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features page

The magazine for 6502 computer enthusiasts!

THE C-3 LETTER SERIES

Ohio Scientific is introducing a new high end product line specifically for small business and research applications. The first in this product line is the C3-B which was first delivered in February,1978. The product line is being rounded out by the just recently announced C3-A and the to-be-announced C3-C, hence, the term C3 letter series. The basic mechanical configuration of the C3 letter series is a computer system fully integrated into a 48" tall equipment rack as shown in the accompanying illustration. Dual floppy disk drives are mounted in the top of the unit. The dual floppy case is 22" deep and houses our standard floppy disk drives via a side mounting configuroation which will accept either the Siemens (GSI) type drive or the Shugart type disk drives. UL recognized power supplies are mounted next to the floppys and the rear of the case is configured to accept an 8 slot backplane, and a computer power supply, as desired for future expansion. Immediately below the dual floppys is a 16 slot computer. This case is also 22" deep and features two 8 slot backplanes which are normally connected together to provide a 16 slot BUS. Each of the 8 slot backplanes has its own stand alone UL recognized power supply. Thus, up to 8 slots of the computer could be used in the case of one power supply failure. Both units are mounted on rack slides and have sufficient cable length to be pulled forward from the case for easy servicing. Below the computer unit goes the Winchester disk drive. The 74 megabyte disk is mounted on rack slides immediately below the computer leaving approximately a 15" open area, which is covered by a metal plate, for future expansion.

Instead of the CD-74, a smaller Winchester technology disk can be placed in this area (C3-C) or it can be simply covered by a metal rack panel (C3-A). The C3 series equipment rack features quick removal side panels. By simply removing two screws near the bottom of each side of the rack, the rack panel lifts off. The rack also features a rear door with lock. These two features combined with the rack slide mounting of the subassemblies gives the C3 series tremendous accessability and service ability. Each module of the C3 rack has its own separate AC line cord, fuse and power on/off switch located in the rear. The dual floppys and the computer have alternate action and reset switches. The only switch which is wired into the circuit of a standard machine is the reset switch on the computer. The alternate action switches can be wired in series or parallel with the rear power switch, at the computer dealer's discretion, to provide override or additional on/off switch capability.

DIFFERENT MODELS

The standard C3-A comes equipped with a computer, dual drive floppy disk and equipment rack. The computer is a full 16 slot unit featuring the 510 triple processor board with 6502A, 6800 and Z80 microprocessor which includes an RS-232 port which is jumperable from 75 to 19,200 baud, 48K of fully static RAM memory and dual floppy disk drives which store a total of 500 kilobytes or more. The standard C3-A comes with the Challenger III manual, OS-65D disk operating system with Microsoft BASIC and a Challenger III multiple processor operations manual and software. The C3-A can be immediately expanded to a C3-B by simply adding a CD-74 disk. It will be expandable to a C3-C by adding the intermediate size Winchester disk drive as it becomes available.

C3-B

The C3-B is a full C3-A configuration including dual floppy disk drives, 48K RAM memory, a 510 CPU board, 48K of static memory and Ohio Scientific's 74 million byte Winchester disk drive. Software includes OS-65D, Challenger III multiple processor operation software and OS-65U Level 1. The C3-B is currently the state-of-the-art in microcomputers providing by far the highest performance available from any microprocessor based computer. Using the included OS-65U big disk BASIC, the user can directly access any entry in a 74 million byte file in a matter of a few milliseconds directly from BASIC.

C3-C

Several disk manufacturers are introducing small Winchester technology disks to fill the gap between performance provided by today's present floppy disks and the larger IBM 3840 type 74 megabyte Winchester drives. The basic difference between these Winchester disk drives and the current CD-74 drive is that they typically have only one or two disk platters instead of the four disk platters the CD-74 has, and they use a stepping motor positioner instead of the much faster rotary position or voice coil positioners of larger Winchester disks. The net result is these new Winchesters store 12 to 20 megabytes which are accessible in tens of milliseconds. Thus, they feature performance which is midway between floppy disks and big Winchesters and are priced accordingly. None of these disk drives are really available in production quantities at the moment. However, Ohio Scientific is evaluating several of the models and will incorporate one of these models into a product which will be designated the C3-C. The C3-C will be the same configuration as the C3-A or C3-B except it will use the new smaller capacity slower access Winchester disks instead of the CD-74. The C3-C should be available in early 1979 and it will be possible for the user to upgrade the C3-A in the field to a C3-C.

C3 EXPANSION

The C3 series is Ohio Scientific's high end business computer system and is a product line that will first see new technological development. One very important advantage to the C3 series is its 16 slot capacity which allows configurations including a lot of memory and several exotic I/O devices. The C3 letter series, for instance, is the only practical configuration for use with OS-65U Level 2 and OS-65U Level 3 (which require significant amounts of memory). Ohio Scientific is developing a proprietary microprocessor which utilizes the 6502 instruction set which will be the first and possibly the only available for use in C3 letter series computers. This option will allow C3 series computers to out benchmark even the largest mini-computers in BASIC program execution. Some possible uses Ohio Scientific is considering for the space behind the floppys are bubble, CCD or a conventional RAM megastore memories providing a few megabytes of very high access speed file capability. Ohio Scientific is also considering breaking the 16 slot backplane into two 8 slot backplanes where 8 slots would support a communications oriented processor and the other 8 slots would support a file system processor. These are just a few of the possible future system expansions in store for the C3 letter series, all of which will be field upgradable!

CHOOSING A C3 LETTER SERIES COMPUTER

The C3-B is obviously the best value in a 74 megabyte storage capacity computer system. It out performs computer systems selling for five to ten times more than its cost with comparable storage capacity. However, it, quite frankly, provides more power than some people need and secondly, its $11,000 plus price tag is sometimes out of range of the beginning small business computer user. In such instances, the C3-A is the best investment for the growth minded business person.

Its retail price of $5,090 gives the user all the capabilities of the C3-B with floppy disks instead of hard disks. It also gives him the instant upward expansion capability to a C3-B by simply adding the CD-74 or the capability to expand to a 1979 state-of-the-art computer by adding the low cost Winchester when it becomes available. No other computer company can offer the business user a system such as the C3-A which will be instantly compatible with the new low cost moderate capacity Winchesters which are now being developed. Ohio Scientific can because we are the first and only microcomputer company which is actually in production with high capacity Winchester disk drives and have the technological edge to make such an offering.

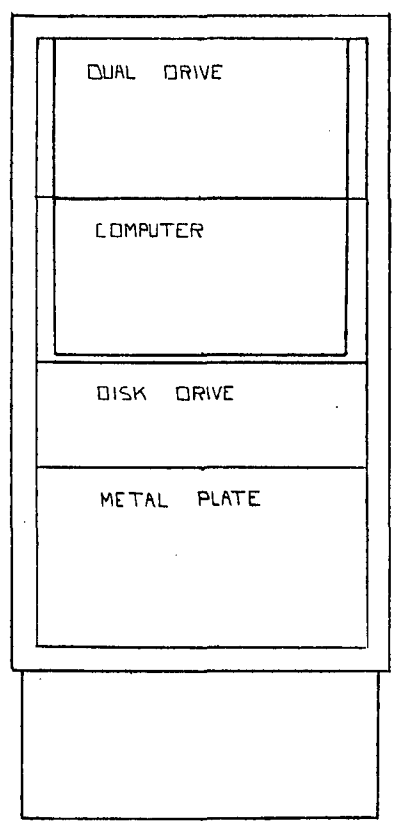
C3 Letter Series Selection Guide

Model	RAM	Floppy Capacity	Hard Disk Capacity	Price	Delivery
C3-A	48K	500K bytes	None	$5,090	Immediate
C3-B	48K	500K	74 mega	11,090	4-6 weeks ARO
C3-C	48K	500K bytes	10 to 20 mega	8,600 to 9,200	Early 1979

EXPANSION KITS

CD-74 kit immediately expandable C3-A to a C3-B at a retail cost of $6,000
Hence, there is no cost penalty for upgrading a C3-A to a C3-B later. A similar expansion kit will be available from a C3-A to a C3-C at no expansion cost penalty to the user.

FRONT VIEW



TRIM PIECES ARE SHOWN IN PLACE

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THE 540 VIDEO BOARD

The Model 540 video board is Ohio Scientific's new video board which completely replaces the old Model 440 video board. The Model 540 is now used in all standard products which incorporate a video board including the popular Challenger C2-4P, C2-8P and video based disk systems. The old 440 board is used only in the very low priced superkit and is used there to keep the price down. The 540 board is a highly sophisticated video display device which is capable of displaying up to 32 rows of 64 characters, symbols, graphics elements and gaming elements. The board also supports a conventional ASCII keyboard or a polled keyboard, a programmable latch and supports the analog portion of an audio cassette interface to minimize the board count in a C2-4P and C2-8P system. The 540 board utilizes the same basic theory of operation as the older 440 board but utilizes much more complex and sophisticated circuitry. Consequently, the parts count of the 540 board is three times that of the older 440 board. The video display interface is based on a crystal control clock operating at 11.79 MHz. This clock is divided by three to generate an approximate 4 MHz clock which feeds a divider chain to provide horizontal and vertical sync pulses at 15,500 hertz and 60 hertz respectively. The 12 MHz clock is also fed to a programmable divider which feeds either an 11.79 MHz clock directly to the dot clock and address counter chain or divides it by two and then feeds it to the dot clock and divider chain. This programmable flop is addressable by the computer and can program the display for 32 by 32 or 32 by 64 character display capability, a unique feature in the microcomputer world. The dot clock signal is then fed to a divider chain which produces the row and column addresses, shift register clock and the dot clock. These addresses are fed through multiplexers and multiplexed alternately with address decoder circuitry then fed to 2K by 6 or 2K by 8 of 2102 memory chips. The output of the memory is fed to a character generator ROM. The output of the character generator ROM is then fed to an 8 bit parallel shift register and then output through a video mixer circuit where it is combined with the horizontal and vertical sync to produce composite sync.

The board typically operates in a display mode where the counter chain outputs are fed to the memory chips which consequently feed their data to the character generator and out to the display. However, the processor can access the memory by addressing the board in the range of $D000 to $D7FF. This changes the multiplexers over to the address BUS so that the memory can be written into or read from just as any other memory. Additionally, the 540 board contains a separate keyboard input port which can be configured either to accept the standard 7 line input ASCII keyboard or it can be configured as a bi-directional 8 line keyboard port for Ohio Scientific's new proprietary 542 polled keyboard. More on the polled keyboard later. The keyboard also has a one bit programmable latch which can be used for sound generation or for some other control application. As stated earlier, the 540 board also contains a complete analog I/O portion for an audio cassette port so that by simply having an ACIA or UART somewhere in the system, one has a complete Kansas City standard audio cassette port.

As stated earlier, the 540 has several enhancements or improvements over the old 440 Board. The 32 by 64 format has been discussed already but several other points have not. First of all, the 540 board utilizes a crystal controlled clock and generates sync pulses very close to the NTSC standard of 15,500 hertz and 60.00 hertz respectively. These signals are close enough for most video tape recorders and other commercial video equipment, such as video monitors, to lock on to the signal with no adjustments to the equipment. The 540 board uses an extremely high dot clock frequency of approximately 12 MHz. This was done to allow for approximately a 30% overscan guard band on both sides of the picture such that all 64 characters can be seen on normal television sets with a normal amount of overscan without requiring any adjustment of the horizontlal width of the video monitor. The unit does not have overscan and guard bands in the vertical dimension, however, to see all 32 lines vertically, the vertical raster must be underscanned on the television set.

This is very simply done, in most cases, by adjusting the vertical height control on the back of the monitor or TV. No adjustment need be made on the television set to typically display 29 lines of 64 characters. All standard Ohio Scientific software assumes 29 or fewer lines of display. The 540's high dot rate clock and high data output rate requires the sophisticated double latched data path called "pipelining" in its output to allow it to display 64 characters on a television set with relatively slow memories and a slow character generator. This latching is accomplished in the data path before the character generator via a pair of 74174's and at the 74165 shift register. Thus, the 540 data path is a two stage pipeline system where the display is always two characters behind the current location being accessed. However, this operation is totally transparent to the user, it would only be of concern to the serviceman. The 540 board can utilize a standard 2513N character generator ROM to provide 64 upper case ASCII characters in conjunction with a 2K by 6 bit memory. It is also set up to accept Ohio Scientific's proprietary 256 character generator ROM, part number CG-4. All 540 boards shipped after July, 1978 incorporate the CG-4 character generator. To convert from a 2513 to the CG-4 the user simply unplugs the 2513 from one socket, plugs in the CG-4 to another socket and cuts four wrap jumpers. He must also add four 2102 memory chips and cut one foil, then install one jumper. The CG-4 contains 256 numeric, graphics and gaming elements including all 64 upper case characters and letters, all lower case alpha, a full set of graphics and plotting characters and a full set of gaming elements including race cars, airplanes, tanks, houses, treess and even the starship Enterprise.

It is the most comprehensive character generator now available and makes programming high performance video games trivial because instead of having to construct the tank for instance, in all eight modes of rotation with dot graphics, the user can simply select between eight different tank orientation characters. Each element of the display is an 8 by 8 dot array. This can present a problem when attempting to graph in a 32 by 64 mode because the character cell is uneven, in other words, it is twice as tall as it is wide. This is why Ohio Scientific included programmable display with 32 by 32 characters or 32 by 64 characters so that the user can have totally symmetric graphics capability for plotting and video games. The 540 board also includes an automatic blanking circuit which blanks the display for an instant whenever the computer accesses memory. This highly minimizes annoying flashes of noise that occur when a CPU attempts to access memory. Furthermore, the 540's keyboard port is a totally separate entity on the board so when the keyboard is polled or operated, it has no effect on the display. Consequently, the 540 board has one of the cleanest and most noise free displays in a dynamic animation mode of any computer display available. It is completely capable of complex animations without the user worrying about objectional noise pulses or snow being present on the screen.

Another added feature of the 540 for real hardware buffs, is that the character generator ROM has the same pin out as the 2716 EPROM so the ambitious programmer could program in his own fonts if desired. The 540 board includes a power up circuit which automatically resets the board to 32 by 64 character mode when first powered up. This power up circuit has a few second time constant so if the computer is flipped on and flipped off quickly, it may revert to 32 by 32 character operation. It is easy to tell a graphics based 540 from an alpha only 540 by the pattern that you get when you first turn the computer on. The graphics based machine will display a random pattern of gaming elements, plotting characters and a few alpha characters, whereas, the 540 board a with 2513 will just display upper case alpha in a random pattern.

The 540 board supports two distinct kinds of keyboards. The standard 7 or 8 level ASCII keyboard such as the Keytronics which OSI carries as option (AC-1) and Ohio Scientific's proprietary new polled keyboard based on the Model 542 PC board. The polled keyboard works basically on the same principal as keyboard encoder chips but utilizes the microprocessors intelligence and versatility to poll the individual key switches. The 542 keyboard is a double thickness PC board (.120 inch board) which utilizes sealed contact key switches for longer life and high reliability. It is a standard 53 key keyboard configuration with one exception that is, the "HERE IS" key is replaced by a shift lock key. The keys are laid out in an 8 by 8 row column matrix with all control keys on one row and the shift lock key on a column all by itself. The rear addresses of the keyboard or row lines are connected to the outputs of latches. In normal operation, the microprocessor sends a row address to the keyboard which activates one row of keys. It then looks at the column outputs for a key closure. When it finds the key closure it translates it to a standard ASCII code and returns this code to the software that asked for keyboard input. The entire software routine to support the polled keyboard resides in a 256 byte PROM or ROM which is typically labeled 65K. This PROM or ROM translates all upper case ASCII characters, lower case characters and control sequences as well as providing automatic repeat when a key is held for more than half a second. The polled keyboard also incorporates roll over protection. Ohio Scientific switched from a standard ASCII keyboard to the polled keyboard to allow more sophistication including user programability of key functions and instantaneous contact closure detection capability.

THE 542 POLLED KEYBOARD INTERFACE

The 542 keyboard gives upper and lower case capability on a standard 53 keyboard with its standard monitor software, however, it is very simple to utilize the keys directly in BASIC or other programs. The user must simply load a row address and look for a bit transition at the column address location so that complicated operations can be programmed as single key strokes. Furthermore, the keyboard can be programmed to accept multiple keystrokes simultaneously and to instantly respond to keystrokes so that, for instance, in a two player tank game the player can have three keys to control his tank and any combination of keys can be depressed simultaneously and still be properly translated by the BASIC program. This level of versatility and capability is simply not found on conventional ASCII keyboards. There is a whole separate article devoted to programming with a polled keyboard in an upcoming OSI Systems Journal. Polled keyboard based OSI computers are easy to spot. They are the computers that have shift lock keys. One important thing to remember with polled keyboard based OSI computers is that the shift lock key must be in the locked or down position for normal operation of the commands in the monitor and in BASIC. Polled keyboard based 540's with graphics directly support upper and lower case alpha characters in print statements in BASIC.

Hardware and Software Compatability

We have talked about several configurations of computer I/O including the old standard 440 display with ASCII keyboard, 540 display with ASCII keyboard, 540 display with graphics and ASCII keyboard, 540 display with polled keyboard and 540 display with graphics and polled keyboard.

Hardware Compatability

The 540 board with or without graphics can be added to any existing Ohio Scientific Computer system. The keyboard socket is pinned out identically to the keyboard socket on the 440 board so that any keyboard that works with the 440 can be plugged directly in to the 540. Polled keyboards are not yet available as separate entities for add on to older computer systems, but they will be offered in the future. If you do get a hold of one, they will not plug in to the old 440 board but will plug directly into a 540. The monitor PROMS in the computer must be changed to support the new hardware configuration. The floppy disk bootstrap PROM is unaffected by the polled keyboard or 540 video board configuration and need not be changed. However,the BASIC support PROM and machine code monitor must be changed to accommodate the new configuration. In addition, if the polled keyboard is used, polled keyboard support PROM at $FDXX must be added. The PROMS must be changed accordingly. Table I shows the proper support EPROM configurations for each hardware configuration.

TABLE I

540 ROM BASIC WITH ASCII KEYBOARD

Monitor	65V2P	at	$FE00
Support	65VB 7.3	at	$FF00

540 DISC BASED WITH ASCII KEYBOARD

Monitor	65V2P	at	$FE00
Support	500-F3	at	$FF00

540 ROM BASIC WITH POLLED KEYBOARD

Monitor	65VK	at	$FE00
Support	65VB 7.6	at	$FF00
Support	65K	at	$F000

540 DISC BASED WITH POLLED KEYBOARD

Monitor	65VK	at	$FE00
Support	500-F3	at	$FF00
Support	65K	at	$FD00

Software Compatability

Once the system support PROMs have been changed to reflect hardware, the machine code monitor will function normally as per the 65V instructions. The only exception being with polled keyboards, the user must always use the space bar to exit a cassette load routine. If the system is cassette based, the cassette port must be changed from a 430 board to a combination of an ACIA on the 500 CPU board and analog portion I/O for the cassette on the 540 board. If the system is disk based, this is of no concern. On any configuration, normal alphabetic only BASIC programs will operate with no modifications. Obviously, the BASIC programs which make use of lower case or graphics characters will only operate properly on a graphics equipped 540. Another area of possible modification is for game programs which make use of special functions of keyboards. These game programs may be specifically programmed to make use of the special features of Ohio Scientific's ASCII keyboard or the polled keyboard. It will be necessary to change the keyboard input routines to accommodate the keyboard that you have. In general, the polled keyboard has far more capability and versatility than the ASCII keyboard in all new programming which utilizes special keystroke input for the polled keyboard. There are now two standard versions of diskette software and one old version. The old version of diskette software supported only the 440 display and the serial port. The software shipped by Ohio Scientific up to June, 1978 could be of this type. After June, 1978, there are two new forms of diskettes for all standard software. One form supports serial port 440 based video and a 540 based video with ASCII keyboards.

This type of diskette automatically configures itself for serial 440 or 540 based systems with ASCII keyboards. The second type of diskette which must be specified by the term polled (after the part number when ordering) is the polled keyboard 540 configuration. These diskettes assume a 540 based system with polled keyboard on power up and will not reconfigure themselves for the systems.

Future Enhancements of the 540

The 540 is a good solid, high performance video display interface providing up to 32 by 64 characters with a selection of 256 different 8 by 8 graphics elements for an effective screen resolution of 256 by 512. It makes full use of all the band width available in medium priced monitors and top of the line television receivers. Future enhancements will be primarily in the form of component and cost reductions as new and large scale parts and more custom circuitry is utilized. Future plans include converting the board over from 2102 memories to higher density 2114 memories as they become more cost effective and adding some color and sound capabilities to the board as the board's base is freed up by the use of higher density components.

WHAT TO DO WITH YOUR OLD 440

If you are currently running with a 440 board we strongly advise you to switch over to the new high performance 540. The 540 occupies the address range from $D000 to $DFFF. You can still use your old 440 by readdressing it for E000 up. If you don't already have dot graphics capability on your 440, it would be great to add it at this time because the individual 128 by 128 dot graphics capability of the 440 is slightly better in some applications than the graphics capability of the 540. The two display approach will allow you to do sophisticated video games as well as graphics and plotting with one screen while controlling the computer with the other screen. If you really want to get fancy, you can combine the two outputs by simply driving the 440 from the 3.97 MHz clock on the 540 and using sync pulses from the 540. This composite signal will allow you to have 32 by 64 character display as well as character graphics and another 32 by 32 character display with 128 by 128 dot graphics. This is possibly a bit outlandish but there is a lot to be said for two separate displays with separate monitors so that you can be programming and controlling the computer without disrupting your video displays. Ohio Scientific's experimenter disk, XD-1.0 has several graphics routines and graphics displays on floppy disk for a 440 display equipped with graphics strapped at $E000 or $D000.

One final note, the 540 with graphics and polled keyboard is great for word processing. The new versions of the word processor disk fully support this keyboard display combination with a complete character insert/delete capability as well as upper and lower case making it a great low cost word processing terminal. The 540 board is available as an add on option as a CA-11 for $249 retail. Delivery is typically thirty to sixty days.

VOICE I/O FOR OSI COMPUTERS

INTRODUCTION

Voice I/O is a current frontier of computer science. It is a very exciting field because we are on the verge of significant breakthroughs and the first real voice I/O products. Original research in voice I/O is possible by individuals and small physics or electronics departments of colleges and universities. High quality research can be achieved on a limited budget. Ohio Scientific is now offering the most general purpose and versatile voice I/O experimental subassemblies to the end user at under $1000. A complete computer system with voice I/O subassemblies can be constructed for as little as $3000. Numerous articles on voice input and output have appeared recently in the technical journals. An excellent article entitled, "Speech Recognition Primer For Computer Experimenters" by Bill Georgiou appeared in BYTE magazine, June, 1978 , Volume 3, No. 6. BYTE magazine, although primarily a hobbyist magazine, has provided several quality articles on voice input and output and language processing. The June, 1978 issue has at least three articles on the subject. A complete overview of the field would take much more space than is available here, so we will provide a little bit of information for the casual reader and then specifically detail what Ohio Scientific has available in the area of voice I/O.

FUNDAMENTALS OF VOICE I/O

Voice I/O refers to the input and recognition of spoken language, typically English, by the computer and the outputting or generation of recognizable speech by a computer. Specifically, the field of voice I/O has as its primary objective of providing the computer the capability of listening to humans and talking to humans. Because the computer is in the middle, the voice input can be separated from voice output in function. For example, there are a few companies which are now offering experimental voice input modules and a few other companies that are providing experimental voice output capability. Ohio Scientific is one of the very few, possibly the only company, that is providing both voice input and voice output capability for its computer systems at the moment.

TWO FUNDAMENTAL TECHNIQUES FOR VOICE I/O - THE DIGITAL PROCESSING TECHNIQUE AND THE ANALOGUE PROCESSING TECHNIQUE

The most successful techniques today in both voice input and voice output are typically a combination of digital and analog processing techniques. Digital Voice I/O works as follows: Sound is spoken into a microphone which is then amplified and fed directly to a fast analog to digital (A/D) converter. The computer stores this digitized speech in memory. The digitized speech can be directly outputted by simply dumping this memory to a fast D/A or digital to analog converter out through an amplifier to a speaker. The A/D then D/A approach can act very much like a cassette recorder. If the sampling rate is high enough, the digitized speech will sound just like an AM radio. In fact, most airlines use digitized music on their airplanes and telephone companies are converting to digitized telephone circuits. There are many drawbacks to a pure digital approach. First of all, the data rate in data processing requirements are phenomenal. In order to digitize speech directly one must at least sample speech at twice the highest frequency that is desired. Considering that telephones have a band pass of 4000 hertz, one should sample the A/D converter at least at 8000 hertz to achieve telephone sound quality. A typical spoken word has a duration of half a second, so 4000 bytes of memory must be devoted to a spoken word. This 4000 byte word can be very easily outputted through a DAC and will achieve the highest sound quality now possible in terms of voice output.
But the memory requirements are high for voice output and the process of converting 4000 bytes spoken word input to something that the computer can recognize as the actual word is a staggering problem. It might require minutes to hours microprocessing computing time to reduce this 4000 byte data field to the actual word which the computer could utilize as a command. To summarize the pure digital approach, digitigal voice output provides the ultimate in quality of spoken output but requires tremendous memory requirements. Digital speech input requires a fairly small amount of circuitry but yields tremendous programming problems. It is not currently possible for even the fastest computers to reduce the resultant data fields to computer recognizable words in a practical amount of time.

The Analog Approach - The analog approach could be more properly called a discrete logic or hardware approach since it usually contains both analog and digital circuitry.

The basic concept to this approach is to provide hardware preprocessing of speech signals to present the computer with the actual word or with a limited amount of information from which the computer can easily derive the word. On output, the computer would simply provide a few bytes to specify the digital word and the hardware or circuitry would speak the word. Since normal English has less than 64,000 spoken words, the ideal system would only present or require two bytes from the computer to specify the input word or the output word. In practice, even the most sophisticated and expensive analog voice input and output circuits can come no where near achieving these goals. In practice, analog and digital hardware preprocessing of voice input and postprocessing of voice output is utilized to greatly reduce the amount of information which must be handled by the computer. Thus, all practical voice input and output systems with the exception of digital voice output are a mixture of both hardware and computer techniques. The most advanced hardware voice output circuitry now available is offered by the Votrax Division of Federal Screw Works, Inc. The Votrax units can accept binary representations of phonetics of words and output those phonetics.

Phonetics are the individidual sounds which make up the words. There are phonetic dictionaries which give you the phonetic spelling or phonetic representation of a word. The Votrax modules can directly accept single byte representations of the standard phonetics and speak these phonetics directly. This requires a computer data rate of only a few bytes per second. Most Votrax units are very expensive; on the order of a few thousand dollars or more, however, they have offered a microcomputer version of their module to some of the microcomputer manufacturers, including Ohio Scientific. Ohio Scientific's CA-14 with Votrax output will be discussed in detail later.

A voice input is not nearly so well refined and, consequently, is in the area of principal experimentation at the moment. One of the fundamental problems is that no one is exactly sure what features or characteristics of spoken English are utilized by humans to recognize speech. For instance, we can easily recognize words in different keys or pitches by different people. We can also easily recognize words which have widely varied durations. We can recognize words that widely differ in intensity or volume. There is no simple way of analyzing incoming speech to derive the vital information from the several thousand byte per second input to identify the word being spoken. By trial and error, several concepts have been developed which have some success. The most successful schemes so far utilize analog feature extractors. Feature extractors attempt to separate the physical properties of spoken English which we have experimentally found to be valuable in identifying or distinguishing one spoken word from another. The ideal feature extractor will throw away all extraneous data that is coming in and simply provide the vital features or physical properties of the spoken word which are necessary to identify or distinguish it from other words.

That is, the ideal unit would reduce a 16,000 byte per second information input from the microphone to information which is only on the order of 15 to 30 bits per second. As stated earlier, this is not achievable. What can be achieved is reducing the rate from 16,000 bytes per second to a few hundred bytes per second so that it is possible for a small computer to analyze the data rate at something like real time. A description of successful feature extractors and a study of feature extraction techniques is the nitty gritty of voice recognition at the moment. We will not attempt to cover the field, but will simply discuss a minimal and moderate performance feature extractor. Most feature extractors now available attempt to separate spoken English into two or more frequency components in real time and then take into consideration the amplitude versus time characteristics of each of these speech components or spectral components. The simplest practical feature extractor simply utilizes two band pass filters to separate speech into two spectral components. Such a unit has the filters set to analyze at a range of 200 to 1000 hertz and a second one at a range of 800 to 3500 hertz. By simply analyzing the amplitudes of these two spectral ranges at the rate of 40 or 50 samples per second, one can construct a speech recognizer that can distinguish between a few words, a few being any where from three or four words to ten or fifteen words depending on what is considered to be an acceptable error rate. The number of words which can be recognized is highly dependent on the preciseness of the speaker.

It might be possible to separate or distinguish between ten or more words with this technique. Such a system requires a very noise free environment and can only be used with an individual speaker and a very limited vocabulary after it has been "trained to recognize the individual's voice. More successful feature extractors utilize four or more filters and do a more complete analysis of the amplitude characteristics of the outputs of each of these filters. The best commercially available speech recognizers today work on this principal and can recognize any where from 60 to 250 words depending on the noise restrictions, articulation of the speaker and the acceptable error rate.

OHIO SCIENTIFIC'S VOICE I/O HARDWARE AND SOFTWARE

Ohio Scientific offers two very important boards for voice I/O, one of which is the Model 430 board which has a high speed tracking A/D converter, two D/A converters, an 8 channel analog input multiplexer and an audio cassette port or RS-232 port. The company also offers the Model CA-14, a voice I/O board which is based on the Model 565 PC board. The Model CA-14 contains the Votrax voice output module and a five filter feature extractor for voice recognition.

430 BASED DIGITAL VOICE I/O

The 430 board is available bare or partially populated with an audio cassette or RS-232 port, as CA-6S and CA-6C respectively, and is available fully assembled as the Model CA-7S with serial port and CA-7C with audio cassette port.

The casual electronics user should buy fully assembled and tested units since the A/D converter is very sophisticated and requires substantial amount of test equipment to set up. Both D/A converters on the 430 board are very well suited to voice and even music output. A tremendous amount of audio and voice processing can be accomplished just with a 430 board as part of the computer system. Sound can be input to the A/D converter and routed through transformation functions back to the output. This can be accomplished with very little memory. The 430 board is well suited to investigate the effects of having less than eight bits and the effects of sampling rate on audio quality. Ultra high quality voice output can be acheived with the system by simply digitizing the voice with the A/D converter and storing it in memory on floppy disk or hard disk and then outputting it via the D/A converter. With an eight kilohertz sample rate, which is adequate for high quality voice output, a single 300K byte floppy disk can store 37.5 seconds of speech or about 64 words. The access time of the floppy disk would limit this device usefulness to just a few words because it would take up to half a second to fetch spoken words from the extreme ends of the floppy disk. The CD-74 hard disk, however, by use of the 430B is capable of spectacular I/O response. The CD-74 disk can store 9,250 seconds of spoken English. Since normal human beings have a vocabulary of 10,000 words or less, only half of the CD-74 disk would be required to store high quality speech comparable to a normal human's vocabulary. The worst case of access time to any one of these words would be 60 milliseconds and a typical access time of about 5 milliseconds. This device is very well suited for simulating a normal human's vocabulary. The 430 board's tracking A/D converter is optimized for audio work.

The tracking converter is specifically designed to follow varying wave forms and does not require a sample and hold circuit on the front end as successive approximation type converters should have. The tracking converter will, as mentioned earlier, follow a 20 kilohertz sine wave because it is a relatively slowly changing wave form. If the tracking converter is used in conjunction with the 8 channel input multiplexer where the inputs are rapidly multiplexed from different sources, one must allow 256 clock periods for the converter to"lock" on to the new signal. That is, one must allow 256 microseconds after switching of the multiplexer before one is assured of being "locked" on to the new signal. This means that one can multiplex or scan multiple inputs at 4000 samplings per second on up to 8 independent inputs. This is an extremely valuable and important feature which will be discussed later in conjunction with the CA-14 unit. The 430 board's A/D converter is well suited for purely computational voice recognition, that is, configurations where the inputted word is digitized then the feature recognition is done completely in software. As stated earlier, however, this technique is extremely lengthy and requires elaborate software so that one should not expect phenomenal results initially. However, as in any research application, someone may make a breakthrough in this form of voice recognition. The big advantage to research work in completely computational analysis of voice input is it will require no additional hardware or no hardware modifications to do experiments. The user must simply vary software parameters. One possible effective research approach would be to do exploratory work with computational analysis and then simulate the computational analysis with hardware circuitry to obtain faster processing. In conclusion to this section, the 430 board and its four assembled counterparts are nearly ideal digitial voice I/O hardware subsystem and capable of high quality voice digitization and reconstruction. The 8 channel input multiplexer and high conversion speed capabilities of the A/D converter provide tremendously valuable research tools in conjunction with the to-be-discussed CA-14 module.

CA-14 VOICE I/O SYSTEM

The CA-14 voice I/O board is based on a Model 565 PC board that represents the state-of-the-art in analog voice I/O processing. The unit is available only as a Model CA-14 which has a fully assembled and tested voice output circuit and is fully laid out to accept but is not populated for a voice input feature recognizer system. The reasons for this will become evident in the following discussion. The board comes with a complete voice output software package on diskette. This package includes a version of BASIC in which the user can simply write "PRINT" statements with phonetic spellings for desired output and when a "PRINT" statement is executed in the BASIC program, those words will be pronounced by the CA-14. The software also includes a stand alone voice editor with disk storage capability that accepts phonetics directly. Also included is a talking calculator demo as a four function calculator with scientific notation that states the problem and the answer correctly. So to use the CA-14 for voice output, the user simply must have a disk system and an audio amplifier and speaker with an auxiliary input jack. This software package is formatted in a menuized form so that with just a few keystrokes one can have talking output.

VOICE OUTPUT CIRCUITRY

The voice output circuit is based on the Votrax voice output module. This module simply acceptc single byte representations of a standard English phonetic and generates an audio output accordingly. It is a fully self clocking system which requests the next phonetic when it is ready for it. Any standard BASIC program can easily provide phoneme as fast as desired by the Votrax module.

The CA-14 provides all the interface and support circuitry for the Votrax unit and an output buffer amplifier. It also has provisions for optional programmable output amplifier to provide additional inflection or amplitude variations on the voice output if desired to enhance its capabilities. The Votrax voice output sounds very much like a computer. It is recognizable but its monotone and output rate uniformity make it easily identifiable as being a computer speaking. In other words, it sounds just like computers sound in science fiction movies. The voice input circuit is not populated because it is very general purpose in nature and allows several distinct classes of audio input experiments. A block diagram of a fully populated Model CA-14 voice input circuit is included. First, we will generally discuss the available features on the board. Then we will discuss some specific configurations. The voice input circuit interfaces to the computer via an 8 bit input buffer and 5 digital counters. The voice input can also, optionally, interface with the 8 channel multiplexed A/D on the 430 board at 6 points on the CA-14. The board has a three stage preamplifier circuit which has provisions for microphone and auxiliary inputs and can have band pass shaping components. It is then followed by a gain control circuit which can provide automatic gain control and logarithmic amplitude compression if desired. The output of this is fed to the threshold detector and up to 5 filter inputs as well as directly to the A/D input on the 430 board so that this microphone preamp with logarithmic compression, etc., can be utilized in purely digital experiments also. The threshold detector output as well as a simple switch contact are connected as bits on an input register to the micro so that the switch and/or the threshold detector can be utilized to initiate voice input sampling. Each of the filters is a two stage op amp filter allowing one pot adjustment. The output of each band pass filter is fed to an integrater or envelope detector and to a zero crossing detector circuit which converts the resultant signal to a digital squarewave. The output of each integrater is made available to the analog to digital converter multiplexer. The to zero crossing detectors are fed to the LSI counters which can then be read by the micro. The filters and integraters utilize part of quad op amps. The zero crossing detectors are RCA 3130 op amps operated as comparators and the counters are Intel 8253 triple programmable counters.

These counters can be preset and cleared and read out in full 16 bit counter sets. Other than the Intel 8253 triple BUS oriented counters and the RCA 3130 op amp, all other parts utilized in the circuit are standard "run of the mill" op amps, resistors and capacitors. Presicision resistors and capacitors in matched sets will be required, however, to obtain optimum filter band pass functions.

CA-14 VOICE INPUT CONFIGURATIONS

The minimum input configuration for useful voice experiments would be a preamplifier, two filters, two zero crossing detectors and a digital buffer. The two filters will be set at the F1 and F2 formants as referred to in several articles including a construction article in BYTE magazine for a simple voice recognizer. The microprocessor would then directly read the outputs of the zero crossing detectors to accumulate counts. The next logical extension upon this scheme is to utilize one Intel counter to automatically accumulate the occurence of zero crossings for each of the two filters. The next logical extension to increase performance would be to expand the unit to more filters, and to utilize the threshold detector to automatically turn on the sampler when the word was spoken. The simplest software configuration for use with the filters is to use the Intel counters which will automatically accumulate counts. However, the counter outputs simply provide the computer with the information about how many total cycles were present in the duration of a spoken word. For more advanced experiments of voice input, it is desirable to have this count over a shorter period of time. The Intel counters are sufficiently fast enough to be read and cleared several times during the course of a spoken word so that the computer could accumulate three or four distinct blocks of counts during a spoken word. For more exacting applications, the computer can directly read the zero detector crossings via the 5 bit buffer input directly. For still even more advanced experiments, the output of the integraters can be utilized by connecting a 430 board's A/D converter to these five integraters and sampling the actual envelopes of each of the filters.

BUILDING AND PROGRAMMING THE CA-14 VOICE INPUT CIRCUIT

Ohio Scientific provides a full set of schematics for fully populating the voice input portion of the CA-14 towards maximum configuration including component values for several different filter center frequencies and band pass characteristics. A simple two filter speech recognition system is documented in an article, "Speech Recognition For Personal Computer Systems", July, 1977 issue of BYTE magazine, Vol. 2, No. 6 by James Bodie of Bell Laboratories and includes a schematic for two filters and a discussion of the learning process and correlation between learned words and spoken words. This article in conjunction with the Ohio Scientific schematics and documentation lay a fairly firm basis for experimentation with two filters. The circuit can be extended to multiple filters via software and the guidance of several of the articles included in the bibliography here. In conclusion of this section, the Model CA-14 provides a sophisticated phonetic voice output capability requiring very modest computer performance and comes complete with sophisticated end user oriented voice output software. The CA-14's voice input circuit is, an extremely powerful and general purpose system which can support from two to five distinct input filters with three distinct types of inputs. Final note, as an experimental system, no clear cut kit builder's guide on how to discover the fundamentals of voice processing is included with the system. The CA-14 is ready to go for voice output. It comes with a complete set of schematics and filter constant tables, but it is the user's responsibility to explore voice input in conjuction with the included bibliography in a true research oriented atmosphere.

Note to retailers, the CA-14 voice module and software is a very popular demo with people "off the street" as well as computer buffs. The CA-14 voice output module will make a very effective addition to your computer demonstrator unit.

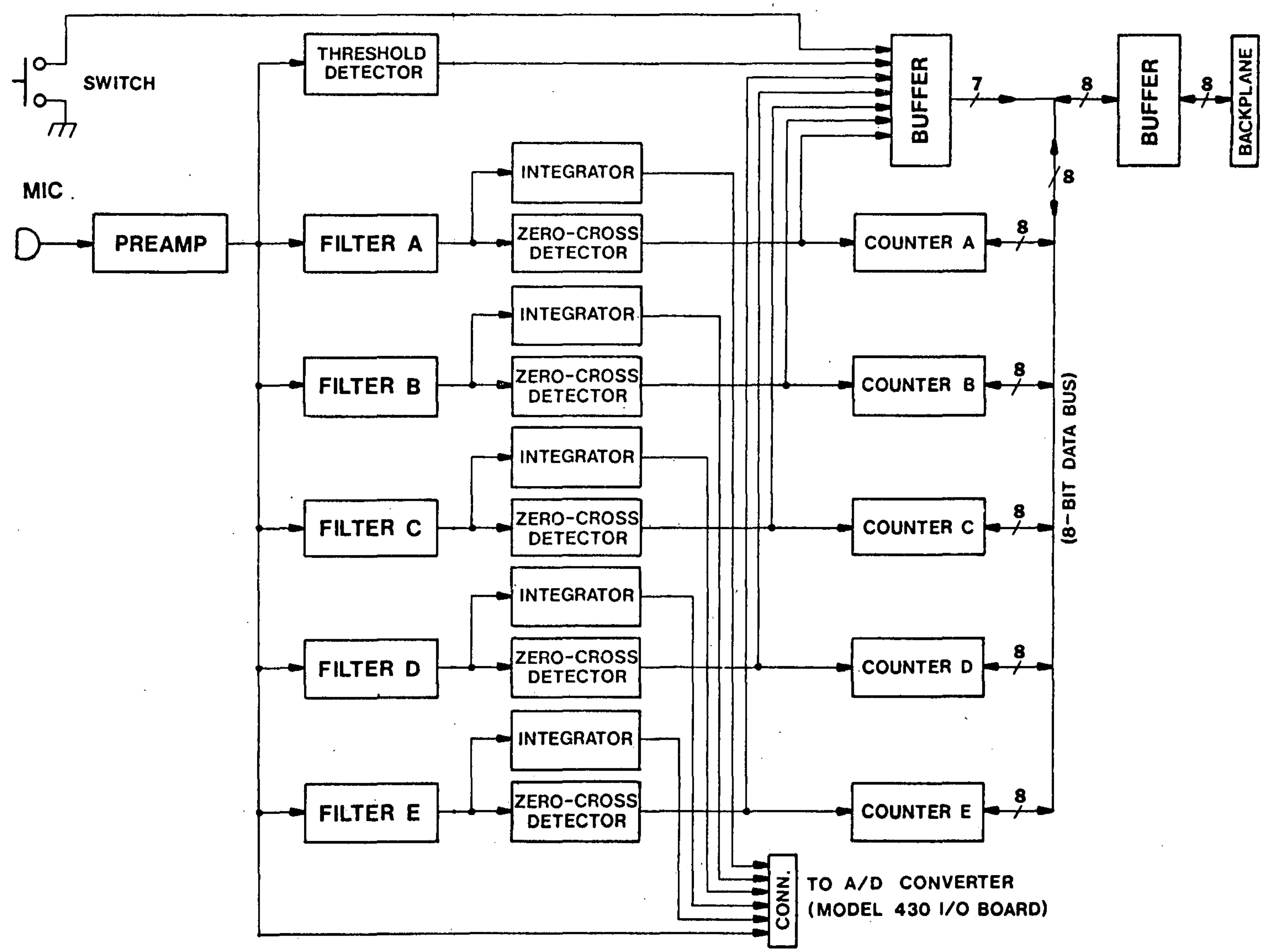
Georgiou,Bill,"Give an Ear to your Computer",BYTE Magazine,Volume 3,Number 6,June 1978

O'Haver,T C,"More Music on the 6502",BYTE Magazine,Volume 3,Number 6,June 1978

Ciarcia,Steve,"Talk to Me !",BYTE Magazine,Volume 3,Number 6,June,1978

O'Haver,T C,"Audio Processing With a Microprocessor",BYTE Magazine,Volume 3,Number 6,June 1978

Boddie,James R.,"Speech Recognition for a Personal Computer System",BYTE Magazine,Volume 2,Number 7,July 1977



Model CA-14 Voice Input System

PARALLEL INTERFACES

The new Model CA-12 parallel interface is now available for $249. The CA-12 board is unique in that it actually is three separate PC boards. One small interface board plugs into the computer and occupies one slot. It can be used in any OSI computer since it requires just 5 volts. This board has two 16 pin connectors which are normally connected to two auxiliary boards via 4 ft. ribbon cables. Each of these auxiliary boards contain three PIA chips which collectively provide 96 I/O lines and 24 interrupt control lines or 48 I/O lines and 12 interrupt control lines on each board. Each of the PIA boards has provisions for prototyping and Molex connectors. Each board is designed so it can be cut down to two PIA's or one PIA without disrupting the support circuitry for the reduced capacity.This is so that it can be conveniently incorporated in other equipment. This unique approach to parallel interfacing greatly relieves the congestion around parallel interfaces within the computer since it effectively provides 96 remote interface lines via two easy to handle 16 pin ribbon cables. The system works quite reliably with 4 ft. ribbon cables. Under low noise conditions, the system could have much longer ribbon cables to the PIA ports. Each PIA line can be programmed as an input or an output. It is TTL compatible and can drive up to two TTL loads. It will be necessary, however, for the user to add his own buffering and protection circuitry to the PIA's. Sample software is provided in BASIC on how to utilize the PIA ports. The board is very simply operated with PEEKS and POKES directly in BASIC at speeds up to a few hundred transitions per second. The 96 line I/O board is ideal for any application requiring more than a few parallel I/O lines. Typical applications include process control, educational experiments and home control. The CA-12 96 line parallel interface is available 30 to 60 days after receipt of order.

NEW ACCESSORY NOTES

SERIAL INTERFACES

Ohio Scientific now offers a Model 550 serial interface board which supports up to 16 independent serial I/O ports. This board is available bare as the Model 550 with schematics for $35.00 and fully assembled with two to sixteen serial ports at $200.00 for the first two ports and $50.00 for each additional port. The 550 serial board utilizes 16 ACIA's in conjunction with 16 RS-232 interfaces, 16 available synchronous interfaces and four available clock interfaces as well as an on board crystal controlled baud rate generator which is jumperable selectable on each port from 75 to 19,200 baud, and 250,000 baud or 500,000 bits per second synchronous. The 550 board can be addressed so that the 16 ports occupy 16 contiguous locations or it can be addressed such that each of the 16 port occupies the same memory position in 16 different memory partitions, where each partition corresponds to a user in a multi-user environment. Hence, the board is very general purpose in nature.

Typical applications include adding a few additional RS-232 ports for modems, extra terminals, and printers. More exotic applications are to use the 550 board to connect several BASIC-in-ROM computers to a floppy disk or hard disk computer for data file storage capability as in OS-65U Level 1. Still another application is to use the 16 port board to connect terminals together under an OS-65U Level 2 system for multi-user BASIC. Finally, the most advanced application is to utilize a 16 port serial board to tie dumb and intelligent terminals together in a true distributed processing system whereby the partition capabilty and high speed synchronous interfaces available on the 550 board are utilized such as under OS-65U Level 3. The 550 board is not currently supported by OS-65D, however, a new version of OS-65D is coming out which supports the individual ports of the 550 board as conventional RS-232 ports. The board is supported under OS-65U Level 1 in both the individual port mode and collectively in the scanned port mode for use in conjunction with BASIC-in-ROM computers. It is supported under OS-65U Level 2 in the same capacity as Level 1 plus a 16 input interrupt driven configuration with 16 input buffers. It is supported under OS-65U Level 3 in the same capacity as Level 2 plus has the capability of high speed synchronous block mode transfer. The bare 550 boards are available from stock, assembled units are available typically 30 to 60 days.

BASIC AND MACHINE CODE INTERFACES

In the process of working on some utility programs for OS-65U, a very important point came to light. That point being that the best compromise between ease of programming and speed of execution can often be obtained by a BASIC/machine code combo. This article will attempt to illustrate the mechanics of interfacing BASIC and machine code. There are several steps to the interfacing and they are:

1. Define the job to be accomplished.
2. Define the functions to be implemented in machine code.
3. Define the functions to be implemented in BASIC.
4. Create and debug machine code.
5. Debug the BASIC program.
6. Debug the BASIC/machine code interface.

The job to be accomplished:

Generate a random star pattern on the screen with a super fast screen clear.

Functions to be handled in machine code:

Super fast screen clear

Functions to be handled in BASIC:

Generate random star fields

The ma~hine code:

The machine must clear the screen as fast as possible. This can be easily accomplished by storing the ASCII code for a space into the video memory. The video RAM resides from $D000 for 2K ($D000 through $D7FF). Therefore, the routine would be as follows:

In line 120, the accumulator is loaded with the ASCII code for a space. In line 130, the Y register is loaded with the number of pages to be cleared (each page equals 256 memory locations). In line 140, the X register is set to zero.

The 6502 has a form of addressing called indexed absolute. What this means is that a base address immediately follows the op-code. This base address is added together with the contents of the X register to form the real address. So in line 150, the code STA SCREEN, X really means store the contents of the accumulator at the address $D000 plus the contents of the X register. The first time through this loop, a space would then be stored at $D000+X or $D000. The X register is now incremented by one in line 160. Then line 170 tests to see if the X register has been incremented through until it "rolls over" to zero (the X register can only represent up to 255, i.e., if X=255 and one is added to X, then X "wraps around" to zero). Therefore, the inner loop consisting of lines 150 thru 170 clears one page of memory at a time. So how do we clear more than one page? We could simply duplicate the code in lines 150 thru 170 eight times, (once per page), but that would be poor programming. O.K., so what are the alternatives? If the inner loop is examined closely, one can see that the only difference between a routine to clear any of the eight pages is the base address (SCREEN). Therefore, by simply incrementing the base address (SCREEN) each time we have cleared one page, we can clear the entire eight pages using the inner loop. To implement this "clear screen" routine, one then only need make a slight modification to the "clear page" routine. That is the function of lines 180 thru 200. Line 180 increments or adds one to the page pointer (the high byte of screen, shown as $D0). The Y register is then decremented by one in line 190 and a branch, if not equal zero (BNE) is used in line 200 to branch back to the point called "LOOP". This branch occurs until Y=0 or all eight pages of memory have been cleared. The final step in this program is a simple "housekeeping" function. Lines 210 thru 230 are used to "reset" the base address "screen" to point back at the beginning of the video memory. This is required because of the fact that "screen" is incremented by this program and must be "reset" so that this routine may be used more than once.

On to the BASIC program. As can be seen from the listing, the "star field" portion of the BASIC program is very straightforward. The FOR-NEXT LOOP uses the RND (Random Number Function) to randomly "POKE" a period onto the screen. The BASIC program uses a simple "FOR NEXT" LOOP to POKE random video RAM locations with a period. The code responsible for this appears as follows:

```
FOR X = 53312 TO 55231
POKE X + INT(RND(X)*63), ASC(".")
NEXT X
```

So much for the BASIC program. Now for the BASIC/machine code interface. The first question to be answered is how the machine code will get into RAM. The easiest way to accomplish this is by placing the decimal values of the machine code program in data statements. Then by using the POKE statement in a "FOR-NEXT" LOOP, the machine code can be POKED into memory. All that remains to be written is the statements that "POKE" the USR vector to point to the start of the machine code routine. The program sequence will execute in the following order:

1) POKE the machine code program into high memory. (This memory is "FRE-ED" by setting memory size to 4050).
2) POKE the USR vector to point at the start of the machine code program.
3) POKE the star field
4) Clear the screen via the USR function, i.e., X=USR(X)
5) Loop back to number 3

One final note:
The sequence for the USR function is the following:

1) The statement X=USR(X) is executed
2) ˙ jump to the machine code program occurs
3) The machine code program clears the screen
4) Finally, a return from subroutine returns execution back to BASIC

```
.A

 10 0000          ;CLEAR SCREEN SUB
 20 0000          ;
 30 0000          ;EQUATES:
 40 0000          SCREEN=$D000
 50 0000          PAGCNT=$08
 60 0000          SPACE=$20
 70 0000          ;
 80 0000          ;
 90 0FE8          *=$0FE8
100 0FE8          ;
110 0FE8          ;
120 0FE8 A920     ENTER   LDA #SPACE
130 0FEA A008             LDY #PAGCNT
140 0FEC A200             LDX #0
150 0FEE 9D00D0   LOOP    STA SCREEN,X
160 0FF1 E8               INX
170 0FF2 D0FA             BNE LOOP
180 0FF4 EEF00F           INC LOOP+2
190 0FF7 88               DEY
200 0FF8 D0F4             BNE LOOP
210 0FFA A9D0             LDA #SCREEN/256
220 0FFC 8DF00F           STA LOOP+2
230 0FFF 60               RTS

.S0
```

USING THE MODEL 22 OKIDATA PRINTER

The Okidata Model 22 line printer has several special "PRINT" Commands. These special commands allow for double height, double width, double height and double width and slew to top of form. The WP-1 and WP1-A word processors both have commands to accommodate the Okidata Model 22.

The logical sequence would be to want to use these commands while in BASIC. The problem that arises is how to get BASIC to print control codes. The easiest way to accomplish this is by using BASIC'S "CHR$" function. By simply saying "PRINT CHR$(12);" will cause the printer to slew to the top of the form. Similarly, one may use "PRINT CHR$(18); TEXT FOLLOWS" to generate a line in the double height font. This particular program uses the OS-65U syntax to print to the printer. If one would like to use these commands under OS-65D, use the following:

```
X=PEEK(8708)
POKE 8708,8
PRINT CHR$(18); "THIS IS A TEST"
POKE 8708,X
```

will print a line in the double height font.

```
10 REM BASIC/MACHINE CODE INTERFACE
20 REM
30 REM MEMORY SIZE MUST BE SET TO 4050
40 REM MAC CODE POKED INTO RAM
50 REM
60 FOR PTR=4072 TO 4095
70 READ MAC: POKE PTR,MAC
80 NEXT PTR
90 REM
100 REM POKE USR VECTOR
110 POKE 11,232: POKE 12,15
120 REM
130 REM STARFIELD CODE
140 FOR X=53312 TO 55231
150 POKE X+INT(RND(X)*63),ASC(".")
160 NEXT X
165 REM CODE TO CLR SCREEN
170 FOR TIME=1 TO 500: NEXT TIME
180 X=USR(X): GOTO 140
190 REM MAC CODE STORED IN DATA STAT.
200 DATA 169,32,160,8,162,0,157,0
210 DATA 208,232,208,250,238,240
220 DATA 15,136,208,244,169,208
230 DATA 141,240,15,96
```

*The SEPT./OCT. issue of the journal will feature the disc operating systems.This article was to have been in this issue of journal but it has been delayed due to the release of several new operating systems.

SAMPLE PRINTER CONTROL STATEMENTS

DOUBLE HEIGHT

DOUBLE WIDTH

DOUBLE HEIGHT & WIDTH

```
10 REM  SAMPLE PRINTER CONTROL STATEMENTS
20 REM
30 REM  SLEW TO TOP OF FORM
40 PRINT #5,CHR$(12);"SAMPLE PRINTER CONTROL STATEMENTS"
50 PRINT #5
60 REM  DOUBLE HEIGHT
70 PRINT #5, CHR$(18); "DOUBLE HEIGHT"
80 PRINT #5
90 REM
100 REM  DOUBLE WIDTH
110 PRINT #5, CHR$(14); "DOUBLE WIDTH"
120 PRINT #5
130 REM
140 REM  DOUBLE HEIGHT & WIDTH
150 PRINT #5, CHR$(18); CHR$(14); "DOUBLE HEIGHT & WIDTH"
160 PRINT #5
170 END
180 PRINT #5
190 PRINT #5
200 PRINT #5
999 END
```

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