF

         MVI      A,10
         STA      STEPTIME             ;SET STEPTIME LONGER THAN IT
                                       ;NEEDS TO BE TO BE SAFE, SINCE
                                       ;COLD BOOT LOADER RESETS IT
         LXI      B,0
         CALL     SETDMA               ;SETDMA DOES NOT CHANGE C REG, SO
         CALL     SELDSK               ;SELECT DRIVE A
         MVI      C,01                 ;LOAD BOOTSTRAP LOADER
         CALL     SETSEC               ;  FROM TRACK 0 SECTOR 1
         CALL     READ
         JNZ      COLDBOOT             ;ON READ FAILURE, TRY AGAIN
         RST      0                    ;EXECUTE BOOTSTRAP LOADER
                                       ;(SAVES 2 BYTES OVER JMP 0000)

MASKTABLE         DB       0BFH,0DFH,0EFH,0F7H
```

Appendix C

CHANGING OPERATING SYSTEM CHARACTERISTICS

This section is divided into three subsections corresponding to three types of operating system alterations.

C-1 Changing the system size
C-2 Changing the IOBYTE and step time defaults
C-3 BIOS and BOOT Alteration

Section C-1 discusses use of the MOVCPM and SYSGEN transient commands to relocate the operating system to reside in a different part of memory. When shipped, the system is configured to use 62K of RAM, the maximum since the DOUBLER is located at F8ØØH.

Section C-2 describes changing the IOBYTE, the byte of memory referred to by the system to set the logical to physical device assignments at cold boot. If you purchased Remex double-sided drives with the DOUBLER, refer to this section to change step time.

Section C-3 discusses altering the Micromation custom BIOS. MM2BIOS.ASM contains a driver for a Centronics 7Ø3/779 printer and all the software necessary to support the various configurations of disk drive types (single or double sided floppies with or without a hard disk) and serial I/O port assignments. A specific application may require additional driver routines or reconfigured I/O assignments.

C-1 CHANGING THE SYSTEM SIZE

Generally, the CP/M operating system should be located at the top of system memory since the O/S uses only that portion of memory below it. Circumstances may dictate a decrease in the amount of memory used, however. For instance, data base management systems typically set aside a portion of memory above the CP/M system area for reference and temporary data storage.

The MOVCPM and SYSGEN utilities (transient commands) are used to relocate the system to a lower portion of system memory. There are several different invocations of MOVCPM, each for a different purpose. Refer to the CP/M document, <u>An Introduction to CP/M Features and Facilities</u>, for a description of the options.

The MOVCPM utility contains the MM2BIOS.ASM and M2BOOT.ASM files in a somewhat altered form. This alteration allows for the size parameter to be specified by the user. All other values are held constant.

In the following example a 6ØK system size is specified. The resultant system image is put on a formatted disk in drive B. In this and other examples the "@" symbol is used to indicate a carriage return. When it appears, press the RETURN key on your keyboard; do not press the @ key. All user entries are underscored.

```
A>MOVCPM 6Ø *@

CONSTRUCTING 6Øk CP/M - Micromation ver 2.x
READY FOR "SYSGEN" OR
"SAVE 35 CPM6Ø.COM"
A>SAVE 35 CPM6Ø.COM@
A>SYSGEN@
SYSGEN VER 2.x
SOURCE DRIVE NAME (OR RETURN TO SKIP) @
DESTINATION DRIVE NAME (OR RETURN TO REBOOT) B
DESTINATION ON B, THEN TYPE RETURN @
FUNCTION COMPLETE
DESTINATION DRIVE NAME (OR RETURN TO REBOOT) @

A>
```

In all cases above, the 2.x indicates the current revision of the program.

Notice the MOVCPM transient command. In this mode, a system with a size of 6ØK is generated and left in the transient program area (TPA); the system originally loaded remains in control of the computer.

SAVE is invoked next. This writes the contents of memory, in this case the operating system, onto the disk. The file name "CPM6Ø.COM" is given to the file. This step is not always necessary. It is included to demonstrate use of the SAVE command. Subsequently, CPM6Ø.COM can be used with DDT to install a new BIOS and BOOT, if necessary (see section C-3 below).

The SYSGEN utility is invoked to write the system image from the TPA to the system tracks (Ø - 1) on the designated disk. Notice that the example above puts the new system on the disk in drive B. "A" could have been specified as well. In this case, the write operation would replace the original system recording residing there with the system just created.

If several formatted disks require the new system, the operation can be repeated, without MOVCPM, by entering the destination drive name again instead of a RETURN in the last step.

C-2 CHANGING THE IOBYTE AND STEP TIME DEFAULTS

Changing the IOBYTE

A single byte at location 0003H sets the logical to physical device assignments in CP/M. It is set at cold boot (reset), but not warm boot (^C), by the BIOS section. The byte is broken down into four 2 bit sections corresponding to the four physical assignments. The bits are allocated as follows

```
          MSB                 LSB
bits | 7 6 | 5 4 | 3 2 | 1 0 |
       LST   PUN   RDR   CON
```

The following codes can be entered for each 2 bit location

```
LST  00 - LIST is Teletype device (TTY:)
     01 - LIST is terminal device (CRT:)
     10 - LIST is a line printer device (LPT:)
     11 - user defined list device (UL1:)

PUN  00 - PUNCH is Teletype device (TTY:)
     01 - PUNCH is a high speed punch device (PUN:)
     10 - user defined punch #1 (UP1:)
     11 - user defined punch #2 (UP2:)

RDR  00 - READER is Teletype device (TTY:)
     01 - READER is a high speed reader device (RDR:)
     10 - user defined reader #1 (UR1:)
     11 - user defined reader #2 (UR2:)

CON  00 - CONSOLE is Teletype device (TTY:)
     01 - CONSOLE is a terminal (CRT:)
     10 - batch mode: READER is CONSOLE input and
          LIST device is CONSOLE output (BAT:)
     11 - user defined console device (UC1:)
```

In BIOS, the entire byte is entered in hexadecimal form. For instance, the value supplied in MM2BIOS.ASM is 81. In binary, this appears as 1000 0001 in the IOBYTE and means the LST is assigned to LPT:, PUN and RDR devices are coded for TTY: and the CON is coded for a terminal (CRT:). The replacement value used in the example below is 1. In binary, this is 0000 0001 which means LST: is assigned to TTY:, RDR: and PUN: are still assigned as TTY:, and CON: remains as CRT:.

The following assignments are made by MM2BIOS at cold boot. To have them displayed on your terminal, type **STAT DEV:**

```
CON: is CRT:
PUN: is TTY:
RDR: is TTY:
LST: is LPT:
```

NOTE: Although PUN: and RDR: are assigned to TTY:, MM2BIOS does not contain a driver routine. An attempt to output to a punch device or input from the reader device will not work.

The CRT: device is a typical terminal (keyboard with screen) attached to the serial port on the DOUBLER. The LPT: assignment for LST: references a Centronics 7Ø3/779 dot matrix printer driver included in the BIOS. Alternately TTY:, CRT: or UL1: may be assigned to LST:. TTY: provides output through the serial I/O port on the Micromation Multi I/O board. A driver routine is present in the BIOS to drive a serial printer. CRT: indicates that the terminal is the LST: device. UL1: references a custom driver written and installed by the user (see section C-3 below).

If your system has a serial printer attached to the Multi I/O Board serial port for the LST: device, you will need to type

STAT LST:=TTY:

after every cold boot (a warm boot does not affect the IOBYTE) to output to the printer. This may prove tedious in daily operation. If so, the procedure below describes how to change that portion of MOVCPM.COM that sets the IOBYTE. Subsequent use of MOVCPM renders TTY: as the LST: device. Of course, CRT: or UL1: can also be specified.

The procedure to change the IOBYTE uses the CP/M transients SUBMIT and XSUB. If you are not familiar with them, read through their descriptions in AN INTRODUCTION TO CP/M FEATURES AND FACILITIES and CP/M 2.x USER'S GUIDE FOR CP/M 1.4 OWNERS. To begin, place the back-up system disk in drive A, close the door and type

SUBMIT LIST xx

where xx is one of the following.

1 if you want TTY: as the default LST: assignment
41 if you want CRT: as the default LST: assignment
81 if you want LPT: as the default LST: assignment
C1 if you want UL1: as the default LST: assignment

The following illustrates use of this procedure. In this example, the system size remains at the value shipped with the Z-PLUS (62K of memory) and the LST: assignment is changed from LPT: (the Centronics printer) to TTY: (the serial port on the Multi I/O board). As in other sections of this manual, user entries are underlined and a RETURN is indicated by the "@" character.

```
A>SUBMIT LIST 1@

A>XSUB

A>DDT
DDT VERS 2.x
-IMOVCPM.COM

-R

NEXT  PC
28ØØ Ø1ØØ
-S2ØCA

2ØCA 81 1
2ØCB 32 .

-GØ

(xsub active)

A>SAVE 39 MOVCPM.COM

A>
```

The only user entry in this example is the first. The remainder of the display is performed automatically under SUBMIT and XSUB. This SUBMIT file uses DDT to alter the location in MOVCPM that sets the IOBYTE. The value entered (1, 41, 81 or C1 for xx) replaces the default setting (81).

After the final prompt is displayed (after SAVE 39 MOVCPM.COM), press the RESET button on the front of the computer. This disengages XSUB. The CP/M sign-on and prompt are displayed. The following steps create a new system image using the new MOVCPM. After the RESET, perform the following.

```
A>MOVCPM 62 *@              Reminder: if you wish to generate a
                            different size, replace 62.
CONSTRUCTING 62k CP/M - Micromation ver 2.x
READY FOR "SYSGEN" OR
"SAVE 35 CPM62.COM"
A>
```

The new system is now in memory. The following transfers it to the disk in A. If you wish to preserve your current system, put a formatted disk in B and specify it as the destination disk.

```
A>SYSGEN@
SYSGEN VER 2.x
SOURCE DRIVE NAME (OR RETURN TO SKIP)@
DESTINATION DRIVE NAME (OR RETURN TO REBOOT) A
DESTINATION IN A, THEN TYPE RETURN @
FUNCTION COMPLETE
DESTINATION DRIVE NAME (OR RETURN TO REBOOT) @
A>
```

To see (and ensure) that the change has occurred, press the RESET button again (if you wrote the new system to the disk in B, exchange the disks before resetting) and type

STAT DEV:@

The procedure described above renders the following response.

```
CON: is CRT:
RDR: is TTY:
PUN: is TTY:
LST: is TTY:
```

Changing the Step Time

IMPORTANT: This section has significance to those who have purchased Remex double sided drives with the DOUBLER. If your model has the standard Shugart drives, the BIOS portion of the O/S contains the appropriate step time setting. **Do NOT execute this procedure if you have Shugart drives.**

The step time value included in BIOS is used by the floppy disk drives to establish the rate at which the drive head moves from track to track. The appropriate rate for the different disk drives (from various manufacturers) is determined by noting the system performance with different settings; the good old trial and error method. Micromation has already done the leg-work and we've determined that the best setting for Shugart drives is 8 milliseconds and for Remex drives is 4 milliseconds. Since most of our systems are shipped with Shugart drives, MM2BIOS sets the step time at 8 ms. Remex drives will work with this setting, but system performance is enhanced by changing this value to 4 ms.

The STEP.SUB file is provided to change the step time value in MOVCPM for Remex drives much as the LIST.SUB file changes the IOBYTE default. In fact, execution of STEP.SUB is very similar. Again, STEP.SUB is SUBMITed, and XSUB and DDT are called up. To invoke STEP.SUB, enter

SUBMIT STEP 4

when the A> prompt is displayed and terminate the command with a RETURN. As in the execution of LIST.SUB, do not make any additional entries until the final A> is displayed. It appears after A>SAVE 39 MOVCPM.COM has been displayed.

When the final A> prompt appears, hit the RESET button on the cabinet to disengage XSUB. Subsequently, perform MOVCPM exactly as illustrated above to generate a system image with the new step time installed.

C-3 BIOS AND BOOT ALTERATION

You will need to change and install MM2BIOS.ASM (the floppy disk only BIOS) if

- you need to insert a special printer driver (Note: several printer manufacturers use the Centronics conventions for data output. Check with your dealer to see if your printer falls into this category.)

- you do not have the Micromation Multi I/O Board. MM2BIOS is set-up to use the parallel and serial ports on this board for output to the Centronics printer and output to a serial interface printer. Code is present in MM2BIOS supporting serial output through a number of I/O boards from other manufacturers. This section describes MM2BIOS alteration to support these boards.

NOTE: If MM2BIOS is changed and inserted into the operating system as described in this section, the MOVCPM utility will not contain the change. Subsequent use of MOVCPM will render a system with the features of the O/S originally shipped with the unit. Consequently, plan ahead; determine the system size and IOBYTE default before installing the new system.

If you change the MSIZE equate in MM2BIOS.ASM, a corresponding change must be made in M2BOOT.ASM. There are two ways to do this:

1) Perform a MOVCPM as illustrated in Step 1 in NEW SYSTEM GENERATION below. The system size generated must match the value entered as MSIZE. In this case, there's no need to alter the MSIZE value in M2BOOT.

2) Change the MSIZE value in M2BOOT.ASM to agree with the value entered in MM2BIOS.ASM. Both must be assembled and inserted into the system as shown in NEW SYSTEM GENERATION. There's no need to perform Step 1 in this case; skip to Step 2.

Of course there are other changes that can be implemented. These should be left to programmers experienced in CP/M and BIOS alteration though. In fact, all changes to the operating system should be left to experienced programmers. This section is for reference to identify and define the significant labels. In addition, installation of the altered BIOS and BOOT with DDT is described.

Regardless of your hardware components, MM2BIOS.ASM and M2BOOT.ASM are the two programs to alter if a change is required. CBIOS.LIB, BIOS.LIB, and BOOT.LIB are examples of the form of these programs and should not be used as the source for changes. They are for reference only. Most alterations will affect MM2BIOS only.

Before demonstrating creation of a new system with altered BIOS and BOOT, the features and options of MM2BIOS are presented. Once the files have been edited and assembled, return to **NEW SYSTEM GENERATION** below to install the them.

MM2BIOS.ASM: This program is supplied with systems that contain the Multi I/O Board. Four serial ports are available (though only one is installed). MM2BIOS assigns this port to the TTY: device. A driver routine for a Centronics 7Ø3/779 dot matrix printer is included to use a couple of the parallel ports. Flags are set to assemble only those features present in a particular system. The listing below is excerpted from MM2BIOS.ASM and shows the conditional flags.

```
MSIZE           EQU     48      ;SIZE OF OPERATING SYSTEM IN KILOBYTES
                                ;(CURRENTLY 48K).  THIS NUMBER MUST BE
                                ;CHANGED FOR LARGER SYSTEMS.
NDRIVES         EQU     4       ;NUMBER OF DISK DRIVES SUPPORTED BY
                                ;THIS CBIOS

*=========================================================================
*I/O BYTE FOR LIST DEVICE IS IMPLEMENTED AS FOLLOWS:
*       "TTY" = MULTLIST (MM MULTI I/O BOARD SERIAL PORT#1)
*       "CRT" = CONOUT   (MM DOUBLER SERIAL PORT)
*       "LPT" = CENTLIST (CENTRONICS 7Ø3/779 TYPE LIST DEVICE)
*       "UL1" = OPTIONAL DRIVER TO BE SELECTED BY USER (SEE BELOW)
*=========================================================================
*                                               ==>UPDATED:2-12-8Ø
;
;LIST DEVICE EQUATES: (THESE COULD BE SET FALSE TO SAVE BIOS SPACE IF
;                      USER LIST DRIVER IS TOO LARGE TO FIT OTHERWISE)
;
MULTLIST        EQU     TRUE
CENTLIST        EQU     TRUE
;-------------------------------------------------------------------------
```

```
;LIST DEVICE OPTIONS: SET ONLY ONE FLAG TRUE FOR DESIRED DRIVER AS "UL1"
;
NONE            EQU     TRUE    ;NO "UL1" FUNCTION DESIRED
GODBIO          EQU     FALSE   ;GODBOUT I/O BOARD AS LST:
SSMIO           EQU     FALSE   ;SOLID STATE MUSIC 2S+P AS LST:
DPIO            EQU     FALSE   ;DELTA PRODUCTS CPU BOARD AS LST:
USERLST         EQU     FALSE   ;SET FLAG TO INSERT USER DEFINED LST:
                                ;THIS CODE MUST BE INSERTED UNDER LIST:
                                ;AND INITIALIZATION CODE UNDER (COLD)
                                ;BOOT:
```

The labels have the following meanings:

MSIZE: The amount of memory to be used by CP/M is set by this equate. Note that a change in MSIZE here necessitates a corresponding change in the MSIZE equate in MPBOOT.ASM (use one of the two methods described above). If only the system size is to be changed in the operating system, use MOVCPM instead. Notice that the value in MM2BIOS is 48. If you reset any flag, be sure to set this one to your current system size (62 in the standard configuration).

NDRIVES: The number of disk drives supported by the BIOS is indicated here. There is no need to change this equate even if your system has only two drives.

MULTLIST is assigned as the TTY: device and is set to use the Multi I/O board serial port (port 1) for output. It is set TRUE. If a user list device (UL1:) is to be incorporated, this flag can be set FALSE. Subsequent assembly will not include the MULTLIST related code. Thus, room can be made if the new code requires it.

CENTLIST is assigned as the LPT: device and is set to use the I/O board parallel ports for output. Subsequent code drives a Centronics printer. It, too, is set TRUE and can be set FALSE if the new code necessitates more room to fit in BIOS.

LIST DEVICE OPTIONS: One of the five labels shown can be assigned as the UL1: device. NONE is set TRUE since none apply. However, if you have one of these boards from other manufacturers or have a special printer driver you wish to incorporate, set the appropriate label TRUE. Note that only one can be TRUE.

If a driver is to be written (i.e., USERLST is to be used as UL1:), the code to assign the ports, to initialize the device, and to output data must be inserted in the appropriate places. The locations within MM2BIOS are identified by IF USERLST. (There are several, each for a separate portion of the code.) Insert the appropriate code after this entry and before the ENDIF statement.

If it is necessary to change the port assignments or install an additional USART on the Multi I/O Board, refer to that manual for a description of the changes necessary to the BIOS. Excerpts from MM2BIOS.ASM and program examples are provided.

To reiterate, the flags described above determine which options to implement. There is little need to alter other parts of MM2BIOS.ASM unless a special printer driver is to be inserted. Also, if you change the MSIZE equate in MM2BIOS, remember to change the MSIZE equate in M2BOOT.ASM.

Once any changes have been made, assemble MM2BIOS.ASM (and M2BOOT.ASM if necessary). Subsequently, proceed with the next part of this section to create a new system.

M2BOOT.ASM ALTERATION

M2BOOT.ASM will need alteration if you purchased REMEX double-sided floppy disk drives in your Z-PLUS system with Hard Disk. In Hard Disk systems, the STEP utility provided on the distribution diskette must NOT be used. Also, some users may want to change the MSIZE value in M2BOOT for convenience sake if the MSIZE in M(H)2BIOS was changed.

To review, changing M2BOOT isn't always necessary. In floppy disk only Z-PLUS systems, the values for MSIZE and STEPTIME can be changed with MOVCPM and SUBMIT STEP, respectively. If you choose either of these options be sure to perform the operation before installing the new BIOS. Subsequently, disregard the two commands for installing M2BOOT.HEX in Step 2 below.

The MSIZE equate appears in the beginning of the M2BOOT.ASM file. As distributed, a value of 48 is present. Change this value with your editor to agree with the value in MM2BIOS.ASM. The MSIZE equate in both MUST be the same.

To change the STEPTIME default for REMEX drives, look in the INIT section of M2BOOT.ASM for the following code.

```
MVI     A,8
STA     STEPTIME        ;STEPTIME FOR SHUGART DRIVES
```

Change the "8" in the first instruction to "4". This is the recommended steptime for REMEX drives.

These are the only changes that should be made to M2BOOT.ASM. After you are finished editing the file, assemble it and insert the new M2BOOT.HEX as described in Step 2 below.

If your intention is to change the STEPTIME only, you will need to change MSIZE as well. This is because the MSIZE equate is set for a 48K system which probable is not the amount of memory you have your BIOS set-up to use.

NEW SYSTEM GENERATION

After the programs have been assembled, MM2BIOS.HEX (and M2BOOT.HEX) must be inserted into the system. If the system size is 62K, you can use CPM62.COM as the source file when DDT is invoked. (Skip Step 1 below.) For another system size, proceed with Step 1.

In the examples that follow, "@" indicates a carriage return should be entered (press the RETURN key). Do not enter the @ character. All user entries are underscored.

To start, put a system diskette with the following files on it in drive A and a formatted (either single or double density) diskette in B.

```
M(H)2BIOS.HEX (assembled MM2BIOS.ASM or MH2BIOS.ASM)
MPBOOT.HEX(assembledMPBOOT.ASM, if necessary)
MOVCPM.COM
SYSGEN.COM
DDT.COM
CPM62.COM (unless a system with a different
          is created)
```

If a system size other than 62k is needed, proceed with the next step. Otherwise, skip to the Step 2.

STEP 1

```
A>MOVCPM xx *@       where xx indicates the new system size

CONSTRUCTING xxK CP/M VERS 2.x
READY FOR "SYSGEN" OR
"SAVE 35 CPMxx.COM"

A>SAVE 35 CPMxx.COM
```

The MOVCPM program read the system image from the diskette, changed the values that specify the system size, and loaded it into memory, specifically the transient program area (TPA). SAVE was used to record the file CPMxx.COM from the contents of the TPA onto the disk in drive A:.

To install the new BIOS and BOOT, DDT is used. In this example, the CPM62.COM file is used. If a different system size was created, substitute the CPMxx.COM SAVEd above for CPM62.COM.

STEP 2

```
A>DDT CPM62.COM@
DDT VERS 2.x
NEXT  PC
24ØØ Ø1ØØ
-L1F8Ø                            List the contents of the
  1F8Ø   JMP   F2C9               1Ø locations starting at
  1F83   JMP   F2FE               1F8Ø.  This is the jump
  1F86   JMP   F496               table for BIOS. Use F2ØØ
  ...    ...   ...                to determine offset in
                                  next step (see descrip-
                                  tion below for reason)
-H1F8Ø F2ØØ                       Determine the offset.
118Ø 2D8Ø                         2D8Ø is the offset
-IMM2BIOS.HEX                      Get MM2BIOS
-R2D8Ø                            Insert it at 2D8Ø
NEXT  PC
24ØØ ØØØØ
-IM2BOOT.HEX                      Get new M2BOOT *
-R9ØØ                             M2BOOT always goes at
NEXT  PC                          9ØØ
24ØØ ØØØØ
-^C                               Exit to the system
A>SAVE 35 CPM62X.COM               Save the new CP/M system
```

* Installation of M2BOOT.HEX is only necessary if some value (e.g., MSIZE or STEPTIME) was changed. Recall that a change is system size can be performed by performing Step 1 above before installing the new BIOS with DDT. If no change was made to M2BOOT, skip this command and the next.

The system was SAVEd as CPM62X.COM as a precaution in case the new BIOS doesn't work. Thus, CPM62.COM is available as a source if the operation needs to be done again.

Unlike M2BOOT, which always goes at 9ØØH in the system, the location of MM2BIOS varies with the system size. Where to put it is determined by finding the difference between the its present location in memory and the location it resides at when in use. Memory location 1F8ØH is always the location of the jump table to the BIOS routines in CP/M. To determine where to put the new BIOS (MM2BIOS), list this portion of the system after executing MOVCPM to see where it has been placed. Since BIOS starts at an xx-hundred location, drop the last two digits, rounding down to the hundred hex number. The following table illustrates this procedure.

Value Shown	Value Used
F2C9	F2ØØ
C2C9	C2ØØ
EAC9	EAØØ

The "Value Used" is then used to calculate the offset necessary. The offset is the negative difference between the location where BIOS resides during execution (in high memory) versus its present location under DDT in the TPA. Use the H command entering first the jump table address (1F8Ø), a space, and then the location pointed to by the jump table. The numbers that result are the sum of the two and the difference. Disregard the sum and use the difference (2D8Ø in the example above) as the location for MM2BIOS in the DDT R (read) command.

Step 3 writes the new system on a disk. Again as a precaution, write the new system to a different formatted disk than the one currently in use. Since it is not known whether the new one works, it's not a good idea to erase the current system yet. To start, keep the system disk in drive A and put a formatted disk (either single or double density, it doesn't matter) in drive B. If you did not use CPM62.COM in the example above, substitute your CPMxx.COM file for CPM62X.COM in the examples below.

STEP 3

```
A>DDT CPM62X.COM@                              Invoke DDT to load the
DDT VERS 2.x                                   the system into memory.
NEXT  PC
24ØØ Ø1ØØ
-^C                                            Exit to system
A>SYSGEN@                                      Invoke SYSGEN to
SYSGEN VER 2.x                                 generate new system
SOURCE DRIVE NAME (OR RETURN TO SKIP)@
DESTINATION DRIVE NAME (OR RETURN TO REBOOT)B
DESTINATION ON B, THEN TYPE RETURN@
FUNCTION COMPLETE
DESTINATION DRIVE NAME (OR RETURN TO REBOOT)@
A>
```

Notice that a RETURN was entered in response to the program question SOURCE DRIVE NAME. DDT had already transferred the system image (in this case CPM62X.COM) from disk into memory.

To test the new diskette, exchange the disks in A and B and hit the RESET button. The CP/M sign-on message and prompt should appear.

STEP 4

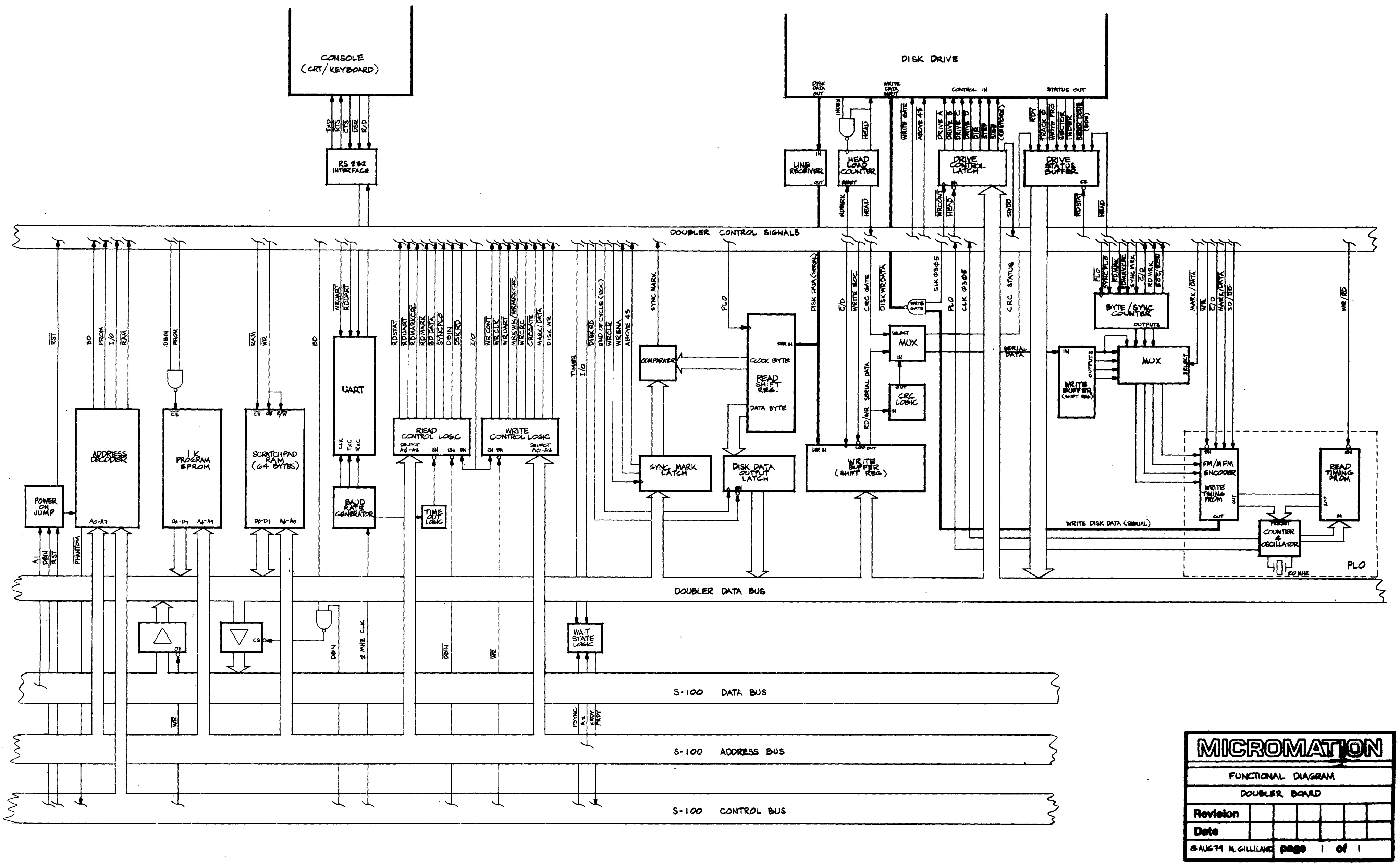
Assuming the new system worked, type

B:PIP A:=B:*.*

to transfer all the files from the disk in B (the former system disk) to the new system disk in drive A. "B:" had to precede PIP since the disk in A: is blank except for the system.

If the new system did not work, try the procedure for creating a new system again. (Perhaps you made a mistake the first time through.) If it doesn't work after the second try, the problem is most likely in the BIOS you wrote or patched.

Once MM2BIOS and M2BOOT have been patched and incorporated into your operating system, use of MOVCPM to change the system size will install the old system rather than the new one. MOVCPM contains the original MM2BIOS and M2BOOT with alterations to relocate the system size according to the value entered. All the other flags described above remain the same. To change the size of the new system, you will need to edit MM2BIOS.ASM and M2BOOT.ASM again changing the MSIZE equate, re-assemble the files, perform MOVCPM (specifying the new system size again to render the appropriate) locations in the jump table described above), and execute DDT to insert the altered files.



CONSOLE
(CRT/KEYBOARD)
TXD RTS CTS DSR RXD
RS 232 INTERFACE
DISK DRIVE
DISK DATA OUT
WRITE DATA INPUT
CONTROL IN
STATUS OUT
INDEX
HEAD
WRITE GATE
ABOVE 43
DRIVE A
DRIVE B
DRIVE C
DRIVE D
DIR
STEP
SIDE
(RESTORE)
RDY
TRACK 0
WRITE PRO
SECTOR
INDEX
LINE RECEIVER
HEAD LOAD COUNTER
DRIVE CONTROL LATCH
DRIVE STATUS BUFFER
RDMARK
WRCONT
RDSTAT
SD/DD
DOUBLER CONTROL SIGNALS
RST
BD
PROM
I/O
RAM
DBIN
WR
WRUART
RDUART
RDSTAT
RDUART
RDMARKCRC
RDMARK
RD DATA
SYNCPLO
DBIN
DSK RD
WR CONT
WRCLK
WRUART
MRKWR/WRMRKCRC
WRCRC
CRCGATE
MARK/DATA
DISK WR
TIMER
I/O
DSKRD
END OF CYCLE (EOC)
WRCLK
WRENA
ABOVE 43
SYNC MARK
PLO
DISK DATA (SERIAL)
C/D
WRITE EOC
CRC GATE
DISK WRDATA
WRITE GATE
CLK Φ305
PLO
CLK Φ305
CRC STATUS
SYNC MARK
RDMRK
EOC/EOW
SYNC/PLO
RDMARKCRC
C/D
MARK/DATA
SD/DD
WR/RD
ADDRESS DECODER
A0-A7
1 K PROGRAM EPROM
D0-D7
A0-A9
SCRATCH PAD RAM (64 BYTES)
D0-D7
A0-A5
UART
CLK
TXC
RXC
BAUD RATE GENERATOR
READ CONTROL LOGIC
SELECT A0-A2
EN
WRITE CONTROL LOGIC
SELECT A0-A2
TIME OUT LOGIC
COMPARATOR
SYNC MARK LATCH
READ SHIFT REG.
SER IN
CLOCK BYTE
DATA BYTE
DISK DATA OUTPUT LATCH
WRITE BUFFER (SHIFT REG)
SER IN
LOAD
OUT
MUX
SELECT
CRC LOGIC
BYTE/SYNC COUNTER
OUTPUTS
SERIAL DATA
WRITE BUFFER (SHIFT REG)
MUX
SELECT
FM/MFM ENCODER
WRITE TIMING PROM
READ TIMING PROM
PRESET COUNTER & OSCILLATOR
20 MHZ
WRITE DISK DATA (SERIAL)
PLO
POWER ON JUMP
A1
DBIN
RST
PHANTOM
DOUBLER DATA BUS
WAIT STATE LOGIC
DBIN
2 MHZ CLK
DBIN
WR
WR
PSYNC
A0
XRDY
PRDY
S-100 DATA BUS
S-100 ADDRESS BUS
S-100 CONTROL BUS
MICROMATION
FUNCTIONAL DIAGRAM
DOUBLER BOARD
Revision
Date
8AUG79 M. GILLILAND
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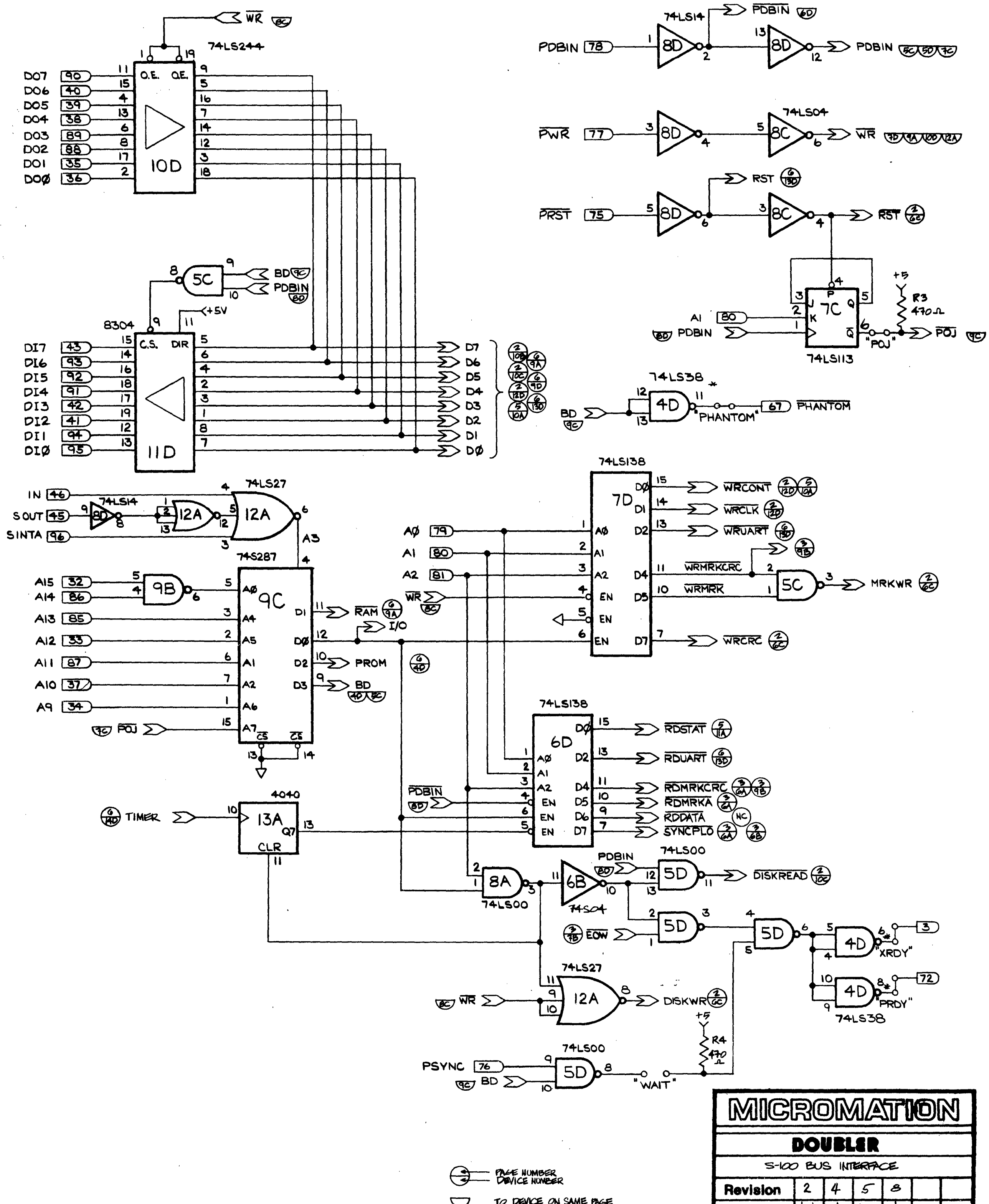


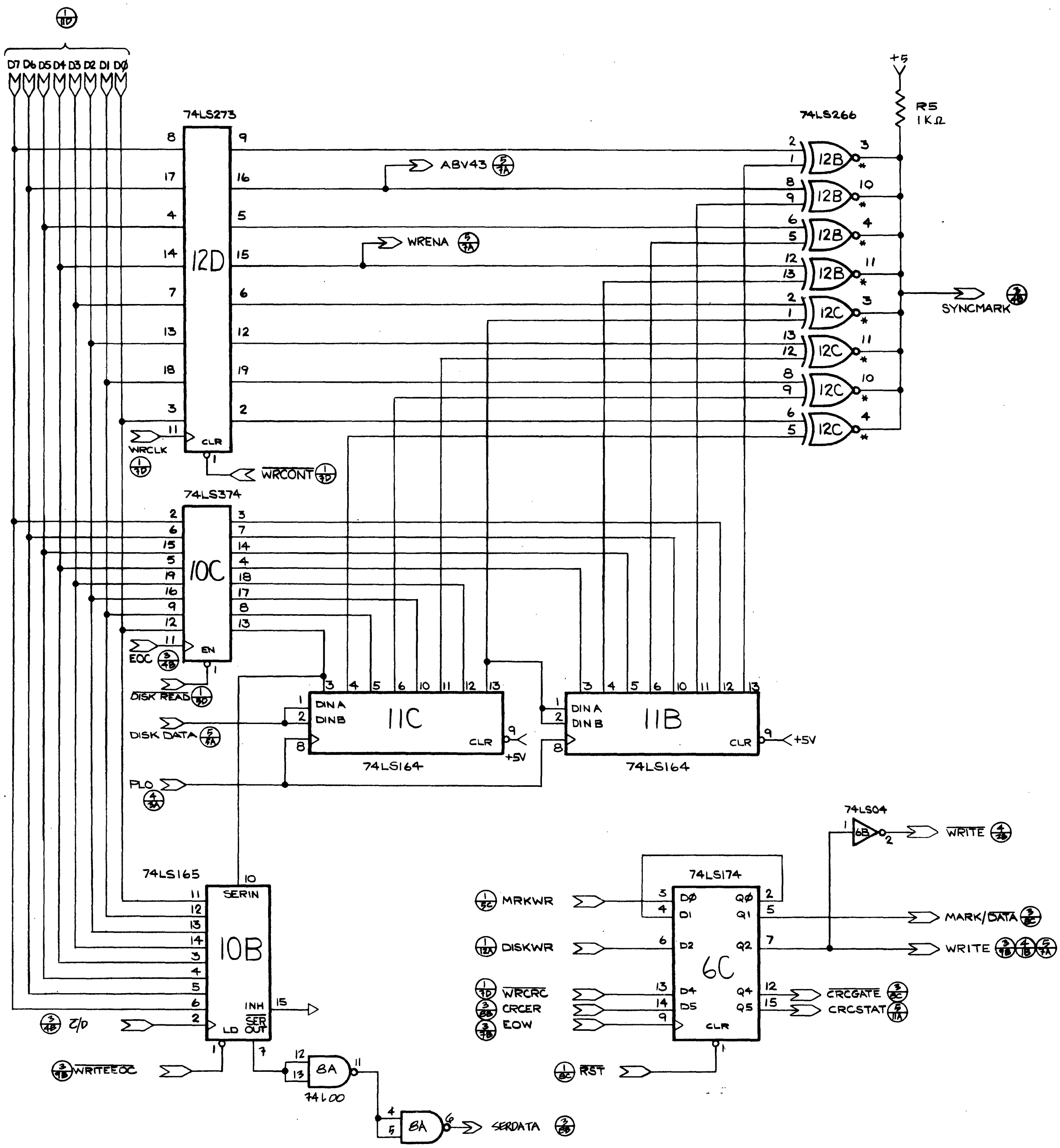
MICROMATION

DOUBLER

S-100 BUS INTERFACE

Revision	2	4	5	8		
Date	7/21/78	11/27	1/21/79	AUG 79		

DWG. NO. 3101 — page 1 of 7



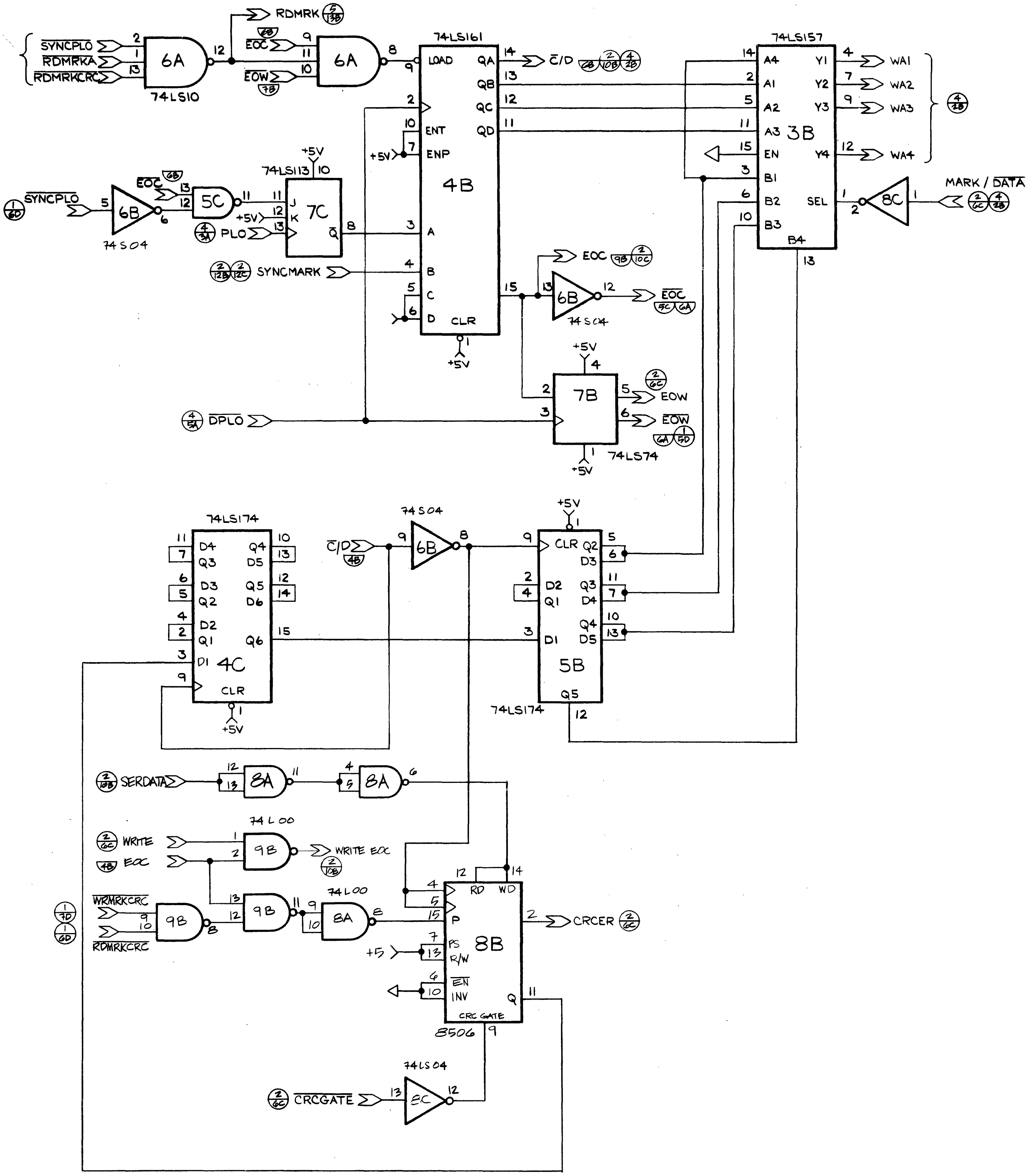
MICROMATION

DOUBLER

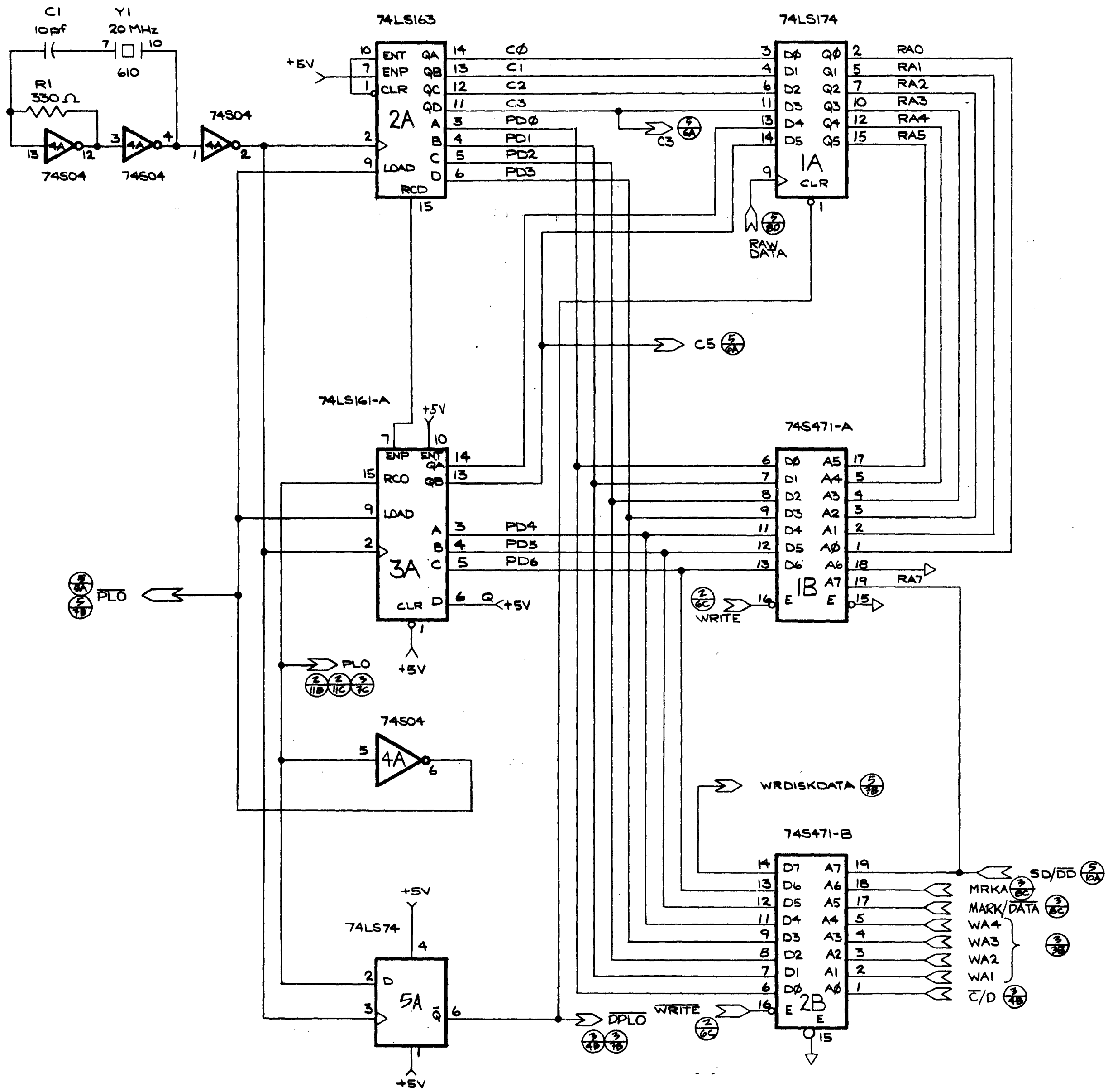
READ CHANNEL

Revision	2	4	5	8		
Date	7/27/78	11/27	1/21/79	[illegible]		

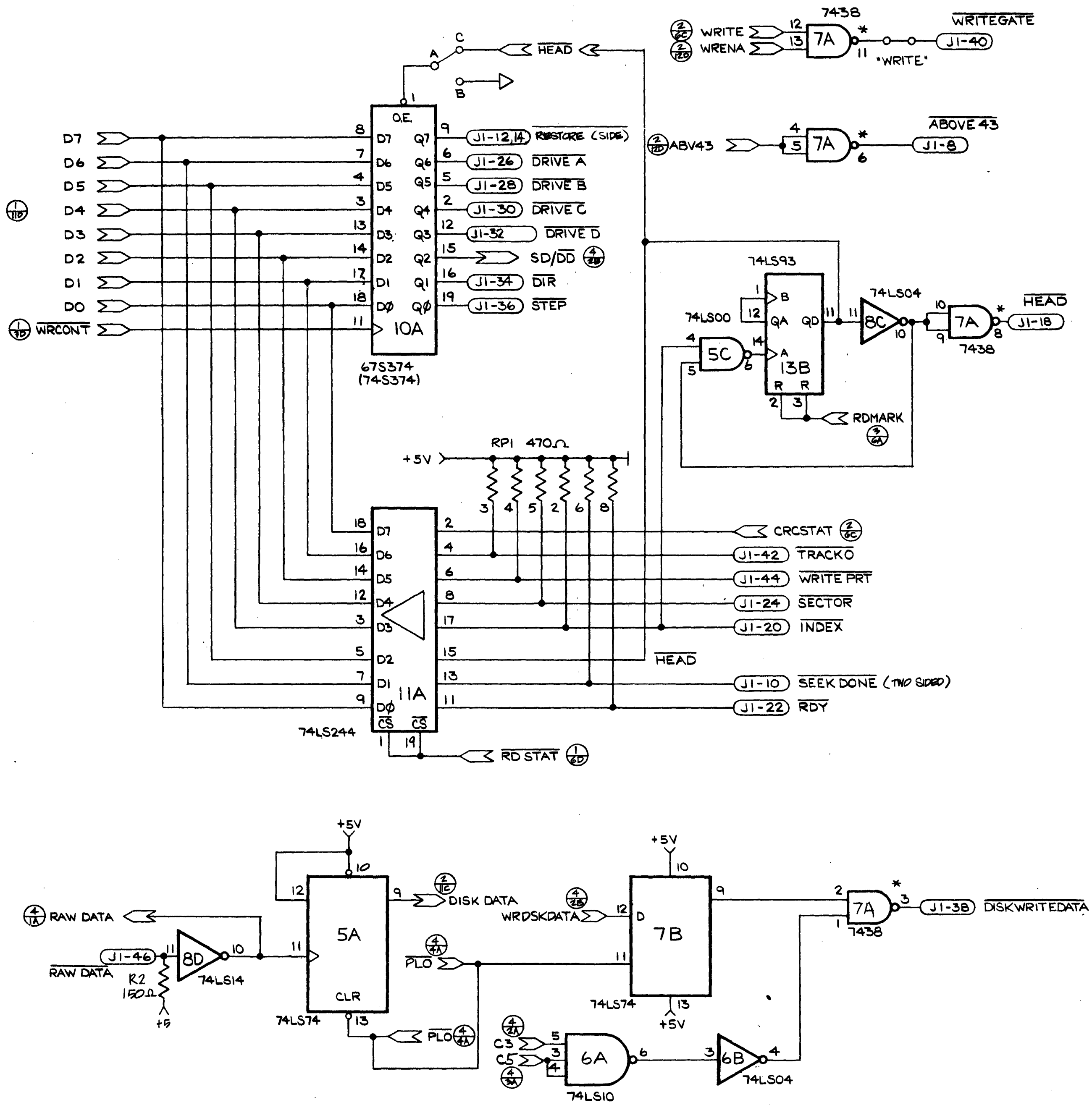
DWG. NO. 3102 — page 2 of 7



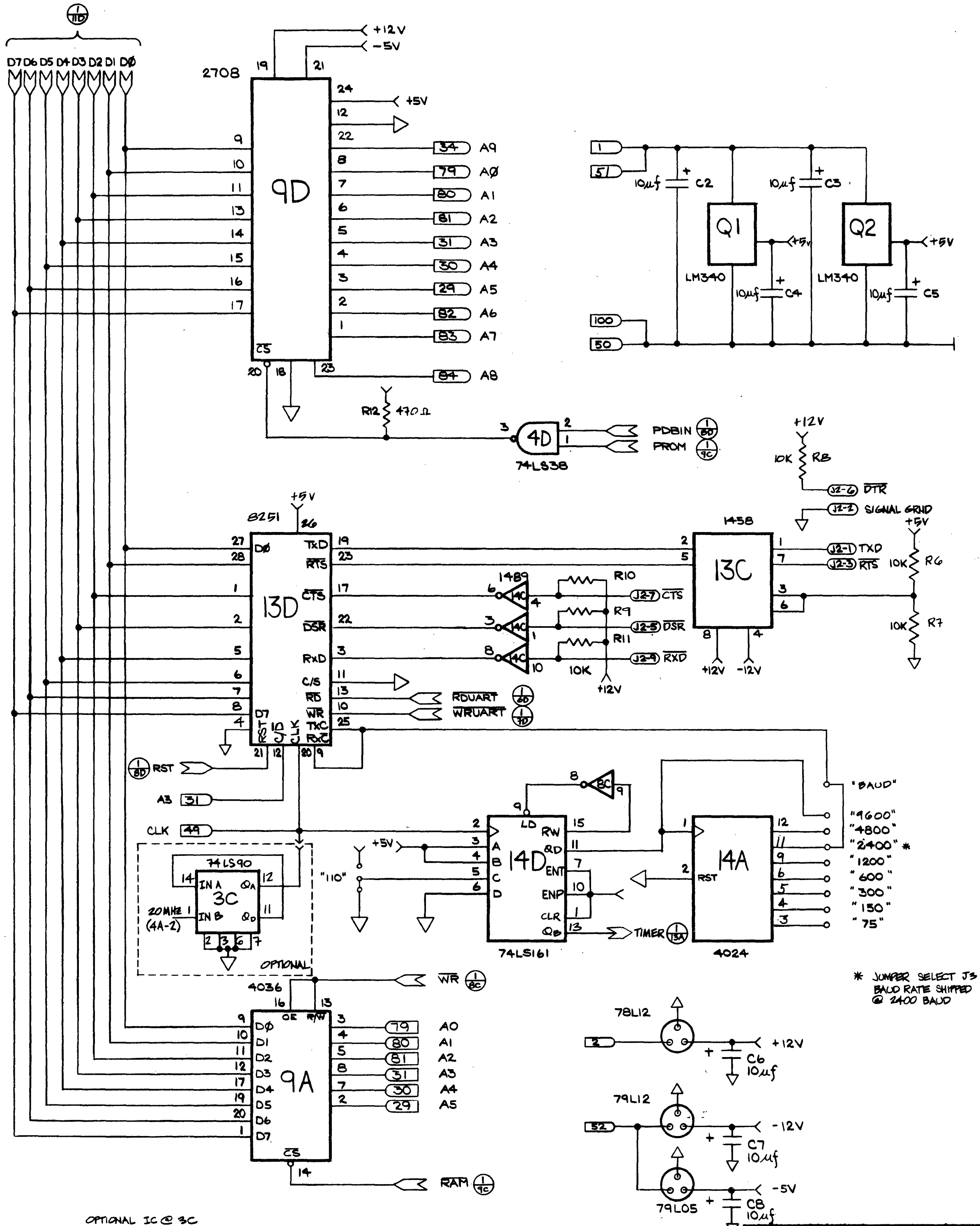
MICROMATION					
DOUBLER					
WRITE CHANNEL					
Revision	2	4	5	8	8.1
Date	7/27/78	11/27	1/21/79	AUG 79	20 MAR 80
DWG. NO. 3103	**page** 3 **of** 7				



MICROMATION							
DOUBLER							
PLO CIRCUITRY							
Revision	2	4	5	8			
Date	7/21/78	11/27	1/21/79	AUG 79			
DWG. NO. 3104		page 4 of 7					



MICROMATION							
DOUBLER							
DRIVE INTERFACE							
Revision	2	4	5	8			
Date	7/21/78	11/27	1/21	AUG 79			
DWG. NO. 3105		**page** 5 **of** 7					



OPTIONAL IC @ 3C
USED FOR TRS-80

MICROMATION

DOUBLER

UART/MEMORY

Revision	2	4	5	8			
Date	9/22/78	11/27	1/21/79	Aug '79			

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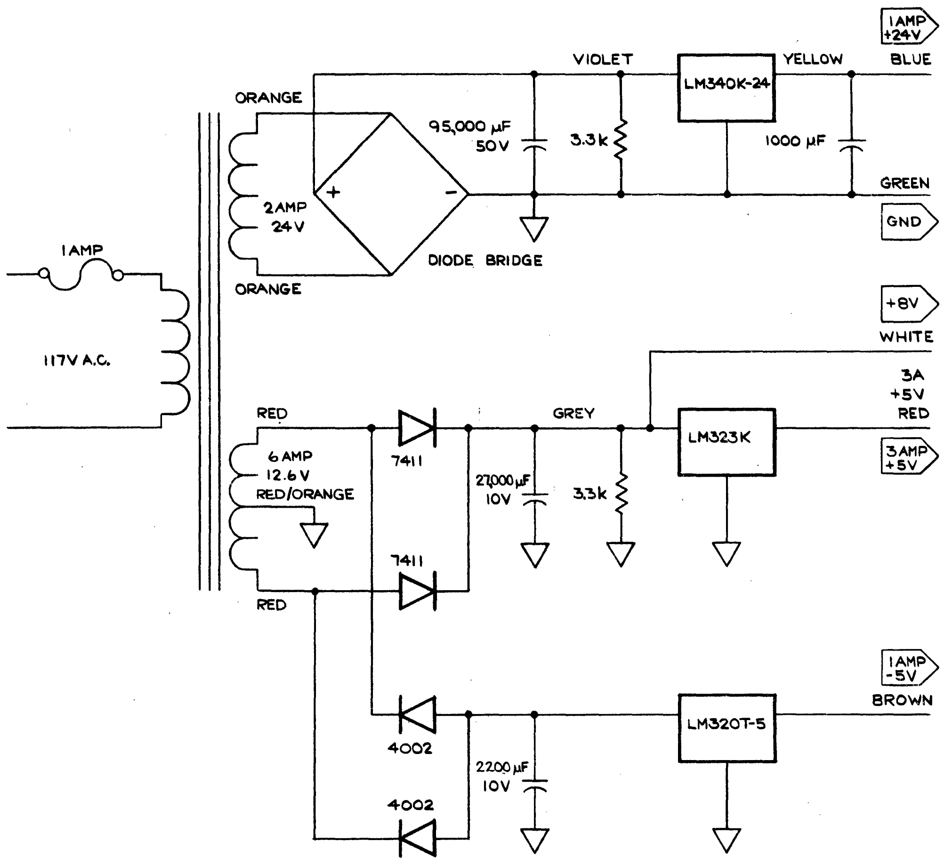

MICROMATION							
DOUBLER							
DISK POWER							
Revision	2	4	5	8			
Date	7/21/78	11/27	1/2/79	AUG 79			
DWG. NO. 3107	page 7 of 7						

```
                ;
                ;PROM ROUTINES FOR MICROMATION DOUBLER, VERSION C.2

                ;THE C.1 VERSION HAS NOPS IN SYNC ROUTINE TO ALLOW MORE FREQUENT REFRESH
                ;OF DYNAMIC RAMS
                ;IT ALSO SETS UP THE SIDE BIT EARLIER TO MEET SETUP TIME FOR Y-E DATA DRIVES

                ;
                ;THIS VERSION HAS THE FOLLOWING CHANGES FROM C.1:
                ;HAS FIX FOR C.1 BUG IN SETTING UP DENSITY
                ;DISABLES INTERRUPTS AFTER FINDING CORRECT SECTOR
                ;HAS SLOWER STEP AND SETTLE TIMES
                ;

                ;               FEB 11, 1980

 F800           BASE            ORG     0F800H
 FC00 =         BUFF            EQU     BASE+400H       ;SCRATCHPAD RAM
                        ;
                        ;START OF HARDWARE PORT DEFINITIONS
                        ;
 FE00 =         WRCONT          EQU     BASE+600H
 FE01 =         WRCLK           EQU     WRCONT+1
 FE02 =         WRUART          EQU     WRCONT+2
 FE04 =         WRMRKCRC        EQU     WRCONT+4
 FE05 =         WRMRK           EQU     WRCONT+5
 FE06 =         WRDATA          EQU     WRCONT+6
 FE07 =         WRCRC           EQU     WRCONT+7
 FE00 =         RDSTAT          EQU     WRCONT
 FE02 =         RDUART          EQU     WRCONT+2
 FE04 =         RDMRKCRC        EQU     WRCONT+4
 FE05 =         RDMARK          EQU     WRCONT+5
 FE06 =         RDDATA          EQU     WRCONT+6
 FE07 =         SYNCPORT        EQU     WRCONT+7
                        ;
                        ;START OF RAM VARIABLE DEFINITIONS
                        ;
 FC00 =         ERRORBYTE       EQU     BUFF    ;NO. OF ERRORS DURING RETRIES
 FC01 =         DENBYTE         EQU     BUFF+1  ;0 FOR SINGLE DENSITY
                                                ;4 FOR DOUBLE DENSITY
 FC02 =         READWRITE       EQU     BUFF+2  ;0  FOR READ
                                                ;10H FOR WRITE
 FC03 =         CONTROLBYTE     EQU     BUFF+3  ;RAM IMAGE OF RDSTAT OR WRCONT
 FC04 =         TRACK           EQU     BUFF+4
 FC05 =         PRESDISK        EQU     BUFF+5
 FC06 =         LOGINTAB        EQU     BUFF+6  ;FOR EACH DRIVE
                                        ;0 IF DRIVE HAS NOT BEEN LOGGED IN
```

```
                                          ;55H IF DRIVE HAS BEEN LOGGED IN
 FC0A =         SECTOR          EQU      BUFF+0AH
 FC0B =         DMA             EQU      BUFF+0BH ;DMA ADDRESS
 FC0D =         DISK            EQU      BUFF+0DH
 FC0E =         TESTNEXT        EQU      BUFF+0EH ;55H IF WANT TO TEST DENSITY
                                                  ; OF NEXT TRACK
 FC0F =         TWOSIDE         EQU      BUFF+0FH
 FC10 =         STEPTIME        EQU      BUFF+10H
 FC11 =         ABOVE43         EQU      BUFF+11H ;10H IF (TRACK)<44D
                                                  ; 50H OTHERWISE
 FC12 =         TRACKTAB        EQU      BUFF+12H
 FC16 =         DENMAP          EQU      BUFF+16H ;SAME CONVENTION AS DENBYTE
 FC20 =         TRY1            EQU      BUFF+20H
 FC21 =         RETRYCOUNT      EQU      BUFF+21H
 FC22 =         CURRDRIVE       EQU      BUFF+22H
 FC23 =         TESTMAX         EQU      BUFF+23H ;NO. RETRIES FOR DENSITY TEST

 000F =         STEPSETTLE      EQU      15
 0028 =         HEADSETTLE      EQU      40
 FC40 =         STACK           EQU      BUFF+64D

                ;BEGIN WITH JUMP TABLE

 F800 C3D3FB            JMP     COLDBOOT
 F803 C397FB            JMP     HOME
 F806 C31EFB            JMP     SELDSK
 F809 C3AEFA            JMP     SETTRK
 F80C C3A9FA            JMP     SETSEC
 F80F C3A3FA            JMP     SETDMA
 F812 C329F8            JMP     READ
 F815 C32DF8            JMP     WRITE
 F818 C369FA            JMP     SKEW
 F81B C303FB            JMP     SETDEN

                PAGE


                WRITEPROTECT:

 F81E CDBEFB            CALL    DISKREADY1      ;LOADS HEAD
                                                ;WAITS TILL DISK READY
                                                ;RETURNS (RDSTAT) IN B
 F821 78                MOV     A,B
 F822 E604              ANI     04      ;WRITEPRT BIT FROM DRIVE
 F824 C0                RNZ
 F825 3A05FE            LDA     RDMARK  ;RESETS HEAD LOAD COUNTER
 F828 C9                RET
                        ;

                READ:                           ;ENTRY POINT FOR READ ROUTINE

 F829 AF                XRA     A               ;(READWRITE)= 00 FOR READ
 F82A C32FF8            JMP     GO

                WRITE:                          ;ENTRY POINT FOR WRITE ROUTINE

 F82D 3E10              MVI     A,10H           ;(READWRITE)=10H FOR WRITE
```

```
F82F 3202FC    GO:     STA     READWRITE
F832 2A01FC            LHLD    DENBYTE          ;(L)=(DENBYTE)
F835 3A03FC            LDA     CONTROLBYTE
F838 2F                CMA
F839 E6FB              ANI     0FBH             ;MASK OUT BIT 2 (SD/-DD = 0)
F83B B5                ORA     L
F83C 2F                CMA
F83D 3200FE            STA     WRCONT
F840 CDBEFB            CALL    DISKREADY1
F843 3A0AFC            LDA     SECTOR
F846 4F                MOV     C,A              ;(C)=(SECTOR)
F847 3A04FC            LDA     TRACK
F84A 47                MOV     B,A              ;(B)=(TRACK)
F84B AF                XRA     A
F84C 3200FC            STA     ERRORBYTE        ;(ERRORBYTE)= 0
F84F 7D                MOV     A,L
F850 B7                ORA     A                ;TEST FOR SINGLE DENSITY
F851 CA70F9            JZ      SD

               ;               DOUBLE DENSITY READ OR WRITE

               READDD:

F854 CD5FF9    BLOOP:  CALL    SYNC             ;SYNC ON HEADER
                                                ;FOUND HEADER
F857 360A              MVI     M,0AH            ;FIND 0A CLOCK FOR ID MARK
F859 1A                LDAX    D                ;SYNC WITH -EOW
F85A 3A04FE            LDA     RDMRKCRC
F85D FEA1              CPI     0A1H             ;DATA FOR ID MARK
F85F C254F8            JNZ     BLOOP
                                                ;FOUND ID ADDRESS MARK
                                                ;
F862 1A                LDAX    D                ;BYTE AFTER ID MARK SHOULD BE FE
F863 FEFE              CPI     0FEH
F865 C254F8            JNZ     BLOOP
                                                ;FOUND FE BYTE
                                                ;
F868 1A                LDAX    D                ;TRACK BYTE FROM DISK
F869 B8                CMP     B                ;(B)=(TRACK)
F86A C2F2F8            JNZ     TERROR1          ;TRACK ERROR

F86D 1A                LDAX    D                ;SECTOR BYTE FROM DISK
F86E B9                CMP     C                ;(C)=(SECTOR)
F86F C254F8            JNZ     BLOOP            ;WRONG SECTOR.  TRY AGAIN

F872 1A                LDAX    D
F873 F3                DI                       ;DISABLE INTERRUPTS BEFORE CHECKING ID CRC
F874 1A                LDAX    D
F875 1A                LDAX    D                ;READ 1 BYTE PAST ID CRC
F876 3A00FE            LDA     RDSTAT
F879 1F                RAR                      ;CHECK ID CRC
F87A 1A                LDAX    D
F87B DADDF8            JC      ERROR            ;ID CRC ERROR

F87E 1A                LDAX    D
F87F 3A11FC            LDA     ABOVE43
```

```
F882 47                  MOV    B,A
F883 1A                  LDAX   D
F884 70                  MOV    M,B              ;(WRCLK)=(ABOVE43)
F885 1A                  LDAX   D                ;NOW 5 BYTES INTO GAP
F886 0609                MVI    B,9
F888 1A         GLOOP:   LDAX   D
F889 05                  DCR    B
F88A C288F8              JNZ    GLOOP

F88D 1A                  LDAX   D                ;NOW 15 BYTES INTO GAP
F88E 3A02FC              LDA    READWRITE
F891 B7                  ORA    A                ;CHECK FOR WRITE
F892 1A                  LDAX   D                ;16 BYTES INTO GAP
F893 C203F9              JNZ    WRITEDD
                                                 ;
                                                 ;DOUBLE DENSITY READ
                                                 ;
F896 1A                  LDAX   D
F897 1A                  LDAX   D
F898 36FF                MVI    M,0FFH
F89A 1A                  LDAX   D
F89B 1A                  LDAX   D
F89C 1A                  LDAX   D                ;21 BYTES INTO GAP
F89D 13                  INX    D                ;(D)=SYNCPORT
F89E 1A                  LDAX   D                ;SYNC ON FF CLOCK PATTERN
F89F 1B                  DCX    D                ;(D)=RDDATA
F8A0 360A                MVI    M,0AH            ;(WRCLK)=0A
                                                 ;CLOCK PATTERN FOR DATA MARK
F8A2 2A0BFC              LHLD   DMA
F8A5 1A                  LDAX   D                ;SYNC WITH -EOW
F8A6 3A04FE              LDA    RDMRKCRC         ;GET DATA PATTERN FOR DATA MARK
F8A9 FEA1                CPI    0A1H
F8AB C2DDF8              JNZ    ERROR            ;MISSING DATA MARK
                                                 ;
                                                 ;FOUND DATA MARK
                                                 ;START TRANSFERRING DATA
                                                 ;
F8AE 1A         RXFER:   LDAX   D
F8AF 77                  MOV    M,A
F8B0 23                  INX    H
F8B1 42                  MOV    B,D
F8B2 1A                  LDAX   D
F8B3 77                  MOV    M,A
F8B4 23                  INX    H
F8B5 4B                  MOV    C,E
F8B6 0A                  LDAX   B
F8B7 77                  MOV    M,A
F8B8 23                  INX    H
F8B9 1EE1                MVI    E,0E1H
F8BB 0A                  LDAX   B
F8BC 77                  MOV    M,A              ;4 BYTES OF DATA
F8BD 23                  INX    H
F8BE 0A                  LDAX   B

F8BF 77         RLOOP:   MOV    M,A
F8C0 0A                  LDAX   B
F8C1 1C                  INR    E
```

```
F8C2 23            INX    H
F8C3 77            MOV    M,A
F8C4 0A            LDAX   B
F8C5 23            INX    H
F8C6 77            MOV    M,A
F8C7 0A            LDAX   B
F8C8 23            INX    H
F8C9 77            MOV    M,A
F8CA 23            INX    H
F8CB 0A            LDAX   B
F8CC C2BFF8        JNZ    RLOOP         ;HAVE TRANSFERRED 128 BYTES
                                        ;AND HAVE READ 129TH BYTE

F8CF 0A            LDAX   B
F8D0 0A            LDAX   B             ;READ 1 BYTE PAST CRC
F8D1 3A00FE        LDA    RDSTAT
F8D4 1F            RAR                  ;CHECK DATA CRC
F8D5 DADDF8        JC     ERROR         ;DATA CRC ERROR
                          ;
                          ;SUCCESSFUL SECTOR READ
                          ;
F8D8 AF            XRA    A             ;RETURN 00 IN ACCUMULATOR
F8D9 3201FE        STA    WRCLK
F8DC C9            RET

             ERROR:

             ;ARRIVE HERE ON ANY OF FOLLOWING CONDITIONS
             ;       30H TRACK ERRORS
             ;       ID CRC ERROR
             ;       MISSING DATA MARK
             ;       DATA CRC ERROR

F8DD 3EEF          MVI    A,0EFH        ;RETURN EFH IN ACC
F8DF B7            ORA    A             ;       (UNSUCCESSFUL READ)
F8E0 3201FE        STA    WRCLK
F8E3 C9            RET

             TERROR:

             ;ARRIVE HERE ON TRACK ERROR IN SINGLE DENSITY

F8E4 CDFBF8        CALL   ERRORCOUNT    ;INCREMENT ERRORBYTE
F8E7 C270F9        JNZ    ALOOP         ;TRY AGAIN IF LESS THAN 30H

F8EA 3EEF    NO    MVI    A,0EFH        ;30H TRACK ERRORS
F8EC B7            ORA    A             ;RETURN EFH IN ACC
F8ED 37            STC                  ;(UNSUCESSFUL DISK OPERATION)
F8EE 3201FE        STA    WRCLK
F8F1 C9            RET

             TERROR1:

             ;ARRIVE HERE ON TRACK ERROR IN DOUBLE DENSITY

F8F2 CDFBF8        CALL   ERRORCOUNT    ;INCREMENT ERRORBYTE
F8F5 C254F8        JNZ    BLOOP         ;TRY AGAIN IF LESS THAN 30H
```

```
F8F8 C3EAF8          JMP     NO

F8FB 2100FC  ERRORCOUNT      LXI     H,ERRORBYTE
F8FE 34                      INR     M               ;INCREMENT ERRORBYTE
F8FF 7E                      MOV     A,M
F900 FE30                    CPI     30H
F902 C9                      RET

             WRITEDD:

             ;DOUBLE DENSITY WRITE
             ;ARRIVE HERE 16 BYTES AFTER ID FIELD

F903 3E4E            MVI     A,4EH
F905 12              STAX    D               ;WRITE 4 BYTES OF 4E
F906 12              STAX    D
F907 12              STAX    D
F908 12              STAX    D
F909 AF              XRA     A
F90A 12              STAX    D               ;WRITE 6 BYTES OF 00
F90B 12              STAX    D
F90C 2A0BFC          LHLD    DMA
F90F 12              STAX    D
F910 12              STAX    D
F911 0104FE          LXI     B,WRMRKCRC
F914 12              STAX    D
F915 12              STAX    D
F916 3EA1            MVI     A,0A1H
F918 02              STAX    B               ;WRITE DATA MARK (A1)
F919 0EE1            MVI     C,0E1H

             ;START WRITING DATA TO DISK FROM MEMORY

F91B 7E      WXFER:  MOV     A,M
F91C 12      WLOOP:  STAX    D
F91D 23              INX     H
F91E 0C              INR     C
F91F 7E              MOV     A,M
F920 12              STAX    D
F921 23              INX     H
F922 7E              MOV     A,M
F923 12              STAX    D
F924 23              INX     H
F925 7E              MOV     A,M
F926 23              INX     H
F927 12              STAX    D
F928 7E              MOV     A,M
F929 C21CF9          JNZ     WLOOP

                             ;WHEN WE ARRIVE HERE WE'VE WRITTEN
                             ; 31*4=124 BYTES TO DISK

F92C 12              STAX    D
F92D 23              INX     H
F92E 7E              MOV     A,M
F92F 12              STAX    D
F930 23              INX     H
```

```
F931 7E              MOV    A,M
F932 23              INX    H
F933 12              STAX   D
F934 7E              MOV    A,M
F935 12              STAX   D               ;128TH BYTE TO DISK
F936 3EFF            MVI    A,0FFH
F938 3207FE          STA    WRCRC           ;WRITE 2 BYTES OF DATA CRC
F93B 3207FE          STA    WRCRC
F93E 12              STAX   D               ;WRITE 3 BYTES OF FF
F93F 12              STAX   D
F940 12              STAX   D
F941 AF              XRA    A               ;RETURN 00 IN ACC
F942 3201FE          STA    WRCLK           ;(SUCCESSFUL WRITE)
F945 C9              RET

                            ;SINGLE DENSITY ROUTINES
                            ;ENTRY POINT IS SD  (BELOW)

             WRITESD:       ;ARRIVE HERE 6 BYTES PAST ID FIELD
F946 3EFF            MVI    A,0FFH
F948 12              STAX   D               ;WRITE 3 BYTES FF (BYTES 7,8,9)
F949 12              STAX   D
F94A 12              STAX   D
F94B AF              XRA    A
F94C 12              STAX   D               ;WRITE 6 BYTES 00 (BYTES 10-15)
F94D 12              STAX   D
F94E 2A0BFC          LHLD   DMA
F951 12              STAX   D
F952 12              STAX   D
F953 12              STAX   D
F954 12              STAX   D               ;BYTE 15 OF GAP
F955 3EFB            MVI    A,0FBH          ;WRITE DATA MARK FOR SINGLE DEN
F957 3204FE          STA    WRMRKCRC
F95A 0EE1            MVI    C,0E1H
F95C C31BF9          JMP    WXFER           ;JUMP TO COMMON WRITE ROUTINE

             SYNC:

             ;ROUTINE TO SYNC ON HEADER

F95F 2101FE          LXI    H,WRCLK
F962 36FF            MVI    M,0FFH
F964 1107FE          LXI    D,SYNCPORT
F967 1A      CLOOP:  LDAX   D               ;SYNC ON FF CLOCK IN HEADER
F968 B7              ORA    A               ;SHOULD HAVE 00 DATA
                                            ;FOUND SYNC PATTERN
F969 00              NOP
F96A 00              NOP
F96B 1B              DCX    D               ;(D)=WRDATA=READDATA
F96C C8              RZ
F96D C35FF9          JMP    SYNC


                            ;SINGLE DENSITY ENTRY POINT

             SD:
F970 CD5FF9  ALOOP:  CALL   SYNC
```

```
                                                ;FOUND HEADER
F973 36C7       MLOOP:  MVI     M,0C7H          ;CLOCK PATTERN FOR ID MARK
F975 3A04FE     LLOOP:  LDA     RDMRKCRC
F978 B7                 ORA     A
F979 CA75F9             JZ      LLOOP
F97C FEFE               CPI     0FEH
F97E CA8DF9             JZ      NLOOP
F981 36FF               MVI     M,0FFH
F983 3A07FE             LDA     SYNCPORT
F986 B7                 ORA     A
F987 CA73F9             JZ      MLOOP
F98A C370F9             JMP     ALOOP
                NLOOP:                          ;FOUND DATA MARK
F98D 1A                 LDAX    D               ;TRACK BYTE FROM DISK
F98E B8                 CMP     B
F98F C2E4F8             JNZ     TERROR          ;TRACK ERROR
F992 1A                 LDAX    D               ;SIDE BYTE FROM DISK (IGNORE)
F993 1A                 LDAX    D               ;SECTOR BYTE FROM DISK
F994 B9                 CMP     C
F995 C270F9             JNZ     ALOOP           ;WRONG SECTOR.  TRY AGAIN

                                                ;FOUND CORRECT TRACK AND SECTOR
F998 F3                 DI                      ;DISABLE INTERRUPTS BEFORE CHECKING ID CRC
F999 1A                 LDAX    D
F99A 1A                 LDAX    D               ;CRC BYTE
F99B 1A                 LDAX    D               ;CRC BYTE
F99C 1A                 LDAX    D               ;GAP BYTE 1
F99D 3A00FE             LDA     RDSTAT          ;CHECK ID CRC
F9A0 1F                 RAR
F9A1 1A                 LDAX    D               ;GAP BYTE 2
F9A2 1A                 LDAX    D               ;GAP BYTE 3
F9A3 DADDF8             JC      ERROR           ;ID CRC ERROR

F9A6 1A                 LDAX    D               ;GAP BYTE 4
F9A7 3A11FC             LDA     ABOVE43
F9AA 77                 MOV     M,A
F9AB 1A                 LDAX    D               ;GAP BYTE 5
F9AC 3A02FC             LDA     READWRITE
F9AF B7                 ORA     A               ;CHECK FOR WRITE
F9B0 1A                 LDAX    D               ;GAP BYTE 6
F9B1 C246F9             JNZ     WRITESD

                ;SINGLE DENSITY READ

F9B4 1A                 LDAX    D               ;READ 6 BYTES OF GAP
F9B5 1A                 LDAX    D
F9B6 1A                 LDAX    D
F9B7 1A                 LDAX    D
F9B8 1A                 LDAX    D
F9B9 1A                 LDAX    D
F9BA 36FF               MVI     M,0FFH          ;(WRCLK)=FF
F9BC 0106FE             LXI     B,RDDATA
F9BF 1A                 LDAX    D               ;GAP BYTE 14
F9C0 13                 INX     D               ;(D)=SYNCPORT
F9C1 1A                 LDAX    D
F9C2 36C7               MVI     M,0C7H          ;CLOCK PATTERN FOR DATA MARK
F9C4 1E04               MVI     E,04            ;(D)=RDMRKCRC
```

```
 F9C6 0A            LDAX    B               ;GAP BYTE 16
 F9C7 1A            LDAX    D               ;READ DATA MARK
 F9C8 E6FC          ANI     0FCH
 F9CA FEF8          CPI     0F8H            ;DATA PATTERN FOR DATA MARK
 F9CC C2DDF8        JNZ     ERROR           ;MISSING DATA MARK

           ;FOUND SINGLE DENSITY DATA MARK

 F9CF 1EE0          MVI     E,0E0H          ;32*4=128 BYTE TRANSFER
 F9D1 0A            LDAX    B
 F9D2 2A0BFC        LHLD    DMA
 F9D5 C3BFF8        JMP     RLOOP           ;JUMP TO MAIN READ ROUTINE


           TEST:

           ;TESTS DENSITY OF DISKETTE IN LOGGED-IN DRIVE
           ;RETURNS 00 IN ACC IF DOUBLE DENSITY
           ;RETURNS 0F IN ACC IF SINGLE DENSITY
           ;RETURNS 0A IN ACC IF TEST FAILS

 F9D8 AF            XRA     A
 F9D9 3223FC        STA     TESTMAX         ;(TESTMAX)=0
 F9DC AF   TEST1:   XRA     A
 F9DD 3200FC        STA     ERRORBYTE       ;(ERRORBYTE)=0
 F9E0 CDC5FB        CALL    DISKREADY       ;LOAD HEAD
 F9E3 0100FE        LXI     B,WRCONT
 F9E6 3A03FC        LDA     CONTROLBYTE
 F9E9 F680          ORI     80H             ;SET CONTROLLER FOR SIDE 0
 F9EB E6FB          ANI     0FBH            ;TRY DOUBLE DENSITY
 F9ED 02            STAX    B

           LOOP6:           ;DOUBLE DENSITY TEST
 F9EE 2101FE        LXI     H,WRCLK
 F9F1 36FF          MVI     M,0FFH
 F9F3 1107FE        LXI     D,SYNCPORT      ;SYNC ON FF CLOCK IN HEADER
 F9F6 1A   LOOP7:   LDAX    D               ;READ DATA PATTERN
 F9F7 2C            INR     L               ;ABORT AFTER 256 TRIES
 F9F8 CA1AFA        JZ      RETRY
 F9FB B7            ORA     A               ;DATA SHOULD BE 00
 F9FC C2F6F9        JNZ     LOOP7
                                            ;FOUND HEADER
 F9FF 1B            DCX     D               ;(D)=READDATA
 FA00 2E01          MVI     L,01            ;(H)=WRCLK
 FA02 360A          MVI     M,0AH
 FA04 1A            LDAX    D               ;SYNC WITH -EOW
 FA05 3A04FE        LDA     RDMRKCRC        ;LOOK FOR ID MARK
 FA08 FEA1          CPI     0A1H
 FA0A C21AFA        JNZ     RETRY
                                            ;FOUND ID MARK
 FA0D 1A            LDAX    D               ;FE BYTE
 FA0E 1A            LDAX    D               ;TRACK BYTE
 FA0F 1A            LDAX    D               ;SECTOR BYTE
 FA10 1A            LDAX    D               ;CRC BYTE
 FA11 1A            LDAX    D               ;CRC BYTE
 FA12 1A            LDAX    D               ;GAP BYTE 1
 FA13 0A            LDAX    B
```

```
FA14 1F                RAR                     ;CHECK ID CRC
FA15 DA1AFA            JC      RETRY
                                               ;ID CRC OK
FA18 AF                XRA     A               ;RETURN 00
FA19 C9                RET

FA1A CDFBF8    RETRY:  CALL    ERRORCOUNT
FA1D C2EEF9            JNZ     LOOP6

               ;SINGLE DENSITY TEST
               ;ARRIVE HERE AFTER 30H TRIES AT DOUBLE DENSITY

FA20 AF        SDTEST: XRA     A
FA21 3200FC            STA     ERRORBYTE       ;(ERRORBYTE)=0
FA24 3A03FC            LDA     CONTROLBYTE
FA27 F684              ORI     84H             ;SET UP SIDE 0, SINGLE DENSITY
FA29 02                STAX    B               ;TO WRCONT
               SDLOOP1:
FA2A 1E07              MVI     E,07            ;(D)=SYNCPORT
FA2C 2101FE            LXI     H,WRCLK
FA2F 36FF              MVI     M,0FFH          ;SYNC ON FF CLOCK PATTERN
               SDLOOP2:
FA31 1A                LDAX    D               ;GET CORRESPONDING DATA
FA32 2C                INR     L               ;ABORT AFTER 256 TRIES
FA33 CA57FA            JZ      RETRY1
FA36 B7                ORA     A               ;DATA SHOULD BE 00
FA37 C231FA            JNZ     SDLOOP2
                                               ;FOUND HEADER
FA3A 1B                DCX     D               ;(D)=READDATA
FA3B 2E01              MVI     L,01            ;(H)=WRCLK
FA3D 36C7              MVI     M,0C7H          ;LOOK FOR C7 CLOCK
FA3F 1A                LDAX    D               ;SYNC WITH -EOW
FA40 3A04FE            LDA     RDMRKCRC
FA43 FEFE              CPI     0FEH            ;DATA FOR ID MARK
FA45 C257FA            JNZ     RETRY1
                                               ;FOUND ID MARK
FA48 1A                LDAX    D               ;TRACK BYTE
FA49 1A                LDAX    D               ;SIDE
FA4A 1A                LDAX    D               ;SECTOR
FA4B 1A                LDAX    D
FA4C 1A                LDAX    D               ;CRC BYTE
FA4D 1A                LDAX    D               ;CRC BYTE
FA4E 1A                LDAX    D
FA4F 0A                LDAX    B               ;GET RDSTAT
FA50 1F                RAR                     ;CHECK ID CRC
FA51 DA57FA            JC      RETRY1
                                               ;ID CRC OK
FA54 F6FF              ORI     0FFH            ;RETURN FF
FA56 C9                RET

FA57 CDFBF8    RETRY1: CALL    ERRORCOUNT
FA5A C22AFA            JNZ     SDLOOP1

                       ;FAILED BOTH DOUBLE AND SINGLE DENSITY
                       ; TESTS 30H TIMES

FA5D 2123FC            LXI     H,TESTMAX
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FA60 34                INR     M               ;INCREMENT TESTMAX
FA61 7E                MOV     A,M
FA62 FE0A              CPI     10
FA64 C2DCF9            JNZ     TEST1
                               ;FAILED TEST 10 TIMES
FA67 B7                ORA     A               ;RETURN 0A
FA68 C9                RET


              SKEW:
                       ;COMPUTES PHYSICAL SECTOR FROM LOGICAL SECTOR
                       ;SKEW FACTOR IS 8
                       ;INPUT AND OUTPUT ARE IN C REG
                       ;OUTPUT=(((INPUT) MOD 52)*8 - 7) MOD 52
                       ;IF INPUT>52, SELECTS SIDE 1

FA69 210000            LXI     H,0
FA6C E5                PUSH    H
FA6D 3A03FC            LDA     CONTROLBYTE
FA70 E67F              ANI     7FH             ;SIDE 1
FA72 5F                MOV     E,A
FA73 79                MOV     A,C
FA74 D634              SUI     52
FA76 47                MOV     B,A             ;(B)=(C)-52
FA77 7B                MOV     A,E             ;(A)=(CONTROLBYTE)^7F
FA78 F27EFA            JP      SKIPY
                                               ;INPUT WAS LESS THAN 52
FA7B F680              ORI     80H             ;CHOOSE SIDE 0
FA7D 41                MOV     B,C
FA7E 320FFC   SKIPY:   STA     TWOSIDE
FA81 78                MOV     A,B             ;(B)=(INPUT) MOD 52
FA82 68                MOV     L,B
FA83 C1                POP     B
FA84 0C       LOOP10:  INR     C
FA85 D60D              SUI     13
FA87 F284FA            JP      LOOP10
FA8A 29                DAD     H
FA8B 29                DAD     H
FA8C 29                DAD     H
FA8D 7C                MOV     A,H
FA8E B7                ORA     A
FA8F 7D                MOV     A,L
FA90 C4A0FA            CNZ     HIGHE
FA93 FE34     LOOP11:  CPI     52
FA95 DA9DFA            JC      SKIP12
FA98 C6CC              ADI     204
FA9A C393FA            JMP     LOOP11
FA9D 81       SKIP12:  ADD     C
FA9E 4F                MOV     C,A
FA9F C9                RET
FAA0 C630     HIGHE:   ADI     48
FAA2 C9                RET


FAA3 60       SETDMA:  MOV     H,B
FAA4 69                MOV     L,C
FAA5 220BFC            SHLD    DMA             ;STORE DMA ADDRESS
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 FAA8 C9               RET


 FAA9 79       SETSEC: MOV    A,C
 FAAA 320AFC           STA    SECTOR          ;STORE SECTOR NUMBER
 FAAD C9               RET


               SETTRK:        ;STEPS DRIVE TO TRACK (C)
 FAAE 79               MOV    A,C
 FAAF FE2C             CPI    44D             ;IF (C)<44
 FAB1 3E10             MVI    A,10H           ;  THEN (ABOVE43)=10H
 FAB3 DAB8FA           JC     SKIP3
 FAB6 3E50             MVI    A,50H           ;  ELSE (ABOVE43)=50H
 FAB8 3211FC   SKIP3:  STA    ABOVE43
 FABB CDC5FB           CALL   DISKREADY

               STEPLOOP:
 FABE 2104FC           LXI    H,TRACK
 FAC1 7E               MOV    A,M             ;GET (TRACK)
 FAC2 B9               CMP    C               ;DONE?
 FAC3 CAEAFA           JZ     DONESTEP
 FAC6 CDCCFA           CALL   STEPHEAD        ;NO, STEP HEAD
 FAC9 C3BEFA           JMP    STEPLOOP        ;REPEAT

               STEPHEAD:
 FACC DAD8FA            JC    STEPIN          ;IF (TRACK)<(C) THEN STEP IN
               STEPOUT :
 FACF 3A03FC           LDA    CONTROLBYTE     ;ELSE STEP OUT
 FAD2 35               DCR    M               ;(TRACK)=(TRACK)-1
 FAD3 F602             ORI    02H             ;DIR=OUT
 FAD5 C3DEFA           JMP    DOSTEP

 FAD8 3A03FC   STEPIN: LDA    CONTROLBYTE
 FADB 34               INR    M               ;(TRACK)=(TRACK)+1
 FADC E6FD             ANI    0FDH            ;DIR=IN

 FADE 12       DOSTEP: STAX   D               ;STORE DIRECTION IN WRCONT
 FADF 3D               DCR    A               ;-STEP=0
 FAE0 12               STAX   D
 FAE1 3C               INR    A               ;-STEP=1
 FAE2 12               STAX   D
 FAE3 3A10FC           LDA    STEPTIME
 FAE6 47               MOV    B,A             ;WAIT 8 MS FOR NEXT STEP
 FAE7 C37DFB           JMP    DELAY           ;DELAY EXECUTES A RETURN

               DONESTEP:
 FAEA 060F             MVI    B,STEPSETTLE
 FAEC CD7DFB           CALL   DELAY           ;WAIT 8 MS FOR STEP SETTLE
 FAEF 79               MOV    A,C
 FAF0 FE02             CPI    2               ;IF (TRACK)<2 THEN SET TESTNEXT
 FAF2 DA69FB           JC     SETTN
 FAF5 3A0EFC           LDA    TESTNEXT
 FAF8 B7               ORA    A
 FAF9 3E00             MVI    A,0
 FAFB 320EFC           STA    TESTNEXT
 FAFE 37               STC
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 FAFF C203FB            JNZ     SETDEN          ;IF TESTNEXT=55 TEST DENSITY
 FB02 C9                RET

              SETDEN:

                        ;TESTS DENSITY
                        ;UPDATES DENBYTE AND DENMAP

 FB03 CDD8F9            CALL    TEST            ;TEST DENSITY
 FB06 3E04              MVI     A,4             ;IF Z IS SET (DOUBLE DENSITY)
 FB08 CA0DFB            JZ      SKIP            ;  THEN (DENBYTE)=4
 FB0B 3E00              MVI     A,0             ;  ELSE (DENBYTE)=0
 FB0D 3201FC  SKIP:     STA     DENBYTE
 FB10 2116FC            LXI     H,DENMAP
 FB13 F5                PUSH    PSW
 FB14 3A05FC            LDA     PRESDISK
 FB17 4F                MOV     C,A
 FB18 0600              MVI     B,0
 FB1A 09                DAD     B
 FB1B F1                POP     PSW             ;SAVE FLAGS
 FB1C 77                MOV     M,A             ;(DENMAP(PRESDISK))=(DENBYTE)
 FB1D C9                RET

              SELDSK:

                        ;SELECTS DRIVE POINTED TO BY C REG
                        ;LOADS HEAD OF SELECTED DRIVE

 FB1E 21F9FB            LXI     H,MASKTABLE
 FB21 0600              MVI     B,0
 FB23 09                DAD     B               ;C CONTAINS DRIVE NUMBER
 FB24 7E                MOV     A,M             ;MASKTABLE CONTAINS 0 FOR
              SELDSK1:
 FB25 3200FE            STA     WRCONT          ; SELECTED DRIVE, 1'S ELSEWHERE
 FB28 320FFC            STA     TWOSIDE
 FB2B 3203FC            STA     CONTROLBYTE
 FB2E 2112FC            LXI     H,TRACKTAB
 FB31 3A05FC            LDA     PRESDISK
 FB34 5F                MOV     E,A
 FB35 50                MOV     D,B
 FB36 19                DAD     D
 FB37 3A04FC            LDA     TRACK
 FB3A 77                MOV     M,A             ;(TRACKTAB(PRESDISK))=(TRACK)
 FB3B 79                MOV     A,C
 FB3C 3205FC            STA     PRESDISK        ;(PRESDISK)=(C)
 FB3F 320DFC            STA     DISK            ;(DISK)=(C)
 FB42 2112FC            LXI     H,TRACKTAB
 FB45 09                DAD     B
 FB46 7E                MOV     A,M
 FB47 3204FC            STA     TRACK           ;(TRACK)=(TRACKTAB(C))
 FB4A 2106FC            LXI     H,LOGINTAB
 FB4D 09                DAD     B
 FB4E 7E                MOV     A,M
 FB4F B7                ORA     A               ;HAS DRIVE BEEN LOGGED IN?
 FB50 C259FB            JNZ     INOK
 FB53 3E55              MVI     A,55H           ;NO. MARK AS LOGGED IN
 FB55 77                MOV     M,A
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FB56 CD97FB          CALL    HOME            ;  AND HOME THE HEAD
FB59 CDC5FB  INOK:   CALL    DISKREADY       ;LOAD HEAD
FB5C 0628            MVI     B,HEADSETTLE
FB5E CD7DFB          CALL    DELAY           ;WAIT FOR HEAD SETTLING
FB61 3A04FC          LDA     TRACK
FB64 FE02            CPI     02
FB66 D203FB          JNC     SETDEN
FB69 3E55    SETTN:  MVI     A,55H           ;ON TRACKS 0 AND 1, WE WANT
FB6B 320EFC          STA     TESTNEXT        ; TO TEST DENSITY OF NEXT TRACK
FB6E C303FB          JMP     SETDEN          ;TEST DENSITY OF THIS TRACK


             HEADLOAD:
FB71 1A               LDAX   D               ;ASSUMES (D)=RDSTAT
FB72 E620            ANI     20H             ;HEAD ALREADY LOADED?
FB74 3A05FE          LDA     RDMARK          ;RESET HEAD LOAD COUNTER
FB77 0628            MVI     B,HEADSETTLE
FB79 C47DFB          CNZ     DELAY           ;IF HEAD WASN'T LOADED
FB7C C9              RET

             DELAY:

                     ;DELAYS (B) MILLISECONDS

FB7D E5              PUSH    H               ;SAVE HL
FB7E 3A03FC  DELAY2: LDA     CONTROLBYTE
FB81 E604            ANI     4               ;IF SINGLE DENSITY,
FB83 2E1F            MVI     L,31            ;31 BYTES * 32 USEC = 1 MS
FB85 C28AFB          JNZ     DELAY1
FB88 2E3F            MVI     L,63            ;IN DD, 63 BYTES * 16 USEC = 1 MS
FB8A 3A06FE  DELAY1: LDA     RDDATA
FB8D 2D              DCR     L
FB8E C28AFB          JNZ     DELAY1
FB91 05              DCR     B               ;END 1 MS LOOP
FB92 C27EFB          JNZ     DELAY2
FB95 E1              POP     H               ;RESTORE HL
FB96 C9              RET


FB97 CDC5FB  HOME:   CALL    DISKREADY
FB9A 2104FC          LXI     H,TRACK         ;FOR STEPIN AND STEPOUT
FB9D CDD8FA  ATHOME: CALL    STEPIN          ;STEP TOWARD 76
FBA0 1A              LDAX    D
FBA1 E602            ANI     02              ;  UNTIL -TRK0 IS INACTIVE
FBA3 CA9DFB          JZ      ATHOME
FBA6 CDCFFA  GOHOME: CALL    STEPOUT         ;THEN STEP TOWARD 00
FBA9 1A              LDAX    D
FBAA E602            ANI     02              ;  UNTIL -TRK0 IS ACTIVE
FBAC C2A6FB          JNZ     GOHOME
FBAF 3E10            MVI     A,10H
FBB1 3211FC          STA     ABOVE43         ;(ABOVE43)=10H
FBB4 320EFC          STA     TESTNEXT        ;(TESTNEXT)=10H
FBB7 AF              XRA     A
FBB8 3204FC          STA     TRACK           ;(TRACK)=00
FBBB C303FB          JMP     SETDEN          ;TEST DENSITY
```

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                DISKREADY1:
 FBBE 3A00FE            LDA     RDSTAT
 FBC1 47                MOV     B,A
 FBC2 E6A0              ANI     0A0H            ;IF DRIVE READY AND HEAD LOADED
 FBC4 C8                RZ                      ;       THEN RETURN
                DISKREADY:
 FBC5 C5                PUSH    B
 FBC6 1100FE            LXI     D,WRCONT        ;(D)=WRCONT=RDSTAT
 FBC9 CD71FB            CALL    HEADLOAD        ;LOAD HEAD
 FBCC C1                POP     B
 FBCD 1A                LDAX    D
 FBCE 07                RLC
 FBCF DAC5FB            JC      DISKREADY       ;LOOP UNTIL DRIVE READY
 FBD2 C9                RET


                COLDBOOT:
 FBD3 3140FC            LXI     SP,STACK
 FBD6 AF                XRA     A
 FBD7 0100FC            LXI     B,BUFF
 FBDA 02        CBUFF:  STAX    B               ;ZERO OUT RAM BUFFER
 FBDB 0C                INR     C
 FBDC C2DAFB            JNZ     CBUFF

 FBDF 3E0A              MVI     A,10
 FBE1 3210FC            STA     STEPTIME        ;SET STEPTIME LONGER THAN IT NEEDS TO BE
                                                ;TO BE SAFE, SINCE COLD BOOT LOADER RESETS IT
 FBE4 010000            LXI     B,0
 FBE7 CDA3FA            CALL    SETDMA          ;SETDMA DOES NOT CHANGE C REG, SO...
 FBEA CD1EFB            CALL    SELDSK          ;SELECT DRIVE A
 FBED 0E01              MVI     C,01            ;LOAD BOOTSTRAP LOADER
 FBEF CDA9FA            CALL    SETSEC          ;  FROM TRACK 0 SECTOR 1
 FBF2 CD29FB            CALL    READ
 FBF5 C2D3FB            JNZ     COLDBOOT        ;ON READ FAILURE, TRY AGAIN
 FBF8 C7                RST     0               ;EXECUTE BOOTSTRAP LOADER
                                                ;(SAVES 2 BYTES OVER JMP 0000)

 FBF9 BFDFEFF7  MASKTABLE       DB      0BFH,0DFH,0EFH,0F7H
FC11 ABOVE43    F970 ALOOP      FB9D ATHOME     F800 BASE       F854 BLOOP
FC00 BUFF       FBDA CBUFF      F967 CLOOP      FBD3 COLDBOOT
FC03 CONTROLBYTE                FC22 CURRDRIVE  FB7D DELAY      FB8A DELAY1
FB7E DELAY2     FC01 DENBYTE    FC16 DENMAP     FC0D DISK       FBBE DISKREADY1
FBC5 DISKREADY  FC0B DMA        FAEA DONESTEP   FADE DOSTEP     FC00 ERRORBYTE
F8DD ERROR      F8FB ERRORCOUNT F888 GLOOP      F82F GO         FBA6 GOHOME
FB71 HEADLOAD   0028 HEADSETTLE FAA0 HIGHE      FB97 HOME       FB59 INOK
F975 LLOOP      FC06 LOGINTAB   FAB4 LOOP10     FA93 LOOP11     F9EE LOOP6
F9F6 LOOP7      FBF9 MASKTABLE  F973 MLOOP      F98D NLOOP      F8EA NO
FC05 PRESDISK   FE06 RDDATA     FE05 RDMARK     FE04 RDMRKCRC   FE00 RDSTAT
FE02 RDUART     F829 READ       F854 READDD     FC02 READWRITE  FA57 RETRY1
FC21 RETRYCOUNT FA1A RETRY      F8BF RLOOP      F8AE RXFER      F970 SD
FA2A SDLOOP1    FA31 SDLOOP2    FA20 SDTEST     FC0A SECTOR     FB1E SELDSK
FB25 SELDSK1    FB03 SETDEN     FAA3 SETDMA     FAA9 SETSEC     FB69 SETTN
FAAE SETTRK     FA69 SKEW       FA9D SKIP12     FAB8 SKIP3      FB0D SKIP
FA7E SKIPY      FC40 STACK      FACC STEPHEAD   FADB STEPIN     FABE STEPLOOP
FACF STEPOUT    000F STEPSETTLE FC10 STEPTIME   F95F SYNC       FE07 SYNCPORT
F8F2 TERROR1    F8E4 TERROR     F9DC TEST1      FC23 TESTMAX    FC0E TESTNEXT
F9D8 TEST       FC04 TRACK      FC12 TRACKTAB   FC20 TRY1       FC0F TWOSIDE
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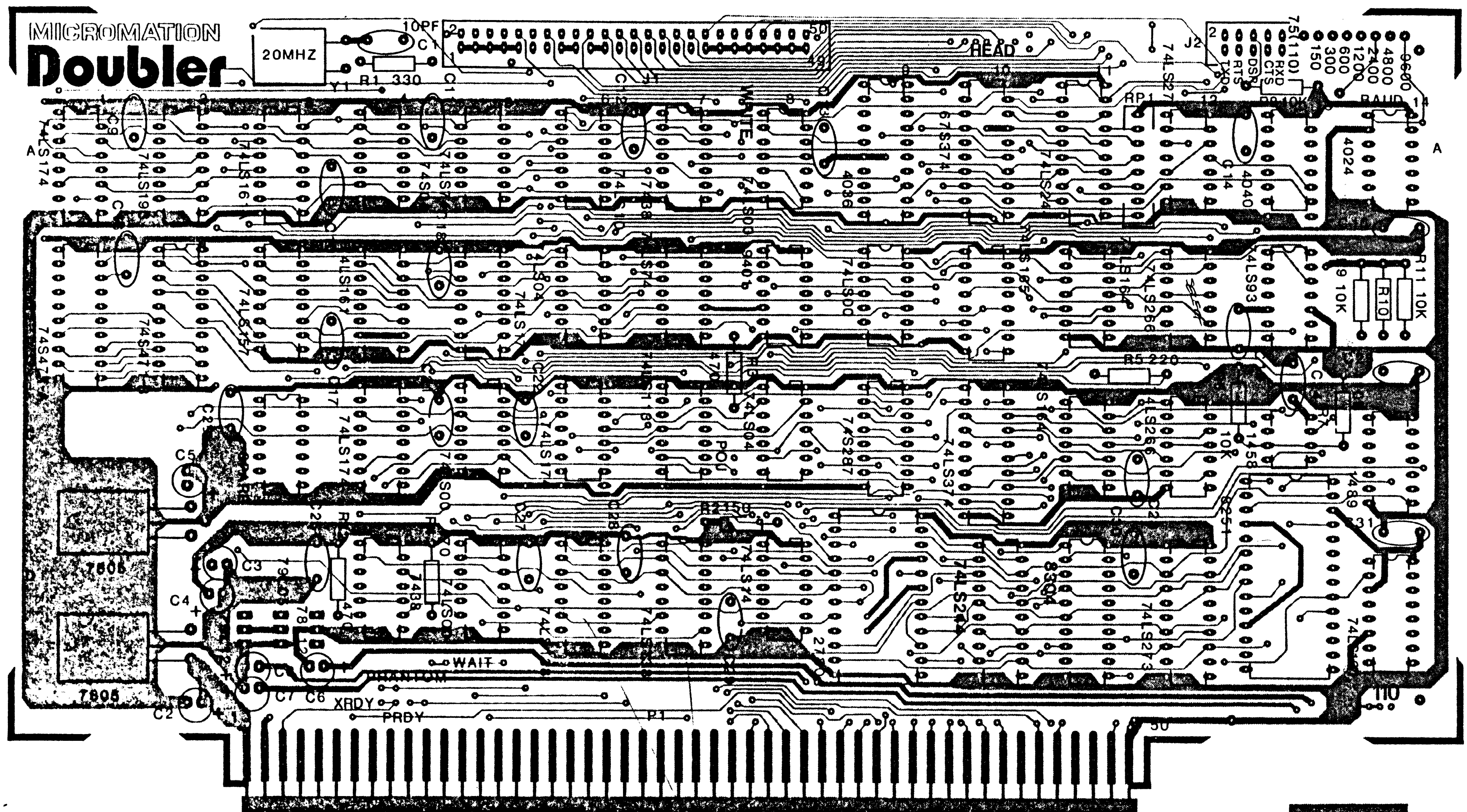
F91C WLOOP	FE01 WRCLK	FE00 WRCONT	FE07 WRCRC	FE06 WRDATA
F82D WRITE	F903 WRITEDD	F81E WRITEPROTECT		F946 WRITESD
FE04 WRMRKCRC	FE05 WRMRK	FE02 WRUART	F91B WXFER	



COMPONENT SIDE

MICROMATION

SILKSCREEN