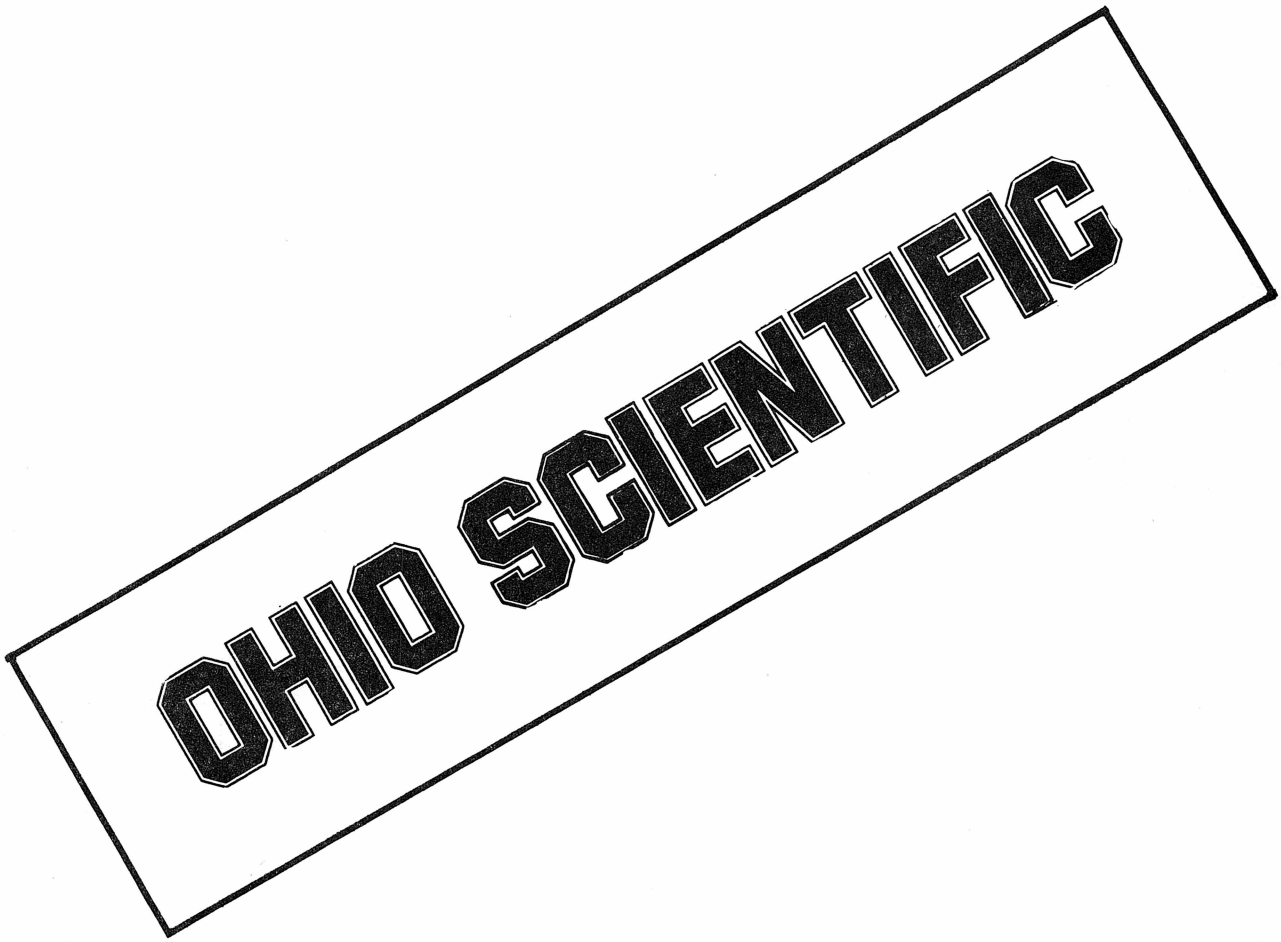


Challenger II
Challenger III
A PRELIMINARY MANUAL

Before you begin...

Please follow the instructions on the following pages. They are organized as steps A., B., C., D.

a Unpack and inspect the computer. Check supplied items against the enclosed check list.

b Connect the computer to the console terminal (serial terminal or video display). Test the operation of the internal monitor program.

c Connect mass storage device (i.e. audio cassette or disk) and run BASIC.

d Connect any special features ordered.

e In case of difficulty, check the troubleshooting section of this manual. To register your Challenger complete the Warranty card below and return it to:

OHIO SCIENTIFIC, INC.
11681 Hayden Street
Hiram, OH 44234

NOTE: All Challenger owners will receive a free one year subscription to Ohio Scientific's Small Systems Journal upon receipt of the Warranty card below.

Warranty Card

NAME_____ PHONE(___)_____

STREET_____

CITY_____ STATE_____ ZIP_____

PURCHASED FROM_____

DATE OF PURCHASE_____

MODEL NUMBER (SEE NAMEPLATE ON BACK)_____

SERIAL NUMBER_____

For a Warranty description see the limited Warranty statement in section E of this manual.

Table of Contents

a - introduction

This general purpose manual covers all fully assembled Ohio Scientific computer products including:

Model 500 Board
500-1
Super-Kit
Challenger IIP
Challenger IIS
Challenger IIV
and Challenger III.

All of these computers with the exception of the Challenger III use the 500 CPU Board. All of these computers have many features in common, but, additionally, have unique features. Please keep in mind that this manual is for several different computers so that you are careful to study all the information concerning your computer and are not misled by the information for another computer configuration.

Unpacking Instructions:

The Challenger System may be delivered in from one to six boxes. It is normally delivered by UPS, but, if line printers or other large items are involved, air or ground freight carriers may be used for some items.

Please carefully unpack all portions of your system and SAVE ALL PACKING MATERIAL. On Challenger IIs and Challenger IIIs with an 8-slot chassis, it will be necessary to remove internal packing material before attempting to power up the computer. This can be accomplished by removing the screws on either side of the unit near the bottom edge and lifting the cover straight off. Then, very carefully remove the foam rubber packing material, paying particular attention not to damage components on PC boards. Audio cassettes, paper tapes, and system cables may be present at the rear of the computer. They should be removed at this time.

Model 500-1 and Challenger IIPs generally do not have internal packing material. They are delivered upside down to minimize vibration of the PC boards inside.

Floppy disk drives do not have any internal packing material, but, are shipped with cardboard dummy diskettes in place to protect the head mechanism. Remove these dummy diskettes, but, keep them since it is necessary to re-install these protectors whenever the disk drive is transported.

Refer to the check list which is to be found in the pocket at the front of this manual. Compare the items you have received against the check list. Keep in mind that your unit may not all arrive in the same day because of the 100 pound per consignee per day UPS limit. In fact, some portions of your system may be delivered by other carriers. Each package of a particular system will be marked X of total number of packages so that a computer system may come in Box 1 of 3, Box 2 of 3 and Box 3 of 3. All computer systems will minimally have the computer itself and the manual containing operating instructions.

Units delivered with disk drives will have a separate box containing the floppy disk drive and a second manual containing diskette software and diskette, and disk operating instructions.

If other accessories such as CRT terminals, audio cassettes, or line printers are ordered, they will be shipped separately and their respective boxes will have the manufacturer's operating manuals and warranty cards for these products.

Please save all packing material and pay careful attention to the warnings in Section E about reshipping any Challenger equipment.

WARNING:

NEVER REMOVE THE TOP OR PROTECTIVE COVER WITH POWER APPLIED TO ANY CHALLENGER COMPUTER OR FLOPPY DISK UNIT. NEVER ATTEMPT TO OPERATE THE UNIT WITH THE TOP OFF. OPERATING THE UNIT WITH THE TOP OFF REPRESENTS A POTENTIAL SHOCK HAZARD SINCE THE COMPUTER AND PERIPHERAL EQUIPMENT HAVE EXPOSED 110 VOLT WIRING INTERNALLY. ALSO, BECAUSE OF THE LOGIC CIRCUITRY INVOLVED, HIGH FREQUENCY RADIATION COULD BE EMITTED WITH THE TOP OFF WHICH COULD BE A POTENTIAL RADIO FREQUENCY INTERFERENCE SOURCE. SO, ALWAYS BE SURE THAT THE UNIT IS UNPLUGGED WHEN PART OF ITS CASE IS REMOVED.

Challenger III Owners Note:

If your unit is equipped with the manual processor select switch, be sure that the switch is rotated full counter-clockwise (when viewing the unit from the rear) to select the 6502 processor for the main body of this manual. The Z-80 and 6800 operating instructions are part of the special features Section D.

b-Part 1

INTRODUCTION TO SMALL COMPUTER HARDWARE

Small computers are made up of several modules, or blocks. The first of these, the microprocessor, is an integrated circuit much like those used in modern watches and calculators. It performs the function of a large computer, which a few years ago would have been prohibitively expensive. This integrated circuit makes the whole field of personal computing possible and affordable.

Next, one must have some memory, which can be in the form of ROM, PROM, EPROM, or RAM. The first three devices provide permanent storage of programs and data, that is, they do not "forget" when the power is turned off. RAM provides modifiable storage, that is, programs and data can be written in and read out repeatedly. However, almost all types of RAM "forget" whenever the power is turned off. Therefore, RAM is used for temporary storage, and ROM, PROM, and EPROM are used for permanent storage of programs which will not change. Generally, a small computer will have a large amount of RAM for general purposes, and very little PROM or ROM. It does need some of the latter, to give it some intelligence when it is first turned on, and this is usually in the form of a monitor program which allows the user to load additional programs from some external device such as a tape recorder into RAM. Today, the most advanced computers put BASIC, the most commonly used programming language in ROM. This has only recently become possible because BASIC requires approximately 8,000 bytes of ROM, which had been a costly feature until now.

Along with memory, the microprocessor requires some form of I/O device (Input/Output), that is, some way of "talking" to the outside world. The computer communicates through interfaces such as the ACIA-Based Serial Interface and the PIA-Based Parallel Interface to external devices called peripherals, such as CRT terminals, Teletypes, paper tape readers, paper tape punches, line printers, and audio cassettes. Other types of interfaces include D/A converters and A/D converters.

The microprocessor communicates with its interfaces and memory with a series of wires, or lines, called buses. There are generally three buses in any microcomputer: an address bus, a data bus, and a control bus. These three buses are combined in what is called a system bus.

The address bus is generally made up of 16 lines. The microprocessor always is the signal generator for this bus. The 16 lines carry specific addresses, that is, 16-bit binary words which select a memory or I/O location. This location can be thought of as a post office box, and the address word can be thought of as the box number. The microprocessor can, therefore, through its address bus, specify memory or I/O locations.

It can place data in these locations, or read memory from them via an 8-bit wide data bus. Its 8-bit width indicates that the microcomputer can read or write one byte at a time. With ROMs, PROMs, and EPROMs, the microcomputer only reads what is already in those locations, and acts accordingly. In the case of RAM and some I/O locations, the microprocessor can also place data in these locations. Unless the computer has a large amount of ROM, it will generally be very "stupid" when first turned on. That is, its main memory, or RAM, has nothing of value in it. The user must enter a program which the microcomputer can then execute in its RAM memory. It does this by use of a PROM Monitor Program, that is, a short program which the computer runs, allowing it to take data from some interface, and ultimately from some peripheral, and place it into its operating memory, or RAM. It can then later perform functions and write or store additional programs based on this stored program. The typical peripherals used for this are a video display interface, and a keyboard, or a Teletype or CRT terminal. Additional mass storage devices, such as paper tape readers, audio cassettes, and floppy disks, are utilized for storage of programs.

The OSI system utilizes a 48-line system bus made up of an address bus of from 16 to 20 lines (depending on the CPU board used in the system), an 8-line data bus, a 7-line control bus, power connections, and spare lines for user connections. The system utilizes 8" x 10" PC boards plugged into an 8-slot backplane, which spaces the system boards one inch apart. For very small computers, the Model 500 can be used without a backplane board as a stand-alone computer, that is, it can be populated with the microprocessor, PROM and ROM memory, RAM memory, and a serial interface, so that it can function as a complete computer by itself. For larger systems, however, a backplane board and additional system boards are used.

It is necessary for anyone servicing or building an OSI system to be somewhat familiar with the 48-line bus utilized by the computer. This bus is outlined on page B-3

Glossary of Small Computer Terms

ACIA- (Asynchronous Communications Interface Adapter) An IC used for serial data transfer between a device such as a small computer and a serial terminal.

A/D- (Analog/Digital) refers to changing an analog signal to a digital signal which the computer can use.

Backplane Board- (Sometimes called mother board) allows simple interconnection between small computer boards using the same bus.

Bit- The smallest amount of data possible; a bit is expressed as a high or low (on or off) state (normally 1 or 0).

Bus- Refers to the set of foils or wires needed to interconnect between system boards provided that the pattern of how each of the connections is used is consistent for all system boards.

Byte- 8 bits of data. The most fundamental microprocessor commands are organized into sets of 8 bits (i.e. bytes).

CPU- (Central Processing Unit) the portion of a microprocessor which does the actual arithmetic calculations and decision making.

D/A- (Digital/Analog) Refers to changing digital signals (from the computer) into analog signals.

EPROM- (Erasable Programmable Read Only Memory) information stored in an EPROM IC can only be removed by special light sources or specific voltages (depending on the type of EPROM). Through the use of a special programming device, the user can store a set of information in the EPROM after it has been erased.

Hardware- that part of a computer consisting of actual electronic circuitry, printed circuit boards, case, and power supply as opposed to software which is the set of commands the hardware is executing.

I/O- (Input/Output) refers to bringing information into the machine in a form it recognizes and allowing the machine to transmit information. In other words, communicating with the outside world.

Memory- a general term referring to parts of the computer where information is stored.

Microprocessor- a large IC (electronic part) which functions as the CPU of the microcomputer. The 6502 on Ohio Scientific's 500 board is a microprocessor.

PC Board- (Printed Circuit Board) a card with foils (electronically conductive pathways) connecting electronic components which are mounted on the board.

PIA- (Peripheral Interface Adapter) IC used for parallel data transfer.

PROM- (Programmable Read Only Memory) Memory which can have information stored on it once, but, is not normally changeable.

RAM- (Random Access Memory) the data stored in this type of memory is easily changed by the user while the machine is in use (unlike ROM, PROM, EPROM) However, it is erased whenever electrical power is turned off.

ROM- (Read Only Memory) preprogrammed, unchangeable memory.

Software- programs or instructions that the machine will execute,

B1 - low true WAIT When pulled low by a system board, causes processor clock to slow down to speed of approximately 500KHz on most processor boards. This is used to service slow memory and I/O devices.

B2 - NMI (non-maskable interrupt) When brought low, a non-blockable interrupt occurs, causing the processor to stop its operation and service this interrupt, that is, go to a specific memory location and start executing an interrupt service routine.

B3 - IRQ (interrupt request) An interrupt which can be masked by the processor, that is, the processor can choose to ignore this interrupt under program control. If the interrupt is not masked, it will cause the processor to stop executing the program it is in, and jump to a different location.

B4 - DD (data direction) When pulled low by system board, it changes the direction of the 8T26 buffers on the CPU board, and thus switches the processor from outputing data to the bus to listening to the bus.

B5 - D0
B6 - D1
B7 - D2
B8 - D3
B9 - D4
B10 - D5
B11 - D6
B12 - D7

Bi-directional eight-bit wide data bus for communication of data between the processor and system boards.

B13
B14
B15
B16

Upper data bits on some systems

B17 Optional reset line used to clear all PIAs and similar I/O circuitry in the system.

B18 spare line

B19
B20
B21
B22

Memory management address lines: Lines 21 and 22 are used on systems with a 500 CPU Board; all 4 are used with the 510.

B23 +12 Power connection

B24 -9 Power connection

B25
B26

+5 Power connection

B27
B28

Ground Connection

B29 - A6
B30 - A7
B31 - A5
B32 - A8
B33 - A9
B34 - A1
B35 - A2
B36 - A3
B37 - A4
B38 - A0

Ten low-order address lines

B39 - Ø2 Used to clock external circuits or external I/O interfaces, such as the A/D converter.

B40 - R/W (read/write) Originates at the microprocessor and specifies read or write operations on the data bus.

B41 - VMA (valid memory address) Only used in conjunction with the 6800 microcomputers. The 6502s always have this line high.
B42 - Ø2•VMA Master timing signal for enabling memory and I/O in the system.
B43 - A10
B44 - A11
B45 - A12
B46 - A13
B47 - A14
B48 - A15
} Six high-order address lines

Ohio Scientific offers a full family of boards which conform to its 48-line system bus. These boards are as follows:

500 CPU Board 6502 microprocessor, provisions for 8K ROM, 4K RAM, serial interface, optional parallel interface. Operates as stand-alone computer equivalent to 12K system, or as a CPU Board in a larger system.

510 CPU Board 6502, Z-80, 6800 microprocessors, including serial and parallel ports, and PROM Monitors. Designed for use with disk and external RAM.

RAM Boards
1) 420 (4K x 8 or 4K x 12) 2102-type
2) 520 (16K)
One RAM board is being developed with 65K dynamic memory.

EPROM Boards
1) 450 with 8K of 512-word EPROMs, with on-board programmer
2) 455 with 4K of 1702 devices.

I/O Boards
1) 430 with audio cassette interface, two D/A converters and A/D converters; can be selectively populated just for audio cassette.
2) 440 video graphics, providing inexpensive video display interface and keyboard port which can be optionally populated for graphics.
3) 470 floppy disk controller board
4) line-printer interface (Centronixs compatible)
5) multiple-port serial interface board.

Ohio Scientific also offers building blocks for multiprocessing, such as our highly advanced 560Z multiprocessor board, which allows multiple CPUs to be connected together, operating simultaneously. This CPU board must work in conjunction with a 6502-based CPU and has a Z-80 and/or a 6800 microprocessor on it. It can also be selectively populated as a porthole to connect two or more standard OSI systems together. Consult our most recent catalogs for details on OSI accessory boards and OSI peripherals and software.

b-Part 2 Bringing up the computer

The first major step in your relationship with the computer is to bring your computer system to the point where you can communicate with it in its fundamental machine language or monitor program.

With a 500 Board & Super-Kit, it will be necessary for you to supply your own power supply along with your own terminal. On other systems, it will only be necessary for you to provide a terminal or a keyboard and video display which you may have optionally purchased from Ohio Scientific.

The following discussion is for owners of 500 Boards and Super Kits only and concerns power supply specifications.

500 Board and Super-Kit Power Supply Connections

Diagram 1. shows the right side of the Model 500 Board and gives information concerning power requirements and connections for bus lines 24, 25, and 27. This bus line orientation is the same as the bus discussion on page B-3. On 500 Board systems, it will be necessary for you to connect well regulated power supplies directly to the PC board via a mating Molex male connector or by direct solder connections. The power supplies utilized should be well regulated and, preferably, should have both overcurrent and over voltage foldback regulation. The -9 volts ground and the +5V power supply's ground should both be connected to B_{27}. Be sure to use 16 gauge or heavier wire on the +5V power supply. Also make sure that the power supplies come up nearly together and go down together, that is, neither power supply voltage should be present for extended periods of time without the other power supply voltage. On Super-Kits, it will be necessary for you to plug the 500 PC Board into the backplane, usually at slot 1 and the 440 video board at some other slot in the computer. Power connections are usually made directly to the backplane board in the same fashion.

-9V to B_{24}
+5V to B_{25}
Ground to B_{27}

For Super Kits, the +5V power consumption can be nearly 3amps. It must be stressed again that it is EXTREMELY IMPORTANT THAT YOU USE WELL-REGULATED, HIGH-QUALITY POWER SUPPLIES. This will minimize the possibility of damaging any of the expensive computer circuitry in case of a malfunction.

Interfacing the Control Console

There are two basic types of computer terminals utilized for communications with the machine. One type is a serial terminal. Examples of serial terminals are the popular ASR-33 Teletype, CRT terminals such as the Lear Siegler ADM-3 or the Hazeltine 1500, and the DEC Writer LA-30. These devices communicate with the computer over a serial interface which is usually composed of three or four signal lines. Fairly elaborate interface circuitry is present at both the computer and the terminal to facilitate interface via a few lines. There are two basic types of serial interface; The RS-232C interface specification and the 20ma current loop specification. CRT terminals usually are configured for RS-232C whereas the Teletype and many DEC-Writers are configured for 20ma current loop. Additionally, terminals come at different print-out or baud rates. Baud rates on terminals can vary from a slow 110 baud to 19,200 baud.

The other general class of computer interface is a video interface. This type of configuration has most of the terminal electronics built into the computer in the form of a video display board such as the Ohio Scientific Model 440B Video Display. It is simply necessary for the user to provide an ASCII parallel keyboard and a video monitor or closed circuit television for operation. The Model 500, Model 500-1, Challenger IIS, and the Challenger III utilize serial interfaces. The Challenger IIP, the Super-Kit, and the Challenger IIV utilize video interfaces. Please refer to the paragraph which discusses your particular computer's interface requirements.

Model 500 Board and Challenger IIS Serial Interface Instructions

These computers are capable of operating under RS-232 or 20ma current loop at 110, 300, 1200, 2400, or 4800 baud. If you specified the baud rate and configuration when you ordered the system from the factory, it should be configured as you requested. If you did not request a specific configuration, it will usually be delivered configured for RS-232 at 300 baud. The first step on your part is to find out which serial interface configuration, that is, RS-232 or 20ma current loop, your terminal requires and the baud rate it requires. Whenever you have a choice, as you usually do on CRT terminals, choose RS-232. We recommend a baud rate of 2400. Please refer to Diagram 2 which shows the upper left hand corner of the 500 Board in conjunction with the following discussions.

Serial interface connections are via the auxilary connector along the top of the board. A Molex male connector has been provided to allow you to solder your own wiring to this connector. On the Model 500 Board, it will also be necessary for you to provide a momentary-action normally open reset switch to pin 2 and pin 3. This will be your system reset switch. Pins 6, 7, and 8 are for RS-232C. Pins 9 through 12 are for 20ma current loop. Only one configuration can be used at a time. The socket directly below the 6850 ACIA can be jumpered for either 20ma current loop or RS-232C. Contrary to the diagram, it may come from the factory jumpered for either 20ma current loop or RS-232. Inspect the PC board and, if it is not as desired, change it so that for 20ma current loop, pin 1 is jumpered to pin 15 of the socket. For RS-232, pin 2 is jumpered to pin 15 of the socket.

Note: All Challenger Systems require that their serial terminals be configured for full duplex operation with 8 bits, no parity, and two stop bits.

On power-up it is possible to change the number of stop bits and parity under software control once the system is up and running by changing the ACIA status word.

RS-232 Interfacing :

The most common RS-232 interfacing technique is via the EIA standard 25 pin Cannon connector. Refer to Table 1 for hookup connections to be compatible with this connector.

20ma Current loops:

The 20ma current loop of the Challenger Systems is configured specifically for the ASR-33 Teletype which has four separate lines for interfacing. The Challenger 20ma current loop is an active loop which requires separate current returns for both receiver and transmitter, that is, it can not be operated in the three-wire mode. It is extremely important that the user insure that

his terminal is fully passive, that is, that the terminal does not provide the current source for the loops. Several Teletypes with modems have a high voltage current source present in them which would destroy the current loop interface in the Challenger if connected. Be sure that your 20ma current loop device is configured to be passive. Refer to Table 1 for 20ma interface connections and the pictorial connections for Teletypes in Diagram 3. Once you have completed and double-checked the interface to your terminal, proceed with the system check-out using the 65A PROM Monitor on page B-14.

Model 500-1 Interfacing

The Model 500-1 comes equipped with EIA standard connectors for interfacing to RS-232 and 20ma loop terminals and modems. Please refer to the interfacing of the Model 500 CPU Board for information on converting your unit back and forth between 20ma current loop and RS-232 and setting the baud rate. Refer to Table 1 for EIA pin-outs. The Model 500-1 also has an additional modem connector. Its pin-out is the same as the terminal. The unit is wired such that the rotary switch which turns the power on and off also connects the modem connector to the terminal connector when power is off and disconnects the terminal from the modem when the power is on and connects it to the CPU Board. In this way, an RS-232C modem can be connected to the modem connector and utilized in loop-through operation when the terminal is off. When the terminal is turned on, the modem is out of the circuit, and the terminal talks to the computer. Be very careful when interfacing the modem and terminal to the 500-1. There are many problems and pitfalls that can occur. For instance, the modem and terminal may be set up with handshaking such as terminal ready and data carrier detect signals. These lines must be bypassed in order for the unit to operate. Also, be very careful not to utilize a 20ma configuration where the terminal is providing the current source or where the modem is providing a high compliance voltage on its current source, such as 70 volts. When in doubt, be sure to have your local Ohio Scientific dealer review your interface before applying power. Do not attempt to utilize the modem for which you do not have complete documentation. In any case, before connecting the modem, first verify use of the computer in conjunction with the serial terminal. This can be accomplished by proceeding to Section B on system check-out with the 65A monitor on page B-14.

Challenger III Serial Interfacing

The Challenger III uses a Model 510 CPU Board which is capable of 20ma current loop and RS-232 interfaces at 110 to 19,200 baud. The 110 baud clock is a continuously adjustable 555 unit. All other baud rates are crystal controlled and do not require any adjustment. Refer to Diagram 5 concerning these details. The serial interface is accomplished by the auxiliary connector at the top of the board. Pins 6, 7, and 8 provide RS-232 signals while pins 9 through 12 provide 20ma current loops. Refer to Table 1 for exact pin-outs in conjunction with this system. If the configuration was specified at the time of order, the unit will generally be configured as specified when delivered. If nothing was specified, the unit will typically be configured for RS-232 at 2400 baud upon delivery. It is recommended that you use RS-232 interfacing whenever possible and we recommend a baud rate of 2400. RS-232 or 20ma current loop can be specified by jumpers directly above the 555 IC. By jumpering the center donut to the right donut, we set it up for RS-232. By jumpering the center donut to the left donut, we set it up for 20ma current loop. The baud rate is then selected by jumpering the receiver and transmitter clock to the desired baud rate donut. When 110 baud is jumpered,

it may be necessary to provide fine adjustment which will be discussed later. The 20ma current loop of this circuit is designed specifically for Teletype operation; that is, it is a four-wire system which does not have a common return. Be sure that the 20ma current loop terminal you are using is passive, that is, that it does not provide the current source for the system. Specific connections to Teletype are shown in Diagram 2. To check out your system, refer to the section on check-out with the 65A PROM Monitor on page B-14.

Video Systems

Video interfacing is composed of two parts connecting the video display, and connecting the parallel keyboard. The Super-Kit, Challenger IIV, and Challenger IIP all utilize video interfaces. On the Super-Kit and Challenger IIV, the video interface is accomplished by a Model 440B Video Interface Board.

If you purchase an Ohio Scientific provided monitor, it is already properly set up for operation. It simply requires that you connect the phono plug from the monitor to the phono jack on your video board or Challenger IIP.

If you ordered your Challenger IIV System with a serial interface, your computer is configured with both the serial and parallel interface capability and both the 65A and 65V PROM Monitors. You can elect to bring your system up with either of these monitors by switching the slide switch on the CPU Board next to the auxiliary connector to the right or towards the backplane connectors for video output or to the left for serial operation. Simply follow the procedure given for serial or video in conjunction with the switch setting you have decided on. The video board option is also available on Challenger IIIs. The slide switch which allows you to select between video and serial monitor PROMs is located along the left edge of the board. Switching this switch up or towards the auxiliary connector, you will select the Serial PROM. By pushing it down, you will select the Video PROM. Simply follow the instructions for whichever power-up mode you have selected to bring your system up.

If your system utilizes a floppy disk, the operating system will allow you to freely switch back and forth between these two ports once the system has been brought in. However, one or the other will have to be utilized as system console at time of system power-up.

On a Challenger IIP, a special dedicated video interface is incorporated in the computer's circuit board. All three computers provide industry standard one volt peak to peak video output via an RCA phone jack. This jack is located on the 440 B video board in the Super-Kit and the Challenger IIV as shown in Diagram 6. It is the upper-most phono jack and is labeled "video out" on the Challenger IIP as shown in Diagram 4. The output of this phono jack can be directly connected to the input of any standard closed circuit video monitor such as those offered by Sanyo, GBC, Koyo, Panasonic, and others. The unit usually operates best when terminated by a high impedance load instead of a 75 ohm load. It may be necessary to provide some adjustments to the monitor, but, this will be discussed later. It is also possible to modify some conventional television sets to be closed circuit receivers by directly injecting video into one of the video amplifier stages. We do not recommend this modification unless you are highly qualified or well versed in television circuitry. It is extremely important that you do not attempt any such modifications on a non-isolated or "hot" chassis television set. Interconnection between any portion of a "hot" chasses television set and the computer will cause severe damage to the computer's video output display. Such damage is DEFINITELY NOT COVERED UNDER THE TERMS OF OUR WARRANTY. A third way to

provide a video display for 440B-based video boards is to construct and install an ATV Research Pixie Verter on the 440B Board. To accomplish this, you will need to purchase an ATV Research Pixie Verter in kit form and a 440B Video Board construction manual which outlines the exact details of installing the Pixie Verter. The installation of the Pixie Verter will allow use with an unmodified television set. In any case, do not attempt to power up your unit at this time, but, simply double check your interconnections and proceed to connecting the keyboard.

Keyboard Interconnections

The Challenger IIP has an internal keyboard which is already connected and requires no further attention. Simply proceed to the check-out procedure for 65V-based computer systems.

The Model 440 Boards provided in Super-Kits and Ohio Scientific Challenger IIVs are interfaced via a 16-pin socket directly above the phone plug on the video board as shown in Diagram 6 . The plug accepts a seven-bit input parallel ASCII keyboard with bit 0 being K10 and bit 6 being K16. The plug also has ground present on pin 7 and +5V present on pin 16. An important strobe signal must be provided at pin 9. The keyboard must be a positive, true logic parallel ASCII keyboard. It can have positive or negative continuous or pulsed strobes. If the unit has a positive going strobe, connect the jumper as shown. If it has a negative going strobe, connect the left-hand-most donut to the inverted strobe input. These three points are directly between the socket and the phono plug. If you purchase an Ohio Scientific keyboard, it is simply necessary for you to plug the keyboard in at this time. Ohio Scientific also often provides a four-foot interconnecting cable and adaptor PC board called an A-10 kit which allows you to conveniently fan out the wires from a ribbon cable to a card edge connector or point-to-point wiring. The diagram and pin-outs for the A-10 connector board are given on Diagram 6 and on Table 2. If your video board is equipped with the graphics option, that is, if the video board is connected to an auxiliary memory board via three ribbon cables, it is necessary for you to carefully read and follow the instructions in the special features section for video boards before proceeding. This is because the graphics option must be inhibited before the computer can be operated. The auxiliary line of ribbon cable connector can be used to provide -9 volts to keyboards which require a -9 volts.

There are quite a few keyboards on the market, particularly surplus, which utilize a General Instruments keyboard encoder chip and require -12 volts. These keyboards will generally not operate on -9 volts and will require an auxiliary power supply, power inverter, or batteries for operation. Once you have connected and checked over your video display interface, and your keyboard interface, you can proceed to actual power-up check out of your system by going through the section on the 65V PROM Monitor check-out on page B-10.

CHECKOUT WITH THE 65V PROM MONITOR

Once you have carefully checked out the interfacing between your video monitor and, optionally, your keyboard, connect the monitor and computer to a common grounded three-wire outlet in an area not susceptible to static discharges. Turn the monitor on and readjust it for a dark screen with mid-range contrast. Then momentarily turn the computer on. You should see a random field of alphabetic and numeric characters. Occasionally, the computer will automatically reset on power-up, causing the screen to go blank and display only a few characters. Turn the computer on and off a few times to assure a non-reset condition, or random field of characters. It will now probably be necessary to adjust horizontal and vertical hold to get a stable display of these characters. If you cannot obtain these results, refer to Section E.

On systems utilizing the 440B Video Board, it will probably be necessary for you to adjust your video display for underscanning to get at least 24 lines of 24 characters on the screen, the recommended minimum for use with Ohio Scientific software. These modifications should not be required on Challenger IIPs. The height of the television display can usually be adjusted by simply reducing the vertical height. Some sets have horizontal width. Other sets will require reduction in the power supply voltage by simply turning down the power supply adjustment. The centering rings on the back of the monitor's picture tube can then be used to recenter the display. Contrast and brightness controls can be adjusted to your liking. Once the video display has been set up at least to the point of legibility, depress the reset switch momentarily and release it. This is the BRK key on Challenger IIPs. On all systems equipped with BASIC in ROM, the message "C/W/M?" should appear in the lower left corner of the screen. On systems configured for disk, the message "D/M?" should appear in the upper left corner of the screen. On systems with neither of these features, four zeros followed by a space and two random hexadecimal digits should appear in the upper left corner of the screen. If the screen clears, but, only part of the display just described is present, you have quite possibly not underscanned the set adequately, or, it may be necessary for you to adjust the vertical and horizontal controls to bring this portion of the display onto the screen. Once you have obtained this message on the screen, type an "M" on the keyboard which will put you in the Monitor Command Mode. At this time, you should see four zeros followed by a space and two random hexadecimal digits in the upper left portion of the screen.

Now, following the instructions for the OS-65V PROM Monitor, you should be able to change data and enter the short demonstration program on your system.

If you wish to become more familiar with the machine language programming for your system, refer to the MOS Technology 6502 Programming Manual, Ohio Scientific's Small Systems Journal, and Ohio Scientific's Model 300 Computer Trainer Manual which provides twenty experiments for self-taught machine code on any 6502 system. The manual is directly available from Ohio Scientific for $10.00 postpaid.

Once you have become somewhat familiar with the operation of the 65V PROM Monitor, proceed to Section C.

65V PROM MONITOR

INSTRUCTIONS

Anyone wishing to become proficient in programming at the machine language level should be well acquainted with the PROM Monitor which is necessary to examine and change the contents of memory locations. The Monitor used in conjunction with the 6502 video system is the OSI 65V PROM Monitor.

As explained above, OSI's 8K BASIC comes up when the computer is reset. When this is done, the letters "C/W/M?" or "D/M?" appear on the video screen or terminal. If you wish to enter a program by means of the Monitor instead of BASIC, type an "M" on the keyboard. This brings up the Monitor and starts it in the Address Mode, that is, the mode in which you can specify memory addresses or locations to simply examine their contents. Appearing on the screen are four digits in hexadecimal notation followed by two spaces and, finally, another two digit number, also in hex. The four digit number is a location, and the two digits are the contents of that location. To examine another address, type the address on the keyboard. The same address will appear on the terminal, as will the corresponding contents of that address.

If you wish to change those contents and thus enter programs using the Monitor, you must exit the Address Mode and get into the Data Mode. To do this, type a slash (/). Then type any two hex characters, and they will be inserted into that location as its new contents. The normal procedure for entering programs via the Monitor is to use consecutive memory locations. While still in the Data Mode, you can open the next address by typing the return key. You can do this continually, each time altering the memory contents according to the needs of the program you are writing. If you want to jump to a non-consecutive location, you need to get back into the Addressing Mode by typing a period (.). Then type the new address you want. Type another slash to get back into the Data Mode and continue as before until you want to open a non-consecutive address. Extreme caution should be used whenever the Monitor is in the Data Mode as you are directly manipulating the computer's memory.

If you wish to enter a program from an audio cassette instead of manually from the keyboard, first get into the Address Mode, then turn on the cassette. Let the tape advance to the point where the program of interest begins, and type L. This transfers control to the audio cassette, such that all ASCII commands are supplied by the cassette instead of by the keyboard. The L command also puts the Monitor into the Data Mode. If the contents of ØØFB are ØØ, the Monitor will accept commands from the keyboard.

If the cassette does not load ØØFB (hex) with ØØ, to transfer control back to the keyboard, press reset. Otherwise, commands are accepted from the Audio Cassette UART.

To run any program which you have entered via the Monitor, get into the Address Mode, i.e., type a period, type the starting address of the program, and type a "G."

Label	Program Entry Points
VM	FE00 - Restart Location FE0C - Bypasses UART and Stack Pointer initialization and the clearing of decimal mode but does clear the screen.
IN	FE43 - Entry into address mode, bypass initialization
INNER	FE77 - Entry into data mode, bypass initialization
Label	**Subroutines**
OTHER	FE80 - Input an ASCII character from Audio Cassette UART
LEGAL	FE93 - Returns stripped ASCII number if 0-9 or A-F. Otherwise returns a FF.
INPUT	FEED - Input an ASCII character from keyboard

Required Hardware

The 65V Monitor requires as a minimum the following hardware: an OSI Model 400 board with a 6502 microprocessor, 1,024 words of RAM memory located from ØØØØ to Ø3FF, and the 65V monitor itself. It also requires an OSI Model 440 Board populated for alphabetic display and keyboard input. The 440 Video Board must be located at DXXX which will automatically locate the keyboard input at DFXX.

The keyboard must be a seven-bit high true ASCII keyboard with a positive or negative going strobe pulse at least 100 microseconds long.

The 65V Monitor will additionally support input from a generalized serial communications subsystem of an OSI 430 board located at FBXX. Specifically, the monitor contains a load program for a 430 board-based audio cassette interface. The same program can be used with a 430 board configured for digital cassette or ASCII teletype input.

Commands

Address Mode Commands:
/ - Change to Data Mode
G - Go -- Jump to location seen on screen and execute program found there.
L - Transfer control to audio cassette.

Data Mode Commands:
. - Change to Address Mode
RETURN - Open next address. In other words, increment location pointer by 1.

If the 65V is in address mode, typing 0 - 9 or A - F will cause that number to be rotated into the LSD of the location pointer. Typing a 4 causes 0123 XX to become 1234 XX.

If it is in Data Mode, the number is rotated into the data contents and memory is thus modified. This permits the easy correction of errors. If, for example, the user typed 0478 when intending to look at location 047B, he would simply type 047B.

All of the non-command keys and non-hexadecimal characters are ignored by the monitor.

65V Demonstration Program

The following is a program which may be entered using the 65V Monitor from the keyboard or audio cassette. An "*" indicates a return key depression.

.0002 Loads the ASCII Message Starting at Location 0002
/4F * 53 * 49 * 20 * 36 * 35 * 56 * 2E * 5F

.0200 Loads the Main Program at 0200
/ A9 * 02 * A2 * 00 * 20 * 00 * 03 * A2 * 00 * 20 * ED * FE * 9D * 24 * D2 * E8 * 4C * 09 * 02

.0300 Loads the Subroutine at 0300 to Output an ASCII Character String.
/85 * 00 * A9 * 00 * 85 * 01 * A0 * 00 * B1 * 00 * C9 * 5F * F0 * 0A * 9D * E4 * D1 * E8 * E6 * 00 * D0 * F2 * E6 * 01 * 60

.0200G Loads the Starting Address of the Program and Execute it.

You should see the message "OSI 65V." on the screen. Now, you may type any keys and they will be echoed just below the message. Press reset to re-enter the 65V Monitor.

If this were entered off of the audio cassette, it would be self-loading and auto starting. Since the cassette is in complete control, it can load the starting address and execute the program without user interruption.

On serial-based systems, once you are confident that you have interfaced the computer correctly, plug in both the terminal and the computer to a common grounded three-wire outlet. It is also recommended that you do not operate the system in areas which produce high static discharges.

First turn on the terminal and allow it to warm up. Then turn on the computer. On Model 500-1, Challenger II and Challenger III, reset lights should glow rather brightly. If the light is very dim or does not come on, turn the unit off and proceed to Section E. On Challenger III systems with the manual processor select switch, be sure that the 6502 is selected by rotating the switch at the rear of the unit counter-clockwise. On systems where you are utilizing your own power supply, monitor the -9V and +5V together with a voltmeter. If the voltage is not 14V, turn the power off and proceed to Section E.

Next, quickly depress the reset switch. On all Challenger systems equipped with ROM BASIC, the message "C/W/M?" should be printed out. On systems configured for use with the floppy disk, "D/M?" should be printed out. On older Challenger configurations, a simple carriage return-line feed will be put out. Occasionally, on the first reset operation under power-up, one or more of the characters may be mistyped due to warm-up. In any case, repeat the reset procedure three or four times and observe the output on the screen. If you are not getting the proper message, but are getting a somewhat garbled message of approximately the same length and characters, your baud rate is probably misadjusted. On systems using the 500 Board or on Challenger IIIs (110 baud), it is necessary to fine-adjust the baud rate. A rough adjustment of the baud rate can be made by rocking the pot back and forth over its range and resetting the computer until you get the desired output. If you are not qualified or experienced in electronic servicing, you should not attempt this procedure with power applied. Simply turn the computer off, remove the cover, adjust the potentiometer, place the cover back on, and turn the computer back on (reset) until you get the proper message. If it is not possible to get the proper output with this procedure, refer to Section E.

Once you have obtained the proper output message, type M. This will place you in the 65A Monitor. Then type PØØØØ. The computer should now start listing memory incolumns of eight hex bytes, or 16 hex characters with spaces between characters, i.e., 0-9 and A-F, with even spacing between characters. If there are any illegal characters or uneven spaces, then your baud rate requires fine tuning. This can be accomplished by moving the potentiometer baud rate pot adjustment clockwise until it provides a large number of errors, and then rocking the back to the right until it provides a large number of errors, and then setting the pot in the middle of its range, thus fine-tuning the baud rate.

Next proceed to the 65A PROM Monitor instructions and execute the sample program. You may or may not desire to become familiar with the machine language operation of the computer. If you do, refer to the MOS Technology Programming Manual which provides an excellent discussion of machine language programming of the computer and, also, to the Ohio Scientific Small Systems Journal which occasionally provides short routines which can be entered directly in machine code. Another excellent introductory source for machine language programming is Ohio Scientific's Model 300 Computer Trainer Manual. This manual provides twenty experiments on the 6502-based Model 300 Computer Trainer, but, these experiments can also be executed on any Challenger system. The manual can be ordered directly from Ohio Scientific for ten dollars postpaid. Once you are satisfied with your familiarity with the 65A Monitor, proceed to Section C.

65A PROM MONITOR
INSTRUCTIONS

The 65A PROM Monitor is used with 6502 serial systems by the programmer who wishes to write at the machine language level. When the reset button is pressed, the letters D/M? or C/W/M? may appear on the screen. To get into the monitor, type an M on the keyboard (D is used only in conjunction with the diskette, which contains BASIC). While using the Monitor program, you can directly manipulate the computer's memory, and write programs using the computer's own language.

First of all, to examine memory locations before changing them, type a P, then the initial location in the block of addresses you wish to inspect. When you do this, the contents of that block will scroll up the screen. You may halt this scrolling by typing any key on the keyboard.

To change memory contents, type an R to return to the Command Mode. Then type an L, together with the location whose contents you wish to change, then an optional space for clarity, followed by the "new" contents which you select. If you are altering the contents of consecutive addresses, simply type the new contents one after the other. You may type spaces, carriage returns, and line feeds between these contents if you wish to make it more legible, but this is not necessary. In any case, the next successive address in memory is opened with each set of contents you type. If the next location you wish is not immediately consecutive, type R to get back into the Command Mode, then type L and the new address, plus the contents you wish to place there. Continue typing new contents if you are changing those of consecutive addresses, otherwise type R, then L, and so on.

To verify any changes you have made, use the P command to examine memory blocks as explained above.

While you are using the L command, the Monitor ignores all non-hexadecimal characters except R. When you use the P command, the monitor inserts spaces, carriage returns, line feeds and nulls.

The fourth command available when using the 65A Monitor is the G command which is used to run programs. This will be illustrated in the sample program below. Some of the following subroutines are used in the course of the program.

Subroutines

FE00	INCH (input character and echo)
FE0B	OUTCH (output character)
FE35	CONTROL (Note: FE40 will bypass ACIA initialization)
FE77	LOAD
FE8D	PRINT
FEC7	BUILD ADDRESS (constructs an address from input at 00FC [low] and 00FD [high])

Go and Breakpoint Locations

0129	Index Register Y
012A	Index Register X
012B	Accumulator
012C	Status Register
012D	Stack Pointer
012E	Program Counter High
012F	Program Counter Low

Vectors:

NMI	0130
RESET	FE35
IRQ	01C0

Sample program to illustrate OSI 65A Monitor

This program prints in double any character you type on the keyboard. Beginning at location 0200, the program would look as follows in user source code:

```
10*=$200
20 JSR INCH
30 JSR OUTCH
40 JMP $200
```

The assembled version of this short program would look as follows:

```
10 0200          *=$200
20 0200 2000FE   JSR INCH
30 0203 200BFE   JSR OUTCH
40 0206 4C0002   JMP $200
```

These lines are interpreted as follows:

Line 10: initialization of program counter

Line 20: actual program begins at given initialization point (0200); 20 is the ASCII code representation for JSR; 00 is the low address byte of INCH; FE is its high address byte.

Line 30: since three bytes have been used since program initialization, we are now at location 0203; 20 is ASCII for JSR; 0B is low address byte for OUTCH; FE is its high address byte.

Line 40: as this is the sixth byte since program initialization, we are at location 0206; 4C is the ASCII code for JMP; 00 is the low address byte for location 0200; and 02 is its high byte.

The bytes in this program are all to occupy consecutive memory locations. Therefore, only one L command will be necessary while we are in the Monitor, until we are ready to run the program. To enter it, engage in the following dialogue with the computer: press reset (your responses are underlined).

```
D/M? M
L0200 2000FE 200BFE 4C0002R
```

To verify that these contents truly are loaded into memory, type: P0200
The contents of all the addresses beginning with location 0200 will immediately scroll up the screen. To stop the scrolling, type any key and examine the contents displayed on the screen. Then type R to get back into Command Mode.

To run the program, you need to set the stack pointer (located at address 012D) to 28, and the program counter high (012E) at 02 and low (012F) at 00, because the starting address is 0200. Since these locations are consecutive, you need only type : L012D280200R
To execute the program, type G
Then any character you type will appear in duplicate on the screen.

C-Part 1 Bringing up BASIC

Once you have dabbled a little with machine language programming, you will be eager to get on with full BASIC. If your machine is equipped with BASIC in ROM, it will not be necessary to connect any additional devices to get to BASIC. Simply reset the computer and type "C" in response to "C/W/M?" The computer then asks "MEMORY SIZE?". Reply with a carriage return. The machine then asks "TERMINAL WIDTH?" to which you may also reply with a carriage return. The BASIC prompter, "OK" will then come up indicating that BASIC is directly accessible. You can then proceed to the BASIC sample program in this section and the BASIC Operating Manual attached to the end of this manual. You may then wish to connect an audio cassette interface, if one is present in your system.

If your computer is configured for floppy disk, it will be necessary to connect a disk drive before you can bring BASIC in. The computer must have at least 16K RAM, floppy disk bootstrap PROM (indicated by the message 'D/M?" when the computer is reset), and a 475 floppy disk controller board present in the computer. When the floppy disk controller board is present in the computer, it is usually the rear-most board in the computer system. With the computer turned off, connect the ribbon cable coming out of the rear of the floppy disk drive in one of the openings in the rear of the Challenger and mate it with one of the connectors coming out of the back of the 470 Board. This should be accomplished such that the ribbon cable falls into the case instead of sticking up out of it. The boards should be mated tightly together and the connector should be backed off about 1/8" to preclude the possibility of the Molex pins touching the PC board foils on the A-12 adaptor board of the cable. That is, you should be sure that the Molex pins on the 470 Board are not touching the A-12 adaptor cable board. Then make sure that all parts of the computer are plugged into a common three wire grounded outlet or distributor box on one circuit. Then power up the floppy disk drive. Place a diskette with OS-65D in the upper disk drive with the label side up and the notched side in first. Follow the dialog and procedures on pages 1-4 of the OS-65D Version 2.0 Manual. After you have obtained the BASIC prompter "OK", proceed with the example in this manual, if desired.

If your system is equipped with neither the floppy disk nor BASIC in ROM, you must load BASIC via paper tape or audio cassette. You must have at least 12K memory to do so. Paper tape versions of BASIC are specifically designed for use with Teletypes while the audio cassette version is for use strictly with video-based computer systems. Follow the instructions at the end of the 8K BASIC on paper tape. Follow the instructions included here on the use of Auto-Load^{tm} audio cassettes, and then proceed to the instructions for loading 8K BASIC audio cassettes at the end of the 8K BASIC User's Manual. This procedure is only necessary if you do not have BASIC in ROM or disk BASIC.

c-Part 2
INTRODUCTION TO SMALL COMPUTER SOFTWARE

In order for a computer to perform even simple operations, it obviously needs a means by which the user can communicate instructions to it. Any such means which consists of a set of rules to convey information, is called a computer language. The numerous languages in use today offer a wide range of specific applications and varying degrees of understandability for the user. They can provide direct communication with the computer at the complex level of machine language, or enable the programmer to use an indirect communication by means of a higher level language which corresponds more closely to human speech.

Machine level languages are really the most practical device from the computer's point of view, because when you use them, you are really speaking the computer's own jargon, and are thus making more efficient use of memory space. On the other hand, when you use an upper level language, every instruction you give, in what resembles "plain English", has to be converted into one or more separate instructions in a machine level language. Therefore it is obviously less wasteful in terms of time and effort to write in machine language, and skip translations from other languages altogether. The major drawback in machine languages, however, is that they are difficult for the average person to learn.

Machine languages consist of binary codes used in all of the commands which are entered by the programmer. These codes are 8-bit groups of on-or-off switches, which in various combinations, serve as instructions for the computer. Although the majority of users will have no need or desire to learn these combinations, there are some who, for one reason or another, will want to program their computer directly. Since it is quite troublesome to commit several dozen combinations of numbers to memory, a system of abbreviations (mnemonics) has been devised which exactly correspond to machine language instructions. The program which converts these mnemonics into machine language is called an Assembler. By following the instructions provided with your computer, you can make use of the Assembler and write a program in mnemonic code. This is directly translated into the binary object code which the machine understands. After you gain proficiency, you can even begin to use the actual object code to do your programming, examine and change memory locations, etc., and thus be in ever greater control of your machine.

Upper level languages, in contrast to machine level languages, are much easier for humans to master. Nevertheless, every upper level language has to originate at the machine language stage, and usually represents a long, tedious effort on the part of the author or authors of that language. Probably the most common upper level language is BASIC (Beginner's All-Purpose Symbolic Instruction Code). An 8K version of BASIC written by Microsoft, Inc. (i.e., it occupies 8×2^{10} locations in memory) is used in all of OSI's 6502 computers. Because of BASIC's popularity, simplicity, and versatility, OSI has made it a standard feature in its product line, either by placing it in a computer's permanent memory (also known as Read Only Memory [ROM], which does not "forget" once the power is turned off), or by reserving special tracks for it on floppy or hard disks. In addition, in OSI products, BASIC is always immediately available to use, because it comes up automatically the instant the computer is reset. Therefore, the programmer is free of the burden of manually bringing in BASIC, which would demand that he be thoroughly versed in the computer's internal thinking processes and machine language. The fact that BASIC comes up automatically is very convenient for computer programmers, most of whom probably have programs they would like to run or write in BASIC.

There are a large number of publications available which describe in detail the commands and functions of BASIC. While this introduction can in no way duplicate

such excellent manuals as Schmidt's outline series Programming with BASIC (McGraw-Hill), it can at least give you some insight into the method for writing your own programs in BASIC.

Refer to the instructions provided with your individual unit to bring up BASIC in the OSI Challenger. Establish the memory size and terminal width for your particular program. When you see an OK appear on your video monitor or terminal, the computer is ready to start accepting BASIC commands from the keyboard.

Every statement in your program must begin with a statement number. These need not be typed in numerical order, since the computer will automatically rearrange them according to statement number when you have finished typing the program. But they must be numbered in the same order in which they are to be run. In OSI's 8K BASIC for the 6502, a variable can consist of one or two characters. If longer variables are to be used, BASIC will recognize only the first two characters. The first character in a variable must be alphabetic. The second character, if present, may be either alphabetic or numeric. Functions, commands, etc., already used by BASIC must not be employed as variables. In order to set a variable equal to a desired value, e.g., Z equal to 10, you use the LET statement, as follows:

```
(line number ⟶) 20 LET Z=10
```

Since LET is optional in OSI's 8K BASIC, you may also type:

```
20 Z=10
```

You may wish the value of the variable to change each time you run the program, without having to rewrite the whole program every time. To take advantage of the option to alter the values of variables, you make use of the INPUT statement, for example, as follows:

```
10 INPUT A,B,C
20 LET X=A
30 LET Y=B+C
```

In this way you can cause X and Y to take different values each time the program is run. Later, when you do run the program, you will see a ? on the terminal. You then type the values for A,B, and C which are relevant to the particular program. If there are no other INPUT statements in the program, it will begin to run immediately with the values you have entered, unless some built-in control prevents this. If the program contains additional INPUT statements, BASIC will keep asking you (by means of a ?) to input whatever data it needs to run the program, until each INPUT statement has been answered.

It can be that a variable has a value which is to change at a regular rate during the course of a single program run. This will require you to set up a loop which makes calculations using these increasing or decreasing values each time a new value is employed. For this you need to use a FOR-NEXT loop. This loop begins with a FOR statement and ends with a NEXT statement. The FOR statement identifies the initial and final values of the variable in question, and includes the constant amount of increase or decrease:

```
100 FOR Z=10 to 20 STEP 3
110 LET A=Z+(2*4)
120 NEXT Z
130 (resumption of program)
```

Step 3 means an increment of 3 upon each pass through the loop. Therefore, the above FOR-NEXT loop will be run four times, namely, when Z=10,13,16, and 19. When the value of Z exceeds 20, BASIC resumes the program by going to the first statement following the FOR-NEXT loop. In addition to signifying the end of the loop, the NEXT statement also contains the variable identifying which loop it terminates. As you may later discover, this is most useful in nesting one loop inside another.

Sometimes you will want the program statements to be run in a different order, if a certain condition is met. In order to change the order of execution, you may use the IF . . . GOTO statement, for example,

```
100 IF X=10 GOTO 150
110 (another program line)
140 (another program line)
150 LET Y=X+5
```

Here, the IF . . . GOTO diverts execution to a non-consecutive statement, line 150, omitting lines 110 and 140, provided only that the value of X is equal to 10. If X is not equal to 10, the program would resume with line 110. A simple GOTO command may also be employed without an accompanying IF, if no condition must first be met.

An IF . . . THEN statement is used to jump to a statement other than the one directly following. It can also be used to issue any other statement allowed in BASIC. For example,

```
100 IF X>10 THEN PRINT "X IS GREATER THAN 10."
```

This will cause the terminal to display X IS GREATER THAN 10 only if X>10. The program will then proceed as normal, with the next consecutive line. If X≤10, the program will, of course, proceed as normal, ignoring the PRINT command.

A PRINT statement will cause the terminal to display whatever follows. If you type:

```
100 PRINT A
```

the value of some previously defined variable A will be printed. If you type:

```
100 PRINT "A"
```

the simple letter A will be printed.

The END statement terminates the program and allows you to run the program, change it, or start to write a new program. As in the case of the LET statement, the END statement is optional in OSI's 8K BASIC.

If you want to erase a program and start a new one, simply type NEW and enter your next program.

BASIC is provided with a large number of mathematical functions, such as sine [SIN(X)], square root [SQR(X)], and absolute value [ABS(X)]. These functions automatically cause the computer to calculate the pertinent value without figuring by the user. For example, in the following statements:

```
100 X=121
110 PRINT SQR(X)
```

the value of the square root of 121 will appear on the terminal when the program is run.

At any time while entering your program, or after you have finished entering it, you can list all the statements up to that point by typing LIST. You can thus list the whole program, or by typing a specific line number after LIST, such as LIST 140, you can display just the one line. If you desire to see a certain block of program lines only, then you can specify the desired range, such as:

```
LIST 100 TO 200
```

If you want to correct a line previously typed, simply type the correction, using the same line number. It is recommended that you number the program statements by jumps of 10 rather than consecutively, so that you can later easily insert additional lines if you wish. To do this, type a line number which falls between the interval where you want the new statement to appear, and add the missing line. If you want to delete a line, simply type the line number, then ⟨return⟩. By using the LIST command, you can easily verify any changes you have made. This will cause every program line to scroll up the terminal, with each line number in consecutive order. If you want to stop the scrolling, type Control-C, examine the listing to your satisfaction, then type CONT (=continue), after you see BREAK IN LINE XX on the terminal.

The following example gives an illustration of editing procedures: Suppose you want to modify the following statements:

```
 90 INPUT A
100 LET X=2*A
110 PRINT "THIS IS A PROGRAM."
120 PRINT "EXAMPLE"
```

If you want to insert a line Y=A between lines 90 and 100, you could, at this point, type:

```
91 LET Y=A
```

If you want to delete line 110, simply type 110, then ⟨return⟩. If you want line 100 to read LET X=3*A, simply type the correction, using the same line number. At any time you could confirm the alteration by typing LIST.

Following these corrections, if you are ready to run the program, type RUN ⟨return⟩. If your program contains any INPUT statements, you will now see a ? on the terminal. Type in the data desired, as explained above, and the program will run. Following program execution, you can start over again by typing RUN, or enter a new program by typing NEW.

The following sample program demonstrates the INPUT, LET, PRINT, GOTO, and END statements, the FOR-NEXT loop, and the IF . . . GOTO command, as well as the SQR function.

Problem: Print the square root of a number; increase the number by five six times, and each time print the square root. If the largest square root is less than twice the first square root, indicate this. Otherwise, indicate only the fact that the program prints square roots.

After the programmer has typed the above program in BASIC, he will see an OK on the screen, signifying that the computer is ready for the next command from the user. If he wants to run the program, he types RUN. The computer will show a ? on the terminal. The user types on the keyboard that number with which he wants to begin the program. The six values (with constant increments of 5, see line 40) will scroll up the screen, each accompanied by its square root. If by chance you have made an error in typing (not including improper spacing), you

will probably see an error message on the screen. If you do, simply edit the line containing the error, as explained above. You can always run the program again by typing RUN. Here are the lines of the program:

```
 10 INPUT A
 20 LET Y=SQR(A)
 30 LET Z=A+30
 40 FOR X=A TO Z STEP 5
 50 PRINT "THE SQUARE ROOT OF";X;"IS";SQR(X)
 60 PRINT
 70 NEXT X
 80 IF SQR(Z)<2*Y GOTO 110
 90 PRINT "THIS PROGRAM PRINTS SQUARE ROOTS."
100 GOTO 120
110 PRINT "THE LAST ROOT IS LESS THAN TWICE THE FIRST ROOT."
120 END
```

All of the special features of Ohio Scientific's 6502 8K BASIC are described in the OSI 8K BASIC Users Manual. For a more fundamental introduction into BASIC, refer to any of the following books:

Gottfried, B.S.: Programming with BASIC, Schaum's Outline Series, McGraw-Hill, New York, 1975.

Gottfried, B.S.: BASIC Programmer's Reference Guide, Quantum Publishers, New York, 1973.

Greunberger, F.: Computing with the BASIC Language, Canfield Press, San Francisco, 1969.

Kemeny, J.G. and T.E. Kurtz: BASIC Programming, 2nd ed., Wiley, New York, 1971.

audio cassette

The Challenger System offers two audio cassette interfaces: one is based on the popular 430B I/O board, the other is a special audio cassette interface which is a part of the Challenger IIP circuitry. Both of the interfaces are functionally equivalent and use the popular and ultra-reliable Kansas City Standard for Audio Cassette information storage technique. The interface requires the use of a medium quality audio cassette recorder such as the Panasonic RQ-309 and medium to high-quality audio cassettes. We recommend that you do not use audio cassettes longer than C-30s to minimize drag and speed variations. The connections between the recorder and the interface are simply interface output, microphone input, and interface input from cassette speaker output. These cables should be fabricated from standard shielded microphone cable.

On the Challenger IIP, two phono plugs are provided as shown in Diagram 4. The user must simply connect the cables from his recorder to these plugs to be up and running.

On systems with a 430B I/O Board, it will be necessary to connect to the included male Molex connector which mates with the 430B Board's output connectors. The connections are shown in Diagram 7. The audio cassette interface is supported by the 65V PROM Monitor, BASIC in ROM, and OS-65D Disk Operating System. That is, all three of these have cassette I/O capability.

The most popular use of the audio cassette interface is as program and data storage for BASIC in ROM computers. The audio cassette interface can be used with any Ohio Scientific BASIC in ROM computer which is either configured for video display or for serial output with a baud rate above 300 baud. The procedure for using the audio cassette interface in conjunction with an audio cassette to store a program in BASIC is as follows:

First of all, complete the program to your satisfaction in the BASIC's editor workspace.

Secondly, connect the audio cassette recorder, turn it on, place an erased or blank cassette in the unit.

Third, "SAVE", carriage return, and then list without carriage return. Turn the tape recorder on record with volume and tone set mid-range. Allow the tape to advance past the white leader. As soon as the recording tape is on the take-up reel, type carriage return. The program will then list out both the screen and the cassette recorder at 300 baud. When the listing is complete, turn off the tape recorder and type "LOAD", carriage return, and carriage return. This will turn off the cassette output and will return the display to full speed. To play a program back into the BASIC workspace, reset the computer or type "NEW", carriage return. This will empty the computer's workspace. Then type "LOAD", turn the cassette recorder on play, and as soon as the tape advances past the white leader, type carriage return.

As soon as the cassette encounters the program on the tape, it should start listing on the screen as it goes through the cassette. Be careful not to type any key after you type carriage return after the load since typing any key will automatically bring the machine out of cassette load. This is how you exit cassette loading mode. Once the program is complete, the program should be played back into the machine flawlessly and at the very end the tape will put out an "OK". "OK" will cause the BASIC interpreter in the machine to report a syntax (SN) error. This is the normal operation of the computer. Once the loading is complete, simply type any key on the keyboard such as an additional carriage return to exit cassette loading. Turn the cassette recorder off.

Data files can be conveniently stored and retrieved in sequential form on an audio cassette by the same technique since both the LOAD and SAVE commands can be used as part of the program. For normal operation, the cassette recorder would be set up and then a programmed SAVE instruction would be executed. The program would then list out the variables followed by carriage returns. Then, the program would have a LOAD instruction at the end to turn off cassette output. Later another program, or, the same program could retrieve data from cassette by adding a LOAD statement followed by an INPUT statement. Once the LOAD statement has been executed, inputs can be from either cassette or keyboard. However, the first time the keyboard is actuated after a LOAD, command will revert completely to the keyboard. The SAVE command can also be used at any other time to slow the display down to 300 baud where there is an audio cassette interface present.

On systems utilizing the 65V PROM Monitor with or without BASIC in ROM, the cassette interface can be used with any of Ohio Scientific's line of Auto-Load^{tm} cassettes. To utilize an Auto-Load^{tm} cassette, you must enter the 65V PROM Monitor, either by resetting in simple machines, or by resetting and typing an "M" with ROM BASIC machines. Then place an Auto-Load^{tm} cassette in the recorder. The cassette is then turned to play back. As soon as the white leader passes, the user types an "L" on the keyboard. The Auto-Load^{tm} cassette is then automatically loaded into the computer and constructs a complete machine language operating system. Programs which are available in Auto-Load^{tm} cassette format for use on any 65V based computer system include: Black Jack, Extended Monitor Program, Assembler/Editor, Tiny BASIC, 8K BASIC, Video Life, and graphics editor for machines equipped with the 440B based video graphics option.

The 8K BASIC on cassette, of course, would not be necessary for anyone who had ROM BASIC, nor would we advise the use of Tiny BASIC since ROM BASIC is much more powerful. However, the Assembler/Editor and the Extended Monitor are extremely valuable developmental tools for anyone interested in machine language programming.

What's Next?

Once you have BASIC up and running, you may have your system complete if it does not have any special features. Such special features are covered in the next section. In any case, Ohio Scientific's powerful 8K BASIC opens up broad areas for your investigation of both pre-written programs and the opportunity to write your own original programs for entertainment, education, and possibly your own business applications. Programs and programming techniques for BASIC along with many applications ideas can be found in the text at the beginning of this section as well as Ohio Scientific's Small Systems Journal and the small computer magazines such as BYTE, Interface Age, and Kilobaud. The system also has full capabilities for machine language programming such as an Assembler and directly in machine code. Again, the Ohio Scientific's Small Systems Journal and several of our pre-packaged programs provide an excellent insight into this area. Several Ohio Scientific dealers and representatives are also providing full applications program packages for small businesses and for industrial users for use in conjunction mainly with eight-slot disk-based Ohio Scientific computer systems. Watch the Ohio Scientific Small System's Journal for details on software for the computer systems. We would also very much appreciate your contribution to the Journal as a user. The Journal is both a user's group forum and a factory forum.

d-special features

The following special features may be present on your computer system. These special features are described here in abstract form; complete instructions are provided in the manual only if your computer is equipped with those special features.

1) Graphics This option has an additional 420 Memory Board and graphics circuitry (on the 440B Board) such that it is capable of 128 X 128 dot graphics. This option requires the addition of a graphics enable/disable switch on the keyboard utilized by the 440B Video Board. Refer to its section for installation details.

2) Auxiliary RS-232C port. The Model 430B Audio Cassette Interface Board can be populated as an RS-232C port instead of as an audio cassette port. This port is supported under the I/O distributor of OS-65D. If this option is present on your computer, refer to the accompanying 430B assembly and operating manual for details.

3) Fully Populated 430B Board The 430B Board can be ordered fully assembled including high-speed A/D converter, D/A converters, and audio cassette or RS-232C. Refer to the discussion of operation of a fully assembled 430B Board in this section and to the 430B Board manual which is included if this option is present on your system.

4) Parallel Interface PIA based parallel interfaces can be ordered as a CPU Board option or on 450 and 455 EPROM Boards. If a parallel interface is present, that board's assembly and operating instructions will be present in this section of the manual. Further information on programming PIA based parallel interfaces is covered in "Get the Most Out of BASIC, Part I", Ohio Scientific's Small Systems Journal, Vol. 1, No. 2, page 4, August 1977.

5) Memory Management on the 500 Board This option allows the lower PIA lines, that is, output lines A_0 and A_1 to drive additional lines A_{16} and A_{17}. The PIA is addressed normally at F7ØØ so that by normal PIA programming, these two upper address lines of a system can be manipulated. The standard system memory boards have provisions for utilizing these upper two address lines. If not used, the operation of the upper address bits is simply ignored by the memory boards. If they are used, then bank-switching will occur. This bank switching allows changing partitions in time-sharing and distributed processing as well as allowing the user to address up to 256K bytes of workspace. This option is required by our distributed processing operating system, but, is not currently supported by any other software.

6) Challenger III 510 CPU Board The Model 510 CPU Board is equipped with 6502, Z-80, and 6800 microprocessors. The main portion of this manual is concerned with 6502 operation. The auxiliary manual optionally included in this section (on the 510) covers the operation of the Z-80 and 6800, and special features such as memory management, software processor switch, and swappable RAM memory.

7) Line Printer Interface The standard Challenger II and Challenger III can be provided with OKI DATA Model 110 or OKI DATA Model 0-22 line printers, complete with Centronix interface to the Challenger System and supporting software. Or, one can purchase just the Centronix printer interface and connector cable. Line printers are generally shipped by air freight or truck and come complete with their own operating manuals. If this option is present on your computer, the interface specifications and turn on procedures are

included here in a subsection. This turn on procedure should not be accomplished until after the user is somewhat familiar with the I/O distributor within the Disk Operating System. Other less frequently offered special features and custom features are also included at the very end of this section. The user should only make use of these features after he has become somewhat familiar with the BASIC Disk Operating System. The one exception to this rule is that the graphics enable/disable switch must be installed within the computer from the start.

Note: Special features and custom features are described only if present on your system and are not included in the standard manual.

WARRANTY AND TROUBLESHOOTING HINTS

Ohio Scientific fully-assembled products are covered by a limited warranty. Challengers are covered for a period of sixty days against defects in materials and workmanship to the extent that any malfunction not caused by abuse, misuse, or mishandling will be repaired or corrected without charge to the owner provided that the unit is returned postpaid to Ohio Scientific within sixty days of day of receipt by the user.

Beyond this sixty-day period, up to one year from day of receipt by the user, the system is further warranted against defects in materials to the extent that Ohio Scientific will repair or replace them, charging only for labor on the portion of the electronic component that is manufactured by Ohio Scientific, without charge for the part(s). This warranty includes power supplies and floppy disk drives. It specifically excludes hard disks, terminals, video monitors, audio cassettes and some keyboards. Ohio Scientific's only obligation under these terms, in either case, is to repair the unit and return it once it has been delivered postpaid to Ohio Scientific. Typical turn-around time under this warranty is two to three weeks plus shipping time from the factory. Ohio Scientific cannot be held responsible for delays beyond its control such as those caused by shipping or long delivery of replacement components, e.g., floppy disk drives, etc.

Ohio Scientific reserves the ultimate authority to determine what constitutes in-warranty repair in circumstances where circuit modification, abuse, misuse, or shipping damage occur. The warranty is also subject to the use of proper packing material in any returns. This is the only warranty expressed or implied by Ohio Scientific and the only warranty which any Ohio Scientific agent is authorized by Ohio Scientific to give in conjunction with the product. Any maintenance or extended warranties that the end user may entertain with an Ohio Scientific representative or dealer are solely between that representative and the customer and are in no way authorized or supported beyond the extent of the above stated warranty by Ohio Scientific. The support of such warranty or maintenance contract is the sole responsibility of the agent offering the warranty.

Ohio Scientific software offers absolutely no warranty. The software is always thoroughly tested and thought to be reasonably bug-free when released. Ohio Scientific maintains a full staff of software experts and will endeavor to correct any serious bugs that may be discovered in the software after release in a reasonable amount of time. However, this is a statement of intent and not a guarantee in such matters.

TROUBLESHOOTING

If you encounter any difficulty in procedures in this manual, first refer to the following troubleshooting guides. If they do not provide sufficient help for you to solve your problems, proceed to the end of this section.

1) Order does not seem complete. First check to see that all packages specified have arrived. Carefully look over the packing lists, manuals, and this manual to determine what is supposed to be present in your system. If you have further doubts, check with the dealer or representative from whom you purchased your system, or the factory, <u>if and only if you ordered directly from the factory</u>.

2) Unit(s) mechanically damaged in shipment. Report damages or losses immediately to carrier. All units are shipped by Ohio Scientific fully insured. Under no circumstances should you ship the unit back in such condition as it would then be impossible to determine where the unit was damaged. This can cause a long drawn-out dispute with the carrier especially if the unit was transported by different carriers.

3) User has difficulty in following manual because of high level of technology involved. Suggestions: Obtain assistance from your local Ohio Scientific dealer or representative. If you ordered factory direct, or, are at a considerable distance from the dealer, contact your local hobby club and see if any members can assist you. Hobby club members are generally very willing to help out, which is a major reason they are in the club. Current club activities are listed in BYTE, Kilobaud, Interface-Age, and bi-weekly publications such as ON_LINE. Any local computer store should be able to assist you in becoming a computer club member.

4) Reset light does not illuminate on power-up. Carefully check power connections. Check to see if unit is plugged in, that the power switch is on and that power is present at the power outlet. If so, turn the unit off and unplug it. Check the 2 amp fuse at the back of the unit and check the reset light itself by pulling the lens cap out and making sure that the lamp is properly seated in its socket.

5) Reset switch is dimly lit or not lit at all after you have checked with the above procedures. Carefully inspect the PC board portion of the computer for foreign matter such as a wire cutting or something leading out from the PC board. Also check to see that all PC boards are properly seated, and that any ribbon cables are properly seated in their sockets. If the unit light is only dimly lit, remove about half of the PC boards. If the light comes up to full brightness with these out, put those boards back in and pull the other ones out. If the same condition occurs, it means that there is a power supply malfunction and that the unit will have to be returned for repair. If the power supply folds back when some PC boards are out, and not with others, you should be able to isolate the board causing the foldback. That board most likely has foreign matter across it, causing the short on the board.

6) Power supplies look fine, but computer doesn't seem to reset at all or properly. Symptoms: nothing comes out on serial terminal or screen doesn't clear on video system. Solution: again, give the system a careful visual inspection. At this point, it would be invaluable to have access to another Ohio Scientific computer system by way of a dealer or another computerist. If neither is available, and you do not wish to or are not able to attack the actual circuitry of the system, it will most likely be necessary to return the unit for repair.

7) Computer appears to reset properly, but there is no response to the keyboard. On serial systems, carefully check your interface. Make sure the terminal is set up for full duplex and no parity. On video systems, carefully check your wiring. Make sure the keyboard strobe is properly connected. It is possible that the keyboard strobe pulse is too short for the computer's polling routine to see. The keyboard's strobe should be at least 5 ms long for proper operation.

8) Last key strobe on video systems is not acknowledged until next key is depressed. Solution: Keyboard strobe is set wrong. Change polarity via the jumper on the 440 Board.

9) Keyboard operation erratic; some keys are missed. Solution: Keyboard strobe is too short. Strobe pulse must be lengthened, usually be adding capacitance to the strobe circuit on the keyboard. Strobe pulse should be on the order of 5 to 10 ms for proper operation.

10) System works fine in machine code, but in BASIC you consistently receive SN error message (Syntax error). Carefully refer to the example given in the BASIC User's Manual.

11) Floppy disk does not appear to work properly. Consult OS-65D Version 2.0 Manual for any problems concerning the Floppy Disk Drive.

12) Audio Cassette Interface does not appear to work. Carefully look at your connections between audio cassette recorder and computer making sure that you are connecting the microphone jack to the cassette interface output and the speaker jack to the cassette interface input. Be sure that you are using shielded cables and that there are no shorts or opens in your cables. Volume controls should be mid-range, tone controls should be mid-range. Be sure you are using high-quality tape and that you are running the cassette on fresh batteries or 110V AC.

13) If you experience errors when playing back cassettes, try adjusting your own control upward or downward from midrange when recording and playing back cassettes. You may also need to adjust your tone controls. The audio cassette is generally extremely reliable with most medium-quality tape recorders. If your system is subject to a noticeable or an appreciable error rate, it is quite likely that your tape recorder is not suitable for use as a computer storage device. We highly recommend the Panasonic RQ309 tape recorder for such applications.

In Case of Difficulty

If you encounter a problem with your system, first carefully look over the trouble-shooting hints in your procedures. The great majority of problems encountered on new computers result simply from the user's unfamiliarity with the computer system. If you decide that you cannot resolve the problem yourself, contact the representative or dealer from whom you purchased the computer. If you purchased it directly from the factory, contact the factory at 216-569-7945. This number is for customer service. Your local OSI dealer representative should be able to help you by providing guidance on operating procedures, and in the case of an actual computer malfunction, should be able to substitute PC boards and subassemblies to isolate the problem. He should then also provide the service of getting the replacement or repair for the malfunctioning unit. If you ordered the computer factory-direct, then you must call Ohio Scientific to obtain a return authorization number before returning any unit for in-warranty repair. When you call, please immediately state that you currently own Ohio Scientific equipment and are experiencing difficulty with it. By stating this, you will quickly be routed to the service department. Please have your situation well organized so that you can present it to the service department personnel. They may then be able to help you immediately, or may need to consult with engineers and production staff to see if there is a simple solution to your problem, which will require another telephone call. If it is then decided that there is a hardware problem which must be repaired, you will then be offered a return authorization no., so that you can send the faulty equipment back for repair.

All equipment returned for repair must have a return authorization no., and must be packaged in the same containers or equivalent containers upon return. That is, all Challenger products are to be shipped in double containers with at least one inch of standard packing material lining all six sides of the inner container to preclude the possibility of puncture and damage. All packages must be stuffed with packing material so that the computer cannot vibrate or move around in the box; that is, it should pass a manual shake test, where there is no shift of load when you hold the box and shake it. Computers not shipped in double-wall containers or double boxes will not be accepted for

in-warranty repair by Ohio Scientific, since it is our experience that such units are often damaged in transit. The preferred method of shipping is by UPS insured. Please enclosed a note clearly stating the problems you have encountered with the unit when you return it for repair, and be sure to include the return shipping address on that note.

TABLE ONE

INTERFACE CONNECTIONS

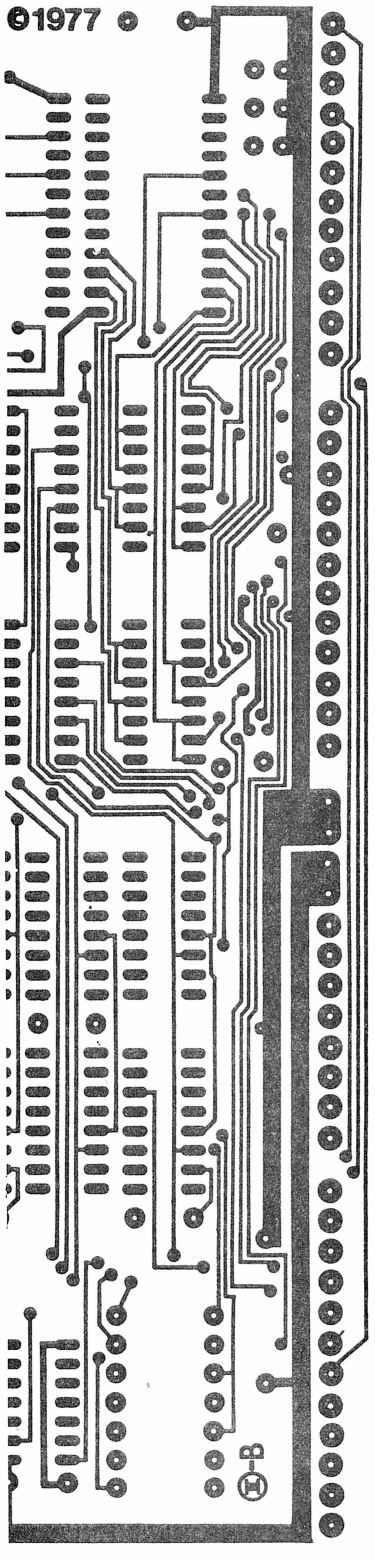
500, 510 Auxiliary Connector	Description	EIA Standard Pinout
6	RS-232 Ground	7
7	RS-232 output from CPU (input to terminal)	3
8	RS-232 input to CPU (output from terminal)	2
9	20ma loop CPU output (+) connect to pin 7 on TTY	13
10	20ma loop CPU input (+) connect to pin 4 on TTY	12
11	20ma loop CPU output (-) connect to pin 6 on TTY	25
12	20ma loop CPU input (-) connect to pin 3 on TTY	24

TABLE TWO

PIN CORRESPONDENCE CHART FOR A-10 CABLE

Molex Pin #	IC PIN #
M1	C16
M2	C1
M3	C2
M4	C3
M5	C4
M6	C5
M7	C6
M8	C7
M9	C9
M10	C10
M11	C11
M12	C8

Note: C12, C13, C14, and C15 may optionally be jumpered to any M-Pin by cutting foil as shown.



(THIS IS TOP RIGHT FRONT CORNER OF THE BOARD.)

B24 - -9v @500 ma.

B25.B26 - +5v @2A

B27.B28 - GND

NOTE: POWER SUPPLY CURRENT REQUIREMENTS ARE FOR FULLY POPULATED BOARD.

Diagram 1.

MODEL 500 - POWER CONNECTIONS

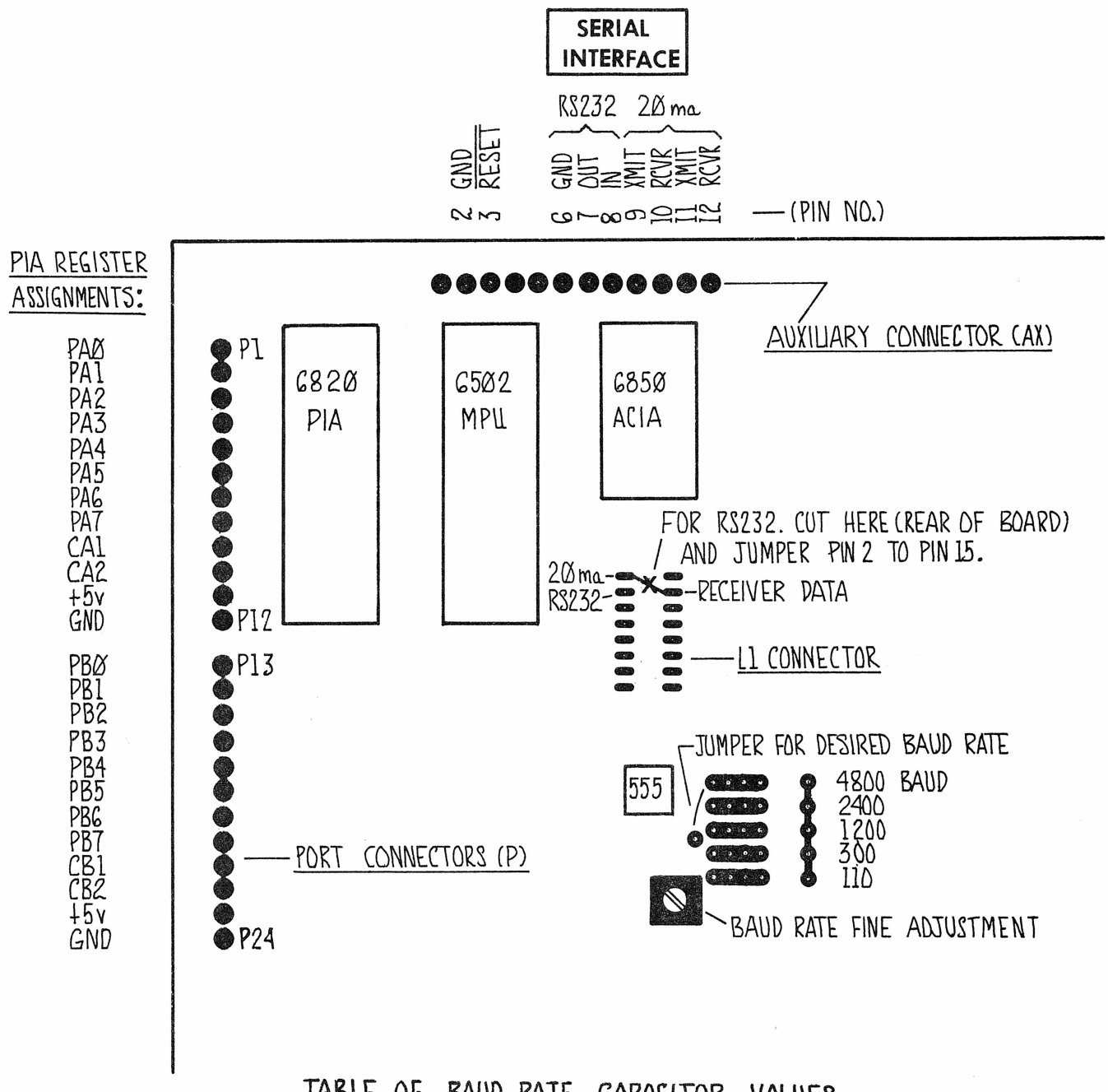


TABLE OF BAUD RATE CAPACITOR VALUES

	MIN	MID-RANGE	MAX
4800 BAUD	.001 µf	.002 µf	.0027 µf
2400	.0022	.0033	.0056
1200	.0045	.0068	.0110
300	.0179	.027	.0446
110	.0489	.082	.1216

MID-RANGE CAPACITANCE VALUES ARE RECOMMENDED, HOWEVER ANY VALUE BETWEEN MIN AND MAX MAY BE SUBSTITUTED. ALL VALUES ARE IN µf.

Diagram 2.

MODEL 500 I/O CONNECTIONS

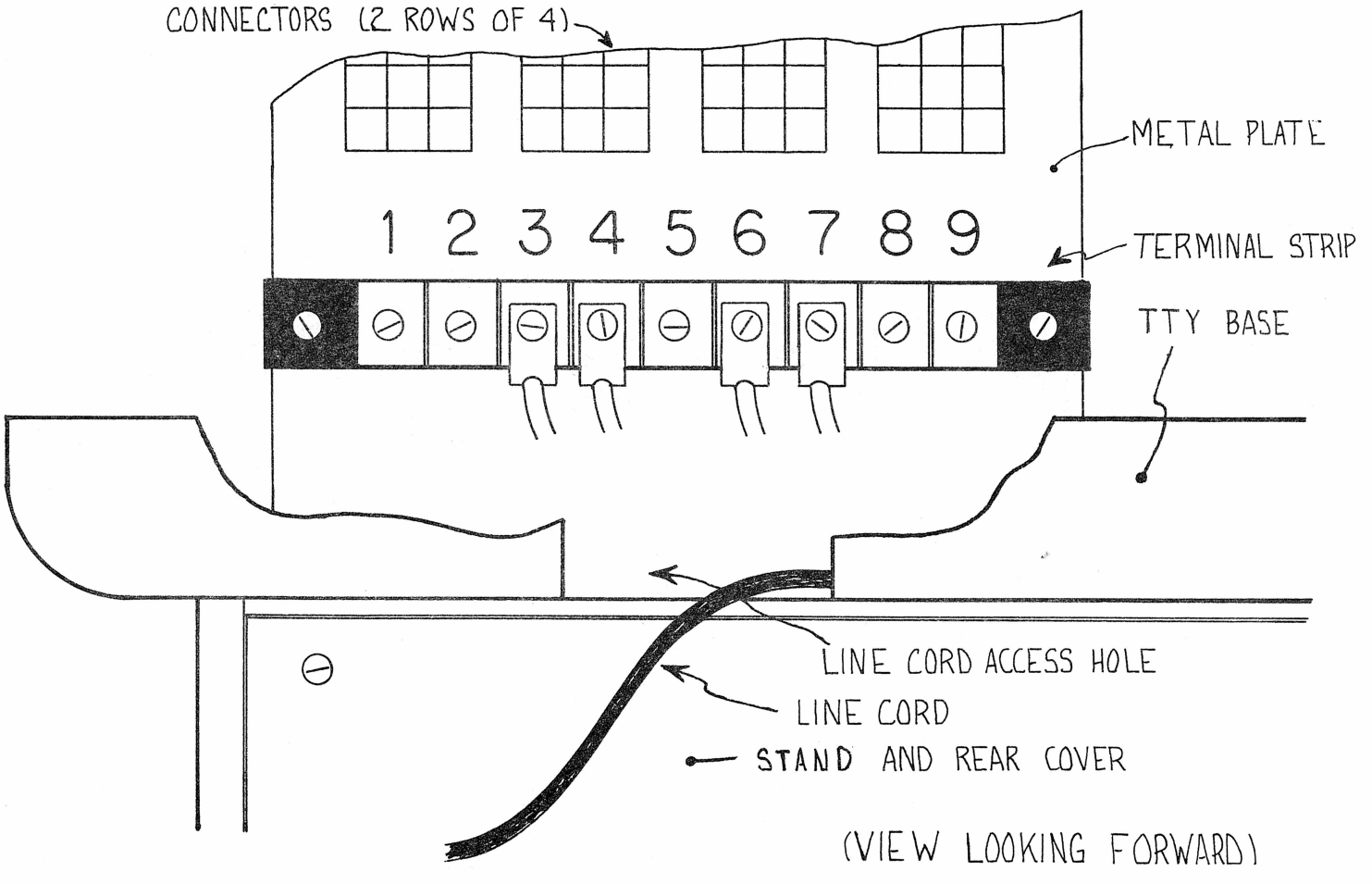
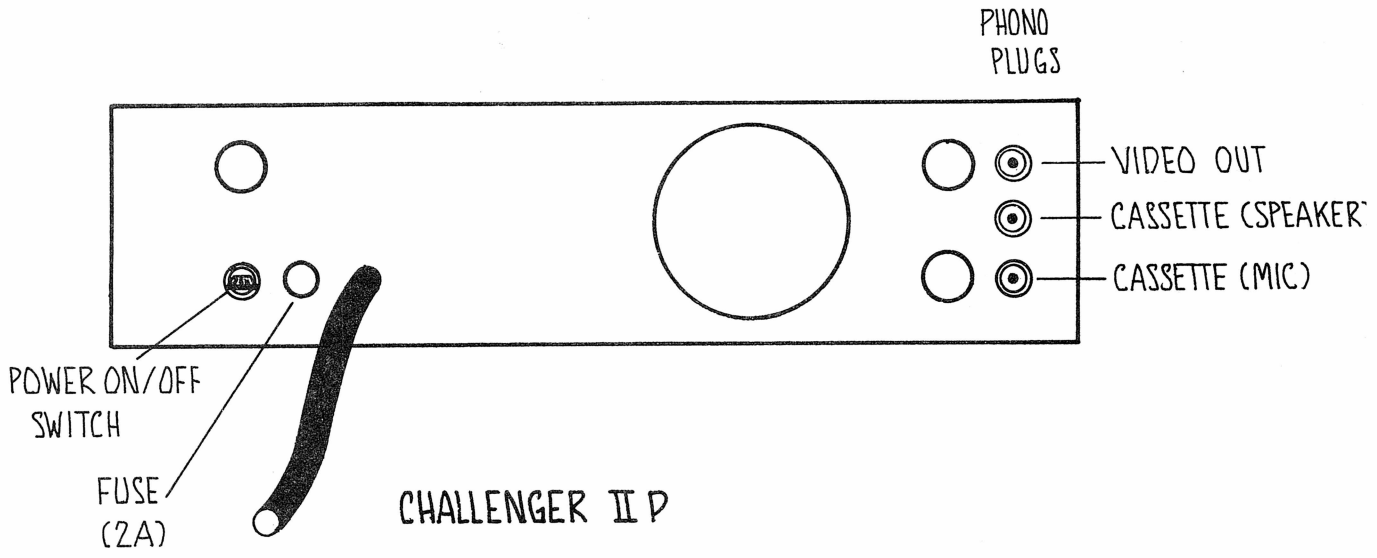
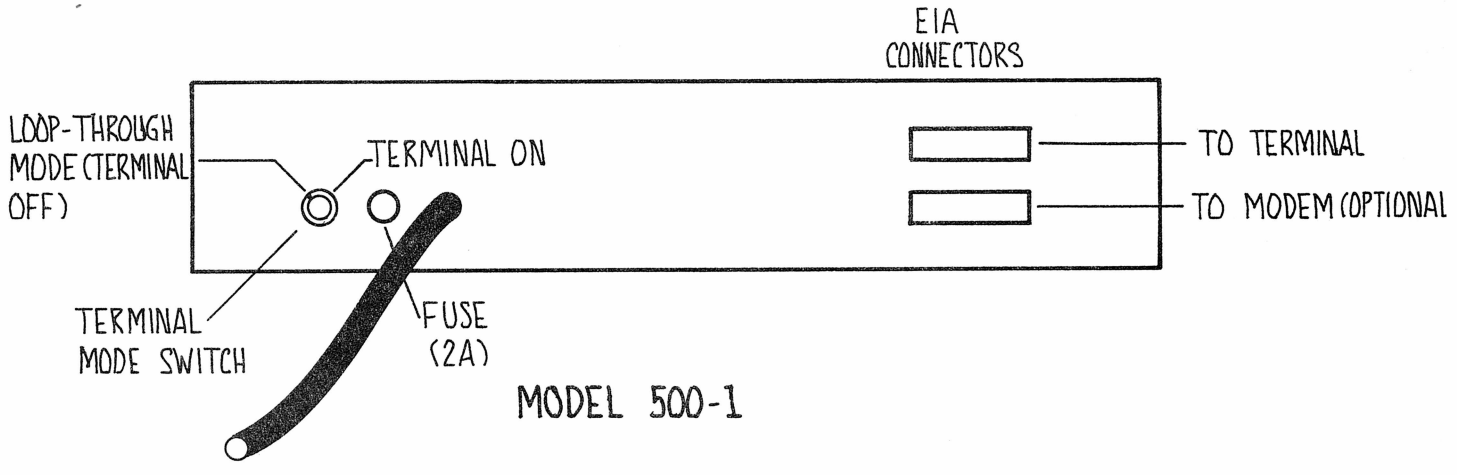


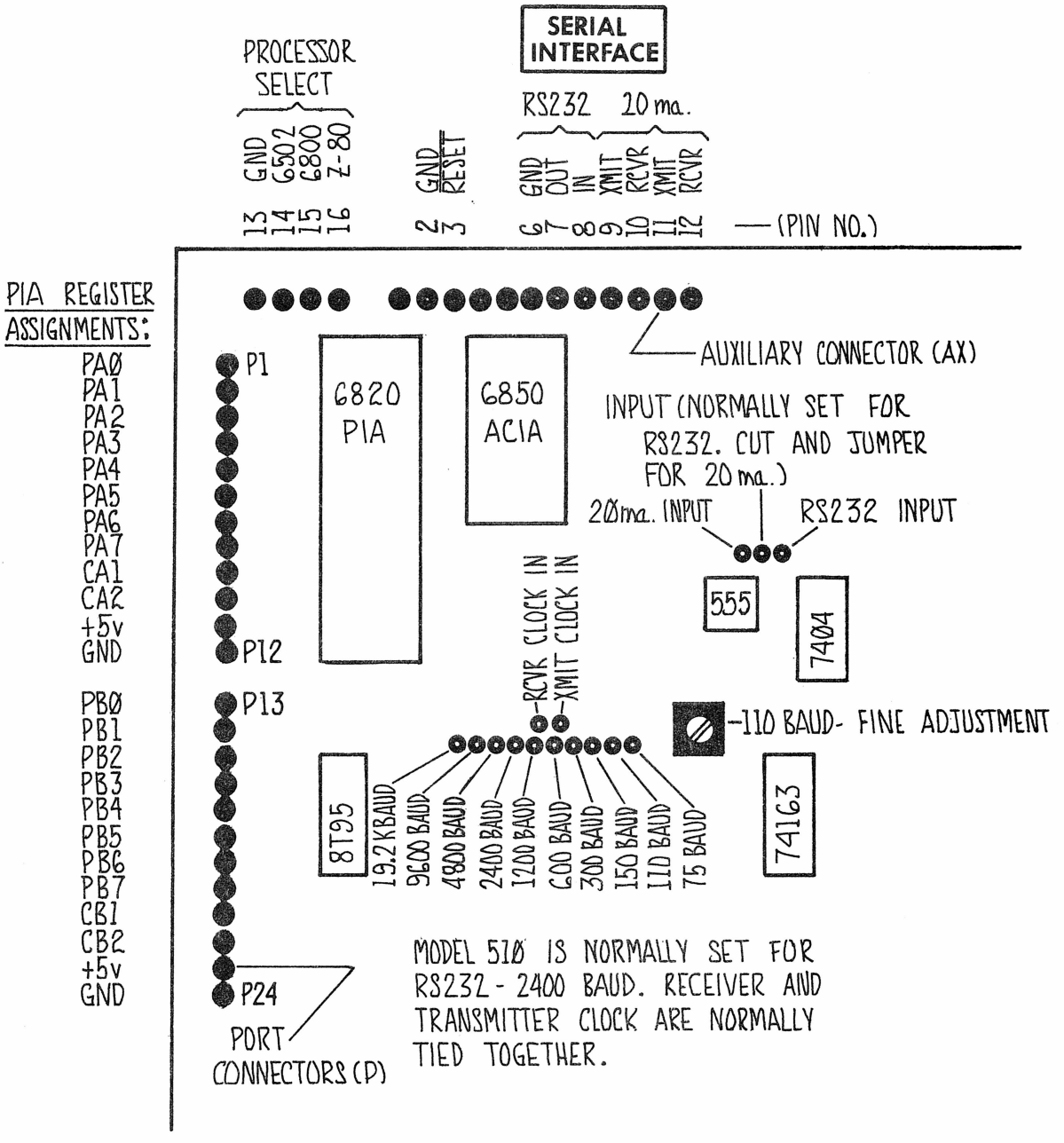
Diagram 3. Connecting to a Teletype





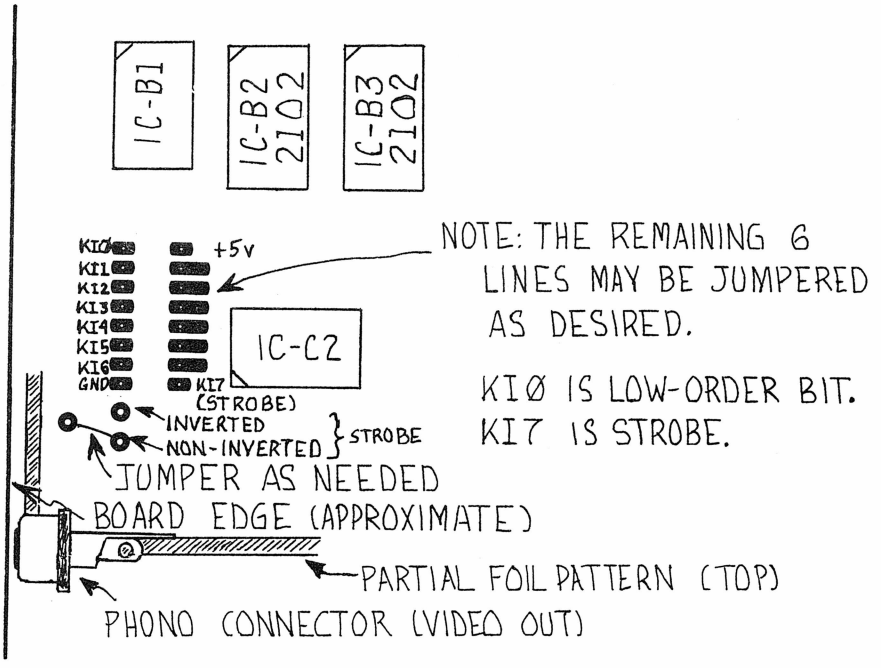
CHALLENGER II P/500-1 REAR PANEL CONNECTIONS

Diagram 4.

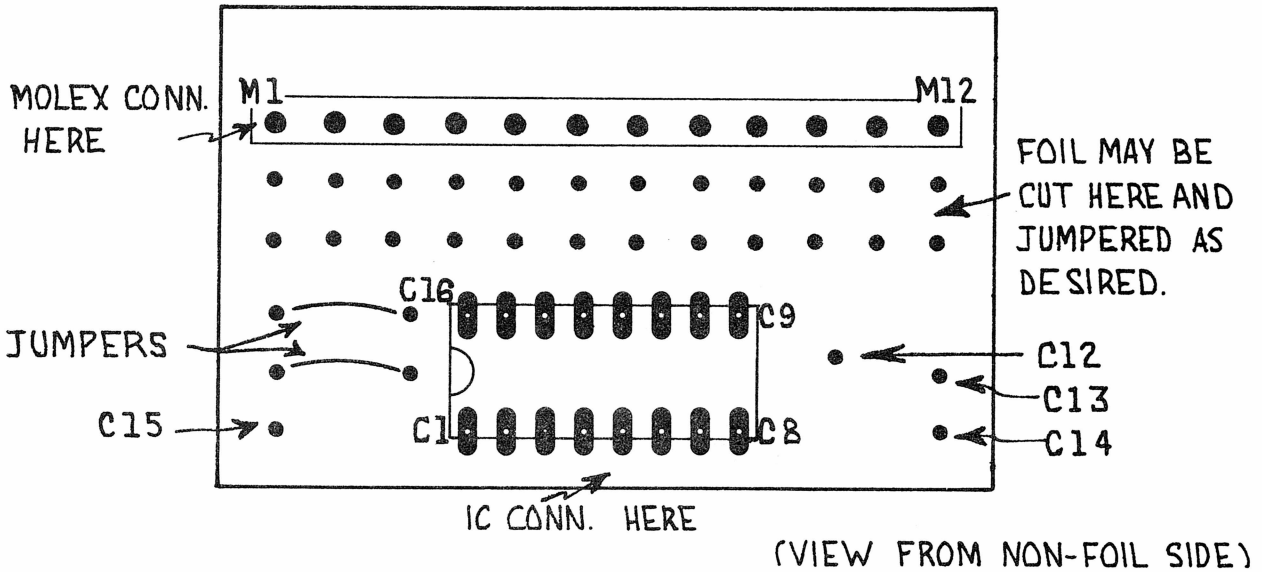


MODEL 510 I/O CONNECTIONS

Diagram 5.



KEYBOARD CONNECTOR DETAIL



A-10 CONNECTOR BOARD

Diagram 6.

430 BOARD CONNECTIONS FOR AUDIO CASSETTE AND OPTIONAL A/D AND D/A CONVERTERS

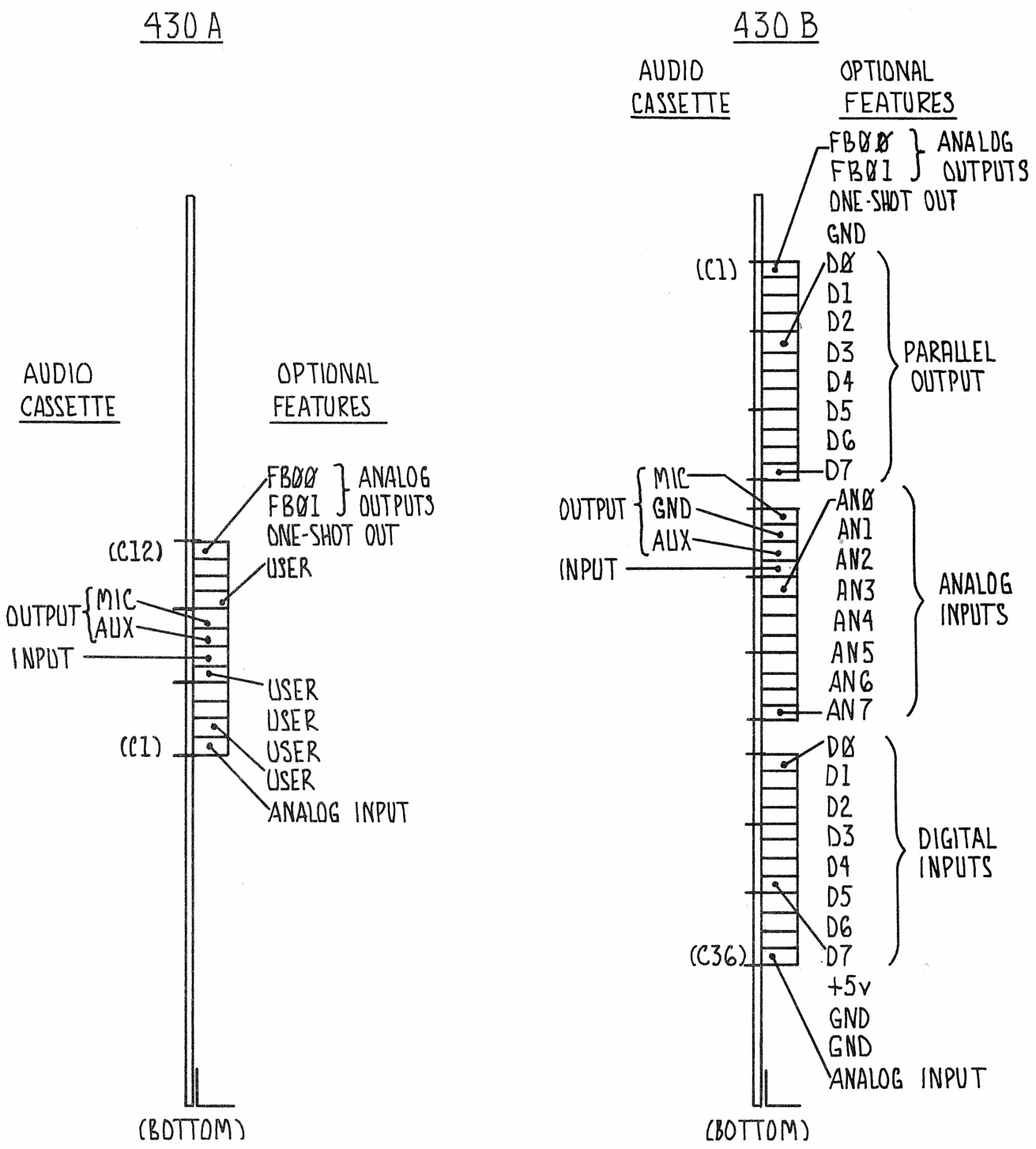


Diagram 7.