CERL REPORT X-20 APRIL, 1971
REVISED MAY, 1972

THE PLATO IV ARCHITECTURE

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This work was supported by the National Science Foundation under Contract NSF GJ 81 and NSF GJ 947.

PLATO has been supported by the Advanced Research Projects Agency through the Office of Naval Research under Contract Nonr 3985(08), in part by the Joint Services Electronics Program (U.S. Army, U.S. Navy, and U.S. Air Force), in part by the Public Health Service, Division of Nursing of the U.S. Department of Health, Education and Welfare under Contract NPG-188-01, and in part by the U.S. Office of Education under Contract OE-6-10-184.

A project of the size of PLATO IV necessarily requires the talents of many people only a few of whom are mentioned here.

Paul Tucker and Mike Johnson assisted in the design of the Network Interface Unit.

Len Hedges, Fred Holy, Jim Knoke, and Rich Slavens all contributed to the actual fabrication of the system hardware.

Thanks also to Susan Rankaitis and Ann Carroll for their help in the assembly and typing of this report and to Jim Parry for the helpful comments.

ABSTRACT

This report provides a general description of the hardware for the PLATO IV system. The various system components are identified and their functions described. Some programming information relating to the control of data in the PLATO network is also included.

The PLATO IV Architecture

by

Jack Stifle

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Introduction

This report is intended to serve as a brief and general description of the hardware used in the PLATO IV system. The function of the various system components is described along with descriptions of operations.

System Description

A block diagram of the PLATO IV system is shown in Figure 1. Operation of the entire system is under control of a large scale centrally located CDC 6400 computer system. The PLATO IV Network Interface Unit (NIU) supervises the flow of all data between the computer and the PLATO network.

The PLATO communications network utilizes educational television (ETV) facilities[1] to distribute data to the PLATO classrooms. The data is distributed in a manner similar to the distribution of commercial cable television (CATV) signals to private homes. Voice grade telephone lines are used to transmit data from the terminals to the computer center. Contained within the NIU are the input controller, the output controller and digital television transmitter (DTX).

The input controller scans all incoming lines from the PLATO network

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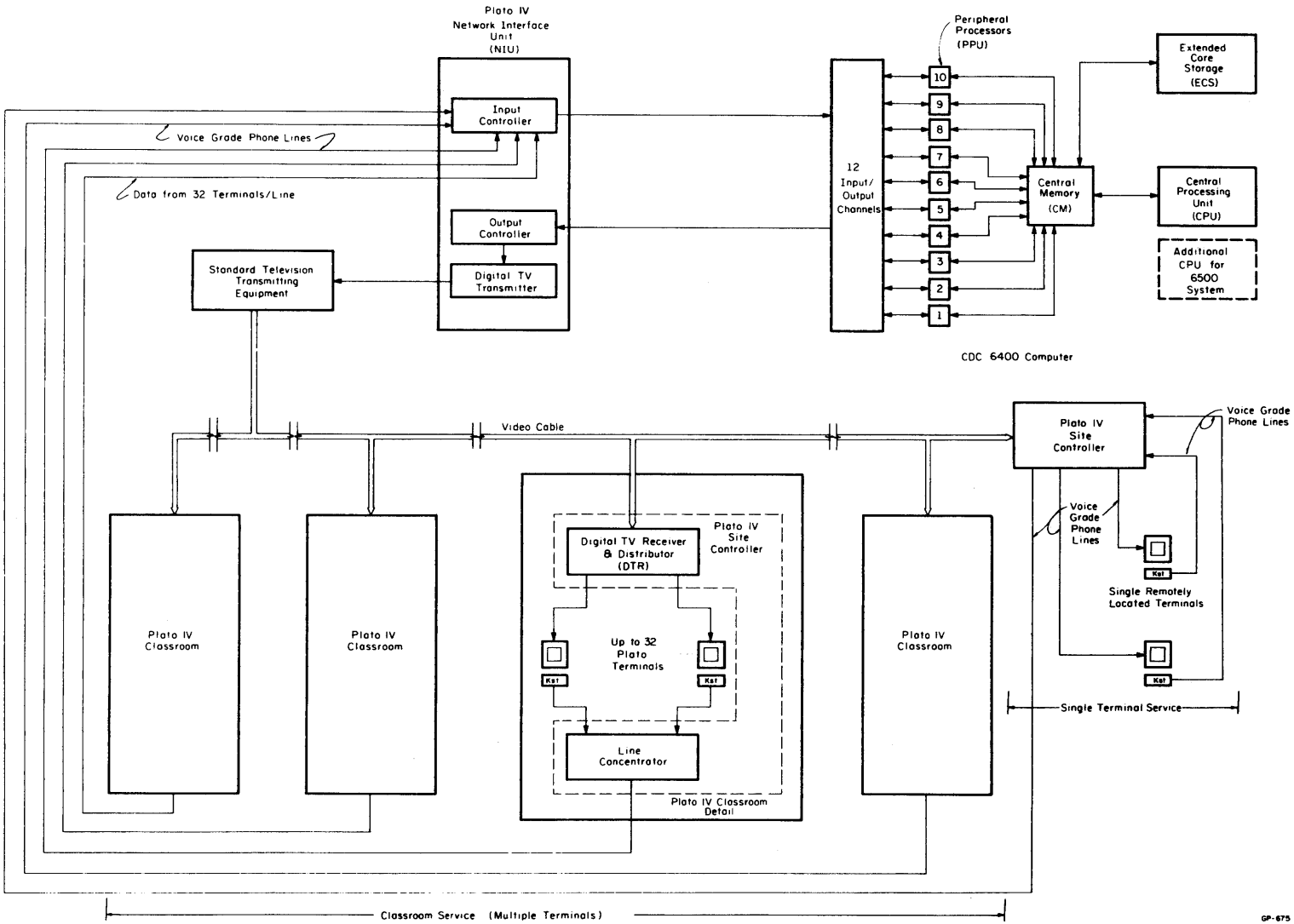
[1] J. Stifle, D. Bitzer, M. Johnson, "Digital Data Transmission Via CATV," CERL Report X-26, June, 1971.



FUGURE 1 PLATO IV

searching for incoming data. If data is present, the input controller attaches a site address to the data, performs a parity check on the data and passes the information on to the computer. Up to 32 lines, each carrying the data for up to 32 terminals, (or a total of 1024 terminals) may be serviced by the input controller.

The output controller accepts data from the computer and prepares it for transmission over the PLATO network. This preparation consists primarily of a parallel to serial conversion. From the output controller the data is delivered to the DTX where it is encoded into a form compatible with the requirements of standard commercial television equipment.[2] From the DTX, the data is sent to television transmitting equipment for modulation and transmission via a video cable. The output controller and DTX are capable of transmitting a 21 bit word to every terminal in the system every 1/60 second. Requirements imposed by the DTX limit to 1008 the number of terminals which can be serviced on one ETV channel. Hereafter, then, a PLATO system will be understood to contain up to 1008 terminals.

Most of the terminals in a PLATO system are grouped into classroom sites of up to 32 terminals each. Each PLATO classroom site contains a PLATO IV Site Controller and up to 32 student terminals. The Site Controller contains a digital television receiver (DTR) and distributor and a line concentrator. The DTR recovers the data from the TV channel and distributes it serially to the terminals over twisted pair lines at a rate of 1260 bits per second. The line concentrator transmits data from

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[2] Ibid., p. 5.

up to 32 terminals to the computer center on a single voice grade telephone line in an asynchronous time-division multiplex mode at a rate of 1260 bits per second. This sharing of one line permits a data rate per terminal of from 2 1/2 to 80 characters per second (10 bits/character). The lower rate is equivalent to a typing rate of approximately 30 words per minute and occurs if all 32 terminals are transmitting simultaneously.

The PLATO network can also provide service to individual remotely located terminals as shown in the lower right corner of Figure 1. Data for such terminals is transmitted over voice grade phones which are connected to a PLATO Site Controller. This Site Controller is identical to that used in a PLATO classroom site and can be located anywhere in the PLATO network.

The PLATO IV student terminal, shown in Figure 2, is an interactive computer graphics terminal which features:

1. An 8 1/2 inch square plasma display panel that is readable in a brightly lighted room without eyestrain.

2. Permanent storage of information on the display screen without flicker. Absolutely no refreshing of the display panel by the computer is required. Selective WRITE and ERASE capability exists for all dots, lines, and characters.

3. Self-contained character and line generators.

4. A character writing speed of 180 characters per second and the capability of displaying 2048 characters on the screen.

5. A line drawing speed in excess of 600 inches per second.

6. A character repertoire of 252 characters, 126 of which are alterable via the computer program.

7. The ability to transmit and receive data on voice grade telephone circuits.

8. A random access slide projector for rear projection of static information on the display screen.

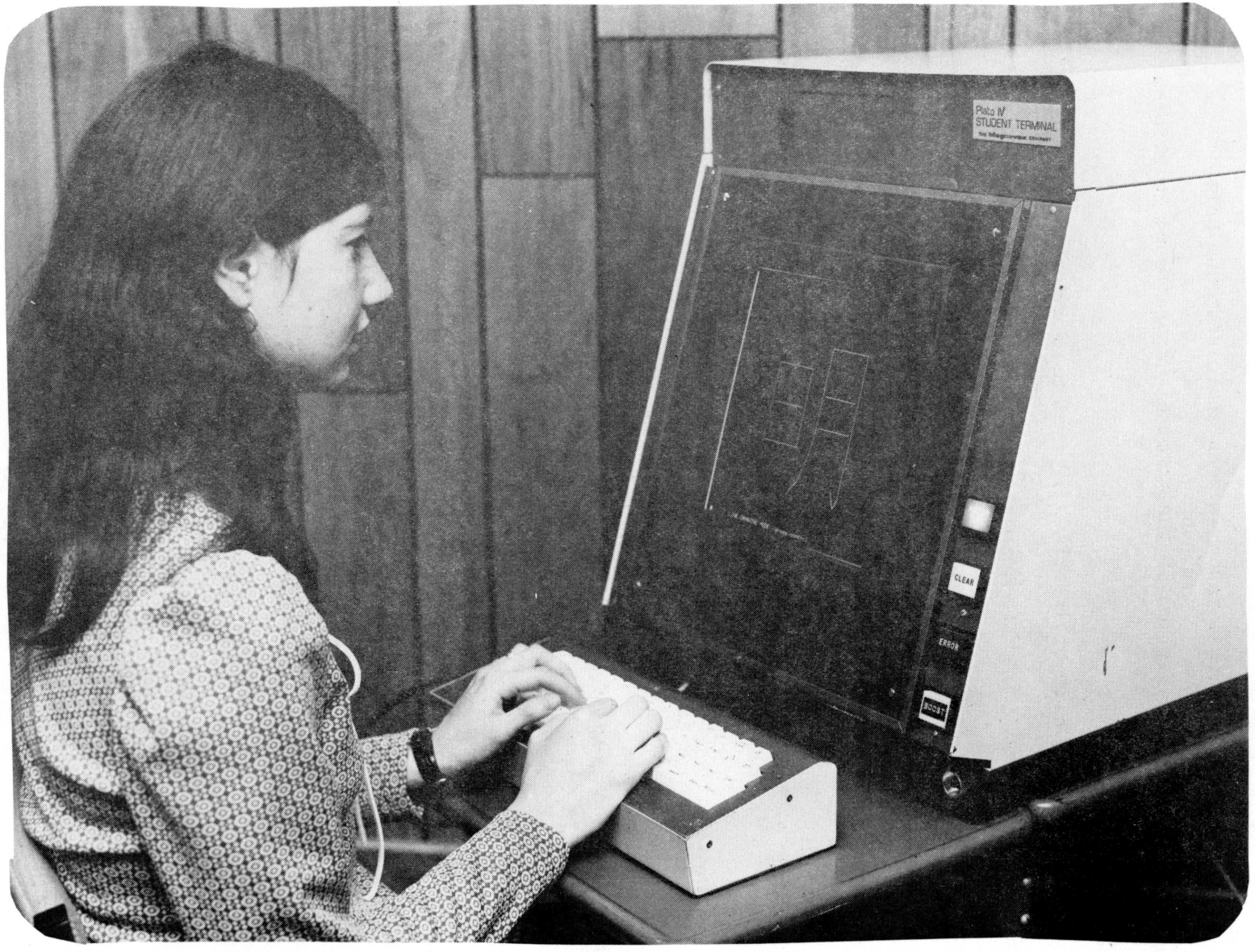

FIGURE 2 TERMINAL

9. Additional input-output channels for the control of auxiliary equipment.

10. An optional random-access audio response unit.

A detailed description of the terminal can be found in reference 3.

Central Computer

Operation of the entire PLATO IV system is under control of a CDC 6400 computer system. This computer, see Figure 3, is a large scale general purpose computer containing one very fast central processing unit (CPU) and 10 independent peripheral processing units (PPU) which communicate with the CPU via the central memory. Augmenting the central memory is the extended core storage (ECS) system which can provide storage of up to two million additional words. Additional mass storage is provided by three disk pack drives, 32 million characters each, and one 75 million character disk. Twelve input-output channels are available, two of which operate the PLATO IV Network Interface Unit with others controlling the various peripheral equipment as shown in Figure 3.

Network Interface Unit--Output Controller

The Output Controller is basically a parallel to serial converter. This equipment accepts data from the computer and prepares it for transmission over the PLATO network.

A functional block diagram of the output controller is shown in Figure 4. The controller consists of two 1024 by 20 bit memories, a word assembly register, a write control, a read control, a four bit

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[3] J. Stifle, "A Plasma Display Terminal," CERL Report X-15, March, 1970.

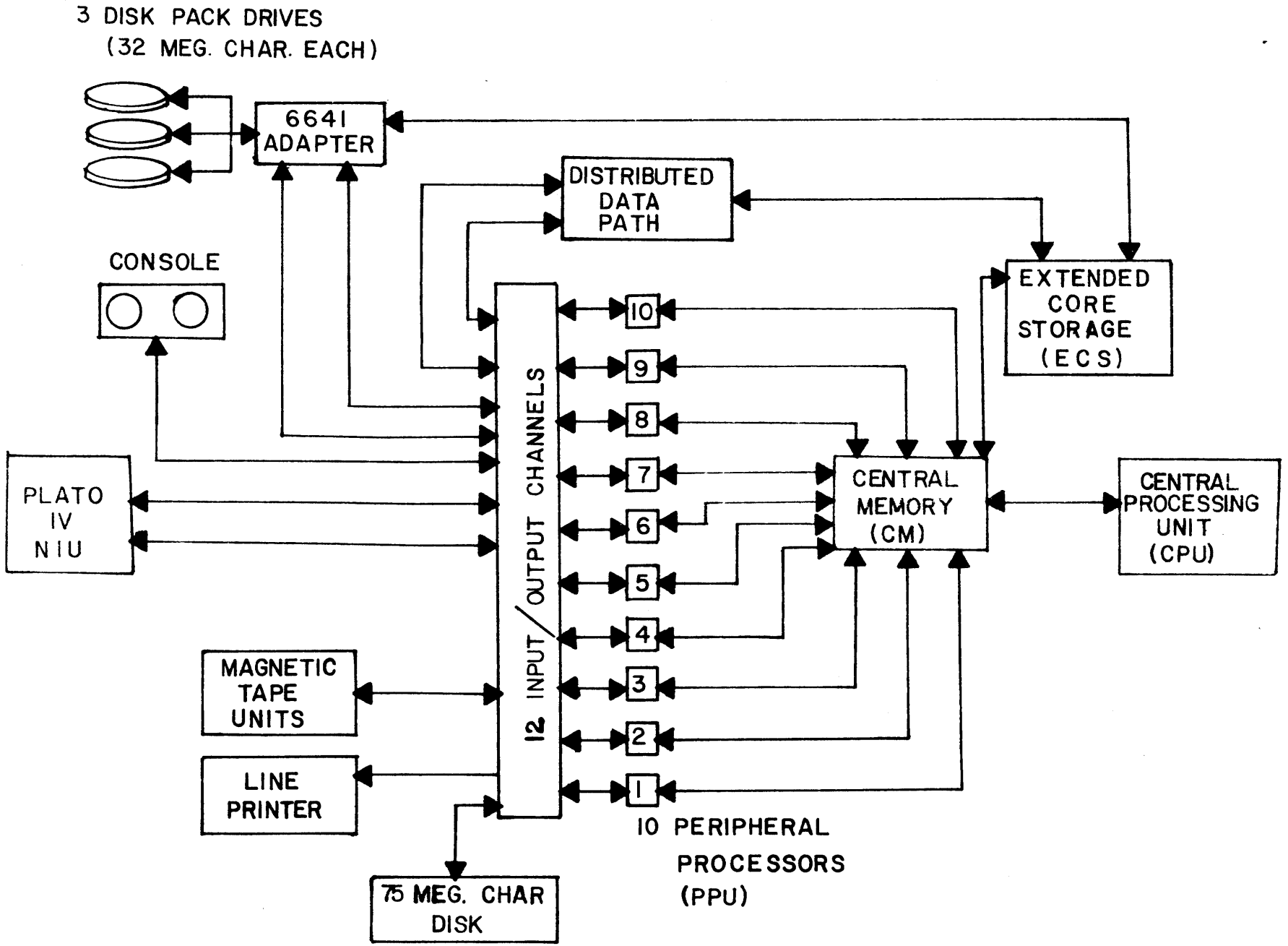

FIGURE 3. 6400 COMPUTER SYSTEM

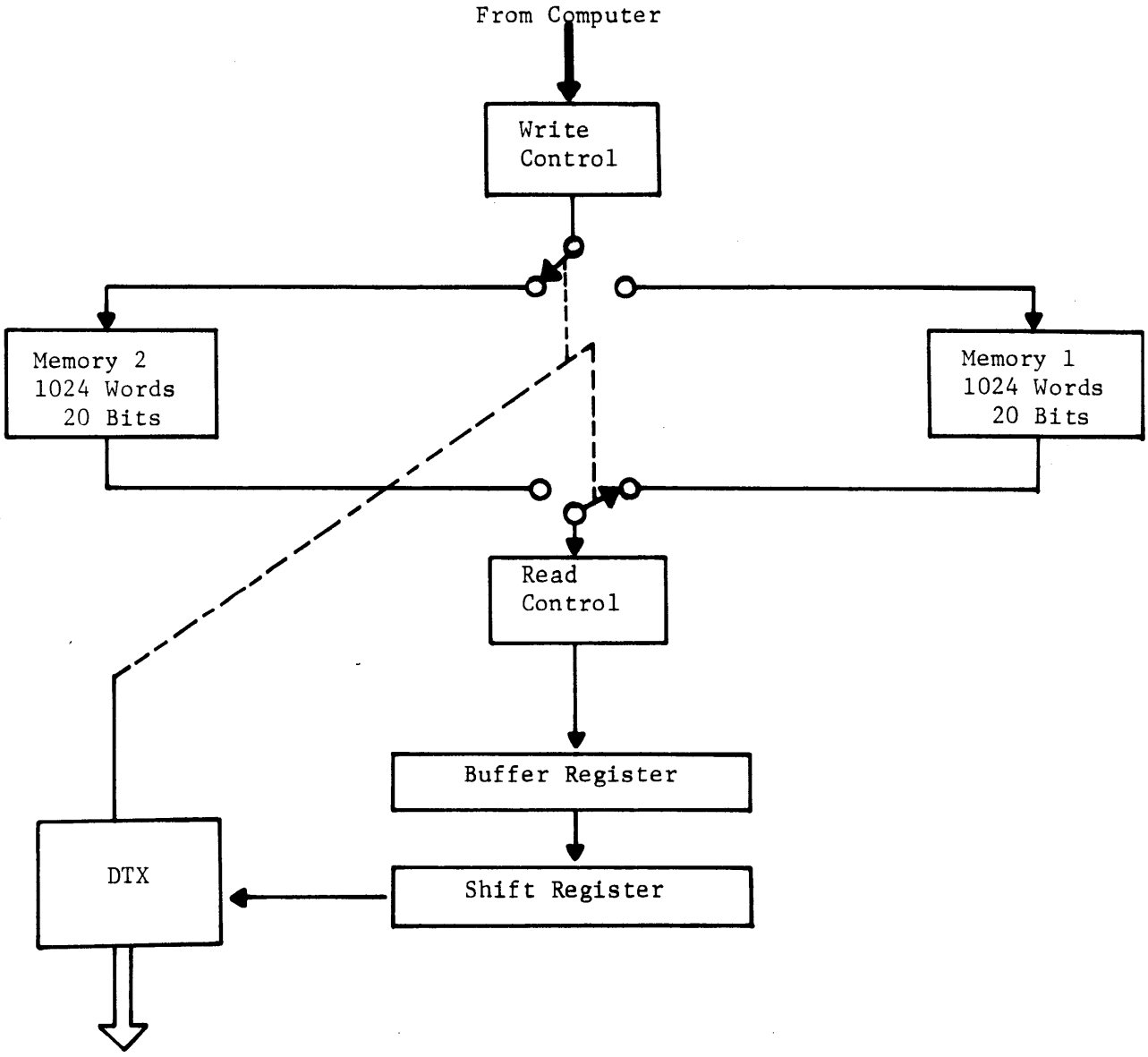

FIGURE 4 OUTPUT CONTROLLER - BLOCK DIAGRAM

memory buffer register, a four bit shift register, and a digital data transmitter (DTX). The contents of either of the memories in the controller are loaded or read in 1/60 second. One memory is loaded by the computer during the 1/60 second that the other memory is being read into the DTX.

Each group of three 12 bit words from the computer is assembled by the Output Controller into one 30 bit word as shown in Figure 5.

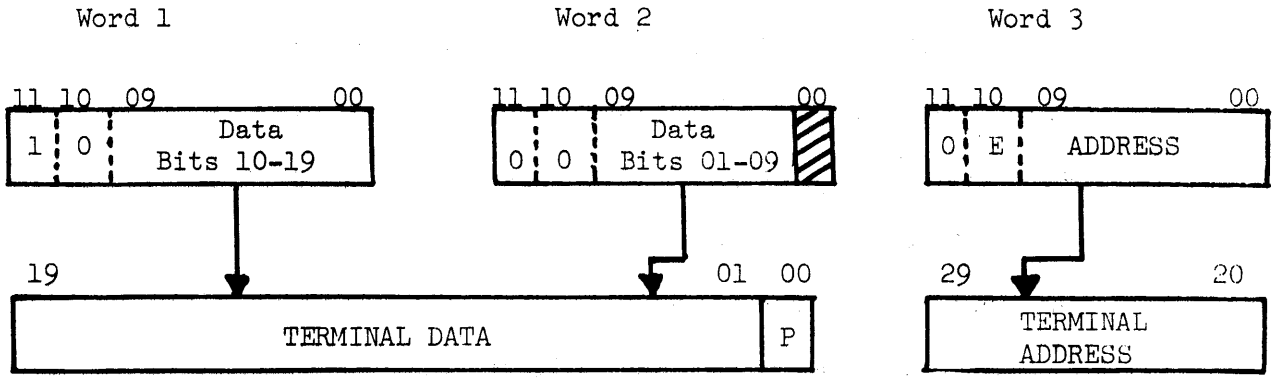

FIGURE 5 OUTPUT DATA FORMAT

Bit 00	Parity Bit. This bit is filled by the controller with a parity bit (odd parity) for the data portion of the word.
Bits 01-19	Terminal Data
Bits 20-29	Address of terminal for which data is intended.

Bits 10-11 of the three 12 bit words are control bits used by the controller as follows:

Bit 11, word 1	This bit indicates the first word of a 3 word sequence.
Bit 10, word 3	This bit, when equal to "1" indicates that this word is the address of the last terminal to receive data during the present 1/60 of a second.

Write (load) operations consist of storing the terminal data portions of the data words in a memory using the terminal addresses as memory addresses. Thus, for example, the data for terminal 355 would be stored in memory location 355. Parity bit assignment on the data is made just prior to the time the data is stored in memory.

A read operation consists of:

1. Read one bit from each of four consecutive memory addresses.
2. Load the four bits into the memory buffer register.
3. Write logical zeros in memory in place of the data.
4. Load the shift register from the buffer register.
5. Shift data from register to DTX.
6. Increment memory address.
7. After 1008 addresses are read, decrement the bit count.

Read operations continue until all 20 bits of all (1008) locations have been read and transmitted. After having been read the contents of each memory location is all "0"'s. An all "0"'s data word is interpreted by the PLATO IV terminals as a no-operation (NOP) code. The computer is therefore required to send data only to those terminals requiring new information; the controller will automatically transmit NOP codes to all other terminals. A more detailed description of the Output Controller can be found in reference 4.

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[4]Paul Tucker, "A Large Scale Computer Terminal Output Controller," CERL Report X-27, June, 1971.

Network Interface Unit - Input Controller

All incoming lines from the PLATO IV terminals are routed to the input controller. The input controller scans these lines for data and controls the flow of the data into the peripheral processor.

The format of the incoming data is shown in Figure 6.

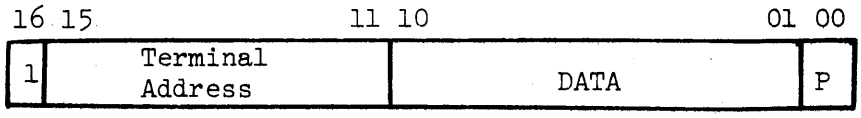

FIGURE 6 INPUT DATA FORMAT

Bit 00	Parity Bit
Bits 01-10	Data
Bits 11-15	Address of terminal sending data
Bit 16	Message start bit, always "1".

A functional block diagram of the Input Controller is shown in Figure 7. The data on each line arrives at the controller at a rate of 1260 bits/second and in the form of a frequency modulated (FM) signal. The demodulators recover the data from the fm signal and stores it temporarily in a holding register until it is read by the controller.

The controller is basically a 32 channel (16 bits/channel) multiplexor. The scanner scans the holding registers in the demodulators; if a register contains data the scanner halts, transfers the data to the peripheral processor and then resumes the scan. The scanner and computer operate at a rate sufficient to ensure that no data is lost on any incoming line. The Input Controller attaches a 5 bit channel (SITE) address to the data word and checks the parity before sending the data

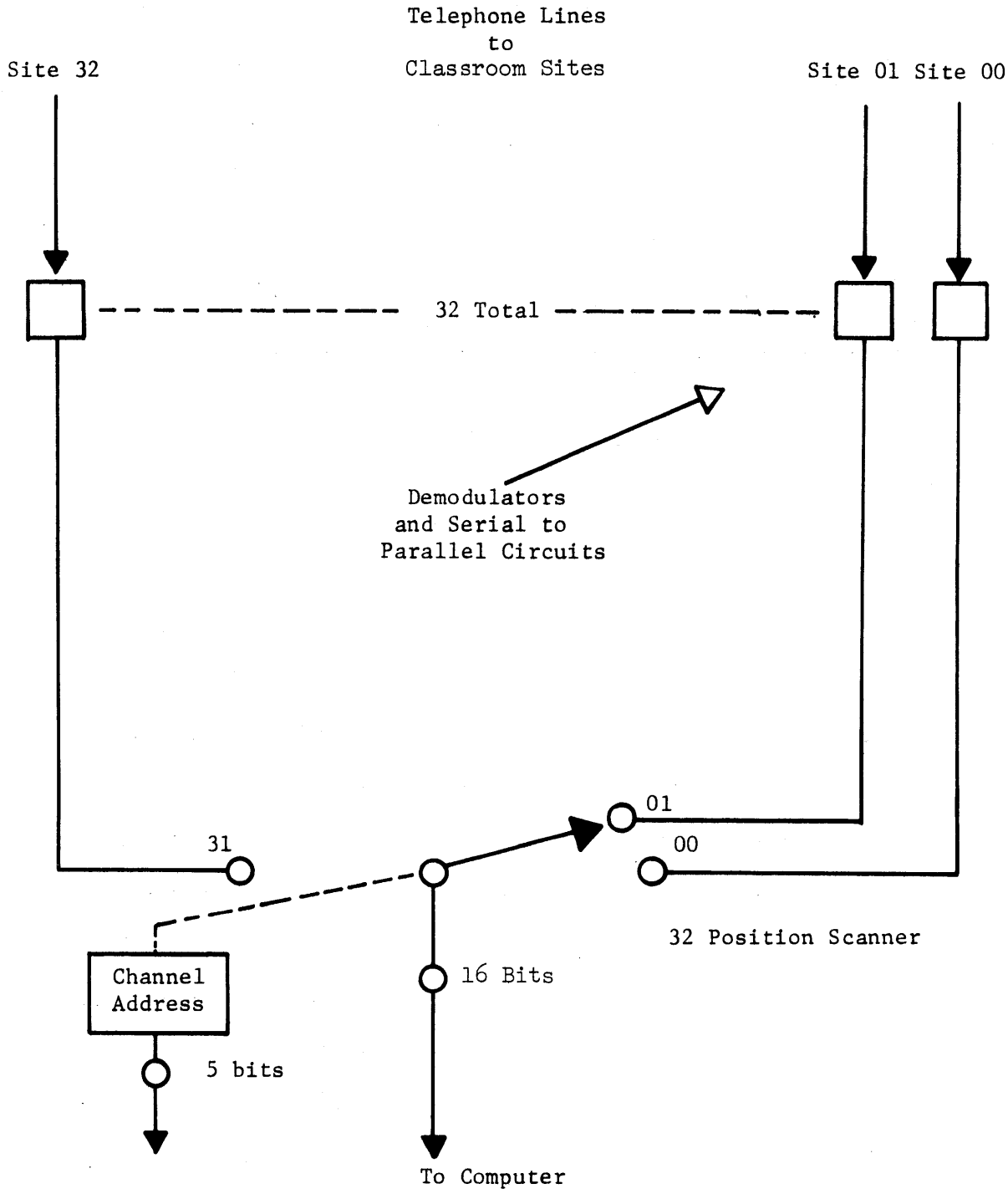

FIGURE 7 INPUT CONTROLLER - BLOCK DIAGRAM

on to the computer. The complete input data word, Figure 8 is disassembled into two 12 bit words for transmission to the computer.

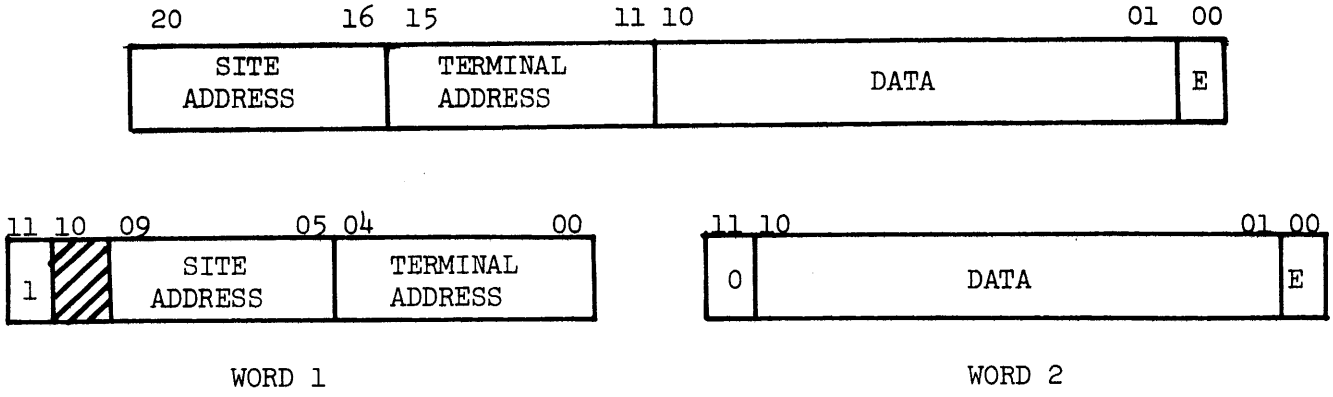

Figure 8 Input Data Word Format

Bit 00	Error Bit. If this bit is a 1, the data word contains an error.
Bits 01-10	Terminal Data.
Bits 11-15	Terminal Address.
Bits 16-20	SITE Address.

Input Controller Programming

The PPU controls the operation of the Input Controller with the external function (EXF) codes. These codes can be used to activate or deactivate any of the data lines arriving from the PLATO network. Status Request codes are also available for sensing the state of any of the data lines. The format of the EXF codes is shown in Figure 9.

Table 1 lists the function and Status Codes for the Output Controller. Each code is described below:

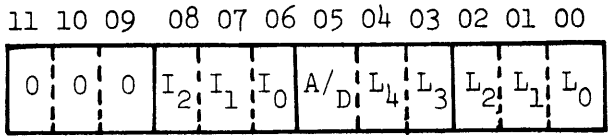

FIGURE 9 EXF FORMAT

Bits 00-04	Specify a scanner channel address.
Bit 05	Specifies an activate (Bit 5=1) or deactivate (Bit 5=0) function.
Bits 06-08	Specify function as follows: 000 - All channel function 001 - Single channel function 111 - Status Request Code
Bits 09-11	These bits specify the equipment number assigned to the Input Controller. They are always 0.

PLATO IV Input Controller EXF Codes

Function Code		
000 000 0 00000	Deactivate	All Channels
000 000 1 00000	Activate	All Channels
000 001 0 XXXXX	Deactivate	Channel XXXXX
000 001 1 XXXXX	Activate	Channel XXXXX
000 111 0 XXXXX	Sense	Inactive
000 111 1 XXXXX	Channel XXXXX	Active
x x x 0	Negative	Response to
x x x 1	Positive	Sense Codes

TABLE 1

Deactivate all lines (0000)

This code deactivates all channels.

Activate all lines (0040)

This code activates all channels.

Deactivate Channel (0100 - 0137)

These codes deactivate the channel specified by the lower five bits of the EXF code.

Activate Channel (0140 - 0177)

These codes activate the channel specified by the lower five bits of the EXF code.

Status Request Codes (0700 - 0777)

These codes may be used to sense the status of the Output Controller. A one word input must follow the Status Request to read in the status word. The status word has the format shown in Figure 10.

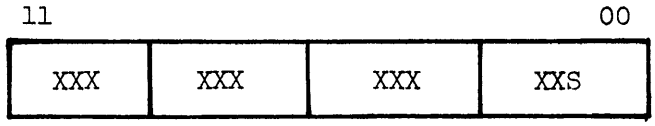

FIGURE 10 STATUS WORD FORMAT

Bit 00	Sense Response. Bit 0 = '0' for a negative or a "1" for a positive response to the condition sensed for.
Bits 01-11	Not used.

Site Controller

The PLATO Site Controller is a communications interface unit designed to process two-way digital communication between 32 PLATO IV student terminals and a remotely located computer.

Data received from the computer by the Site Controller arrives in the form of a standard FCC television signal in which that portion of the signal which normally contains video (picture) information contains instead digital data. This data must be recovered from the television signal and distributed to the terminals serviced by the Site Controller. That portion of the Site Controller which performs this receiving and distributing function is referred to as a Digital Television Receiver (DTR).

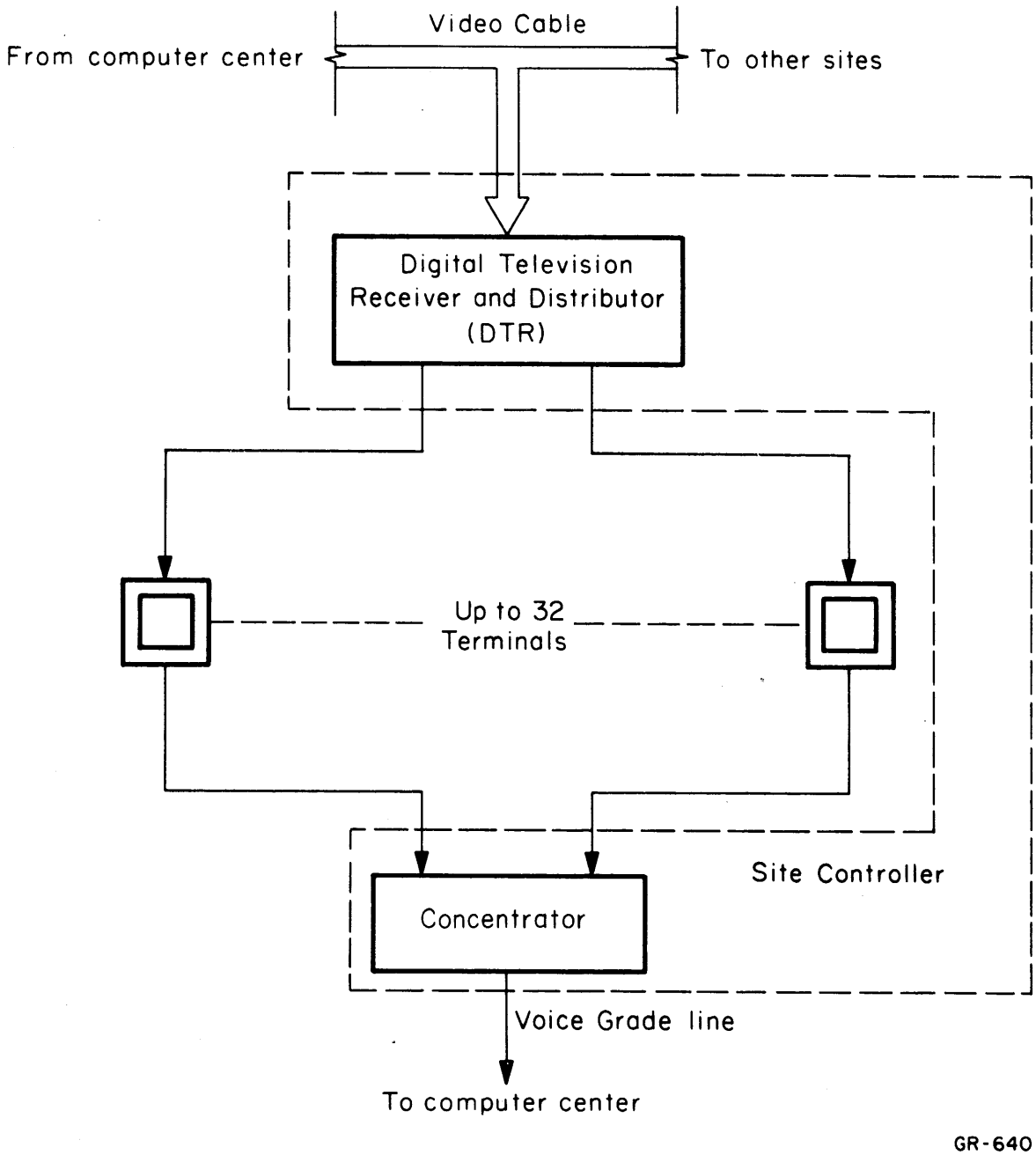

FIGURE 11 SITE CONTROLLER

Data generated by the terminals is transmitted to the Site Controller and from there the data is transmitted in a time division multiplex mode on a voice grade telephone circuit to the computer center. The data from up to 32 terminals is transmitted on a single voice grade circuit. That portion of the Site Controller which performs this function is referred to as a Concentrator.

A block diagram of the Site Controller is shown in Figure 11.

Concentrator

Data received by the Concentrator from each of the terminals is in the form of 12 bit words with the format shown in Figure 12. These words

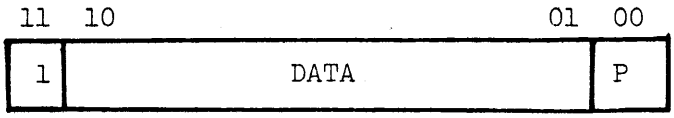

FIGURE 12 TERMINAL TRANSMITTED DATA FORMAT

arrive serially, bit 11 first and bit 00 last, at a rate of 1260 bits per second. Bit 11, the first bit in every word, is always a logical one. Bit 00 is a parity bit which forces the number of ones in a word to always be odd.

These data words are transmitted as a frequency shift keyed (FSK) signal as shown in Figure 13. Tp is 1/1260 second and represents one

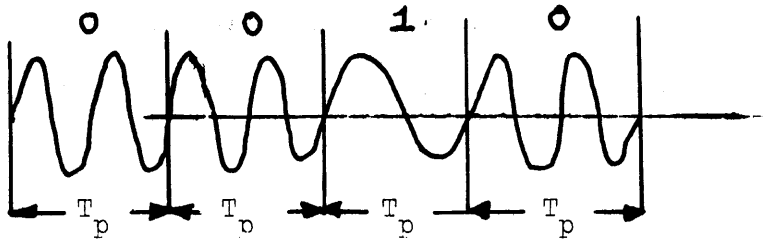

FIGURE 13 FSK SIGNAL

bit interval. A logical one is represented by one cycle of a 1260 hz signal and a logical zero as two cycles of a 2520 hz signal.

The Concentrator must (1) receive these data words, (2) attach a 5 bit address to the word identifying the terminal transmitting the word, (3) adjust the parity bit taking into account the address, and (4) transmit the expanded word to the NIU at the computer center. The format of the data words transmitted from the Concentrator is shown in Figure 14. These 17 bit words are transmitted serially, bit 16 first and bit 00 last, at a rate of 1260 bits per second. Bit 16, the first bit transmitted in

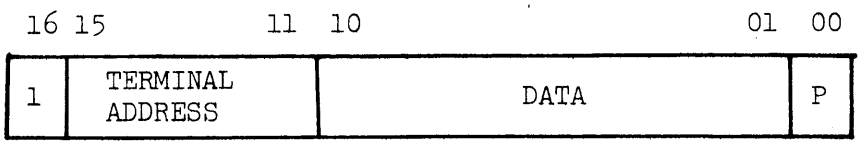

FIGURE 14 CONCENTRATOR WORD FORMAT

every word is always a logical one. Bit 00 is a parity bit which forces the number of ones in a word to always be odd. The data words are transmitted as a frequency shift keyed (FSK) signal as shown in Figure 13.

DTR

Information (data) destined for the PLATO terminals is transmitted in a time-division multiplexed mode as a NTSC (National Television Standards Committee) television signal.[5] The DTR must recover the data from the television signal, generate the terminal addresses for the data, and distribute the data to those terminals serviced by the Site Controller. When the terminals are in close proximity, i.e. same building, as the

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[5]Stifle, Bitzer, Johnson, "Digital Data Transmission Via CATV," pps. 5-7.

Site Controller, the data is distributed via twisted pair wires. For remotely located terminals, the data is transmitted via voice grade telephone lines.