CHAPTER 4 SYSTEM EXPANSION

4.1 Options

4.1.1 ROM cartridge

The ROM cartridge can accommodate any of CMOS/NMOS mask ROMs and PROMs which have the pin configurations compatible with those of the 2764 (8KB), 27128 (16KB), or 27256 (32KB). Since programs and data are stored in the ROM housed in the cartridge, the memory contents are not destroyed even if an overrun error occurs. The ROM cartridge features much shorter access time than that with conventional cassette tape, etc. and assures complete data read. Reading of data from the ROM is performed in serial mode.

(1) Principles of Operation

The ROM cartridge is connected to the connector CN8 on the MOSU board through cable set #701. The ROM cartridge is controlled by both the master CPU and slave CPU. The master CPU handles address output and data readout, while the slave CPU controls power ON/OFF and address counter and shift register clear operations. As the programs and data stored in the ROM cartridge are in the form of files, a filename must be specified to read data from the cartridge.

Upon execution of a LOAD command, the power supply of the cartridge is turned on and the address counter and shift register are cleared. The contents of the header are then read from the address "0000" of the ROM cartridge in serial mode by the address output and the shift clocks for readout as follows.

If the filename in the header matches that specified by the LOAD command, the contents of the header (containing filename, starting address, etc. of the specified file) are transferred to the system area in the RAM. Simultaneously, message "Found" appears on the LCD, and the read operation proceeds up to the starting address of the specified file. Upon reaching the starting address, the shift clocks for readout are generated and the contents of the file are read in the master CPU in serial data format. (8 shift clock pulses are required to read 1 byte of data).

This operation continues until the ending address of the file. The data read serially are then converted byte by byte into parallel data and stored in the specified RAM addresses.

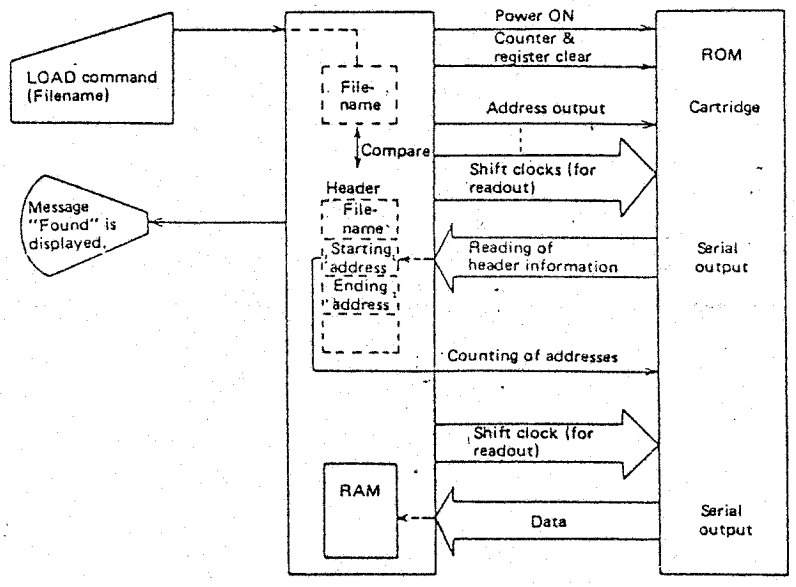


Fig. 4-1 Reading Data from ROM Cartridge

(2) Address counter

This address counter employs 2 counter ICs to specify memory addresses sequentially starting from the lowest address using MO1 signal (shift pulses for addressing).
Therefore, after reading the header information, MO1 signal pulses must be output continuously until the starting address of the file. (With the ROM cartridge, random file addressing is not allowed.)

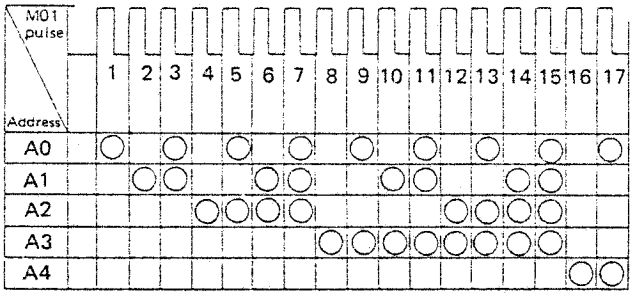


Fig. 4-2 M01 Shift Pulses for Addressing

(3) Shift register

The shift register reads 1 byte of data from the ROM and transfers the data bit by bit to the MI1 signal line (Serial Data Line) using "MO2" shift clocks.

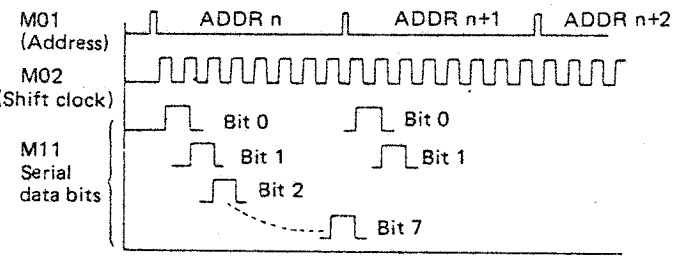


Fig. 4-3 Shift Clocks for Readout

(4) Operation sequence

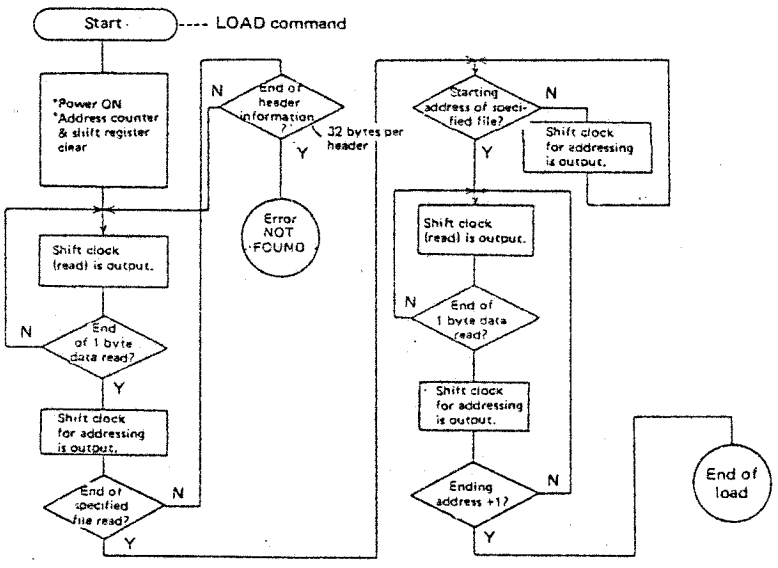


Fig. 4-4 LOAD Operation from ROM Cartridge

(5) ROM format

In the HX-20, the ROM cartridge is handled as a sequential file. Therefore, headers are provided in the starting address part of each file to facilitate file accessing. A maximum of 32 bytes of data may be set in each header.

NOTE: The HX-20 is designed to allow the setting of a maximum of 32 headers. However, the program for writing data into the ROM supports only 31 headers.

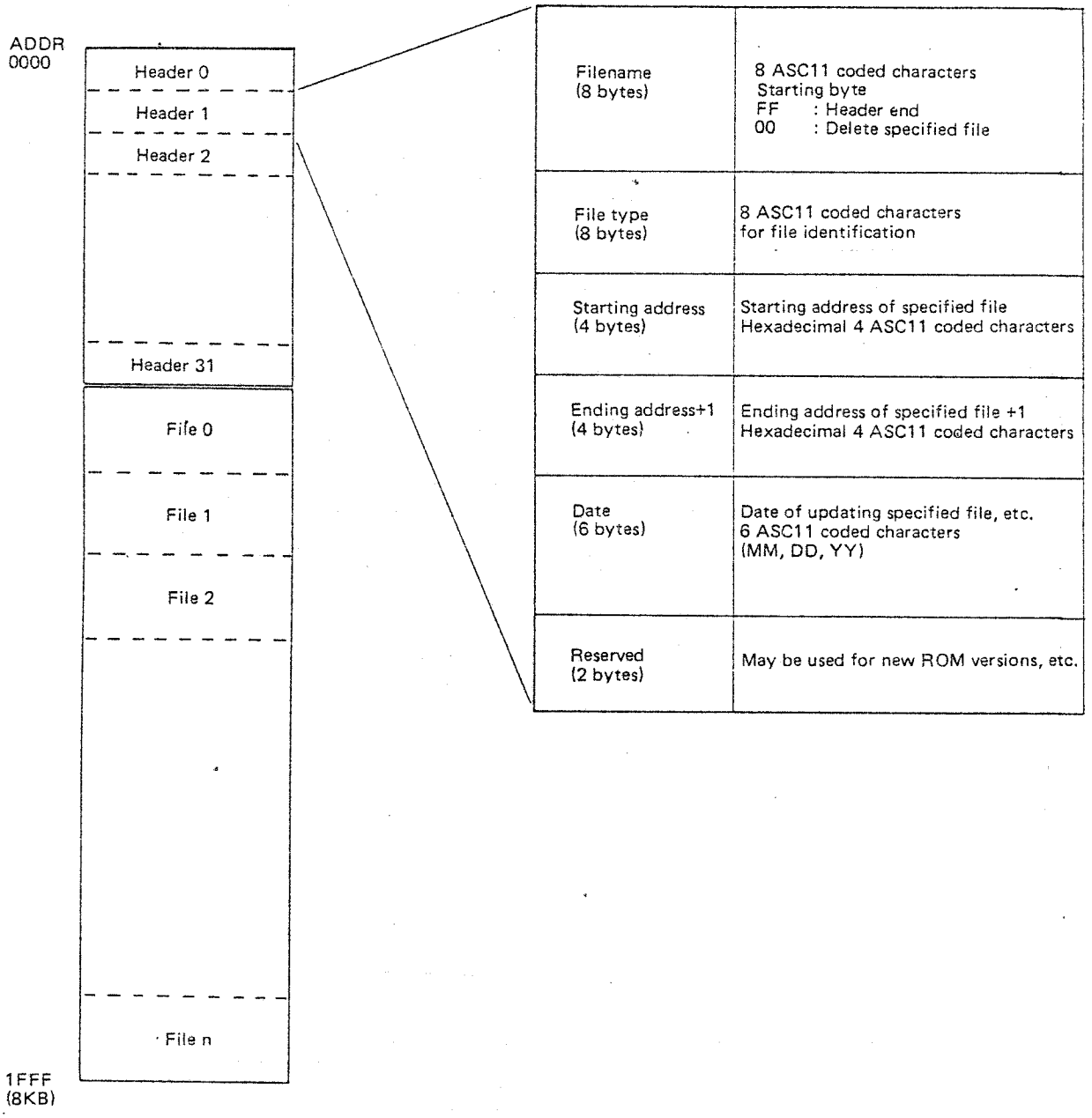


Fig. 4-5 ROM Format

4.1.2 Microcassette drive

The microcassette drive is controlled by both the master CPU and slave CPU. The mechanical operation of the microcassette drive is controlled by the slave CPU by commands which are output serially from the slave CPU and stored in the instruction register. The microcassette drive has a counter circuit incorporating a photo reflector. Using this counter circuit, the tape may be fast forwarded to the required position.

(1) Hardware configuration

The microcassette drive consists of a power supply section, a motor drive circuit section, a read/write control section, a motor speed control section, etc., and is designed to operate only when the power supply is turned ON.

The tape speed of 2.4cm/sec. is obtained using a capstan motor rated at 2,400 rpm. Data read/write is performed at a rate of 1,300BPS. Up to 50K bytes of data can be recorded on a 30-minute microcassette tape.

(2) Data read/write

Read/Write operations to and from the microcassette drive are the same as those with the external audio cassette, with the ON-OFF ratio of a read/write signal at 1KHz for OFF and 2KHz for ON. Data write format is also identical. Namely, one byte of data is written in 9 bits (consisting of 8 data bits and 1 stop bit).

(3) Operation sequence

The microcassette has two motors. One is used for loading or unloading the R/W head, while the other is a main motor used for driving the cassette reel. The two motors are controlled by the command bits set in the instruction register. As these commands are transferred serially, a shift register as shown in Fig. 4-6 is employed as an instruction register.

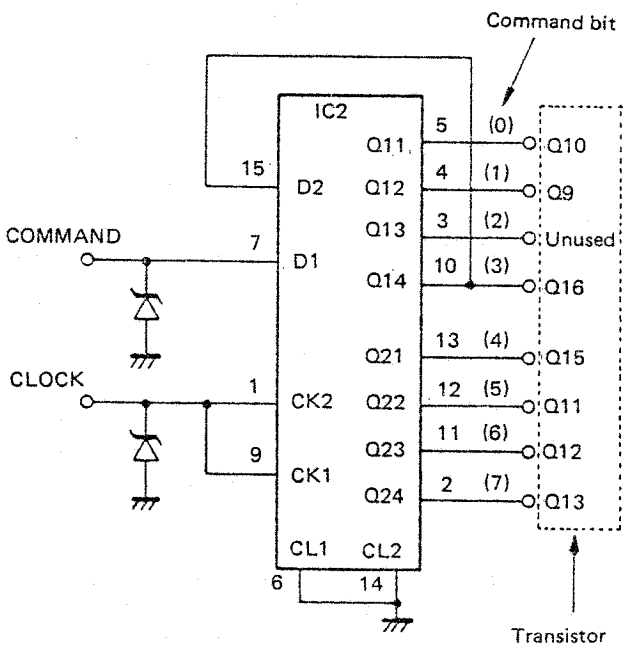


Fig. 4-6 Instruction Register

Outputs from the above instruction register serve as the inputs to the bases of the respective transistors controlling the motor operation.

The following 8 microcassette control commands are provided.

Table 4-1 Microcassette Control Commands

Command	Code (Hex)	Code bit								Function
		7	6	5	4	3	2	1	0	
STOP	00									Motor stop command
REW	0A					o		o		Tape rewind command
PLAY	01								o	Data read command
FF	11				o				o	Fast forward command
REC	81	o							o	Data write command
BRAKE	18				o	o				Capstan motor control command
HLD	20			o						Head load/unload command
H BRAKE	40		o							Head motor control command

An example of a series of operations from the fast forwarding of the tape, reading of data from the specified file to the termination of the data read operation is described below. (Also see Fig. 4-8.)

① The R/W head switch is checked to determine whether or not the tape is in the Unloaded state. If the tape is in the Loaded state, the head motor is activated to place the tape in the Unloaded state.
(In Fig. 4-7 below, the tape is in the Unloaded state when shaft C is disengaged from the pinch roller and in the Loaded state when shaft C engages the pinch roller.

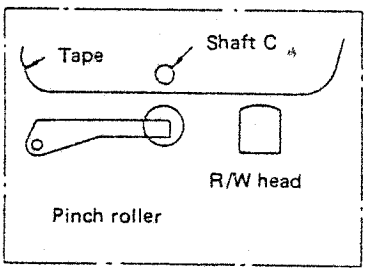


Fig. 4-7 Unloaded State of Tape

② After the motor power supply is turned off, both ends of the head motor are short-circuited and brake is applied to the head rotation due to the inertia of the head motor.
③ The capstan motor runs without speed control and the tape is fast forwarded until it reaches the specified count. (The tape feed length is counted by the photo reflector in the counter circuit.)
④ After the motor power supply is turned off, both ends of the capstan motor are short-circuited and brake is applied to the capstan motor.
⑤ The read/write head is placed in the Loaded state.
⑥ Brake is applied to the head motor rotated in the above step.
⑦ The tape is rewound at a constant speed and the tape is read. (The tape speed can be controlled to 2.4cm/sec.)
⑧ Brake is applied to the capstan motor.
⑨ The read/write head is placed in the Unloaded state.
⑩ Brake is applied to the head motor.
⑪ A STOP command is sent from the slave CPU to reset the contents of the instruction register to "00".

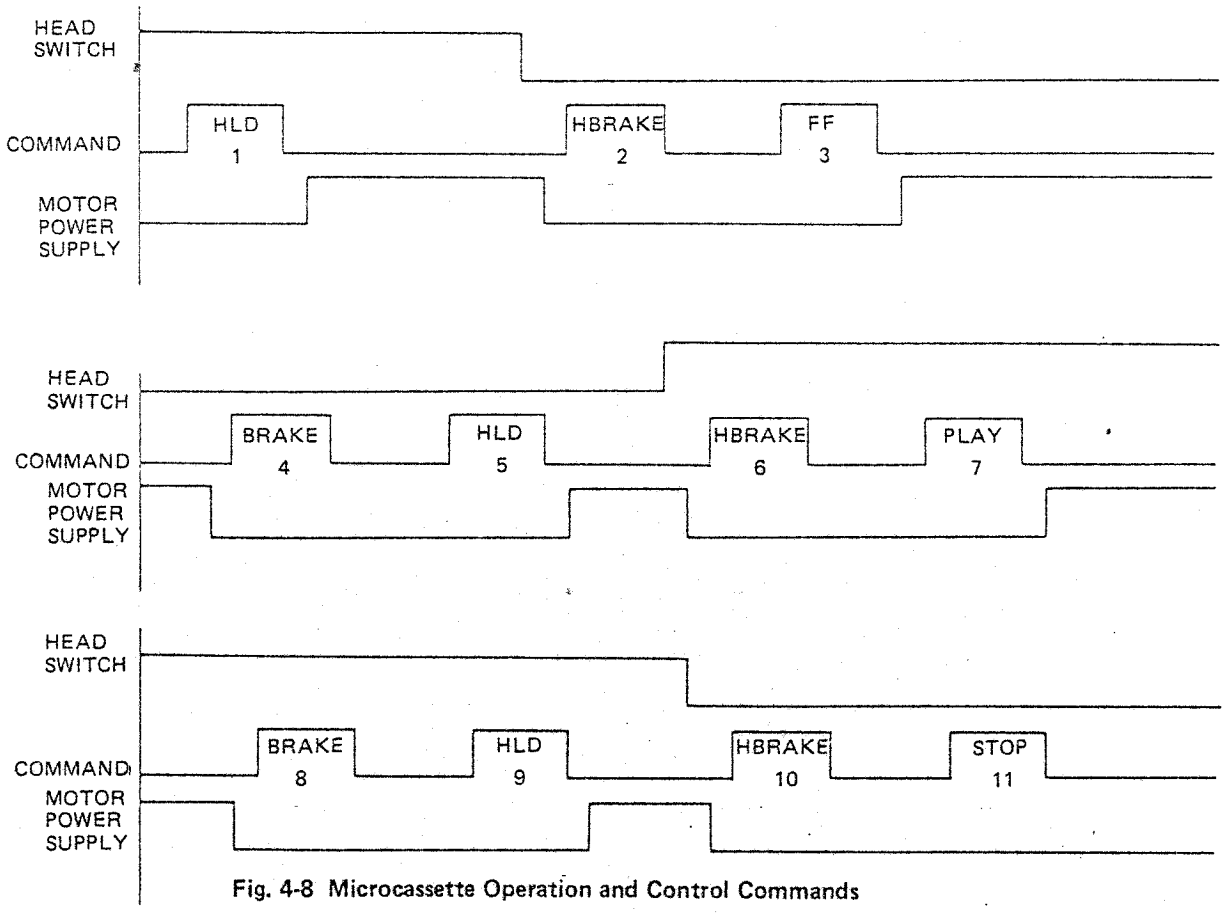


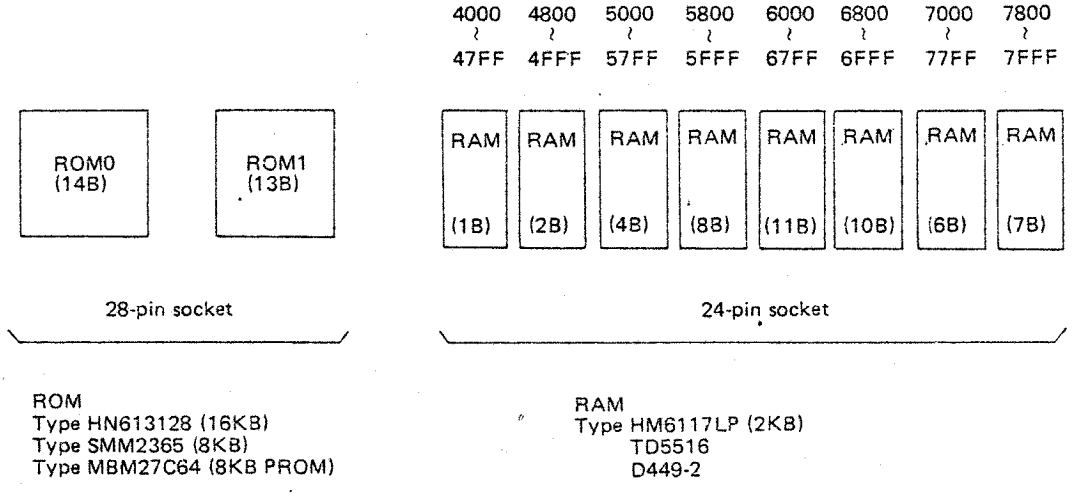
Fig. 4-8 Microcassette Operation and Control Commands

4.1.3 Expansion unit

The expansion unit is used for expansion of the ROM/RAM memory. The memory may be expanded up to 32K bytes.

(1) Expansion IC sockets

There are 2 28-pin IC sockets for ROM expansion and 8 24-pin IC sockets for RAM expansion as shown below.



ROM
Type HN613128 (16KB)
Type SMM2365 (8KB)
Type MBM27C64 (8KB PROM)

RAM
Type HM6117LP (2KB)
TD5516
D449-2

Fig. 4-9 Expansion IC Sockets

(2) RAM/ROM structure

The RAM/ROM memory can be expanded to a total of 32K bytes. Two jumpers (J1 and J2) and one DIP switch (SW2) are located on the Expansion Board for RAM/ROM memory assignment and ROM type (8KB/16KB) selection. (See Fig. 4-10.)

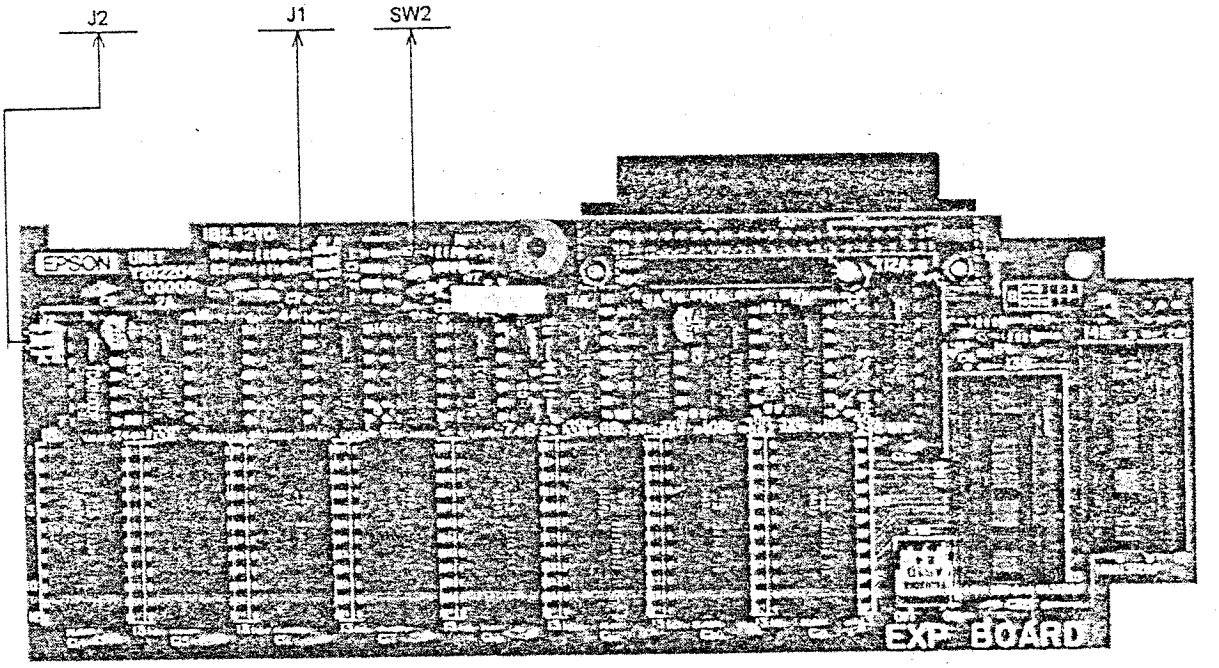


Fig. 4-10 Expansion Board

(3) Setting of jumpers J1 and J2 and DIP SW2

(a) The pin Nos. 1 and 2 of SW2 are used to assign RAM/ROM area.

NOTE: DIP SW1 is used to turn on and off the backup voltage (V_C) supplied from the HX-20.

(b) The pin Nos. 3 and 4 of SW2 and jumpers J1 and J2 are used to specify the ROM type (8KB/16KB) to be used.

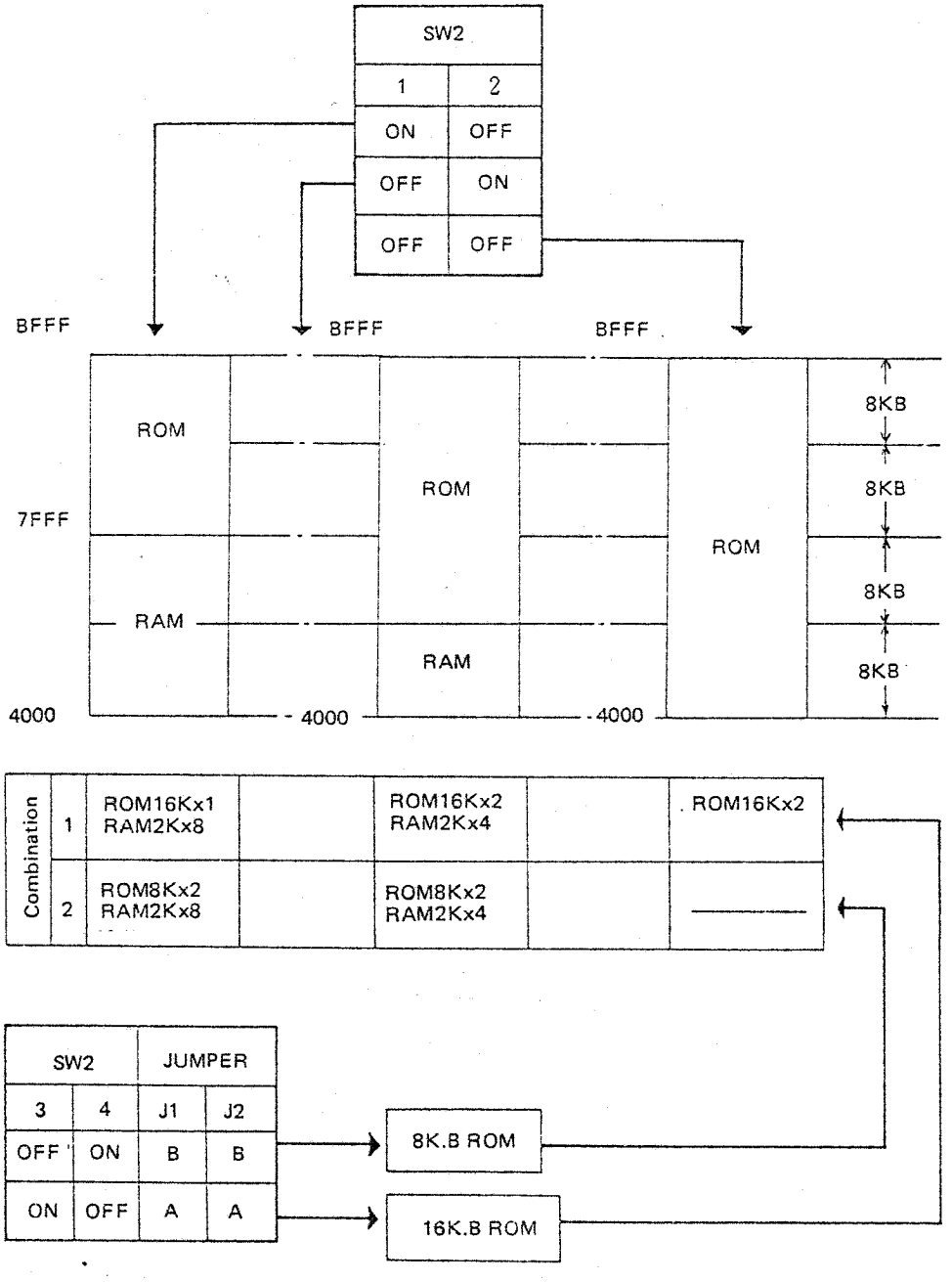


Fig. 4-11 Setting of Jumpers and DIP Switch

(4) Bank switching

The HX-20 can directly address up to 64K bytes of memory space (65,536 addresses). However, the memory capacity of the HX-20 may exceed 64K bytes when an expansion unit is connected to the HX-20. Therefore, bank switching is executed in the HX-20 so that the CPU can access a different memory area with the same logical addresses. The bank switching can be done by both the hardware and software. As the HX-20 operates in Multiplexed/RAM mode, addresses 0100 to FFFF can be used by the external memory. The addresses 4000 to BFFF (32K bytes in total) of this external memory area can be accessed by switching the ON/OFF position of the bank select DIP switch. The ROM E signal line is also available as a control signal on connector 7. This signal may be used to disable the ROM (address 8000 to FFFF) provided in the HX-20 as standard equipment.

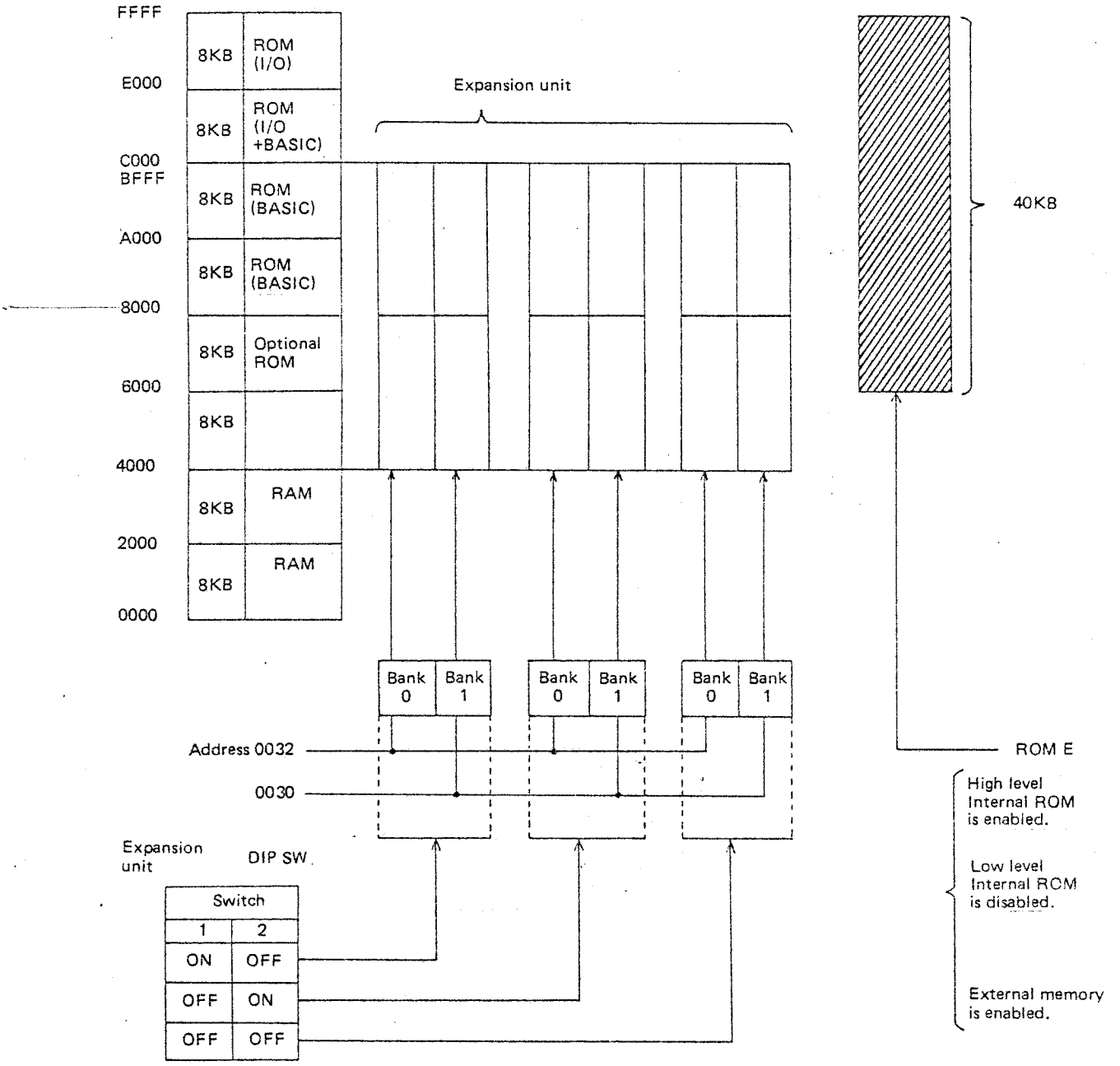


Fig. 4-12 Bank Switching

(5) ROM E (Internal ROM ENABLE)

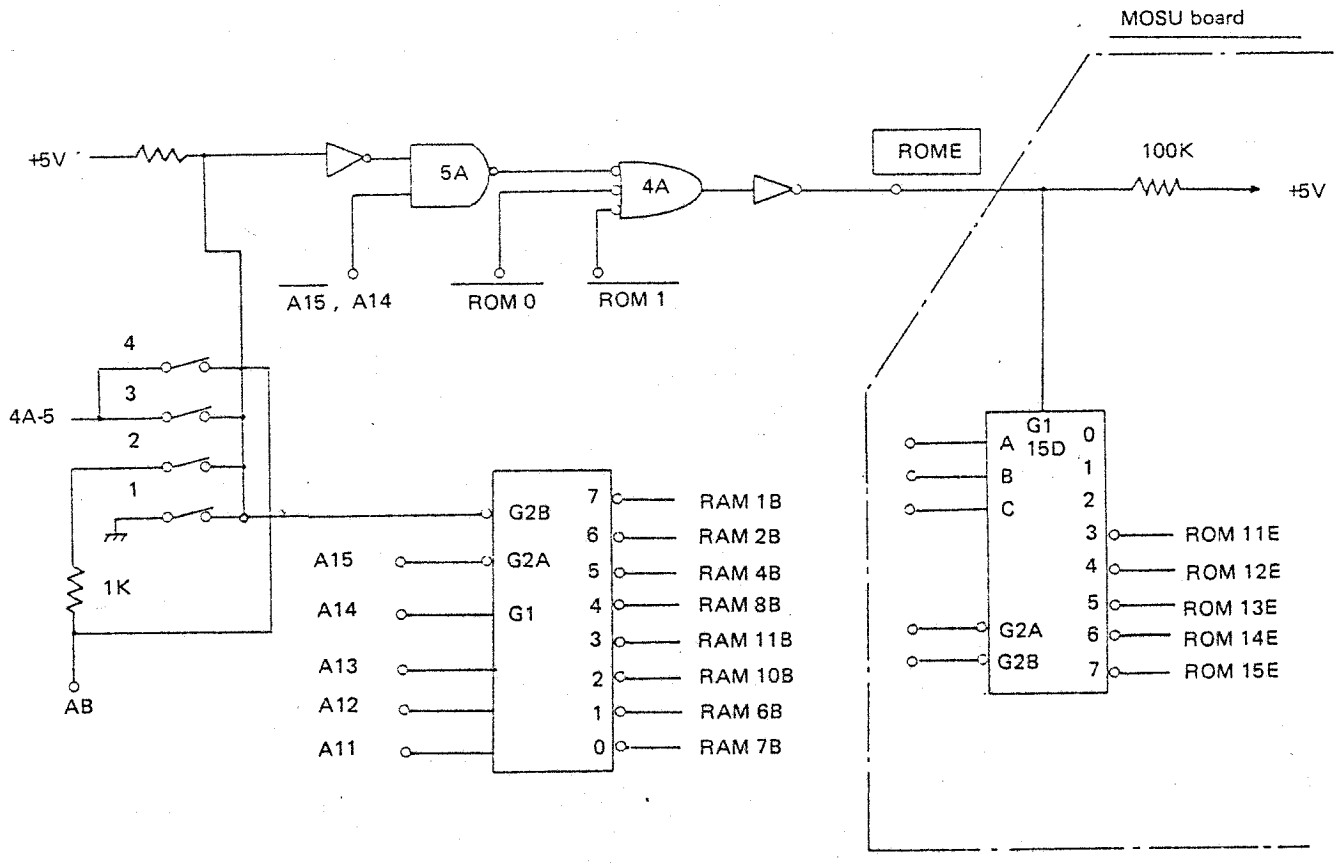


Fig. 4-13 ROM E Signal

The ROM E signal is normally High to select the internal ROM (addresses 6000 to FFFF) of the HX-20. This signal goes Low when the addresses higher than 6000 of the ROM0, ROM1 or RAM in the expansion unit are selected, thus disabling the internal ROM of the HX-20. Accordingly, with this ROM E signal, the internal or external memory having the same addresses can be used as required.

4.1.4 Display

As the master CPU operates in Expanded Multiplex mode "6", the memory map for display is as shown below.

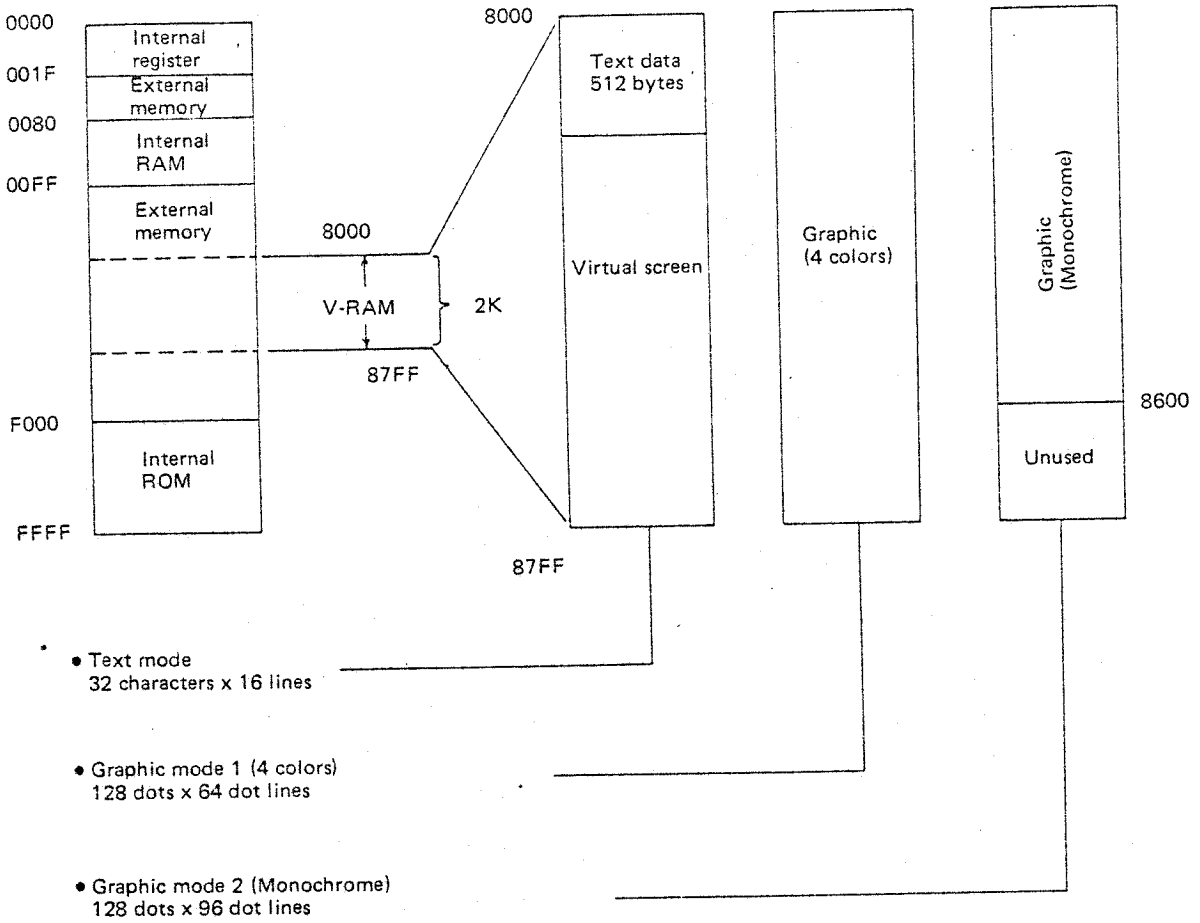


Fig. 4-14 Memory Map for Display

4.1.5 Floppy disk unit

The EPSON TF-20 Terminal Floppy is a floppy disk unit that can be connected to the HX-20 via a serial interface. The floppy disk unit has two 320KB disk drives and enables the use of DISK BASIC.
(Disk specifications: 16 sectors/track, 40 tracks/drive, double-sided double-density)

4.2 Applications

The HX-20 is an all-in-one type portable computer incorporating an LCD and a microprinter as standard equipment. The HX-20 also has the built-in rechargeable battery to allow the use of the computer for an extended period without connecting it to the AC power receptacle.

As all the operations of the HX-20 are supported by EPSON-MICROSOFT BASIC, programs can be developed with ease. If necessary, programs can be written in machine language using the computer in the Monitor mode. Therefore, systems ideal for a wide variety of applications can be configured by adding various EPSON options to the HX-20.

(1) Changing the interface operation

The HX-20 is equipped with a total of 6 interfaces (i.e., RS-232C, Serial, Barcode reader, External cassette, optional cartridge and expansion unit). These interfaces can operate entirely different from what they are originally intended if the programs to control their operations are modified. In this case, use of more effective BASIC subroutines and preparation of machine language programs will become necessary.

(2) Connecting the external unit

Special external units meeting the specific applications may be connected to the HX-20 interfaces. When connecting such units, careful consideration must be given to the interface specifications, timing, power requirements, etc. If the external unit to be connected to one of the HX-20 interfaces is an intelligent type, the external unit may have its own control functions. By so doing, the interface may operate entirely different from what it is originally intended by operating a relatively simple program from the HX-20 side.

If the external unit is not of an intelligent type, all the functions of the external unit must be controlled by the HX-20, which may require the use of a more sophisticated control program.

In any case, it is best to connect the external unit to the external unit interface of the HX-20 to which the address/data bus is open.

4.2.1 Power supplies

When connecting special units to the HX-20 to expand the system functions, pay attention to the points described below. Also note that the external units to be connected to the HX-20 have their own power supplies, since the built-in battery of the HX-20 has a limited capacity (approx. 1100mAH).

(1) Cautions when operating the external unit with the built-in battery of the HX-20

(a) The V_L line (line voltage) must be 50mA max. at +5V.
(b) The V_B (battery voltage) line must be 1000mA max. at +5V.
(c) The V_C (backup voltage) line must be 40mA max. at +5V.
(d) A fuse (1A max.) must be attached to the V_B line for overcurrent protection.
(e) The V_C line must be connected to the GND (Signal Ground) through a 30μF electrolytic capacitor at the external unit. Also, attach a 0.01μF (capacitor to the circuit wired to each element and to the V_{CC} of each element (RAM, ROM, etc.), respectively for voltage stabilization or noise prevention.

(2) Cautions when operating the external unit with its own power supply.

(a) The power supply section of the external unit must have an independent ground line (in the 3-conductor power cord).

(b) The ground line must be separate from the signal ground.

(c) The power supply lines of the HX-20 must not be connected to the external unit.

(d) The external unit must have its own reset circuit so that it does not operate before the HX-20 becomes ready for operation.

(e) The external unit must have a protective circuit against abnormalities in the power supply (overvoltage, overcurrent, low voltage, etc.).

(f) The external unit must be provided with measures against noise due to electromagnetic waves, etc.

(g) The external unit must satisfy all other requirements specified in the safety and various other standards.

(3) Power ON/OFF control

When operating the external unit with the built-in battery of the HX-20, pay attention to the following points.

(a) V_B line

- Power must be turned on and off with the built-in switch of the external unit or by the program so as to prevent the unwanted battery consumption except when the external unit is in operation.
- The V_B voltage line must be protected against overcurrent by inserting a fuse rated at 1A max.

Example:

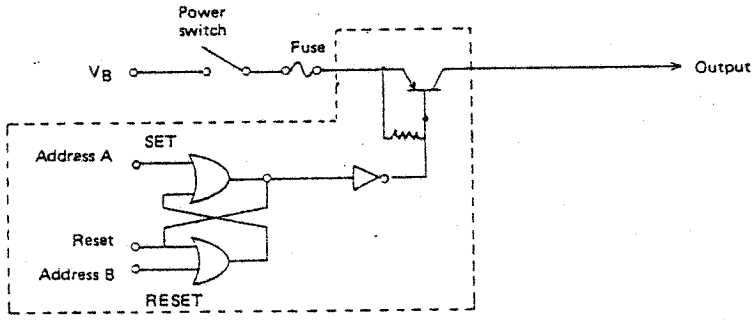


Fig. 4-15 Overcurrent Protection

The circuit enclosed by the dotted line in the above figure indicates a power ON/OFF circuit which uses two addresses for power ON/OFF control.

By this circuit, the unwanted battery consumption may be prevented by turning the power ON only when the external unit is used and turning it OFF immediately after the unit has been used.

(b) V_C line

- Use of this line must be limited to only the case where the external unit requires battery backup voltage.
- The V_C line must not be connected to any other voltage lines such as V_L (line voltage).
- The element to be backed up must be of a C-MOS type.

(c) V_L line (+5V)

- This line must not be used when load fluctuations on the external unit side are great.

4.2.2 Interfaces

The interface cables specified by EPSON must be used for RS-232C and serial interfaces which employ a USART IC in the interface board. When using other than the above two interfaces such as expansion unit interface, etc., pay attention to the following four points.

(1) Connection

- ° Use a connector conforming with the interface standard.
- ° Secure the expansion unit interface connector using the screw (M3x8) mounting holes provided on the side of the HX-20 for this purpose.
- ° The distance between the expansion unit interface and the I/O elements on the external unit should be less than 150mm. Avoid the use of an interface cable, etc. as much as possible. If the interface cable is required, see paragraph (2) below.

(2) Interface specifications

Signals for the expansion unit interface, cartridge interface, etc. are output directly from the master or slave CPU. Therefore, the interfacing distance between the HX-20 and the external unit must be minimized and a line buffer (or driver) be provided on the external unit to prevent signal levels from dropping as well as to prevent the HX-20 from malfunctioning due to noise. The interface differs depending on the cable material, elements, etc. used. However, the interfacing distance from the I/O connector section of the HX-20 to the line buffer on the external unit must be less than 150mm.

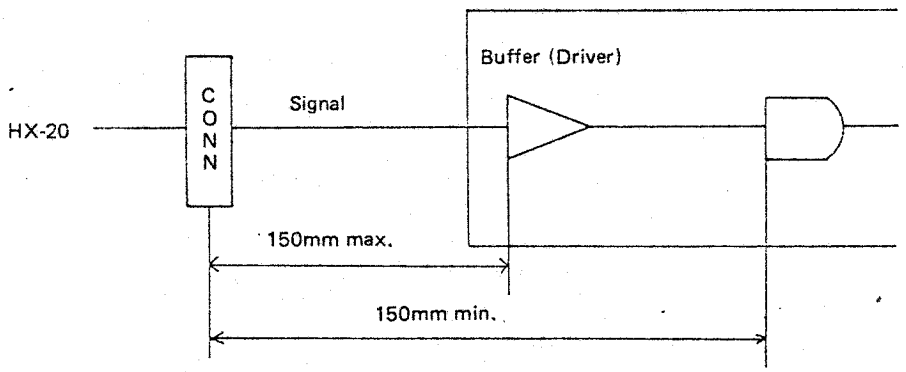


Fig. 4-16 Interfacing Distance

(3) Interface cables

The interface cable to be used for connection of the external unit to the HX-20 must be twisted pair. The return wire of each signal line must be connected to the signal ground.

The interface cable must also be shielded and the both ends of the shield be connected to the chassis grounds of the HX-20 and the external unit, respectively.

Connect the return side of twisted line to grounding terminal.

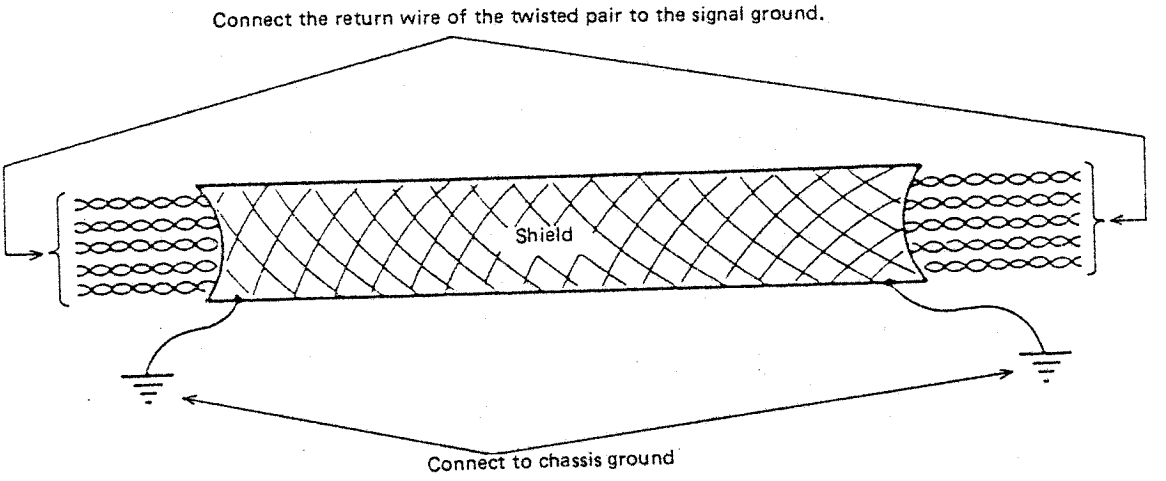


Fig. 4-17 Connection of Interface Cable

NOTES:

1. The length of the interface cable must be minimized, as the extensible cable length is governed by the cable material and the type of element used as a signal driver.
2. When using the interface, avoid use of the HX-20 power supplies (V_B, V_L and V_C) as much as possible to prevent voltage drop.
   - Input signal lines to the HX-20 and all other signal lines except voltage and ground lines must be connected to the signal GND via a 1MΩ resistor.
   - A bidirectional gate circuit (H245, etc.) must be provided for each data bus line.
   - Use of open collector type elements is recommended for the input signal lines to the HX-20.
   - The signal levels for the external unit must be TTL compatible.
   - The signal GND must be separate from the chassis GND.
   - When the external unit has a built-in power supply, make sure that noise due to power ON/OFF does not have any adverse impact on the signal lines.

[Application Example]

° Memory expansion

When the same control as that for the expansion unit is to be effected on external units via the interface connector CN7 on the MOSU board, memory may be expanded up to 40K bytes (address "6000" to "FFFF") per bank by using unassigned addresses "0030" to "003F" for bank switching. If multiple banks are to be used, a program is required to cover the set/reset control involved in the bank switching.

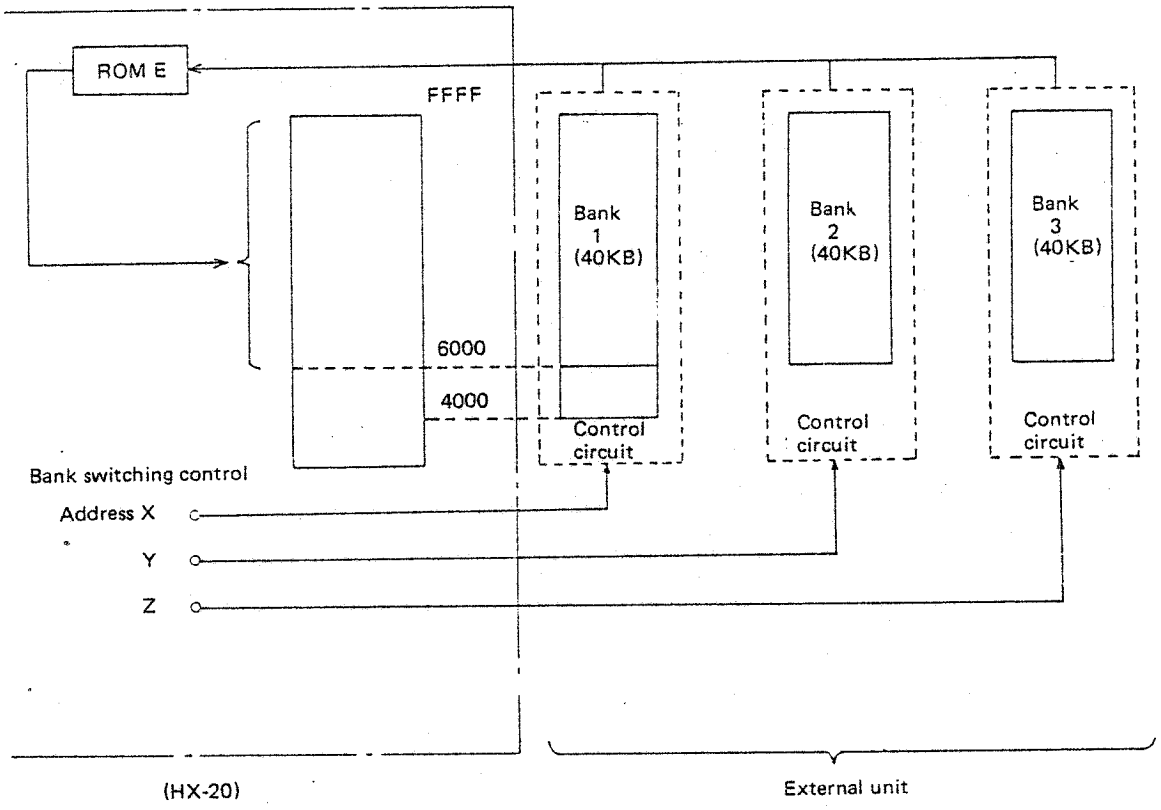
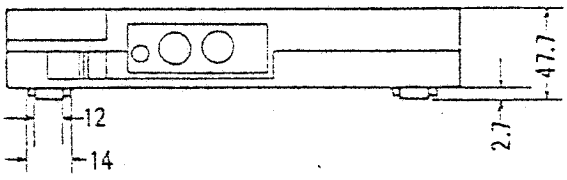


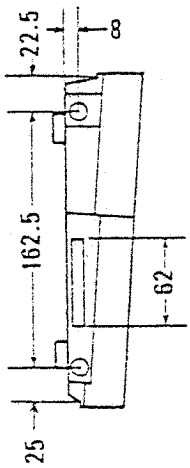
Fig. 4-18 Bank Switching Control

APPENDIX 1 OUTLINE DIMENSIONED DRAWINGS

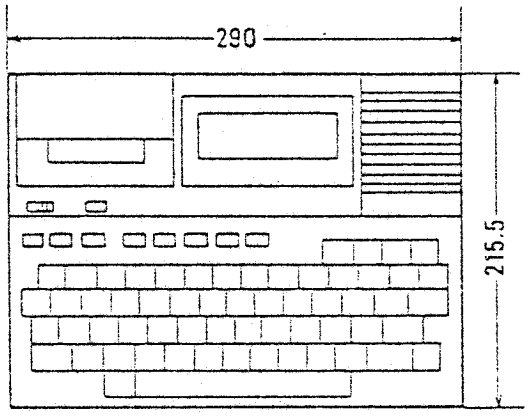
APP1-1 Outline Dimensions of HX-20



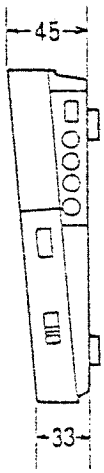
(Rear View)



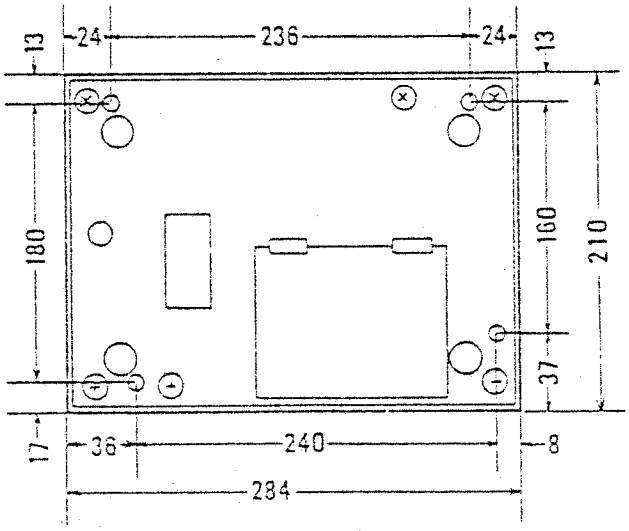
(Left Side)



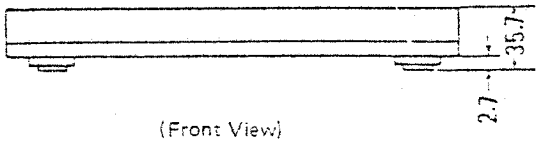
(Top View)



(Right Side)



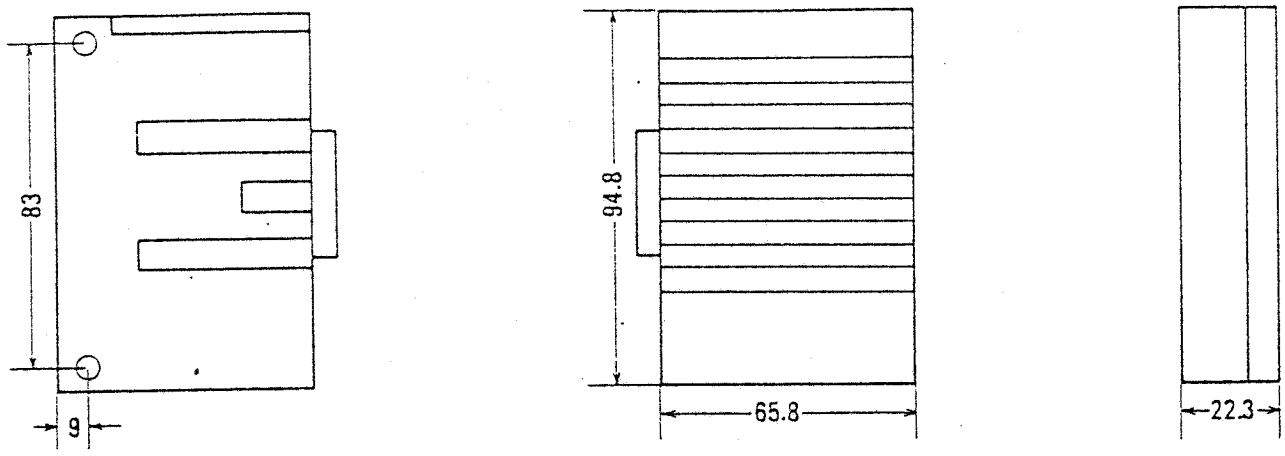
(Bottom View)

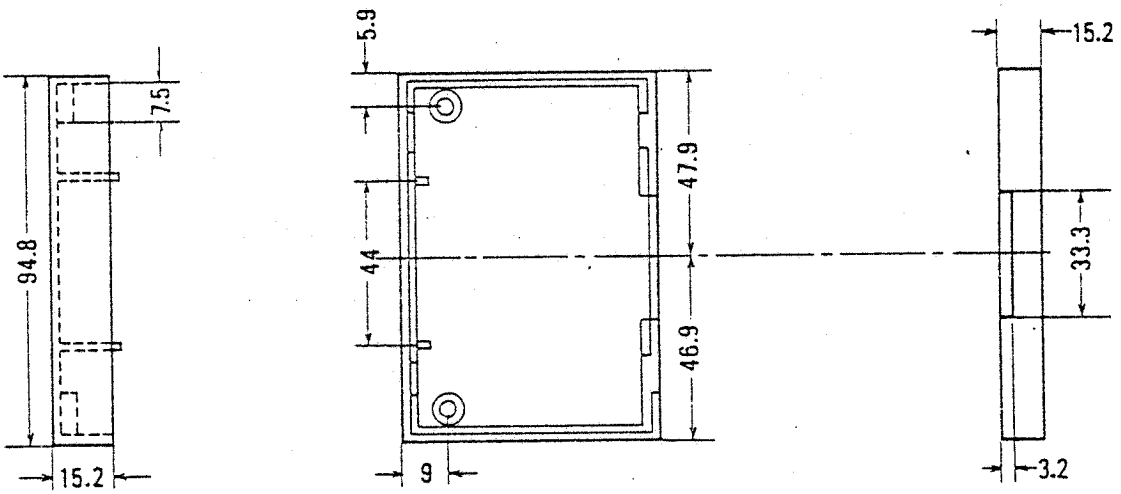


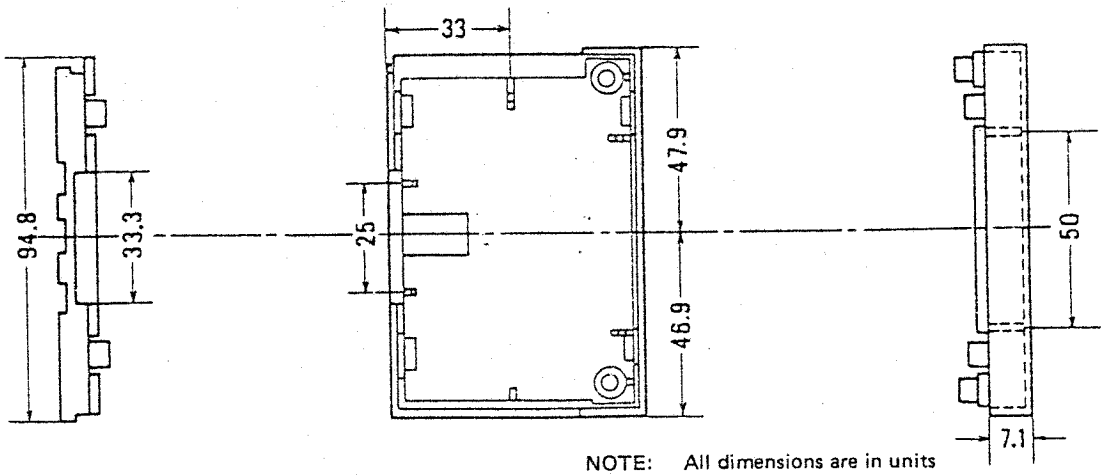
(Front View)

NOTE: All dimensions are in units of millimeters.

APP1-2 Outline Dimensions of ROM Cartridge

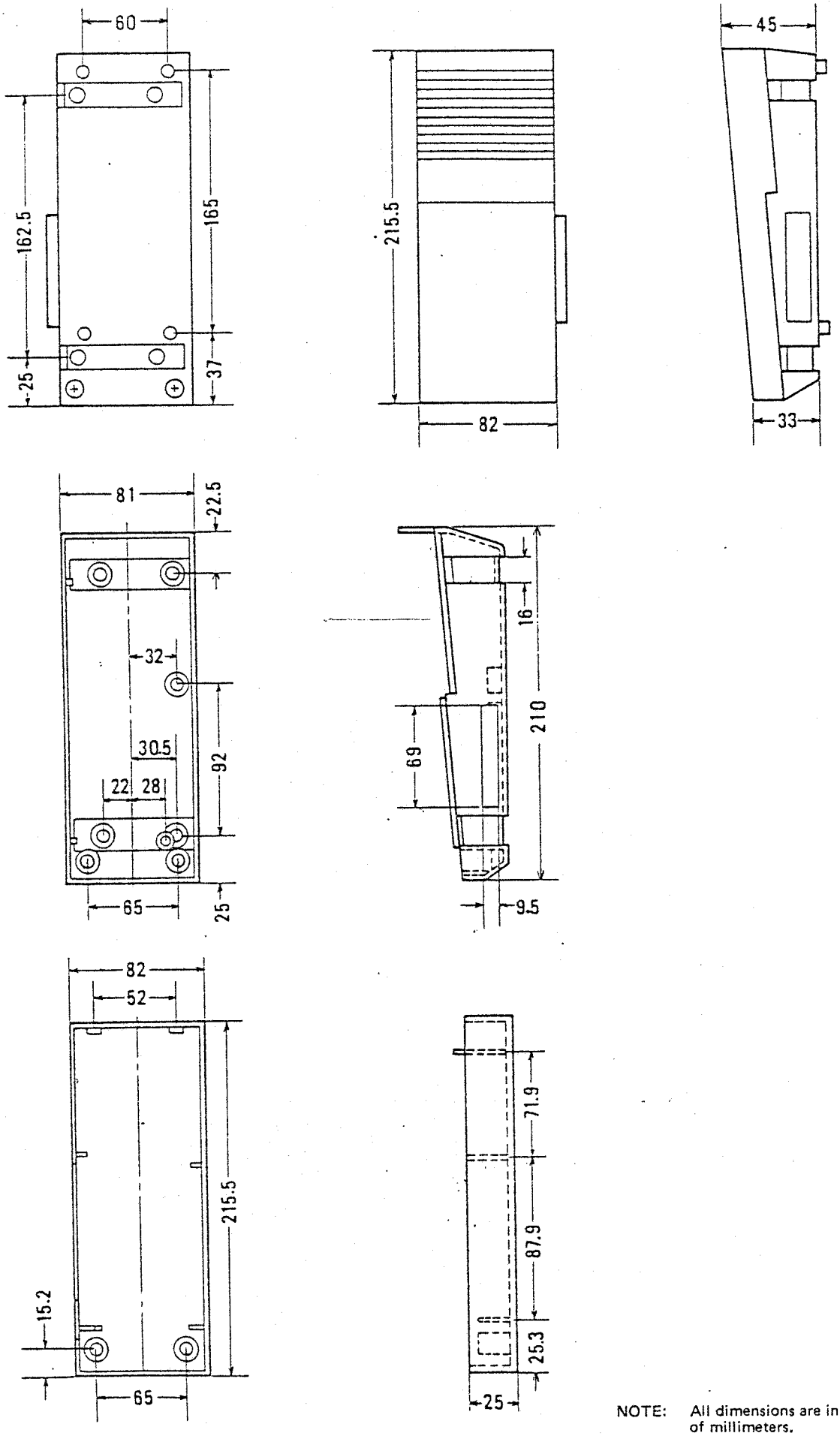






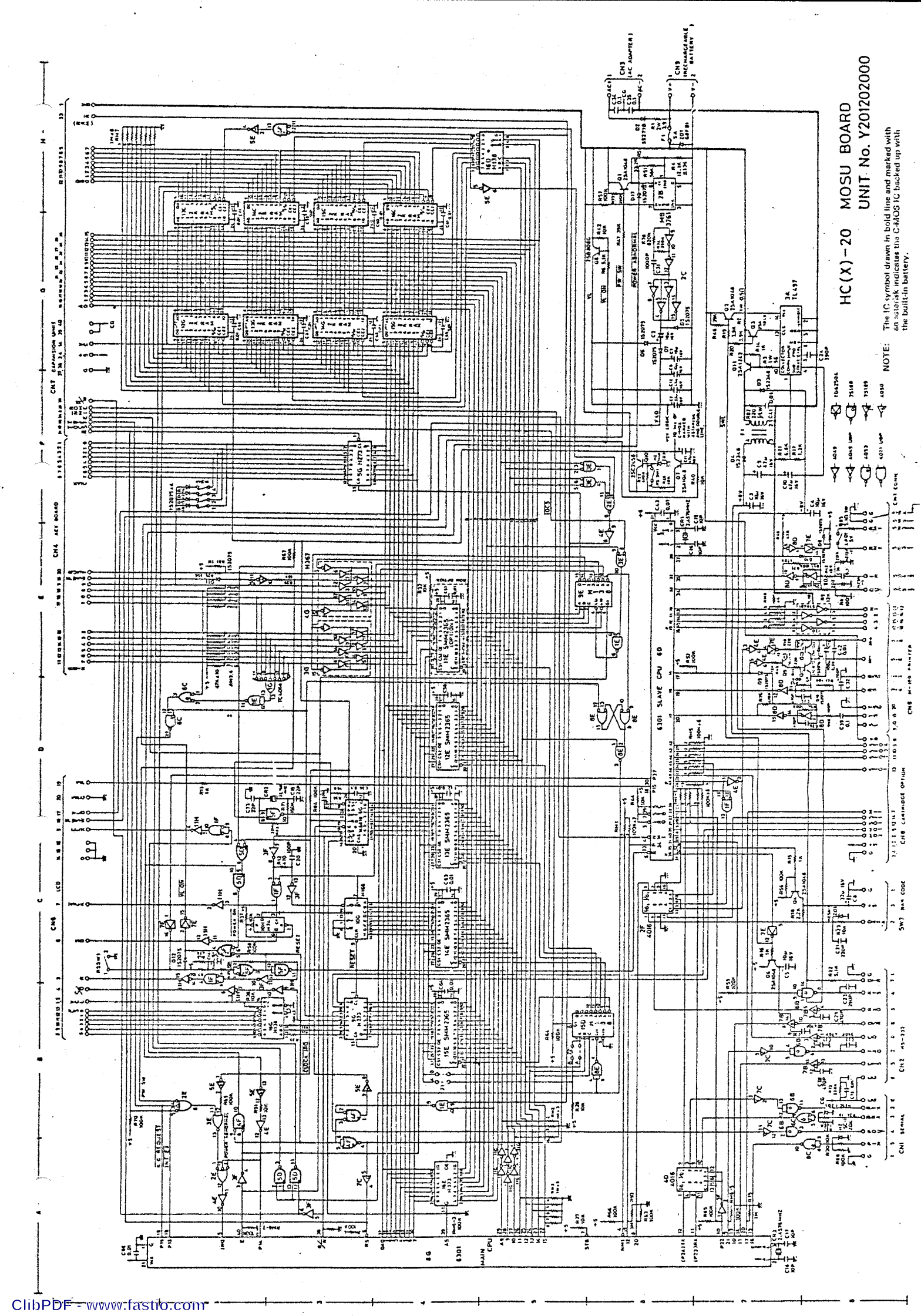
NOTE: All dimensions are in units of millimeters.

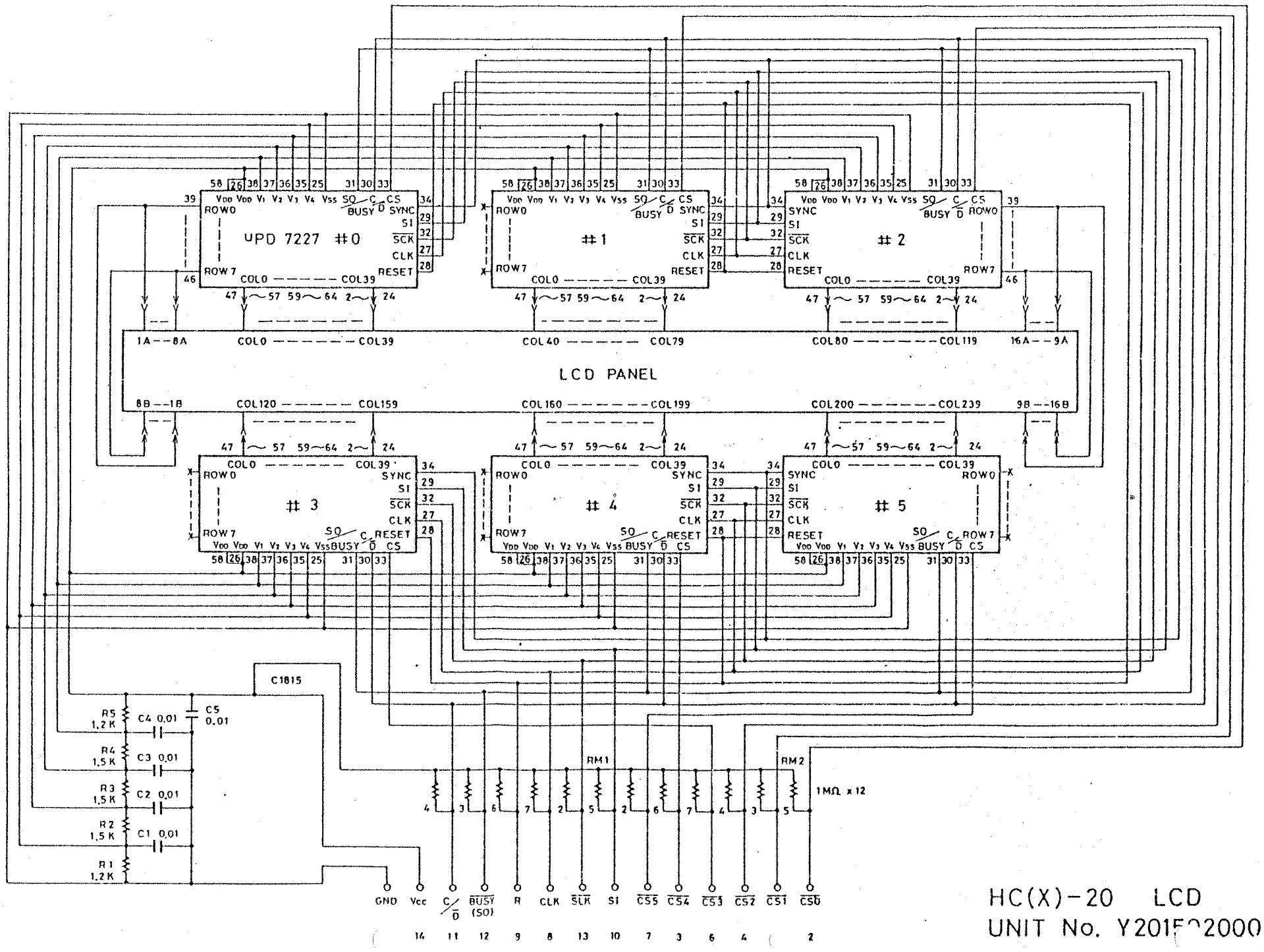
APP1-3 Outline Dimensions of Expansion Unit



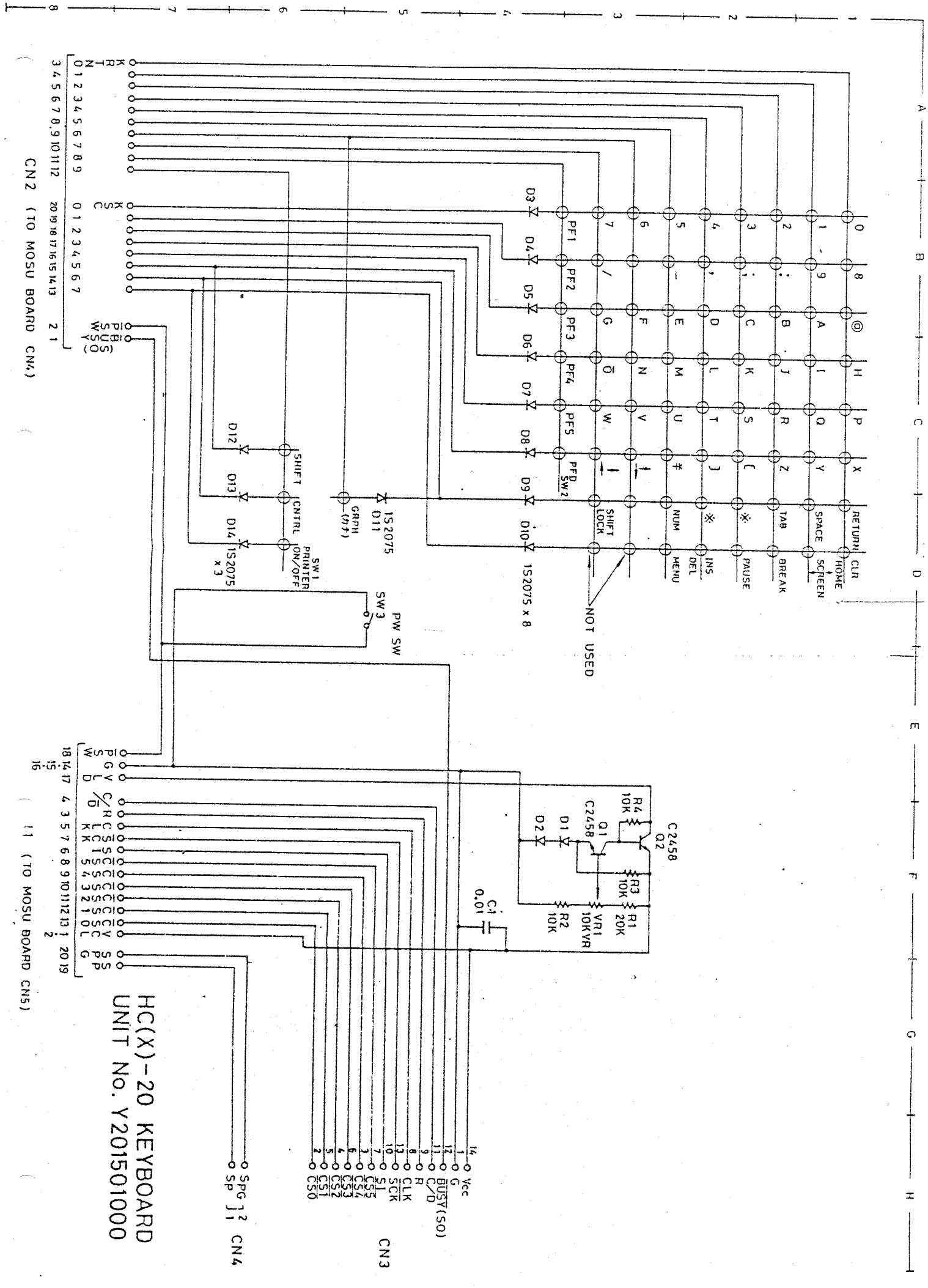
NOTE: All dimensions are in units of millimeters.

APPENDIX 2 CIRCUIT DIAGRAMS

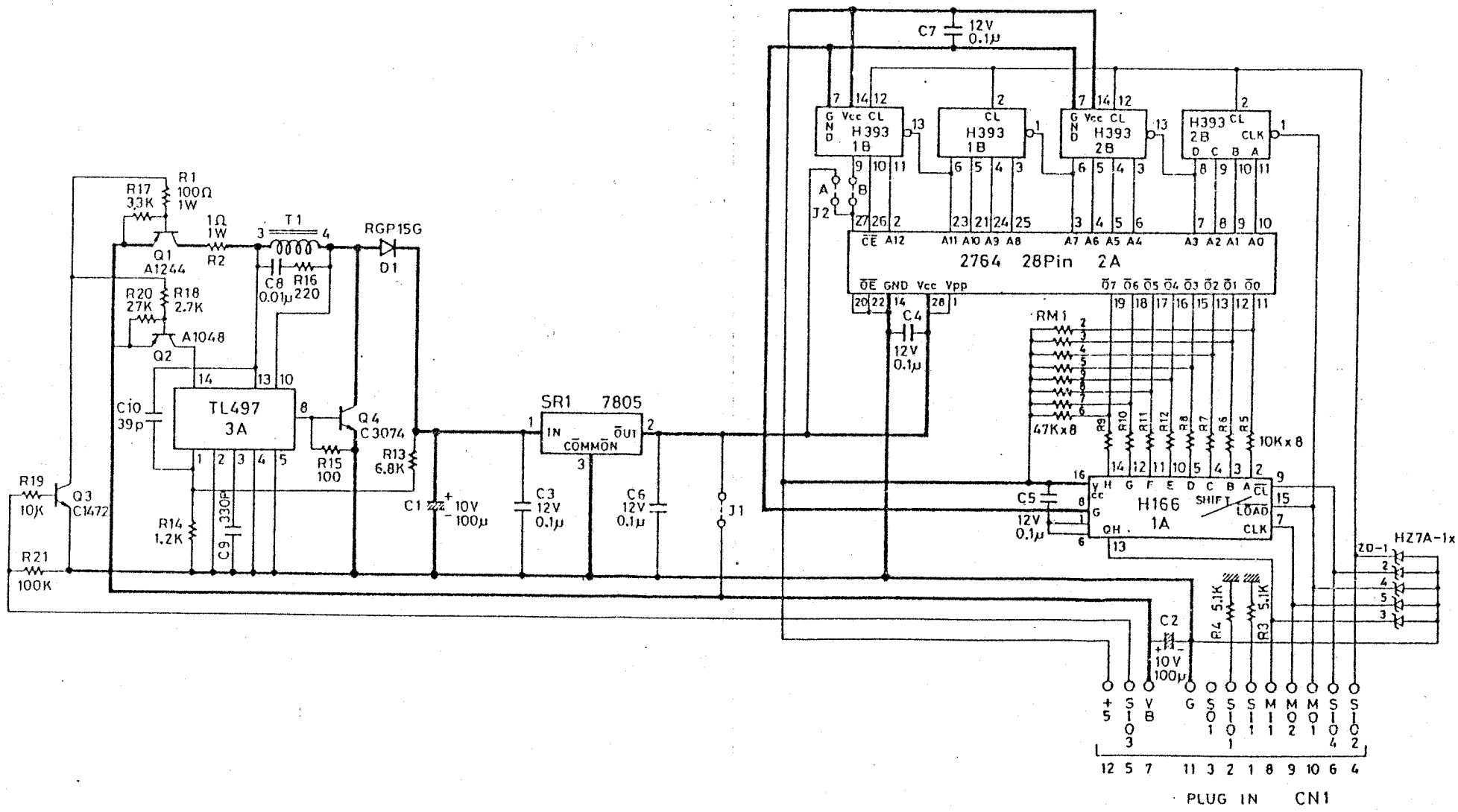




HC(X)-20 LCD
UNIT No. Y201F02000

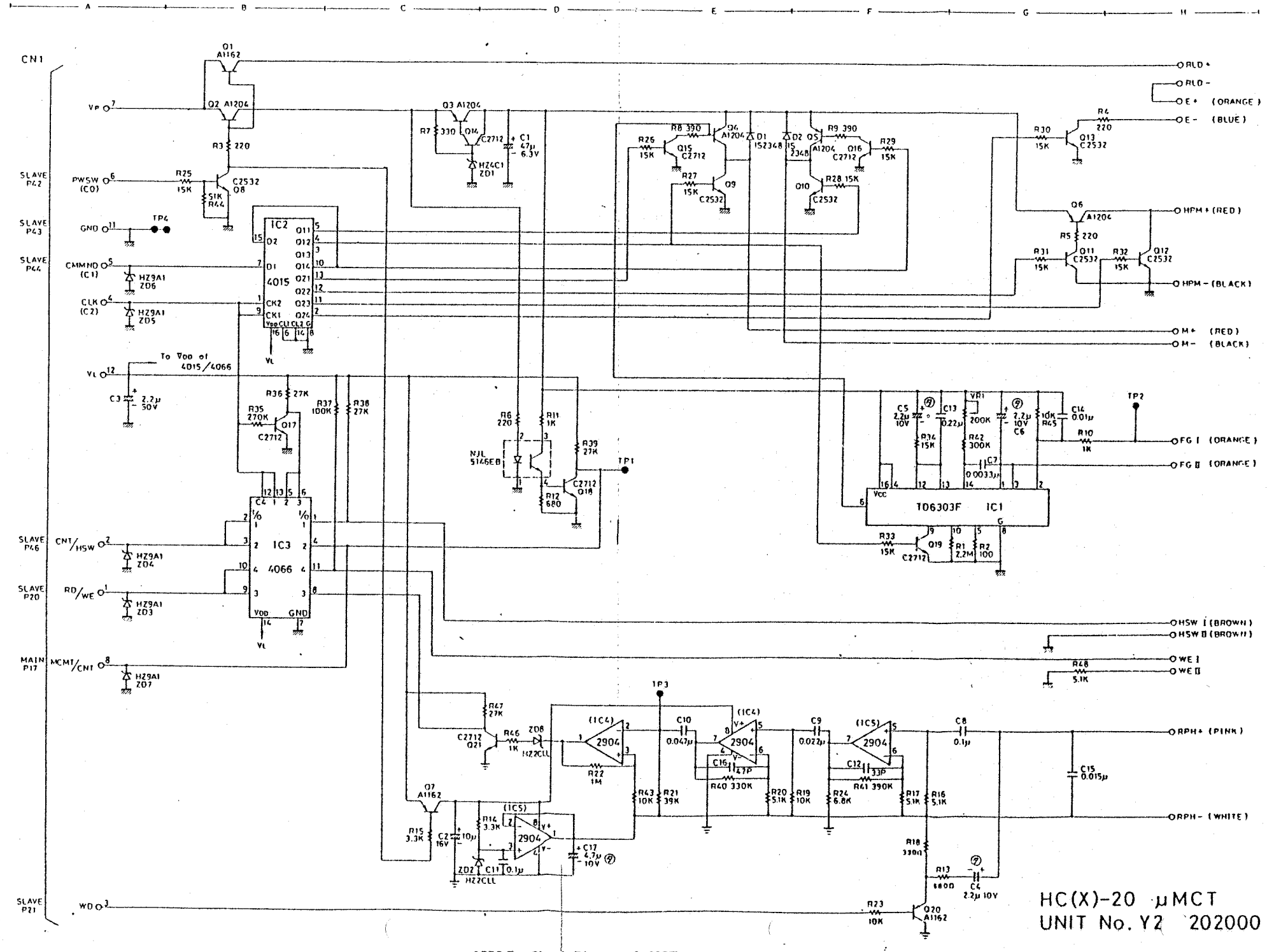


APP2.3 Circuit Diagram of Keyboard

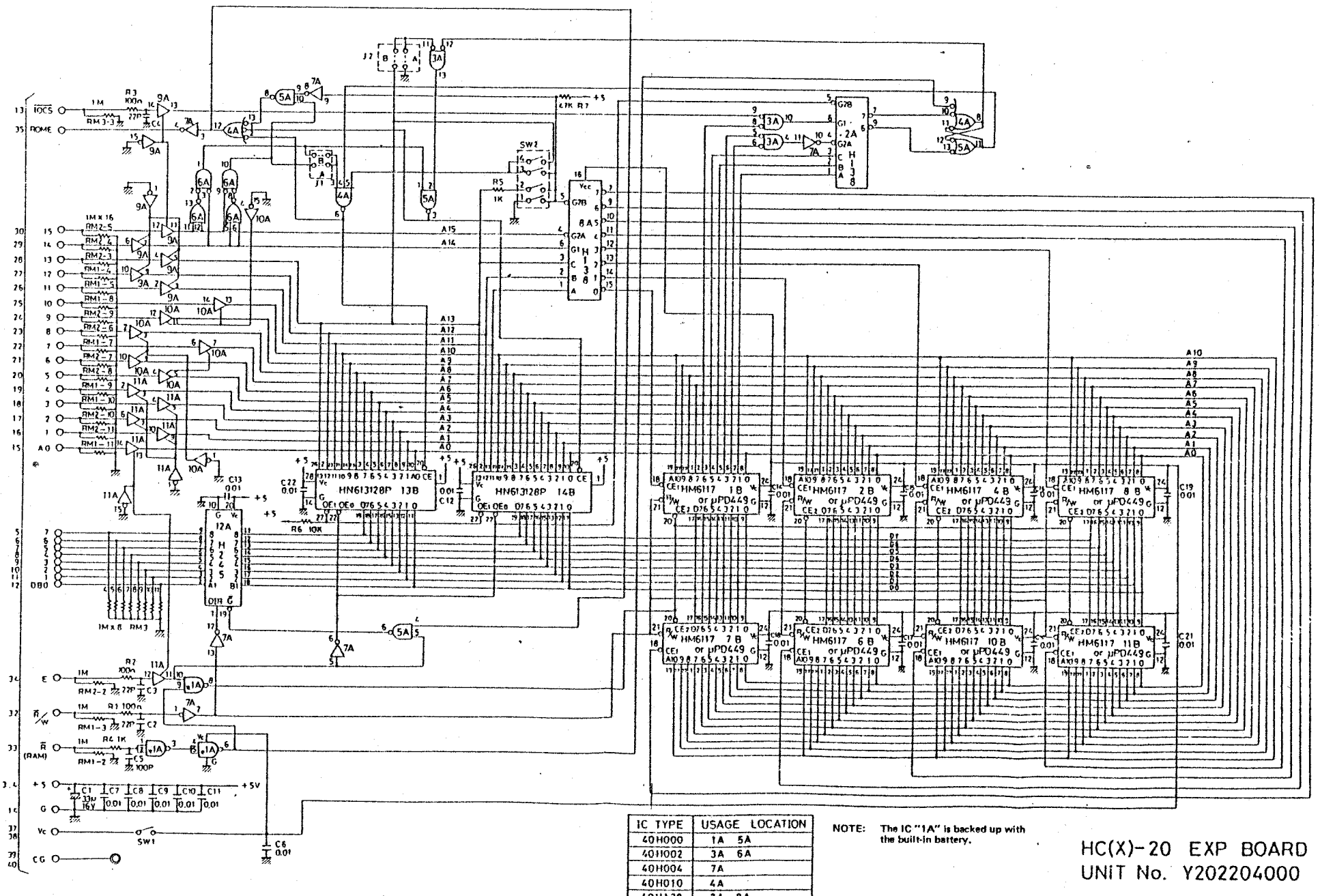


HC(X)-20 ROM CAT
UNIT No. Y202201000

APP2-4 Circuit Diagram of ROM Cartridge



APP2-5 Circuit Diagram of μMCT

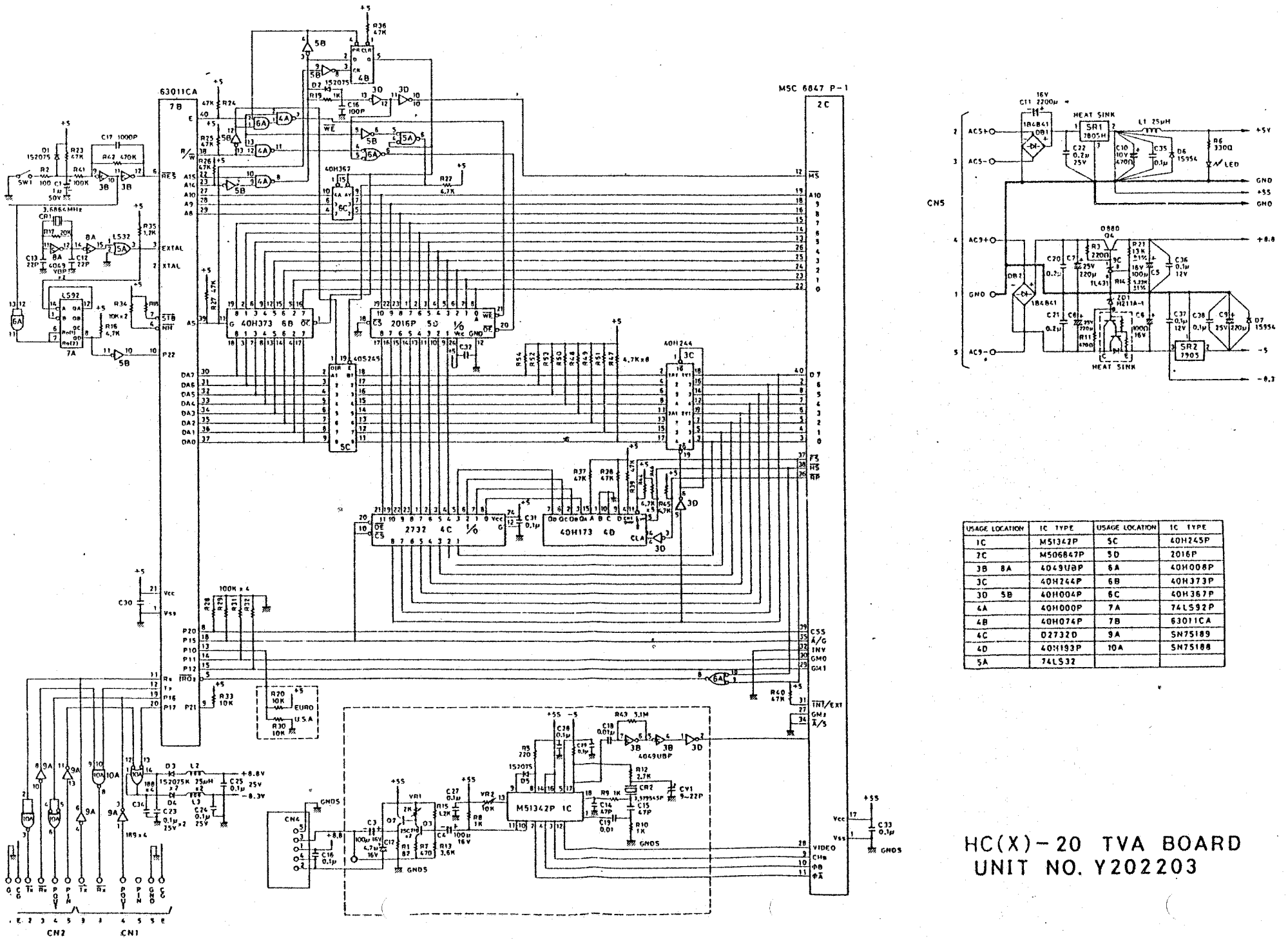


IC TYPE	USAGE LOCATION
40H000	1A 5A
40H002	3A 6A
40H004	7A
40H010	4A
40H138	2A 8A
40H367	9A 10A 11A
40H245	12A

NOTE: The IC "1A" is backed up with the built-in battery.

HC(X)-20 EXP BOARD
UNIT No. Y202204000

APP2-6 Circuit Diagram of EXP Board



USAGE LOCATION	IC TYPE	USAGE LOCATION	IC TYPE
1C	M51342P	5C	40H243P
2C	M5068 47P	5D	2016P
3B 8A	4049UBP	6A	40H008P
3C	40H244P	6B	40H373P
3D 5B	40H004P	6C	40H367P
4A	40H000P	7A	74LS92P
4B	40H074P	7B	63011CA
4C	D2732D	9A	SN75189
4D	40H193P	10A	SN75188
5A	74LS32		

HC(X)-20 TVA BOARD
UNIT NO. Y202203

APP2-7 Circuit Diagram of TVA Board