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## INTERACTIVE SIMULATOR SYSTEM

### BACKGROUND OF THE INVENTION

5 The present invention relates to teaching machines, and in particular to training devices which present problems to, and require active responses from, the student and the instructor. More specifically, the present invention relates to an interactive, computer based training system which utilizes alphanumeric and graphic  
10 displays, visual simulations of objects, and tactile responses to provide a course of instruction, without requiring instructor intervention.

15 There is an ever increasing demand for technicians in both civilian and military environments. This has resulted in a need for a machine capable of rapidly training individuals in the operation and maintenance of particular electronic and other hardware, without requiring instructor intervention or handling of the actual hardware. It is desirable that such a training machine be capable of  
20 testing a student so that his or her progress can be monitored. Furthermore, it is desirable that such a training machine be capable of providing courses of instruction in a wide variety of disciplines. In order to maximize the knowledge and skill imparted to a student,  
25 such a training machine must keep the student's attention. This could be done by providing sufficiently interesting visual displays and by responding rapidly to student commands or responses.

# SUMMARY OF THE INVENTION

Accordingly, it is the primary object of the present invention to provide an improved training machine.

5 It is another object of the present invention to provide a computer based interactive training system which provides graphic and alphanumeric displays, along with visual simulations of equipment or other objects which are the subject of the course of instruction.

10 Yet another object of the present invention is to provide a system of the aforementioned type which utilizes tactile responses of the student.

15 Still another object of the present invention is to provide a system of the aforementioned type which includes dual CRT displays, one of which is utilized for graphic and alphanumeric instructions and the other of which is utilized to display images of objects.

20 Still another object of the present invention is to provide a training system of the aforementioned type which utilizes a video disk player to allow visual images to be rapidly accessed and displayed.

Yet another object of the present invention is to provide a training system of the aforementioned type which can be rapidly programmed with different lessonware.

25 Still another object of the present invention is to provide a training system of the aforementioned type which is capable of testing a student so that his or her progress can be monitored.

30 In the illustrated embodiment of the interactive simulator system disclosed herein, a minicomputer controls a video disk player, a pair of CRT displays, interface

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electronics, and a memory device in the form of a dual floppy disk drive which stores software and lessonware. The student requests textural information and images by touching pressure sensitive panels on the CRT displays. 5 The minicomputer translates these tactile user inputs into digital information, and depending upon software and lessonware instructions contained on the floppy diskettes, transmits the appropriate responses in the form of textural and image information on the CRT displays. The system also 10 includes a detachable keyboard and printer terminal which allows the user to author new software and lessonware, or to change existing software and lessonware.

#### BRIEF DESCRIPTION OF THE DRAWINGS

Figure 1 is a perspective view illustrating a preferred embodiment of the interactive simulator system of the present invention. 15

Figure 2 is a simplified block diagram of the system of Figure-1.

Figure 3 is a functional block diagram of the system of Figures 1 and 2. 20

Figure 4 is a functional block diagram of the alphanumeric and graphic modules of the system of Figures 1-3.

Figure 5 illustrates the hierarchical image presentation structure of the system of Figures 1-4. 25

Figure 6 illustrates the command select menu which appears on the lower portion of the adaptive CRT display of the system of Figures 1-4.

# DESCRIPTION OF THE PREFERRED EMBODIMENT

Referring to Figure 1, the illustrated embodiment 10 of the interactive simulator system of the present invention comprises an adaptive CRT display 12, an image CRT display 14, a computer 16, a video disk player 18 and a keyboard/printer instructor's terminal 20. The aforementioned components of the system are installed in the base cabinet 22 of a desk 24 and in a console 26 bolted to the desk top 28. The computer 16 and video disk player 18 are accessible via a hinged front door 30 of the desk cabinet 22. The computer 16 is mounted in the lower portion of the cabinet and includes a microprocessor assembly, dual floppy disk drive and peripheral interface assembly hereafter described, along with a power supply. The video disk player 18 is mounted in the upper portion of the cabinet 22 on a slide-out drawer 32 which enables easy access for loading and unloading video disks.

The image CRT display 14 (Figure 1) is mounted within the console 26 so that its face extends substantially perpendicular with respect to the desk top 28. The adaptive CRT display 12 is mounted within the console above the display 14 so that the face of the display 12 tilts forwardly at approximately fifteen degrees with respect to the face of the display 14. This affords an optimum viewing angle for a student user seated at the desk with his or her legs underneath the desk top 28. The console 26 is further provided with a shroud or hood 34 which surrounds the faces of the CRT displays 12 and 14 and considerably reduces glare on these faces from overhead ceiling lights.

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The face of each CRT display is covered with a touch panel hereafter described which provides the user interface with the computer 16. The keyboard/printer terminal 20 is positioned on the desk top 28 adjacent the console 26 and is connected to the computer 16 through a cable not illustrated in Figure 1. The terminal 20 is of the portable type and may be moved around on the desk top as desired for use either by the instructor seated at the desk or by the instructor standing to one side of the desk. Floppy diskettes containing different lessonware may be stored in binders 36 positioned on the desk top 28 adjacent the console 26. The left-hand disk drive in the computer 16 may have a student data diskette 38 loaded therein. The right-hand disk drive may have a data base and lesson plan diskette 40 loaded therein.

The overall architecture of the system is illustrated in the simplified block diagram of Figure 2. As indicated therein, the computer 16 includes a microprocessor assembly 42, a dual floppy-disk drive unit 44 and a peripheral interface assembly 45. In addition, the computer 16 includes a power supply which is not illustrated. In the preferred embodiment of the system, the computer 16 includes an ALTOS (trademark) ACS 8000-02 single-board microprocessor based computer system manufactured by ALTOS Computer Systems, 2360 Bering Drive, San Jose, California, 95131. It utilizes a Z-80 microprocessor as a CPU. The dual floppy disk unit is preferably a SHUGART (trademark) SA800/801 disk drive. The power supply for the computer 16 is preferably a XENTEK (trademark) CP125. The peripheral interface assembly 45 is manufactured by Cubic Corporation,

the assignee of the subject application, and its architecture is described hereafter in greater detail.

5 The keyboard/printer terminal 20 (Figure 2) is a portable, combination computer-input keyboard and hard-copy printer. Preferably, the terminal 20 is a Texas Instruments (trademark) model 743 KSR Data Terminal which communicates with the computer through an SIO port at 300 bauds. The video disk player 18 is preferably a SONY (trademark) LDPL000 Video Disk Player. This unit provides  
10 all of the color images that are displayed on the image display 14. Under control of the microprocessor assembly 42, the video disk player 18 can produce any one of up to 54,000 TV frames, or a continuous series of frames (in movie fashion) for periods up to approximately thirty  
15 minutes in duration. The images are recorded on a video disk using laser beam technology. The video disk player 18 reads the video information on the plastic disk, using a He-Ne laser. The player 18 can search and locate any single frame of 54,000 frames with an access time within  
20 approximately 2.5 seconds (mean) to 5 seconds (maximum). The video disk player 18 is controlled through a Z-80/SIO device with standard 8-bit ASCII character and 2 stop bits format. Data transfer rate is 1200 baud.

25 The adaptive CRT display 12 (Figure 2) provides a black and white display of alphanumeric and graphic information which makes up the user instructions and/or questions. The adaptive CRT display 12 is controlled by the microprocessor assembly 42 utilizing the program extracted from the data base and lesson plan diskette 40  
30 (Figure 1) for the particular lesson. By way of example,

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the adaptive CRT display 12 may be a MOTOROLA (trademark) twelve inch CRT, MD3000 series.

5 The image CRT display 14 may be a color television set less the RF tuning components. It provides a full-color spectrum display of equipment or other objects utilizing video signals from the video disk player 18. Thus, the image is displayed on the image CRT display 14 may be color, three-dimensional simulations of objects, equipment, etc., whatever is recorded on the video disk for a particular lesson. By way of example, the image CRT display 14 may be a nineteen inch RCA color television set, chassis CTC101 series. The tuner switch assembly and tuner control module of the television set are removed. The maintenance controls of the color television set (COLOR, CONTRAST, TINT, BRIGHTNESS, VIDEO and AUDIO INPUT LEVEL) are mounted, along with the video in/out board, on an image display control panel (not shown) for adjustment by the student or instructor.

20 Touch panels 46 and 48 (Figure 2) cover the faces of the adaptive CRT display 12 and the image CRT display 14, respectively. These touch panels provide the interface between the user and the microprocessor assembly 42. Both touch panels function in the same manner. When the user presses a finger or any other implement such as a pencil against any point on the surface of either touch panel, a set of voltage signals is generated and sent to the microprocessor assembly 42, via the peripheral interface assembly 45. The microprocessor interprets the signals as the XY-coordinates of the specific locations on the specific panels being pressed. The resultant data is

compared by the microprocessor assembly, utilizing the program on the data base and lesson diskette 40, to significant data points stored in memory for the particular CRT display being touched. The comparison with a known data point results in the microprocessor assembly performing the required action.

Each of the touch panels 46 and 48 (Figure 2) is preferably constructed of two layers of transparent, flexible, MYLAR (trademark) plastic sheet. This construction is not illustrated herein. One side of each sheet is coated with a transparent conductive film. The two plastic sheets are mounted on a frame that separates them by approximately fifty-thousandths of an inch. The conductive surfaces face each other on the inside of the assembly. A bus strip runs along the top and bottom edge of the film on the inside surface of the forward sheet (facing the user), and along each side of the film on the inside of the rear sheet. A separate lead from each bus is routed out of the lower right-hand corner of the assembly through a four-wire ribbon cable. In operation, a fixed reference voltage level is impressed across the film on one sheet of plastic, for example sheet A. When the touch panel is pressed against the face of the CRT, the two films make contact at the point or location of touching. A specific voltage level is picked off by the film on the other sheet (sheet B). The procedure is then switched. The fixed voltage is impressed across the film on sheet B, and the voltage level at the point of touching is picked off by the film on sheet A. The two output voltage levels at the point of touching are routed to the microprocessor

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assembly 42 where they are interpreted as the XY-coordinates of the point of touching.

5 Having described the overall architecture of the interactive simulator system, its operation will now be described, before returning to a more detailed description of the circuitry of the system. The system described herein was designed to provide instruction, without requiring instructor intervention, in the areas of functional theory, operation, and maintenance of various families of electronic equipment and systems. Guided "hand-on" experience is made possible by three-dimensional simulation of the subject equipment. The system provides instruction, using both visual and tactile techniques, in the functions, purpose, operation, and maintenance of units, sections, subsections, groups, circuits, and other active elements of each generic type of equipment. The operation of the system will be described in this context. However, it should be understood that the system can be utilized in a wide variety of civilian and military environments to teach individuals both technical and non-technical subjects.

25 The operation of the system is as follows. Before the power to the system is turned on or off, the diskettes which are in the disk drive unit 44 should be removed. This will prevent an unpredictable magnetic field from erasing a part of the data on the diskettes. Once the power to the system has been turned on, a video disk 60 having stored thereon the images for the desired simulation is installed into the video disk player 18. A student data file diskette 38 (Figure 1) is then inserted into the left

hand drive of the disk drive unit 44. A data base and lesson plan diskette 40 is inserted into the right hand drive of the disk drive unit. Next, the RESET pushbutton on the computer 16 is pressed and released. The system then automatically initializes itself and data is displayed on the adaptive CRT display 12. The computer then determines the limiting pool number which is the highest problem set allowed at this point. The limiting pool number is the number of the pool of problems from which problems may currently be drawn. This procedure assures that students do not work problems which deal with malfunctions or methods which have not yet been covered in class. The computer then causes the adaptive CRT display to present the following message:

THE CURRENT LIMITING POOL NUMBER IS (some number).  
DO YOU WISH TO CHANGE THE LIMITING POOL NUMBER?

\* YES

\* NO

The instructor then touches the asterisk next to the YES or NO depending on whether or not the instructor wishes to change the limiting pool number for the session. If the instructor touches the asterisk next to the YES, the adaptive CRT display presents the numbers from one to the limiting number of possible pools. Touching the asterisk next to the desired limiting pool number for the current session will cause the adaptive CRT display to present the following message:

THE NEW LIMITING POOL NUMBER IS (number selected)  
IS THIS CORRECT?

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\* YES

\* NO

5 The instructor then verifies the limiting pool number selected by touching the asterisk next to the YES or NO in response to the display. Once the above procedures have been completed, a student may now seat him or herself at the desk 28 and begin the lesson. The computer reads the student name from the student data file diskette and then causes the adaptive CRT display to present the following message:

10 ARE YOU (some student's name)?

\* YES

\* NO

15 The student touches the asterisk next to YES if the name is correct. Otherwise, the student touches the asterisk next to the NO. The result of this action is:

If YES was touched, the student's first problem will be presented. If the name was "INSTRUCTOR", and YES was touched, the adaptive CRT display will present each of the possible problem numbers and the message:

20 PLEASE TOUCH THE \* BEFORE THE EXERCISE YOU WOULD LIKE.

The instructor may then select the desired problem by touching the appropriate asterisk. If the asterisk next to the NO was touched, the adaptive CRT will display:

25 INSERT NEW DISKETTE FOR NEW STUDENT.

TOUCH THE SCREEN WHEN DISKETTE HAS BEEN INSERTED.

30 The user then removes the present student data file diskette and installs the corrected student file diskette. The student then closes the disk drive door and touches anywhere on the screen or face of the adaptive CRT display.

The computer will then cause the interrogation leading to the determination of the correct student name to be repeated as outlined above.

Each lesson on the system is presented in a two-mode learning strategy, namely, practice and test. In the practice mode, lesson instructions (alphanumeric and graphic) are presented on the adaptive CRT display 12, and associated images (for example equipment and circuitry) are presented on the image CRT display 14. In addition to the lesson instructions, questions in alphanumeric and graphic form are also presented on the adaptive CRT display 12. These questions include not only the lesson material, but in addition, a modifiable command select menu 50 (Figure 6) which is continuously presented across the bottom of the face of the adaptive CRT display 12. Each of the indicated commands may be initiated by touching the associated asterisk 52.

Touching the "HIGHER-LEVEL" asterisk (Figure 6) causes the next higher-level image to be displayed on the image CRT display 14. The system presents color images simulating equipment on the image CRT display 14 in a prescribed hierarchial structure. Each data base and lesson plan stored on a diskette such as 40, includes a set of photographic images plus an alphanumeric data base. All simulation takes place at the scene level, which is presented on the image CRT display 14. The alphanumeric data base controls the image presentation so that the student sees scenes that are the same as would be seen on the actual equipment.

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Figure 5, illustrates a typical image presentation hierarchical structure. At the top level, the image CRT display 14 presents an overall layout of the system to be studied, which may comprise a photographic image 54 of a radar antenna, a photographic image 56 of a power supply, and a photographic image 58 of a radar receiver/transmitter. In addition, at the top level, various interconnecting cables (not shown in Figure 5) may be displayed which interconnect the antenna, power supply and receiver/transmitter.

The student may cause the next higher level image to be presented on the image CRT display 14 either by touching the HIGHER LEVEL asterisk on the command select menu 50 (Figure 6) on the adaptive CRT display 12. This may also be done by touching a triangle (not shown) displayed on the image CRT display 14 on top of the particular component. For example, an enlarged image 54' (Figure 5) of the antenna could be called up on the image CRT display 14 by touching a triangle (not shown) displayed on top of the system level image 54 of the antenna displayed on the image CRT display 14. Enlarged images 56' and 58' of the power supply and the receiver/transmitter could also be similarly called up. The enlarged images 54', 56' and 58' are referred to as equipment level images.

Still further touching of the HIGHER LEVEL asterisk (Figure 6) on the adaptive CRT display 12 or particular triangles on top of images displayed on the image CRT display 14 may cause scene level images states 1-N to be consecutively presented. For example, in Figure 5, the state 1 scene level image may be a photographic image of

the control panel of the receiver transmitter. The state 2 scene level image may be a photographic image of the receiver/transmitter with its protective housing removed. The state 3 scene level image may be a photographic image of a variable compacitor within the receiver/transmitter, and so forth.

Touching the REPLACE asterisk (Figure 6) causes the element of the system represented by the current image to be replaced, if it is replaceable. The system first checks if the image is replaceable. If so, it is updated to reflect changes required, and the adaptive CRT displays the following message: THE (element name) HAS BEEN REPLACED.

If the image is not replaceable, the image displayed by the image CRT display remains the same and the adaptive CRT display presents the following message: THE ELEMENT BEING DISPLAYED IS NOT REPLACEABLE.

The system further evaluates the replacement and prerequisite conditions, and if either condition is not satisfied, the adaptive CRT display presents the following message: REPLACEMENT IS NOT PERMITTED WITH THE SYSTEM IN THE CURRENT CONDITION.

Touching the TEST EQUIPMENT asterisk causes a list of test equipment to be displayed including any test points to which it may be connected. For example:

| <u>TEST EQUIPMENT</u> | <u>CONNECTED TO</u> |
|-----------------------|---------------------|
| * OSCILLOSCOPE        |                     |
| * MULTIMETER          | 1A1A2J14            |

A test equipment item is selected by touching the asterisk next to the name. A displayed next to the item name identifies the currently selected item. If the item

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selected is currently connected to a test point, and leaving it connected would cause signal distortion or interference with operation, the adaptive CRT display presents the following message:

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\* DISCONNECT

After a test equipment item is selected, an image of the item is displayed on the image CRT display 14. The equipment can be adjusted as desired, and then the student can touch the HIGHER LEVEL asterisk to return to the previous image. To connect the test equipment, the student may touch the test point. The test equipment will be disconnected from its previous connection (if applicable) and connected to the new test point. Finally, a picture of the test equipment reading is shown on the image display.

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Touching the SWITCH SETTING asterisk causes a list of the present equipment switch settings to be displayed on the adaptive CRT display. For example:

|    | SWITCH              | SETTING  |
|----|---------------------|----------|
| 20 | LOCAL MODULATION SW | 1200 PSK |
|    | LOCAL XMTER KEY     | OFF      |
|    | LOCAL HANDSET KEY   | OFF      |

25

This function allows the student to check the switch setting whenever desired during a troubleshooting procedure.

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Touching the EVALT/E READING asterisk allows the student to question whether a test equipment reading is normal or abnormal for the test point touch. If the reading is normal, the adaptive CRT displays:

THIS READING IS NORMAL

If a reading is abnormal, the adaptive CRT displays the following message:

THIS READING IS ABNORMAL

5 The aforementioned function is not available during a test problem. If the student selects EVALT/E READING during a test problem, the adaptive CRT display will display the following message:

NOT AVAILABLE DURING TEST

10 The PROBLEM SOLVED asterisk is touched when the student feels a problem has been solved. Because initiating this function can terminate a problem, the adaptive CRT display presents the following message:

DID YOU POINT TO PROBLEM SOLVED ON THE MENU?

\* YES

15 \* NO

In the practice mode, if the problem has indeed been solved, the adaptive CRT displays the following message:

GOOD, YOU HAVE SOLVED THE PROBLEM.---

20 Then a new problem is presented. If the PROBLEM SOLVED asterisk is touched, but the problem has not been solved, the adaptive CRT display presents the following message:

THE PROBLEM HAS NOT BEEN SOLVED

TOUCH THIS SCREEN TO CONTINUE THE PROBLEM.

25 In the test mode, the system will automatically select the next problem.

30 The STOP PROBLEM asterisk is touched when the student wishes to terminate the present problem to either (1) end a session or (2) choose another problem, if additional problems are available. To ensure that the student does

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indeed want to terminate the problem (in case the touch was accidental), the adaptive CRT display presents the following message:

DO YOU WANT TO STOP THIS SESSION?

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\* YES

\* NO

If YES is selected, the session is terminated, and the same problem is presented at the next session. If NO is selected, either of two actions may occur as follows:

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(1) If sufficient additional problems are in the current pool, the problem may be terminated, and the adaptive CRT display presents the following message:

DO YOU WANT TO WORK A NEW PROBLEM?

\* YES

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\* NO

If YES is selected, the problem stopped will be scored as "aborted" and a new problem will be presented. If NO is selected, the problem will resume with the problem being presented before the STOP PROBLEM asterisk was touched.

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Along with each problem, an associated complaint is displayed. In the test mode, TEST MODE is also indicated by the adaptive CRT display as follows:

TEST MODE

OPERATOR'S COMPLAINT: THE MALFUNCTION LIGHT IS ON.

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Simultaneously with the foregoing display, the top level image of the system which is the subject of the lesson is displayed by the image CRT display. The student then proceeds to work through the problem as follows. To view an intermediate level image or to reach the scene level, the student touches the selection symbol on the

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higher level image which provides access as to that section. Each section for which there is a more detailed picture contains this marker. To change the position of a switch showing on the image display, the student touches the desired switch position. A new image reflecting the new switch position and any indications affected by this new switch position are automatically shown. To connect test equipment to a test point or pin and view the test equipment reading, the student touches the TEST EQUIPMENT asterisk on the command select menu and proceeds.

After the last practice problem has been presented and worked, the adaptive CRT display presents the following message:

YOU HAVE COMPLETED THE PRACTICE PROBLEMS.

DO YOU WISH TO PROCEED WITH THE TEST AT THIS TIME?

\* YES

\* NO

If YES is selected, the first test problem is presented. If NO is selected, the training session is terminated, and the first test problem will be presented at the beginning of the student's next session.

When the last session has been completed, the system goes into a state of waiting for a new student data file diskette to be installed. This state is indicated by the adaptive CRT display by presenting the message:

INSERT DISKETTE FOR NEW STUDENT

TOUCH THE SCREEN WHEN DISKETTE HAS BEEN INSERTED

If a new student data file diskette is inserted, the training lesson operation is repeated.

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After each student has completed the prescribed lesson problems, the instructor may perform data management tasks or shut down the system. Data management tasks include printing student performance data and copying the student performance to a master copy diskette. The keyboard/printer terminal 20 facilitates direct control input to the Z-80 microprocessor for initializing the "data base and lesson plan" diskette, and for setting up specific lesson step sequences and limits. At the conclusion of the lesson, the terminal can provide a hard-copy printout of the student's test results.

Having described the operation of the preferred embodiment of the interactive simulator system, its circuitry may now be described in greater detail. Referring to Figure 3, the system has a bus-oriented architecture in that a single 8-bit data bus 62 provides data interface between all system peripheral devices and the Z-80 microprocessor 61 which functions as the central processing unit (CPU) of the computer 16. A 16-bit address bus 64 is extended directly and indirectly to the peripheral devices. The data and address buses are extended to the peripheral interface assembly 45 which contains video controllers and touch panel interface circuitry hereafter described. The adaptive and image touch panels 46 and 48, the adaptive CRT display 12, the image CRT display 14, the video disk player 18, and the instructor's terminal 20 all interconnect with the computer 16. This computer, as illustrated in Figure 2, includes the microprocessor assembly 42, the dual floppy disk drive unit 44 and the peripheral interface assembly 45.

As previously indicated, the computer 16 is preferably an ALTOS ACS 8000-2 computer whose CPU 61 is a Z-80A microprocessor. It has a bus-oriented architecture which incorporates the 8-bit data bus 62 and the 16-bit address bus 64. The Z-80 microprocessor features 158 instructions, and operates at up to 4 MHz with a minimum of 1-microsecond execution time. It has a duplicate set of general purpose and flag registers (sixteen total) which use such software programming operations as single-context switching, background-foreground programming, and single-level interrupt processing. Two 16-bit index registers allow efficient processing of tables and arrays. The extensive instruction set includes string, bit, byte, word operations and block transfers along with efficient addressing modes such as indexed and relative. All communications between the microprocessor assembly 42 and memory or peripheral devices are via the 8-bit data bus 62. Priority interrupt capability is provided.

Referring to Figure 3, the microprocessor assembly 42 includes 64 K of dynamic random access memory 66. The refresh function is done automatically by the microprocessor 61. The RAM 66 may be constructed of 16 K X 1 memory chips. Eight of these chips may be connected in parallel to provide an 8-bit byte. By connecting four of these chips in series, a total of 32 chips (4 X 8) provides 64 K bytes of memory.

The initialization and diagnostic programs for the microprocessor assembly 42 are stored in a 1 K read-only memory or ROM 68. After start-up or reset, the ROM 68 is no longer involved in the operating system. The RAM 66 and

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the ROM 68 are interfaced with the microprocessor 61 on the 8-bit data bus 62.

5 The microprocessor assembly 42 further includes a Z-80 serial input/output (SIO) chip which provides two serial ports 70 and 72. Each of these ports can provide full-duplex operation with data rates from 0 to 800 K bits per second. Message formatting in the asynchronous mode is provided for complete messages in 5, 6, 7 or 8-bits per character. This operation includes variable stop bits and  
10 several clock rate multipliers, break generation and detection, parity, overrun, and framing error detection.

The basic function of the SIO ports 70 and 72 is to interface serial data to the data bus 62. As such, the ports act as converters of serial-to-parallel and parallel-  
15 to-serial data. They also buffer the data for compatible data flow. Receiver registers buffer the data four times, and transmit data registers buffer the data twice.

The CPU 61 communicates with the video-disk player 18 via the SIO port 70 with a serial data standard ASCII 11-bit word format. The hardware interface is standard RS232C  
20 compatible. Data rate is approximately 1200 baud. A Z-80 counter/timer circuit (CTC) device 74 supports the counting and timing functions for the SIO port 70.

The CPU 61 of the microprocessor assembly 42  
25 interfaces with the dual floppy disk drive unit 44 via a Z-80/PIO device 76 and a FDI791 floppy-disk controller device 78. The controller 78 performs parallel-to-serial data conversion for write data which is sent to the disk-drive circuitry, and serial-to-parallel conversion for read data  
30 which is sent from the disk-drive circuitry. The floppy-

disk controller device 78 also provides read and write control functions to the drives of the disk drive unit 44.

The Z-80/PIO device 76 provides a direct 8-bit parallel interface between the Z-80 CPU 61 and the peripheral devices. The Z-80/PIO 76 device provides two 8-bit parallel ports. It can be operated in four different modes, either under software control or under fully nested interrupt control. The four modes of operation are: 1) byte output, 2) byte input, 3) byte input/output, and 4) bit input/output.

The Z-80 CPU 61 communicates with the instructor's terminal 20, when used, through the SIO port 72. This interface operates at approximately 300 baud. One port of the PIO 76 is provided for interface with three-dimensional simulation circuitry 80 to be developed in the future.

The peripheral interface assembly 45 (Figure 3) provides the interface video and sync signals and the refresh function for both the alphanumeric and graphic display data to the adaptive CRT display 12. The alphanumeric and graphic data displayed on the adaptive CRT display 12 are programmed outputs from the microprocessor assembly 42. The microprocessor assembly 42 outputs character selection and position display data to an alphanumeric controller module 82. This module performs the character generation at the correct positions on the adaptive CRT display 12 and provides the continuing refresh of that display. The alphanumeric controller module operates in sync with a graphic controller module 84. A touch panel interface module 86 contains circuitry for the

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switching functions A/D conversion logic, and control logic for both of the touch panels 46 and 48.

Figure 4 is a functional block diagram of the alphanumeric and graphic controller modules 82 and 84, illustrating the interface with the system data and address buses 62 and 64, respectively, and the outputs to the adaptive CRT display 12. The alphanumeric controller module 82 interfaces with the microprocessor assembly 42 via a 1K byte RAM 88. Data is transferred to the RAM 88 in 8-bit words at RAM addresses determined by the computer program. The RAM address (10-bit) also determines the location of the character on the display. The six least significant bits (LSB) determine the column. The fourmost-significant bits (MSB) determine the row. Thus, 1920 characters are arranged in twenty-four rows of 80 characters each. The character selection word to the RAM is the standard 7-bit ASCII code. The 8-bit selects the desired character attribute, that is, displayed normal, blink, or inverse. Blinking or inverse video selection is hardware selectable for the system and not on a per character basis. Of the 1920 characters, 128 are displayed with a five by seven dot matrix with below-line extendors and special characters using a six by ten dot matrix.

The adaptive CRT display 12 provides a black and white display of the alphanumerics and graphics which make up the user instructions and/or questions. The display 12 includes only the high voltage and electronic's assembly power supplies. and the deflection and intensity amplifiers. The video input is video data only and is not a composite of video and sync signals. The adaptive CRT

display 12 receives all alphanumeric video and positional data (vertical and horizontal sync signals) from the peripheral interface assembly 45. The video input is video data only and is not a composite of video and sync signals. The input sync levels are held constant by the peripheral interface assembly 45 and no adjustments are required.

The alphanumeric controller module 82 further includes a data bus interface 90 for the RAM 88 and a ROM 92 in which the characters are stored. The alphanumeric controller module 82 further includes a sync generator 94 and a video generator 96.

The graphic controller module 84 (Figure 4) provides a 256 X 256 X 1 dot matrix display on the adaptive CRT display 12. This module contains a sync generator 98, video generator 100, built-in refresh RAM 102. The module 84 also includes the other electronics required to interface with the microprocessor assembly 42 via the data bus 62. This is done through ports 104, 106 and 108. The horizontal and vertical sync signals from this module provide the sync for the alphanumeric controller module 82 and the adaptive CRT display. The video output is mixed with the video from the alphanumeric module to provide a composite video output. The graphic controller module 84 receives a 16-bit address word (8-bit X address and 8-bit Y address). This 16-bit address is supplied to an address multiplexer 110 and defines a location in the 64 K bit RAM 102. The data input for the particular location is a single bit (1 or 0). When an output is being sent to the adaptive CRT display 12, the RAM 102 is addressed in sequence from 0 address to 65536. RAM locations which are

(41)

marked (data equals 1) are displayed on the adaptive CRT display 12 as dots. The refresh rate is 60 Hz which eliminates any perceptible flicker. A read/write control 112 is provided between the port 108, the refresh RAM 102 and the video generator 100.

Having described a preferred embodiment of the interactive simulator system, it should be apparent to those skilled in the art that our invention permits of modification in both arrangement and detail. Accordingly, the protection afforded out invention should be limited only in accordance with the scope of the following claims.



CLAIMS

1. An interactive simulator system comprising:

2 adaptive CRT display means for displaying on a face  
thereof alphanumeric and graphic instructions and  
4 questions;

6 first touch panel means associated with the face of  
the adaptive CRT display means for generating signals  
representative of user input commands made by touching  
8 specific locations on the face of the adaptive CRT display  
means;

10 image CRT display means for displaying on a face  
thereof images associated with the instructions and  
12 questions;

14 second touch panel means associated with the face of  
the image CRT display means for generating signals  
representative of user input commands made by touching  
16 specific locations on the face of the image CRT display  
means;

18 video disk player means for providing to the image CRT  
display means video signals representative of the images;

20 memory means for storing a digital operation program  
including the instructions and questions to be displayed by  
22 the adaptive CRT display means;

24 peripheral interface means for receiving first digital  
signals representative of the instructions and questions  
and providing the adaptive CRT display means with  
26 compatible signals to enable it to display the instructions  
and questions, and for receiving the signals representative  
28 of user commands from the first and second touch panel



means and generating second digital signals representative thereof; and

digital control means connected to the memory means, video disk player means and peripheral interface means for providing the interface means with the first digital signals representative of the instructions and questions and for receiving from the interface means the second digital signals representative of the user commands and for causing the instructions and questions and the images associated therewith to be displayed in accordance with the operation program and user commands to thereby provide an interactive lesson.

2. An interactive simulator system according to Claim 1 and further comprising:

keyboard/printer terminal means connected to the digital control means for permitting modifications of the digital operation program and for generating hard-copy printouts of data including test results.

3. An interactive simulator system according to Claim 1 and further comprising:

console means for supporting the adaptive CRT display means above the image CRT display means with the face of the image CRT display means extending substantially vertically and the face of the adaptive CRT display means inclined slightly forward from the plane of the face of the image CRT display means.



4. An interactive simulator system according to Claim 3  
and further comprising:

a desk having a top for supporting the console and  
having a base cabinet for housing the video disk player  
means and the digital control means.

5. An interactive simulator system according to Claim 1  
wherein the peripheral interface means includes:

touch panel interface circuitry means for receiving  
the signals representative of the user commands from the  
first and second touch panel means and generating the  
second digital signals representative thereof;

alphanumeric control circuitry means for receiving the  
first digital signals representative of the instructions  
and questions and providing the adaptive CRT display means  
with compatible signals to enable it to display the  
alphanumeric portions of the instructions and questions;  
and

graphic control circuitry means for also receiving the  
first digital signals representative of the instructions  
and questions and for providing the adaptive CRT display  
means with compatible signals to enable it to display the  
graphic portions of the instructions and questions.



6. An interactive simulator system according to Claim 5  
2 wherein the alphanumeric control circuitry means includes:  
a refresh RAM;  
4 a data bus interface;  
a ROM;  
6 a sync generator; and  
a video generator.
7. An interactive simulator system according to Claim 5  
2 wherein the graphic control circuitry means includes:  
an output port;  
4 a refresh RAM;  
an address multiplexer coupled between the output port  
6 and the refresh RAM;  
a sync generator;  
8 a video generator; and  
read/write control circuit means connected between the  
10 output port, the refresh RAM and the video generator.
8. An interactive simulator system according to Claim 1  
2 wherein the digital control means and the operation program  
contain means for generating a command select menu along  
4 the lower portion of the face of the adaptive CRT display  
means.



9. An interactive simulator system according to Claim 1  
2 wherein the digital control means and the operation program  
contain means for permitting the user to cause the image  
4 CRT display means to present images in a predetermined  
hierarchical structure by successively touching  
6 predetermined locations on the faces of the adaptive CRT  
display means or the image CRT display means.

10. An interactive simulator system according to Claim 1  
2 wherein the memory means includes a dual floppy disk drive  
for receiving a student data file diskette and a data base  
4 and lesson plan diskette.

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