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DEMONSTRATION AND EVALUATION OF THE PLATO IV
COMPUTER-BASED EDUCATION SYSTEM. (COMPUTER-
BASED EDUCATION FOR A VOLUNTEER ARMED SERVICE
PERSONNEL PROGRAM)

Illinois University at Urbana-Champaign

Prepared for:

Advanced Research Projects Agency

September 1975

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ADA017399

SEMI-ANNUAL REPORT

328161

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ARPA Order No. 2245   Program Code No. P3D20

U.S. ARMY CONTRACT DAHC-15-73-C-0077

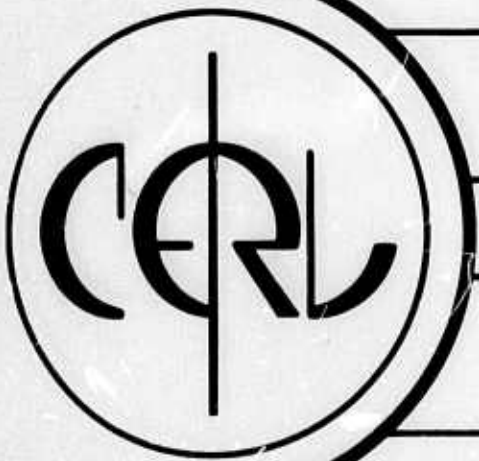Effective: August 1, 1972 thru June 30, 1975

DEMONSTRATION AND EVALUATION OF THE PLATO IV
COMPUTER-BASED EDUCATION SYSTEM

(Computer-based Education for a Volunteer
Armed Service Personnel Program)

For the Period

January 1, 1975 -- June 30, 1975

Computer-based Education Research Laboratory

University of Illinois   Urbana Illinois

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September , 1975

PREFACE

This report under Contract DAHC 15-73-C-0077 describes a program
aimed at the demonstration, test and evaluation of the educational and
economic effectiveness of the PLATO IV computer-based education as imple-
mented in several geographically dispersed military training sites. It
also describes a program aimed at increasing the cost effectiveness of the
PLATO system, both in its deployment in the ARPA community and in its con-
tinuing development as a national resource for education.

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PART I

SITE SUPPORT PROGRAM FOR
SERVICE TEST OF PLATO IV

INTRODUCTION TO THE SITE SUPPORT PROGRAM

This report describes a program aimed at the demonstration, test, and evaluation of the educational and economic effectiveness of the PLATO IV computer-based education system as implemented and tested in several geographically dispersed military training sites.

Familiarity with the two preceding reports of this project will facilitate understanding of this one. These will be referred to as "The First Annual Report" and "The Second Annual Report." The First Annual Report nominally covers the time from August 1, 1972, to January 1, 1974; the Second Annual Report covers January 1, 1974 to December 31, 1974.

Note: Due to shifts in the reporting schedule, some of the data presented and the activities described in this report fall into the period beginning September 1, 1974. All data not otherwise labeled is assumed to be for the period beginning January 1, 1975 to June 30, 1975.

1.1 MTC ACTIVITIES

The MTC group was established in 1972 primarily to provide the ARPA/PLATO sites with TUTOR training and programming consultation. In response to the varied needs of the several sites, however, MTC began to undertake and now carries out a wide variety of additional tasks. Because of the generally high level of programming competence at the sites, the most important services MTC provides for the sites falls under the general category of instructional design. Under this category fall the activities of assisting with lesson design and curriculum development, providing lesson reviews and revisions, and consulting on lesson validation. Also, because MTC has been able to watch the inception and growth of several remote PLATO sites, it has been able to offer advice on project planning, staffing, and management. Finally, MTC serves as a general liaison between the 15 remote sites and CERL.

Most of these services are adequately provided by means of inter-terminal and telephone communications. However, more extended contact are sometimes needed, and for those cases, MTC staff members spent approximately 71 man-days during the last ten months on consulting visits to the sites while hosting site visitors for about 40 man-days.

1.1.1 TRAINING AND CONSULTATION

The series of reference lessons on TUTOR created by MTC several years ago for novice programmers is still being used at the rate of approximately 75 times per week even though it has not been advertised for 2 years and is not mentioned in any official literature.

During this reporting period, four authors from Sheppard
Air Force Base and six from Maxwell Air Force Base (See sections 1.27
and 1.25.) were given MTC's courses on the fundamentals of the TUTOR lan-
guage and on instructional design. Each of these courses was revised
before presentation with the major modifications being the inclusion of
parts of a yet unpublished book on lesson review and the expansion of
the lesson development section of the instructional design course.

1.1.2 SUPPORT PROGRAMMING

At this time, most sites have reached a level of competency
in the use of the TUTOR language that matches their current needs.
Thus, they require a minimal amount of help with day-to-day coding prob-
lems. The assistance once provided by MTC in this area now centers mainly
on the more advanced facets of TUTOR. In particualr, since several
of the sites are in the final stages of their projects, they have needed
help with the collection of data either through the packages already
available on the system or with collection routines fashioned for their
special needs.

At several sites we have promoted the use of and provided
help with system-furnished data crunching routines such as "area," "qarea,"
"course," etc. We also worked to devise special data compacting, storage,
and retrieval routines for experimental data being gathered by HumRRO
authors.

Another area of significant work in support programming
has been the development (in progress) of routines which will circumvent
the problems caused by telephone line errors at remote sites which affect
plasma display and touch routines.

Also, to date, five diagnostic mathematics tests employing a complex branching algorithm have been designed and programmed. Each analyzes a student's strengths and weaknesses in some fundamental area of mathematics. The topics of the presently existing test are:

1. Addition, subtraction, multiplication, and division of positive integers

2. Addition, subtraction, multiclication, and division of positive rational numbers with a section testing comprehension of basic terminology of rational numbers, e.g., numerator, denominator, lowest common denominator, reduced, etc.

3. Conversion of rational numbers to decimal representation, and addition, subtraction, multiplication, and division of decimal numbers

4. Multiplication and division of decimal numbers by integral powers of ten

5. Addition, subtraction, multiplication, and division of numbers with integral exponents.

1.1.3 LESSON REVIEW

A very busy reviewing schedule has been maintained (particularily with the Sheppard project). Details are given in section 1.2 -- "Interactions with the Sites." In addition, a significant portion of the last eight months was spent readying for publication a paper entitled Lesson Review. Authored by MTC staff members, it describes the review procedures developed by the group based on its experiences with the ARPA sites.

The 150 page book details topic such as:

1. The rationale and importance of reviewing

2. The uses of a review

3. Various reviewing procedures and techniques

It includes examples of the different types of lesson reviews as well as practice exercises for the reader. The substance and approach of Lesson Review make the book most valuable to authors and reviewers, but it could also be useful for project directors wishing to know some of the pitfalls of lesson development.

1.1.4 LESSON CO-DEVELOPMENT

During this reporting period, "Sheppard East," MTC's support group for the School of Health Care Sciences at Sheppard AFB, undertook, with the staff at Sheppard, joint development of some lesson materials. In this endeavor, the major effort was to write simulated patient encounters since one of the MTC staff already had extensive experience in this area. For these simulations, Sheppard East assisted in the design of the lesson formats and coded extensive -help-sequences and data collection routines. This group also arranged for students associated with the PLATO medical network to use the patient encounters as lesson so that data for formative evaluation could be gathered.

In other efforts to co-develop lessons, Sheppard East co-developed a lesson on pulmonary function testing. A Sheppard author wrote a hard copy "script" and members of Sheppard East used this script as a basis for designing the lesson as it was to be presented on PLATO. Because of the problems inherent in dividing the complex task of lesson development in this way and in separating the developers by many miles, we envision continued co-development only for those lessons that would gain special benefit by being developed at CERL.

1.1.5 COOPERATIVE EFFORTS

The pattern of liaison activities established during the first two years of the ARPA/PLATO project (cf. section 2.6.2 of the Second Annual Report) has been maintained in this reporting period at a somewhat reduced level due to the state of near completion of several of the remote sites. These activities still include distribution and naming of file spaces, acquisition of inventory information, terminal repair verification, and borrowing or copying microfiche.

One liaison function MTC no longer performs is that of memory allocation supervision or ECS monitoring. Before January, 1975, when an additional one million words of ECS was installed, this activity was a necessity to insure that there would be sufficient memory available for the sites to carry out their missions. Since January, there have been no shortages of ECS nor are any anticipated.

At the same time that the additional ECS was being installed, several system-level packages that greatly increased the capabilities of local site directors were introduced for general use. Since the advantages of these packages could best be used by grouping terminals into logical sites according to the purposes those terminals were serving, the ARPA terminals were grouped into five logical sites. Then a site director for each site was selected and trained in the use of the director's capabilities. These capabilities include being able to restrict the user's terminal access, send instantaneous messages to users, delete users from the system, etc.

The use of the communication features on PLATO continues to play an integral role in the day-to-day functions of ARPA authors. From September, 1974 to June 30, 1975, a total of 5,000 personal notes were

received by ARPA authors through the newly instituted system mail

feature. With the advent of this feature, the MTC communications program

-itc- was retired. Also, a large, but unrecorded number of "talk" con-

versations were used by remote ARPA authors to maintain contact with

other users, and to request and receive MTC and CERL services.

In the future, we anticipate that the liaison activities

will reflect the fact that the curriculum development sites are becoming

involved with their final reports and evaluations. In the case of

Aberdeen, for example, MTC compiled terminal maintenance records

for that site.

1.2   INTERACTIONS WITH THE SITES

1.2.1   U.S. ARMY ORDNANCE CENTER AND SCHOOL
ABERDEEN PROVING GROUNDS

The final phase of the Aberdeen project has required fewer inputs than did earlier phases. All lesson development was completed by late 1974; hence few requests in the areas of lesson review and revision were made. The main MTC efforts were directed towards maintaining and modifying the data crunchers designed for Aberdeen's project. In addition, a number of statistical routines and procedures were reviewed or suggested by the PEER group personnel.

Aberdeen completed all of their student runs in May 1975, and the staff is now finishing their final report. They will soon begin redistribution of their terminals to other sites.

1.2.2   FORT BELVOIR

Fort Belvoir's terminals came on-line during May 1975. They sent two staff members to Aberdeen for a brief familiarization with the system. Two MTC staff members visited Fort Belvoir in April to assist in planning for the use of the terminals.

1.2.3   CHANUTE TECHNICAL TRAINING CENTER
CHANUTE AIR FORCE BASE

In January 1975, the courseware that Chanute's PLATO project had been directed to develop (cf. the Second Annual Report, section 3.1.2) was substantially completed and ready for student validation. This validation procedure which requires that 27 of 30 students must meet pre-established testing criteria has continued throughout

this reporting period, and as of July 1975, about 80% of the lessons had been validated. The Instructional Systems Design staff at Chanute anticipates that all the lessons will be validated by October 1975, and they will cease to take evaluation data on these lessons at that time.

During this period of developing lesson material for the Special Vehicle Computer Based Training System, very little advice on educational matters was sought from the MTC group since the ISD team used lesson development techniques adapted to producing efficient military training instruments. MTC did, however, serve as a technical liaison between the PLATO project at Chanute and CERL. In this role, for example, MTC facilitated the production of 102 microfiche. MTC urged the manufacture by CERL of a microfiche mounter so that the photographic personnel at Chanute could not only develop but also mount their own microfiche. Two mounters were delivered to Chanute in April 1975. The presence of the mounters at Chanute and the fact that Chanute develops their own microfiche has reduced their microfiche production time from eight or more days to as little as two days.

In February, review of Chanute's PLATO project was held at the request of ARPA. At ATC's request, MTC made an assessment of the courseware being developed as well as of Chanute's evaluation plans. The courseware assessment was made on the basis of lesson features and options rather than on student data because at that time limited student data was available. Based on progress reports and assessments delivered at the meeting, goals and directions were established for the continuation phase of the project.

1.2.4 HUMAN RESOURCES RESEARCH ORGANIZATION HumRRO

A large set of data reduction routines were written by

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MTC and CERL for HumRRO. Specifications for these data collection programs (for experiments conducted at Fort Belvoir) were the topics of discussion during a three day visit to CERL by three of the HumRRO staff.

1.2.5 AIR UNIVERSITY
MAXWELL AIR FORCE BASE

Maxwell Air Force Base came on-line in June with four terminals. The MTC group conducted a two-week PLATO training program on site. The first week consisted of training in the TUTOR language; the second was devoted to introducing sound instructional design techniques to the authoring staff there. Maxwell plans a comparison of TICCIT and PLATO for teaching career development courses.

1.2.6 NAVAL TRAINING EQUIPMENT CENTER
ORLANDO

The Orlando staff, in cooperation with personnel from the Institute of Social Research, published a report on their pilot study for teaching interpersonnel skills. Based on the successes and failures found in this initial study, Orlando, in February, began to reorganize their courseware. They are structuring their lessons in a new format which will subsume most of their previously written lessons and require the creation of many new ones. Support to Orlando NTEC included datafile manipulation, data reduction and display, lesson reviews, and evaluation suggestions.

1.2.7 SCHOOL OF HEALTH CARE SCIENCES
SHEPPARD AIR FORCE BASE

Shpeast, that part of the MTC group that is concerned mainly with providing support for the Sheppard Project, has been working with the Sheppard authors on new types of reviewing techniques to help

bring authors and consultants into closer, more frequent contact and thus hopefully speed quality lesson development (see sections 1.1.3 "Lesson Review" and section 1.1.4 "Lesson Co-Development"). In-depth reviews for about 40 lessons were done in preparation for the first student run starting on July 2, 1975.

The math diagnostic test materials written by MTC (see section 1.2 "Support Programming"), were used by the February Physician Assistant class at Sheppard. See section 1.1.4 for a description of the lesson co-development carried on with Sheppard.

Throughout the year MTC's consulting trips to Sheppard were augmented by visits from individuals and small groups of people from Sheppard. In addition to dealing with specific items such as TUTOR training, advanced TUTOR consulting, Varian hardcopier maintenance, and the Chanute Review, the visits helped maintain an exchange design and Sheppard's upcoming evaluation plan.

1.3

SUMMARY INFORMATION

Note: For a detailed explanation of the following tables, see section
3.2 "Summary Information" in the Second Annual Report.

1.3.1
Site Data

Site	Total # Authors	Authors > 3 hrs/wk.	Author Hours 9/1 - 6/30	Disk Space Used	Terminals 6/30	Touch	Audio	Fiche	Varian	Visits To Sites[1]		Visits to CERL[1]	
										Trips	Man-Days	Trips	Man-Days
ARPA	1	0	n.a.	0	1	1							
ARI	4	-	n.a.	41	1	1		5	1	1	2	1	2
ABERDEEN	5	2	2804	79	14	4			1	2	5	1	3
CHANUTE	11	8	4095	167	23	23	1	103	1	6	9	2	
MTC	10	10	3739	121	3	2	2	4	1	2^2	14^2		
BELVOIR	5	5	443	9	4^3	4	2		1	1	2		
ETS	n.a.	n.a.	n.a.	0	2	2	2						
HumRRO	8	2	2399	45	2	2							
ISI-USC	4	1	319	2	1	1							
MAXWELL	6	6	108	26	4	4				3	14	4	14
MONMOUTH	2	1	1347	30	2	2						2	2
NSA	2												

this site disbanded 1/75

[1] Visits from 9/1/74 to 6/30/75

[2] MTC staff members have attended two conferences: five members attended the September ARPA author conference at Aberdeen; two members attended the April AGRA meeting in Washington, D.C. -- a total of 14 man-days

[3] Bought on a separate Air Force contract

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1.3.1
Site Data

Site	Total # Authors	Authors > 3 hrs/wk.	Author Hours 9/1 - 6/30	Disk Space Used	Terminals 6/30	Touch	Audio	Fiche	Varian	Visits To Sites		Visits To CERL	
										Trips	Man-Days	Trips	Man-Days
LOWRY	10	5	2043	27	4	4	1		1				
NRPDC	11	5	5589	95	12	12	1		1				
ORLANDO	8	5	3136	39	4	4	3	1	1	1	4	1	
RAND	this site disbanded 12/74												
STANFORD	this site disbanded 6/75												
SHEPPARD	12	9	5170	188	29	20	2	12	1	5	21	5	13
USC	5	2	791	21	3	3	1					2	2
UCSB	1	0	n.a.	0	1	1							
Total	103	62	>30,000	896	101[1]	88	12[2]	126	7	21	71	19	40

[1] Does not include one terminal at University of Illinois Psychology Department or two terminals in the Electrical Engineering Department

[2] An additional 12 units were available during this period, but not distributed pending a decision by Chanute.

Site	1973	1/74	2	3	4	5	6	7	8	9	10	11	12	1/75	2	3	4	5	6
Cha	5	4	3	11															
Orl	1	3																	
Nav	12																		
USC	0		2									1							
Abe	7	3			3	4													
Mon	4										-2								
Sta	0					4													-4
Hum	0		1				1												
Arpa	3					-1			-1		-1		2						-1
Rand	0				1							-1							
Shp	0			4						4	12								
Cerl	2				1				-1			1							
Low	4																		
ISI	0					1													
USCB	0					1													
ARI	0					1													
NSA	0								1		1		-2						
Max	0																		4
																			4

1.3.3.1

PLATO IV - Terminal Usage

December 1, 1974 - March 31, 1975

User	Terminals (March 1975)	Mean Hours per Week per Terminal							
		December		January		February		March	
		Prime	Total	Prime	Total	Prime	Total	Prime	Total
CERL	64	23.8	36.1	21.2	32.2	28.6	45.4	27.4	39.6
U of I	285	22.4	32.6	14.6	21.3	28.3	42.3	25.9	39.2
Ill. Univ.'s	76	--	-	11.2	15.3	17.2	24.1	16.3	21.6
Other Univ.'s	61	20.7	32.6	27.0	43.7	31.3	51.8	26.6	44.6
Comm. Coll.'s	117	15.5	15.9	9.3	10.8	13.6	14.9	21.1	22.1
Schools	88	10.3	10.4	8.5	10.1	10.3	11.3	11.4	12.0
Government	25	15.4	20.2	14.8	18.8	20.4	25.8	21.0	25.6
Military	99	12.8	15.4	13.1	17.0	13.9	17.8	14.7	17.6
Commercial	12	11.1	12.7	20.6	27.2	18.0	24.5	21.6	28.9

April 1, 1975 - June 30, 1975

User	Terminals (June 1975)	Mean Hours per Week per Terminal					
		April		May		June	
		Prime	Total	Prime	Total	Prime	Total
CERL	62	26.6	40.0	24.3	32.8	27.9	36.2
U of I	285	27.8	42.5	18.8	28.0	16.7	22.5
Ill. Univ.'s	73	23.4	31.2	21.1	25.8	16.1	19.3
Other Univ.'s	69	31.5	53.6	30.7	49.3	32.0	46.5
Comm. Coll.'s	118	22.5	24.0	17.7	17.9	9.0	8.6
Schools	76	12.7	13.8	11.1	11.2	3.6	3.7
Government	26	18.8	22.4	16.5	18.7	20.1	22.0
Military	104	15.8	19.0	13.4	14.8	17.5	18.1
Commercial	10	23.0	31.2	21.5	26.4	28.7	35.0

1.3.3.2

ARPA Terminal Usage

December 1, 1974 – March 31, 1975

User	Terminals (March 1975)	December Prime	December Total	January Prime	January Total	February Prime	February Total	March Prime	March Total
						Mean Hours per Week per Terminal			
ARPA-MAIN	2	0.0	0.3	1.2	2.4	22.7	24.5	6.2	6.4
ARI	1	8.6	9.0	21.4	24.7	32.7	36.4	38.9	41.9
ARPA-CERL	2	34.0	40.5	33.5	44.0	22.8	30.8	27.7	34.1
Aberdeen	14	14.8	15.0	11.5	13.7	11.5	13.7	12.0	12.6
Chanute	23	7.7	8.1	7.7	9.3	12.9	14.2	16.9	18.8
Monmouth	2	16.1	16.4	17.4	19.8	18.2	23.1	17.3	22.6
Humrro	4	23.5	31.5	26.8	33.5	26.9	36.0	22.6	27.8
Lowry	3	18.0	19.9	10.0	12.4	7.2	10.8	13.5	19.2
San Diego	12	12.8	14.5	20.2	24.8	18.9	26.1	16.0	20.7
Sheppard	21	9.3	9.8	8.7	10.3	9.1	10.4	11.2	12.3
USC	8	14.9	27.6	16.6	28.3	13.0	15.8	7.2	7.7
Stanford	3	17.0	52.5	13.7	35.5	9.1	30.2	10.0	31.5
Orlando	4	25.3	25.1	24.7	28.2	26.9	33.0	29.1	34.2

April 1, 1975 – June 30, 1975

User	Terminals (June 1975)	April Prime	April Total	May Prime	May Total	June Prime	June Total
				Mean Hours per Week per Terminal			
ARPA-MAIN	2	3.5	3.7	10.4	10.5	10.7	10.3
ARI	1	36.0	38.5	22.9	23.3	36.8	36.7
ARPA-CERL	2	27.0	35.4	18.6	20.9	27.7	29.6
Aberdeen	14	16.3	17.2	12.3	12.4	16.6	16.3
Chanute	23	19.4	20.5	16.1	16.2	20.7	20.2
Monmouth	2	31.8	48.0	30.7	42.8	18.8	19.3
Humrro	4	21.8	24.8	12.2	13.8	10.4	12.1
Lowry	3	15.6	19.1	16.2	20.8	22.0	22.3
San Diego	12	16.6	23.5	15.8	18.8	19.0	20.4
Sheppard	21	11.2	12.2	9.6	10.2	13.2	13.9
USC	8	6.7	7.6	6.1	6.5	4.3	4.6
Stanford	–	14.0	43.1	6.7	16.1	–	–
Orlando	4	31.9	36.6	22.5	24.8	26.9	29.8
Belvoir	4	0.0	0.0	11.7	12.1	31.8	33.0
Maxwell	4	–	–	–	–	20.6	22.6

1.3.3.3

PLATO IV System Performance*

(December 1, 1974 - June 30, 1975)

	Dec.	Jan.	Feb.	Mar.	Apr.	May	June
Mean hours to interruption	10.73	4.10	3.61	6.79	12.96	21.35	16.45
**Mean down time (hours)	.33	.73	.23	.21	.14	1.15	.25
Proportion of class hours interrupted once or more	.08	.28	.27	.14	.09	.09	.06
Weeks to terminal failure	8.00	15.60	12.70	12.90	13.00	15.00	16.30
Days to repair a terminal	1.20	.40	.40	.70	.50	1.10	1.60
% of scheduled time up	95.50	84.80	93.80	96.40	98.40	94.20	97.20
Terminal hours used (1000)	56.50	65.20	102.40	104.90	115.90	89.30	73.10

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*Times are prime times for the indicated months. In general, about 70 to 80 hours were scheduled for such non-experimental use each week.

**Down time includes time required for 99% of users to return to normal operation.

The MTC Group

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PART II

TECHNICAL PROGRAM

INTRODUCTION TO THE TECHNICAL PROGRAM

The technical program at CERL has for over a decade been guided by considerations of both performance and cost in the delivery of high quality education through the interactive use of computers. This work has led to a new display device, the Plasma Display Panel, a new interactive graphics oriented language, TUTOR, and a new architecture for information processing. What is perhaps most important is that these and other developments fit together in a highly effective system which is greater than the sum of its parts. Part II of this ARPA report describes the status of a program that with ARPA support is maintaining the momentum of technical development at CERL.

2. AUXILLIARY MASS STORAGE

The AMS memory system was specifically designed to satisfy the stringent performance requirements of the PLATO computer network and to provide a swapping memory very low in cost. This memory system consists basically of standard semiconductor serial shift-register devices, configured to allow a fairly sophisticated controller to maniuplate them according to commands issued by the CPU. The shift-registers provide an average access time of 400 μsecs and a transfer rate of 600 megabits per second, achieved through parallelism. The use of eight independent sub-controllers causes the effective access time to approach 50 μsecs.

There are two fundamental elements in the AMS memory: the actual memory section and the memory controller.

2.1 THE AMS MEMORY STORAGE

Figure 2.1 illustrates the organization of the AMS storage elements. The basic element utilized is a 1024 x 1 serial shift-register chosen to operate at 1.25 MHz. Groups of eight of these devices have been arranged in such a fashion that a group appears as if it were a single 8192 x 1 register operating at a maximum rate of 10 MHz. Furthermore, 64 groups have been paralleled to form a file unit which represents the basic memory module. The basic module, called a file, is an 8192 x 64 serial register capable of reading or writing 10 million 64-bit words per second. At these rates, and since the file is serial, the average access time to an
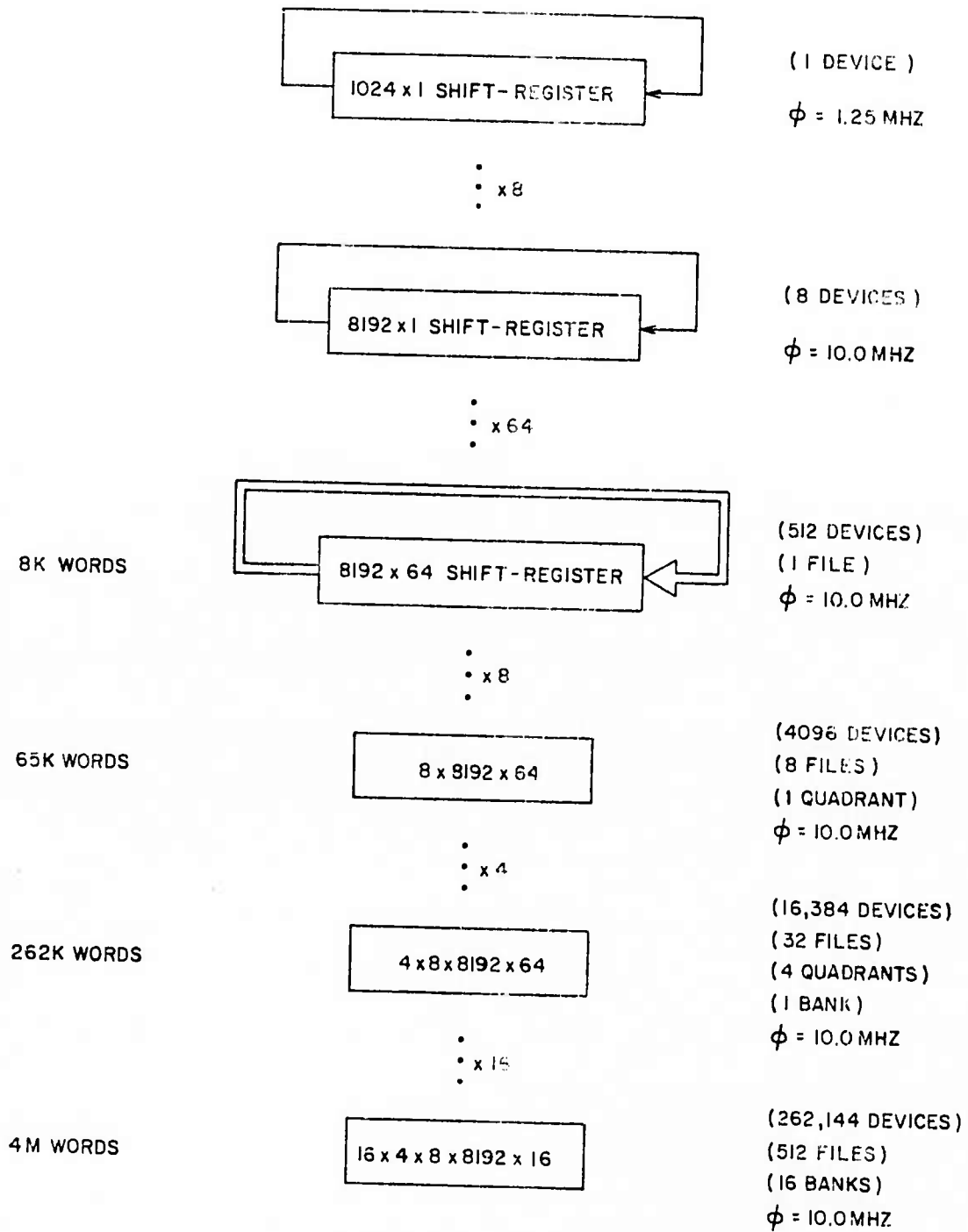
AMS MEMORY ORGANIZATION

Figure 2.1

individual storage location varies from 0 to 819.2 μsecs. The average access time is therefore 419.6 μsecs.

Any number of files can be installed to assemble a complete memory: groups of eight were chosen as the minimum size. This grouping is called a quadrant. For convenience of power supply and chassis wiring, groups of four quadrants are arranged as banks. Banks can be added until the total memory size desired is achieved. The AMS system was designed for a maximum of 16 banks.

A file is 8192 words, a quadrant is 65k words, a bank is 262k words, and a fully completed AMS system would be four megawords. A word is 64 bits.

2.2 THE AMS MEMORY CONTROLLER

The heart of the AMS controller is an array of eight independent controllers. These units are called subcontrollers and have the task of manipulating individual files for the purpose of data transfer into and out of the AMS memory. In addition to the subcontrollers, there are several other units including an idle controller which maintains control over those files not under the control of a subcontroller, and a data channel through which all data and transfer parameters are communicated.

In the PLATO system, the AMS memory is connected to one of the ports of a high-speed random access swapping memory, and that memory in turn is connected to a high-speed port of the CPU's central memory. The high-speed random access memory utilized is a product of Control Data Corporation

and is called Extended Core Storage (ECS). This memory is characterized by
a 3.2 μsecs access time, 600 megabit transfer rate and four access ports.
Since the CPU is the origin of all of the AMS control parameters and is the
unit that interprets the status information provided by the AMS controller,
a 128-word buffer communication area is established in the random access
swapping memory accessible by both the CPU and AMS. The CPU plants transfer
parameters called jobs in the communication area. Groups of eight of these
jobs are combined and called batches. A job contains the exact parameters
for one transfer (file number, starting address within a file, starting
transfer address in the random access memory and transfer length). A
batch containing up to eight jobs is intended to contain a list of all the
jobs that would be required by the CPU to service a request by an individual
user: program files, datafiles and status information. The AMS controller
treats the group of transfers within a batch as a unit and supplies the CPU
with status information relative to the entire batch as well as relating
to the individual transfers. In this manner, the CPU is relieved of the
burden of figuring out whether all of the files needed for a particular user
have been transferred or not.

Presented here is a description of the sequence executed by the AMS
controller in the course of responding to a set of batches posted by the CPU.

At the beginning of a CPU execution timeslice, the CPU takes the
assemblage of keys that have been inputted from various terminals and deter-
mines what files of data will be required for each key to be processed. The
CPU then posts the proper transfer information in the form of one batch for

each user, even if partial batches are the result. In the meantime, the AMS controller has been interrogating the communication area. As soon as the CPU has posted the first batch, the AMS controller begins to execute that batch. The AMS controller samples the CPU-AMS communication area only once each 30 μsecs in order to avoid jamming the ECS data channel with unnecessary transfers.

Once the AMS controller has recognized that a batch has been posted by the CPU, it proceeds to assign those jobs that are contained in that batch to the eight subcontrollers. If a batch is partially filled, NOP (no-operation) jobs are assigned to the unused subcontrollers. As soon as all of the jobs associated with a batch have been assigned, the AMS controller begins to interrogate the next location of the communication area for the next batch. As a batch is posted in this location, and as individual subcontrollers become completed (those with NOP's become completed immediately), parts of the next batch are assigned to the idle subcontrollers. In the meantime, the AMS controller posts status information in the control area where the first batch was picked up, overwriting the original batch parameters. In this fashion, the AMS controller attempts to keep as many of the subcontrollers active as possible. As those subcontrollers that were issued valid jobs become ready for transfer, they request access to the data channel. When granted that channel, they transfer their assigned data. After transferring their data, the subcontrollers return the files to their original position and detach themselves. At this point, they are ready to accept another job. Any unassigned jobs in the second batch are assigned to the subcontrollers.

At the point that all of the jobs in the original batch have been completed, the AMS controller writes status information to the control area one last time, indicating that the entire batch was completed, and proceeds to pick up any remaining jobs in the second batch. When all of the jobs in the second batch have been accepted by an AMS subcontroller, the AMS controller proceeds to the next batch. This sequence of processing one batch at a time and starting the next batch in those subcontrollers that are idle continues until all of the batches that the CPU has posted have been processed. Chapter 5 discusses in detail the resultant access and transfer characteristics.

2.3 SYSTEM PERFORMANCE

The performance of the AMS memory system will be described in two sections: 1) Controller performance and 2) Memory performance.

2.3.1 CONTROLLER PERFORMANCE

The PLATO system is heavily dependent on the availability of a very high-speed mass memory and presently uses two million words of Extended Core Storage (ECS). In this memory are stored many types of data necessary for the proper operation of the system. The position of an AMS-type memory as a partial supplement to the large ECS bank and as a further extension of this memory to the much larger numbers of words necessary to service thousands of users depends on its ability to provide a service level comparable to that of the present ECS system. The tasks that will be assigned to this new memory will be similar to but increased over those presently assigned

to the ECS memory. The AMS controller, whose structure determines the AMS system performance, was designed with the particular characteristics of the PLATO system in mind. The corresponding performance levels of the controller were determined by modeling the task profile of the PLATO system and testing this model in side-by-side operation of PLATO and a parasitic AMS driver.

The model for the AMS controller operation takes into account the following parameters:

1. Transfer length.

2. Search length.

3. Return length.

4. ECS channel access queuing and CPU-AMS access conflicts.

The AMS hardware elements involved are:

1. The actual data file.

2. The eight access subcontrollers.

3. The single 600 megabit per second ECS data channel.

4. The idle file controller.

Definitions:

Transfer Length. The CPU assigns a transfer length to an AMS transfer job by specifying between 1 and 1024 records to be transferred (a record is eight words). The data length will be transferred to or from ECS sequentially from the starting address, which is also specified by the CPU. This variable is indicated as TL (Transfer Length) and has an average value $\overline{TL}$.

Search Length. The CPU assigns a starting address (from 0 to 1023 records) where the AMS subcontroller is to start transferring with ECS, and

the subcontroller must rotate its specific file (always in the forward direction) from its instantaneous position to this starting position. The Search Length is the number of record locations that the subcontroller is required to rotate its file prior to transferring data, which is the difference of the starting address and the instantaneous idle address at the time the file was attached to the subcontroller. This length is assumed to be a uniformly distributed number between 0 and 1023 and the time required to move the search length is SL (Search Length) x .8 μsecs. The average of this length is 512 records and is indicated by $\overline{SL}$.

Return Length. Once the subcontroller has conducted its assigned data transfer, it must return the file to the control of the idle controller. It must first align the file with all of the other files controlled by the idle controller and then detach itself, thus attaching the file to the idle controller. This phase of a job's execution is a function of the size of SL, TL and the number of rotational locations that the idle controller has moved since the file was detached. If the idle controller did not rotate at all, the total of SL + TL + RL (Return Length) would always be an integer multiple (N) of 1024, which is the file length. Instead, the sum is N x 1024 + δ, where δ = T (time)/100 μsecs because the rotational stepping rate of the idle controller is one step per 100 μsecs. The total time of SL + TL + RL if N = 1 is approximately 800 μsecs (1024 x .8 μsecs) and would therefore result in a δ of 8 so the sum of SL + TL + RL + δ = 1024 + 8 = 1032, or less than a 1 percent increase. Larger values of N (the largest possible value is 3) and conflicts for access to the ECS data channel cause larger values

of δ. The worst case value is 72 and results a particular file is δ required to wait for access to the ECS data channel for seven other maximum length transfers and had a SL = TL = RL = 1024. The worst case value of δ results in a 7 percent increase. Because this percentage is very small, future calculations will assume $\delta = 0$.

ECS Channel Queuing. Even though there are eight AMS subcontrollers simultaneously executing transfer jobs, only one channel to ECS is available for the transfer of data and all data must be transferred over this channel. This ECS channel transfers at 600 megabits per second, which is a record transfer rate of one record per .8 µsecs. Access to the channel is granted to just one AMS subcontroller at a time on a first-come first-serve basis. Once the channel is granted to a subcontroller, that subcontroller maintains the channel until it has completed its transfer, which is a function of the transfer length. After the completion of a transfer, the next numerical subcontroller requesting the channel is granted it.

When a subcontroller has performed the job of positioning its file properly for a data transfer, it requests access to the ECS channel in order to conduct that transfer. If the channel is busy, the requesting subcontroller waits until the channel is available.

AMS-CPU Access Conflicts. The ECS controller has four ports which allow access to the ECS storage system. In the PLATO system these ports are connected to:

1. The CPUs.

2. The Distributed Data Path (DDP), which allows direct PPU to ECS transfers.

3. The Side Door Adapter (SDA) which allows the disks to communicate directly with ECS.

4. AMS.

The DDP and SDA can be neglected with regard to their interaction with the AMS and CPU, because the activity in these units is very small. The interaction between the AMS and CPU is significant, however, and results in what is referred to as AMS-CPU ECS Access Conflicts, to be discussed later.

In the PLATO environment, the most indicative factor concerning the level of performance of the AMS controller is the time required to complete all of the jobs in one batch since all of the transfers related to a particular user's demand would be packed into one batch, and the CPU must wait or otherwise engage itself while that batch is in process. In addition, even with processing overlapped with swapping, the average time for swapping in and out must be less than the average process time; otherwise the CPU will eventually run out of work to do. A batch contains from one to eight jobs, with each job having its individual parameters. The parameters of each job and their relation to the parameters of the remaining jobs determine the time required to completely execute a batch.

For a running system, it will be shown that usually only the execution time of the first batch among several will be important, because the average time required by the CPUs to process an individual user's data is longer than the average time required for the AMS controller to execute the batch for the next user. The AMS controller will, therefore, be ahead and continue to get further ahead as long as there are batches to do.

One of the simplest types of batches is one containing a single job, and this batch presents a special case of the batch process model. When the AMS controller engages in a single job batch, no overlapping can be employed. The batch execution time is simply the job execution time, which is:

Time (T) = SL + TL + RL

(Search + Transfer + Return)

The sum of:

SL + TL + RL

must be an integer multiple of 1024 records if the rotation of the idle controller is ignored. The integer is a function of TL and the exact relation between the starting address of the transfer and the idle address when the job was started. If the file is positioned at a location which is before but not within the area that is to be transferred, the SL will be that distance to the beginning of the transfer area, the TL will be the transfer length and the RL will be (1024 - TL - SL). In this case, the integer is 1. If the address transferred from the idle controller is within the transfer length area of the file, the file must be rotated through the remainder of the transfer length and around to the beginning of the transfer area. Then TL is cycled through, and at this point, more than one complete cycle has already been completed. The RL will be (2048 - SL - TL) and the integer is two. In the special case where the idle address is very close to the transfer starting address and the TL is very close to 1024, a total of three revolutions

might be necessary to complete a job. The SL will be 1024, the TL is 1024, and the RL is 1024. The integer is 3.

The average time to process a single job batch assuming a uniform distribution of job lengths and no correlation between the starting address and the idle address, is:

$$P(N=1) \times 819.2 + P(N=2) \times 2 \times 819.2 + P(N=3) \times 3 \times 819.2 \text{ } \mu secs$$

where $P(N=x)$ is the probability that the number of cycles equals x.

$P(N=1)$ is the probability that only a single rotation will be required, which is the probability that the idle address falls outside of the transfer field. If we assume an average transfer length of 512, we have:

$$P(N=1) = \overline{TL}/1024 = 512/1024 = .5$$

$P(N=2)$ is the probability that two rotations of the file will be required to transfer and return, which is the probability that the idle address falls within the transfer field.

$$P(N=2) = (1024 - \overline{TL})/1024 = 512/1024 = .5$$

$P(N=3)$ is the probability that three rotations of the file will be required in order to process a job. This condition occurs only when the idle address is almost exactly the same as the transfer starting address. Its probability is very samll and will be neglected.

Therefore, the average time to process a single job, assuming that no other jobs are competing for the ECS channel and the CPU-AMS conflicts are negligible, is:

$$T = .5 \times 819.2 + .5 \times 2 \times 819.2 = 1230 \text{ } \mu\text{secs}$$

More typical batches encountered in normal operation of the AMS system in the PLATO environment are those which contain more than one job. In the evaluation of these more complex jobs, additional factors need to be considered. In particular, since more than one subcontroller is operational, only the access time to the first job will be of concern, and the queuing for the AMS-ECS channel will be dominant.

The overall time required to execute a batch is determined by the sum of the access time to the first job, total time to transfer and the average time to return the last job to the idle controller. Since it is assumed that there is no correlation between the idle address and the file starting addresses and that the starting addresses are randomly placed, the value of the first term can be calculated as a function of the number of jobs in a batch and the P (TL).

The distribution of access times to the first job for a uniform distribution of TL can be shown to be:

$$P(FSL) = \int_0^{1023} (TL/1024) \times n(1-TL/1024) \text{ } d(TL)$$

and results in an access length with an average value of $1024/(n+1)$.

For non-uniform distributions of access times, the distribution of P(FSL) is:

$$P(FSL) = \int_0^{1023} (P(FL) \times n \times (1-P(TL))) \text{ } d(TL)$$

In the case of a uniform P(TL), the average difference between the access time of the first job and the access time of the second job, which determines the amount of data that must be transferred in order for the access time to the second job to be covered up is:

$$(1/n) - (1/(n+1)) = 1/n \times (n+1)$$

For a batch using all eight subcontrollers, the average access to the first batch is 1024/9 or 113 records or 91 μsecs. The length from the access to the first job to the second job is 14.2 records or 113 words. In the PLATO system, the minimum usable data parcel is greater than 400 words, and therefore a very high probability exists that the transfer of the data from the first job will completely overlap the access to the second job.

Once the first job has been accessed, the ECS data channel is the time-determinant factor, and as such, the sum of all of the transfer lengths enters into the total batch time. After the last has finished with the data channel, it must be returned to its idle position and at this point the batch will be complete. There is no overlapping available for this return length; thus, the expected value is simply 512 cycles.

The total batch time therefore is as follows:

$$BT = (1024/(n+1)) + (n \times \overline{TL}) + 512 \text{ cycles}$$

if the minimum transfer length is $1024/((n+1) \times n)$. Table 2.1 shows expected total batch time and minimum transfer lengths to maintain high AMS efficiency as a function of the n and $\overline{TL}$. These numbers assume that the distribution of transfer lengths is uniform, that the transfer starting address is uncorrelated to the idle address, and that the transfer addresses are randomly located.

TABLE 2.1
BATCH TIMES AND MINIMUM TL (RECORDS)

$\overline{TL}$[a]	n 2	3	4	5	6	7	8
100	1053	1068	1116	1182	1258	1340	1425
200	1253	1368	1516	1682	1858	2040	2225
400	1653	1968	2316	2682	3058	3440	3825
600	2053	2568	3116	3682	4258	4840	5425
800	2453	3168	3916	4682	5458	6240	7025
1000	2853	4768	4716	5682	6658	7640	8625
minTL	170	51	34	24	18	14	11

[a]The total amount transferred is the $\overline{TL}$ x n.

The efficiency of the AMS controller can be seen by calculating an effective access time which is the difference between the time required to actually transfer the required data and the total batch time divided by the number of different files transferred.

Effective Access Time (EAT) = (BT - (TLxn))/n

When the transfer lengths are subtracted, the effective access time is only a function of the number of subcontrollers active. See Table 2.2.

TABLE 2.2
EAT vs. n

n	2	3	4	5	6	7	8
EAT (cycles)	426	256	179	136	109	91	78
EAT (μsecs)	341	205	143	109	87	73	62

A parasitic CPU program was run at a different control point from PLATO, at a higher priority than PLATO, and used the student bank list supplied by PLATO to assemble jobs for the AMS controller. File lengths of 512 words were used. Since the parasitic program was operating at a control point above PLATO, all of the time spent executing this logic detracted from the time available to PLATO. Various different loads were tried from slightly over 100 users to over 220 users, which resulted in a variation from five to eight jobs per poll on the average. The results of these tests are shown in Table 2.3.

TABLE 2.3
EMPIRICAL DATA

Users	Jobs/Batch	ms/Batch Meas.[a]	ms/Batch Calc.[b]
116	5.19	1.50	1.499
120	5.77	1.65	1.522
155	6.04	1.66	1.535
185	7.15	1.90	1.625
220	7.87	2.23	1.934

[a] ms/Batch Meas. is milliseconds per batch measured.
[b] ms/Batch Calc. is milliseconds per batch calculated.

The measured values were consistently slightly higher than the calculated values, which indicates some degradation due to the CPU-ECS transfers. If reasonable amounts of CPU time are assumed to determine the amount of ECS data channel bandwidth by the CPU, (5 percent at 116 users to 10 percent at 220 users) plus an additional 10 percent for the ECS bandwidth required by the parasitic test program, the results in Table 2.4 are obtained.

TABLE 2.4
EMPIRICAL DATA VS. CALCULATED DATA

Users	Jobs/Batch	ms/Batch M	ms/Batch C	Error
116	5.19	1.50	1.622	7.5%
120	5.77	1.65	1.659	.5%
155	6.04	1.66	1.688	1.7%
185	7.15	1.90	1.813	-4.8%
220	7.87	2.23	2.195	-1.6%

The average transfer per job is only 300 μsecs, which is short enough to make AMS usable even for short jobs.

Overall, the AMS controller proves itself to be entirely usable in the PLATO system even when operating with only short jobs and would be a usable addition to the memory hierarchy.

2.3.2 MEMORY PERFORMANCE

One significant problem was encountered in the development of the AMS memory system. This problem resulted in the unacceptability of the p-channel MOS shift registers in the application due to excessive device failure and poor storage integrety.

More than 17,000 integrated circuits are assembled to construct a single bank of AMS memory (262k words). Of these, one device comprises the bulk of 16,384 and a second is used in a quantity of 512. These two devices also accounted for almost all of the device failures encountered. The modes of failure of the two devices were similar and took two forms:

1. Immediate failure upon initial insertion.

2. Failure after several hours of operation.

Failure percentages for the two devices are tabulated in Table 2.5.

TABLE 2.5
DEVICE FAILURE STATISTICS

Device	Usage	Failure (Initial)	(Later)
MM5013	16,384	420 – 3%	610 – 4%
MH0026	512	48 – 9%	5 – 1%

Once the assembly and testing problems were overcome and the memory could be fully tested, the major concern was total reliability of the memory system. The AMS memory was designed to operate in the PLATO system.

and since this system services almost 1000 users, it would be unsatisfactory for any memory element to fail except on very rare occasions. The memory section of the AMS memory did not prove to be capable of such a high level of reliability. The reason for this general volatility proved to be inherent in the operation of the P-channel MOS devices used.

The basic storage element within the P-channel MOS dynamic shift register is a simple capacitor. Figure 2.2 is a schematic of this basic cell and shows a capacitor connected between the substrate and the gate of the transmission gates. This capacitor serves as the storage element and is refreshed every cycle of the clock, which also shifts the data of one cell (shown) into the next cell and shifts the data from the previous cell into this cell. The implementation of the capacitor is in the form of a reverse-biased diode junction, which has a capacity proportional to $V^{-2/3}$ and has a leakage current proportional to e^T, where T is the temperature of the junction. The amount of time that data is stored on a capacitor is a function of the capacity and the temperature. The manufacturer's specification guarantees that the device will maintain data over a frequency range from 0.01 MHz to 2.5 MHz, corresponding to a cycle time of from 100 μsecs to 0.4 μsecs over an ambient temperature of 0°C to 70°C. The AMS system limits the operation of the devices to a range of 100 μsecs to 0.8 μsecs. However, although the devices are rated to operate over this range, they will not reliably operate if the frequency is quickly varied from one extreme to the other. The reason for this failure is as follows.

Leakage through the storage capacitor is an exponential function of the temperature of the junction. At slow speeds, the temperature of the junction is very low (even though the ambient temperature might be relatively high) because the nearby transistors are not switching very fast and saturated MOS transistors dissipate the bulk of their power during the actual switching function. Since the capacitor leakage rate is low, long periods between refreshes can be tolerated, as is true during low-speed operation. At the other extreme, during high-speed operation, the temperature of the junction is quite high and the leakage is very high as well. However, the cell is refreshed very often by the clock and so data is maintained. However, when the data rate is instantly changed from a high rate to a low rate, the temperature of the cell does not change instantly, and for a short period of time the temperature of the junction is high but the refresh rate is low. During this time the margins are greatly reduced and an occasional bit is dropped.

This problem is very difficult to observe carefully and as such has been diagnosed by observation and through discussions with engineers of the integrated circuit manufacturer. No mention of any problem of this sort is contained in the data sheets on the uses of the device.

The purpose of this work was to discover and demonstrate a new method of controlling serially-organized memories in such a fashion as to make them usable as high-performance swapping memories in interactive computer systems. This purpose was accomplished. All of the controller tests and evaluations were satisfactory and a great deal of valuable data was

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gathered which will be used to guide future AMS projects. Although functional,
the actual memory plans used in this research would require error correction
and detection circuitry for sufficiently reliable operation in the PLATO
system. Accordingly, further development should await evaluation of more
reliable and also less expensive technology which are now becoming available.

P. Tucker

L. Hedges

D. Anderson

3.   PLATO IV TERMINAL DEVELOPMENT

Fabrication of the second prototype has been completed and the unit
placed into operation in the PLATO IV system.   The prototype terminal is
shown in Fig. 3.1a while Fig. 3.1b shows the microcomputer mounted in a drawer
in the base of the terminal.

Work is proceeding on the development of the terminal resident pro-
gram.   This program, in addition to emulating the existing PLATO terminal,
has been expanded to include the following additional features:

1.   Character writing in both vertical and horizontal mode.

2.   Character writing in two directions in both horizontal and
     vertical modes.

3.   Additional character formatting functions including two dyna-
     mically adjustable margin settings and two dynamically adjust-
     able tab settings.

4.   Incorporation of a boldface character set (typeface).

In addition to the above resident programs, additional programs
have been developed to help reduce the processing load on the central computer.
To date these programs include:

1.   A local animation routine which performs animation sequences
     given only the identity of the object, the starting and ending
     points and the rate of movement.

2.   A circle generation routine requiring only the center and radius.

3.   A compose program which allows the user to store messages in the
     terminal and later call them up for display as a part of his
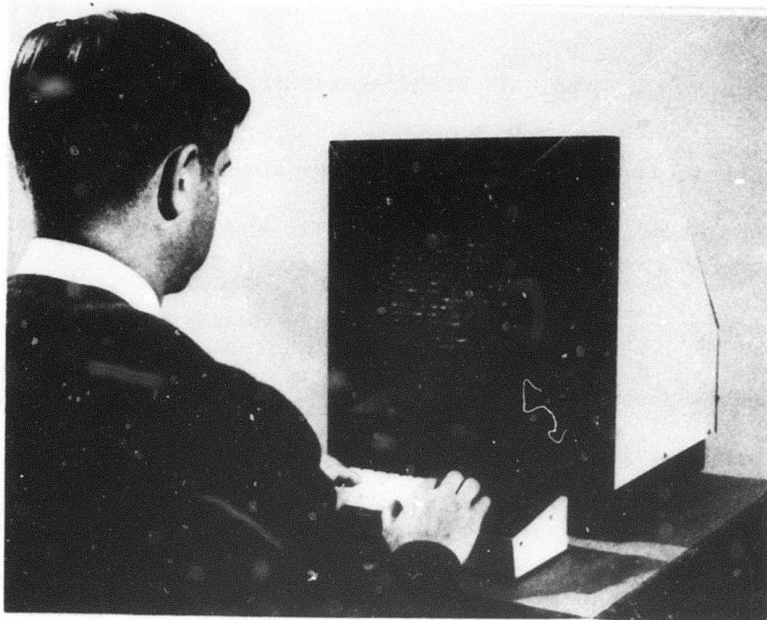   program.

FIG. 3.1a PROTOTYPE TERMINAL

FIG. 3.1b MICROPROCESSOR CONTROL UNIT

4. A memory dump program to permit the contents of the terminal memory to be displayed on the plasma panel. This program is used primarily for debugging purposes.

In April, a parallel panel was obtained from Owens-Illinois and has been installed in the terminal. Software has been developed which allows block erase of user specified areas of this panel without erasing the entire panel. This feature requires the user to specify two xy locations and the terminal will erase (or write) the area specified by $\Delta x = x_2 - x_1$, and $\Delta y = y_2 - y_1$.

A ROM programmer has been designed and built for use in generating new terminal resident programs. This unit which attaches to the terminal IO bus can program a 1K x 8 bit ROM in two minutes. Data to be written into ROM is first loaded into the terminal RAM memory from the central computer. The data is then transmitted to the ROM programmer to be written into the ROM. The terminal controls the rate of writing into the ROM as well as reading back the data for validity testing. The ROM programmer is shown in Fig. 3.2.

<div style="text-align: right">
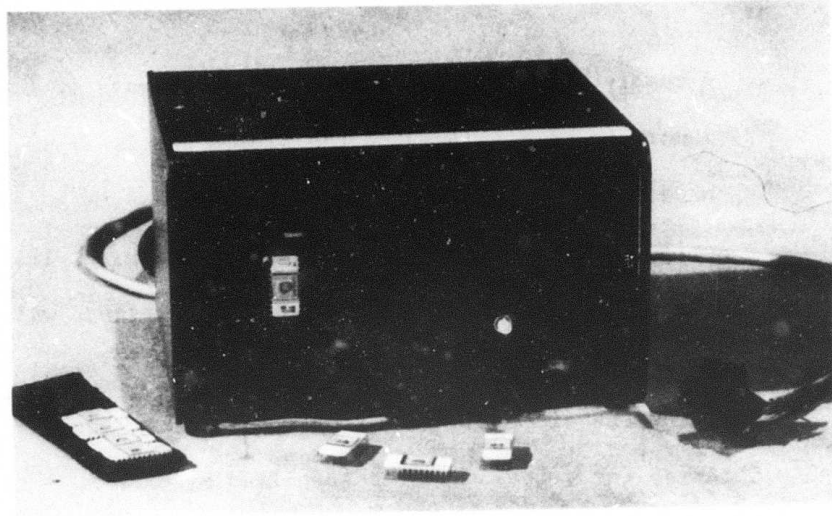
J. Stifle
L. Hedges
M. Hightower

</div>

FIG. 3.2 ROM PROGRAMMER

4. AUDIO VISUAL FACILITY

4.1 RANDOM ACCESS AUDIO

The assembly of all but two audio units awaiting accessors has been completed, thus ending the University of Illinois audio production program. All future random access audio devices will be obtained from industrial sources.

An order for 102 random access units from E.I.S., Inc., has been placed and a prototype was submitted by E.I.S. for our inspection. The audio performance exceeds all of our specifications and all indications are that the new device will feature improved reliability and easier operation.

The audio disc production facility has been steadily supplying audio discs to present audio users. These discs are of the same size as those required for the newer audio devices, except for some additional holes that can readily be punched.

4.2 RANDOM ACCESS SLIDE SELECTORS

A facility for maintaining and repairing slide selectors has been set up and put into operation. In order to provide uniform alignment, test and repair procedures, a slide selector user's manual is being prepared. This facility will also be responsible for maintaining the audio devices.

4.3 MICROFICHE PRODUCTION

Microfiche production, using one camera for square and another for rectangular formats, is expanding with increasing numbers of users. In

order to decrease costs and microfiche turn-around time, and possibly to increase the quality of color reproduction, CERL has ordered an automatic color processing system for processing our exposed films.

D. Skaperdas

5. HIGH SPEED MODEM DEVELOPMENT

5.1 INTRODUCTION

A new teachnique for high speed data transmission has been developed and modems (MODulator/DEModulator) have been designed and are being tested. The purpose of this investigation is to provide a new and less expensive media of multi-terminal communication between the computer site and a remote site. Utilizing this communication technique, 9600 bits per second (bps), enough to service eight terminals, can be transmitted on a single voice grade telephone line.

9600 bps modems are available commercially at a price of approximately $4000 per end. All of these modems exhibit similar characteristics in that they are generally two to four bits per baud, 2400 to 4800 baud modems. This is to say that data elements are transmitted at 2400 Hz to 4800 Hz with each element containing from two to four bits of information. In contrast, the transmission technique being investigated in the PLATO laboratory involves many parallel channels, each of which transmits data elements at a 60 Hz rate, and each data element contains five bits. Thirty-two data channels are used to complete the 9600 bps. Two additional channels are used to communicate basic timing information so a total of thirty-four channels are used.

Table 5.1 is a general detail of standard design voiceband data channel.

TABLE 5.1
STANDARD DESIGN VOICEBAND DATA CHANNEL

Frequency Response: 500-2500 Hz (-2db to +8db)
                      300-3000 Hz (-3db to +12db)
Envelope Delay[1]: 1750 microseconds (800-2600 Hz)
1004 Hz Response: -12db to -20db (18±4db)
Noise level (C-message[2]): -68 to -40db max[3]
Signal/Noise (1004 Hz tone): 24db min
Single frequence interference: 3db below noise
Frequency Shift: less than 5 Hz
Phase Jitter: no more than 10° peak-to-peak
Nonlinear distortion: 2nd harmonic -25db max
                       3rd harmonic -30db max

[1]Envelope delay is defined as $\Delta\phi/\Delta f$ = rate of phase change with respect to frequency change.
[2]C-message is a standard weighting curve used by phone company when measuring noise.
[3]The maximum allowed noise is a function of the wire miles encountered in a line.

Based on Table 5.1, the usable telephone bandwidth ranges from 300-500Hz to 2500-3000Hz depending on the tolerance of the modem equipment used to amplitude and envelope delay distortions. All of the presently available modems operating at 2400 to 4800 baud are severely effected by the envelope delay distortions encountered in standard lines. This is because of the fact that the delay distortions are of a significant magnitude when compared to the signaling rates. 2400 baud represents one signal per 417 microseconds. All high baud rate modems incorporate a delay equalizer (usually a transversal equalizer) to correct or flatten the phone line so that the modem sees very small differential delays over the bandwidth of the channel.

Another characteristic of the typical phone line that has a severe degrading effect on the operation of high baud modems is the presence of impulse noise. Impulse noise is that noise of such a nature that it presents a spike superimposed on the normal phone line signal and has amplitudes which are comparable to the data signal. The duration of the impulses are normally 100-500 microsecond in duration. The presence of this type of noise will invariably cause an instanteous error in the data that is recovered by the modem receiver of a high baud rate modem system. This is because the duration is comparable to the duration of the data signaling element. High baud rate modems have no real defense against impulse noise and can only attempt to recover as quickly as possible.

The modem technique that has been developed in the PLATO laboratory is very tolerant to both of the phone line distortions listed above. The reason for this is the fact that the baud rate or data signaling rate of this new technique is only 60Hz or one signal element per 16.7 milliseconds. The magnitudes of the envelope delay are small compared to this as is the typical duration of impulse noise hits. The new modem does not require any equalizer for compensation for envelope delay. In addition, since the signaling time is 16.7 milliseconds, and the contents of the phone line are integrated over this period of time to determine the data that was transmitted, the vast majority of the impulse noise encountered will be integrated out.

5.2 DATA ENCODING AND TRANSMISSION

Each 16.7 milliseconds (60 times per second), 160 data bits must be encoded into a complex data signaling element and then that element is

transmitted for the next 16.7 milliseconds while a new element is assembled. The 160 data bits are grouped into 32 sets of five bits. Each of the sets are used to determine the amplitude and phase of a single frequency carrier. There are 32 carriers used to communicate data. Since the absolute phase of a carrier is indeterminant when that signal arrives at the receiving end of the phone line, the phase and amplitude are actually determined by the difference (binary subtraction) of the data transmitted during one signaling element and the next. The binary data transmitted is represented by the change in the amplitude and phase from one element to the next. Figure 5.1 depicts the mapping of data into the amplitude and phase domain (shown as x,y).

The composite phone line waveform consists of 32 frequencies which are modulated according to the data in Fig. 5.1 plus two channels which are not modulated and instead act as timing pilots. All of the channels are single frequency channels and the frequency of those channels are related as multiples of 63.75Hz. The lowest frequency is eight times 63.75Hz or 510Hz and the highest frequency is 41 times 63.75Hz or 2614Hz.

Each 16.7 milliseconds, the phase and amplitude of each of the 32 data channels is updated with new data. The 16.7 millisecond period is divided up into 17 slots. During the first 16 slots, the sum of all of the 32 data channels plus the two timing channels is applied to the phone line. The amplitude of the composite signal is adjusted to average Ødbm. Figure 5.2 shows the signal which is applied to the phone line.

The entire transmission mechanism is implemented digitally. The phase and amplitude modulation, and the frequency generation and summing are
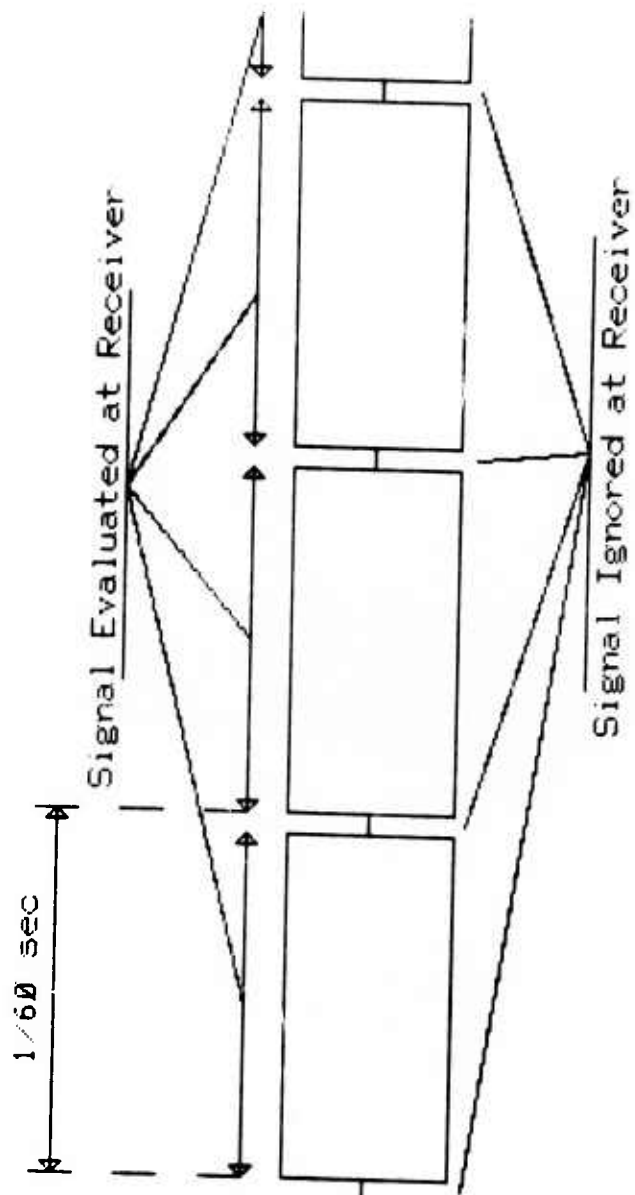
Figure 5.1
Data to Space Mapping

53

Figure 5.2

all digital processes. The output of the digital summer is fed to a digital
to analog converter to generate the complex phone line signal.

5.3 DATA RECEPTION AND DECODING

At the receiving end of the phone line, the complex composite sig-
nal that is presented by the phone line must be interpreted and the value of
the data package that the transmitter encoded to generate the phone line sig-
nal must be extracted. Unfortunately, the phone line is not a perfect trans-
mission media and, therefore, distorts the signal transmitted by the trans-
mitter before it arrives at the receiver. The major types of distortion that
are affected are:

1. Amplitude distortion (both uniformly at all frequencies and
   differentially at different frequencies).

2. Phase distortion (envelope delay).

3. Gaussian noise.

4. Impulse noise.

5. Frequency shift (all frequencies are translated by a small
   amount).

6. Non-linear distortions (harmonic distortions).

As stated earlier, most of the noise and phase distortions have little or no
effect on the data reception due to the fact that the baud rate is so low
(60 baud). However, the amplitude distortions, the frequency shift and the
non-linear distortions must be compensated for in order for the transmitted
data to be recovered.

The frequency domain representation of the transmitted signal, taking into account the mluti-frequencies, the modulation at 60Hz and the pulsed t nsmission (Fig. .2) consists of the sum of 34 signals each of which appears as a sin(x)/x shaped distribution. Figure 5.3 shows the shape of the frequency domain signal for one channel and Fig. 5.4 shows the composite phone line signal. The receiver incorporates 34 filters each of which is shaped like Fig. 5.3 and centered on the individual channels. These filters are digitally implemented and produce the values of:

$$\int_{\emptyset}^{16ms} \sin(nwt) \; v(t) \; dt = Y$$

and

$$\int_{\emptyset}^{16ms} \cos(nwt) \; v(t) \; dt = X.$$

The value of 'n' varies from 8 to 41, the value of w is $63.75/2\pi$. The process is actually a sampled digital one and the sampling rate is 30.7kHz. The values of 'X' and 'Y' can be used to calculate the angle of the carrier within the bandpass of the filter with respect to the sine wave by the relationship of:

$$\theta = \text{Arctan } (X/Y)$$

and if the major portion of the energy within the passband is the energy due to the transmitted carrier at the center frequency (f_o) of the filter, the angle of that carrier can be determined and thus the data that was transmitted can be recovered.
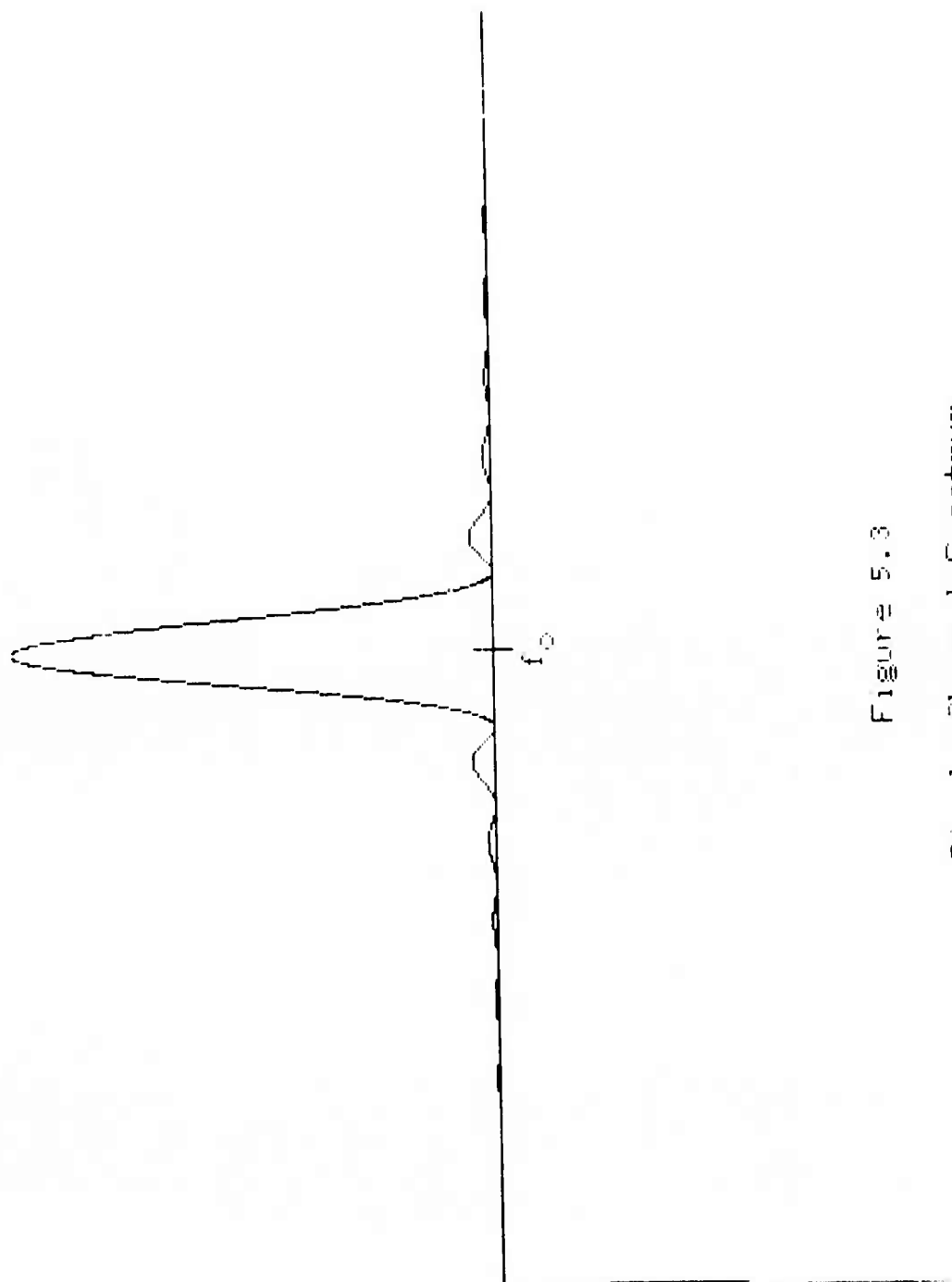
Figure 5.3

Single Channel Spectrum

Figure 5.4

Composite Phone Line Spectrum

In order for the modem to operate properly, the exact timing of the transmitter must be recovered. Since the filters in the receiver integrate over a 16.7 millisecond period, this interval must exactly match the interval over which the transmitter transmits. The two timing channels are not modulated and are therefore usable as pilots for the receiver to derive the transmitters timing period. In addition, since the phone line has the possibility of shifting all of the frequencies that are transmitted by as much as 5Hz, and this amount of offset would cause a significant amount of phase shift on all channels as well as move the centers of the filters from the centers of the transmitted carriers, this parameter of the phone line must be compensated for. One of the timing channels is used to derive the frequency offset of the channel and this information is fed back to the sine-cosine generators to cause those generators to match the frequencies of the incoming signals. The third characteristic of the phone line that must be taken into account is the differential amplitude distortion. All of the channels are computed individually, however, and a digital decision threshold feedback is incorporated to totally account for this characteristic. All three of the three compensating sections mentioned (timing period alignment, frequency offset and individual amplitude thresholds) are interactive and recursive so that once they have been aligned after the unit is first turned on, they continue to maintain themselves while data is being transmitted even if the phone line changes.

A 7200 bit per second, 120 baud unit has been built and operated in the laboratory. A 9600, 60 baud unit is presently being constructed for

testing and is expected to be operational in the third quarter of 1975.

This new unit will incorporate the knowledge gained from the 7200 bps unit

as well as several new innovations.

D. Bitzer
W. Keasler
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6. ADVANCED TERMINAL TECHNOLOGY RESEARCH

The advanced terminal technology research program is concerned with the improvement of the cost-performance characteristics of the man-machine interfaces that will be used in future PLATO systems. The activities deal with exploration of techniques which may provide near-term improvement of existing terminal related hardware, firmware and software cost-performance characteristics, and with exploration of totally new approaches to make the man-machine interface more efficient, e.g. to improve the impedance match between machine and human through his audio, visual and tactile senses. Work is being carried on in five major project areas; these are:

1. Terminal architecture.

2. Display technology.

3. Audio input and output.

4. Tactile input.

5. Terminal-based auxilliary memory.

6.1 TERMINAL ARCHITECTURE

The objective of the advanced terminal architecture project is two-fold. First, research is being performed to support the design of the hardware, firmware and software for future processor-based PLATO terminals. Second, research is being conducted in order to evolve a powerful (yet low cost) laboratory and office terminal design which is compatible with PLATO yet exhibits wide ranging multi-host and stand-along capability. Both projects are being carried out using mini- and micro-computer-based plasma display terminals developed at CERL.

6.1.1 SOFTWARE FOR PROCESSOR-BASED TERMINAL SYSTEMS

Work on the software for processor-based terminals has yielded the design of the ICONIC[1] System. This system includes specifications for software resident in the central computer as well as the terminal. To fully identify what software is required locally requires an examination of what is performed centrally.

Description of this design is presented under three headings:

1. Human factors.

2. Software.

3. Hardware.

Human Factors. The design rests on certain assumptions about the uses of the system by people. These assumptions have been derived from a variety of sources, including data on the PLATO system. A list of these sources is included in Appendix A. The assumptions are listed below.

1. People can perform a sequence of muscular actions, spatially locate, and recognize a pattern, long before they have a name for the sequence, location or pattern.

2. Individual intellectual work is usually performed as part of "small" group such as a class, project team or academic department.

3. The use of a properly designed iconic notation[2] for information

---

[1] Image Construction, Organization and Network Interchange Control.

[2] The symbols in notation have a physical similarity to things represented.

stored in a data base would allow people to process data at
rates greater than 1200 baud.

4. People will readily accept an interactive graphical model of
something as a "description" of it.

The examination of man-machine interaction underlying these assump-
tions has yielded a method of description that utilizes graphical models.

Briefly described, this method consists of representing the inter-
action with a directed graph. The nodes are images (di plays) and the edges
are user actions. This method has been incorporated in the ICONIC system
software.

Software. The software consists of system routines called collec-
tively the "ICONIC Designer", and applications packages called "presentations".
The ICONIC Designer is a generalization of the TUTOR editor on PLATO. The
Designer is used to create presentations analogously to the way the editor
is used on PLATO to create lessons.

The following two sub-sections describe some of the distinguishing
features of the Designer and presentations.

1. ICONIC Designer. The designer prompts the user in performing
two operations. They are: "Construct an Image" and "Construct
a Control Table".

a. Construct an Image. This choice produces a situation like
PLATO's "SD" option in the editor. However, it has the
additional options of:

    (1) Attaching parameters and operators to the image.

    (2) Setting those parameters and inspecting their effect
on the image.

    (3) Modifying image by "adding" or "subtracting" other
images.

    (4) Moving back and forth through an image like a reel of
film to allow insertions and deletions to image.

   b. Construct a Control Image. This choice allows the user to
complete a table. Such tables are used to organize the
presentation of images in response user inputs. The format
of such a table and the method entering data are outlined
in Appendix B.

  2. Presentations. A "presentation" is a collection of control
tables that satisfy references among themselves, and a collec-
tion of all those images referenced by the tables. Presenta-
tions are best thought of as maps, models and simulations.
They also include special designers. They allow a user to
"move through" or examine various images which in turn repre-
sent data in computer or the state of some other physical system.

Hardware. The hardware organization reflects the division of soft-
ware into two main classifications. The central computer contains the
Designer and is used very interactively during the design of presentations.
The peripheral processor controls most, if not all, of user interaction with
presentations. For many applications, a communications between the central
computer and the peripheral processor/memory would not be necessary.

Appendix D contains a schematic representation of the network. The display controller represents key compromise between the extremes of total centralization as embodied by PLATO and a collection of toally autonomous mini-computers. It can also be seen as a generalization of the intelligent terminal.

The Display Controller is the heart of the ICONIC system since it handles the bulk of human interactions with the system. The disk memory memories attached to each controller give the ICONIC system a massive distributed memory system which is competitive with the ECS of the PLATO system. The "slowness" of the disk medium is compensated for by the samll number of terminals accessing it. The resulting tradeoff yields a system which can be more responsive to user input than PLATO.

The use of the Display Controller also allows the ICONIC system to be implemented with a greater variety of computers, than is possible with PLATO. This greater adaptability appears to be more valuable than the virtually unlimited communications capability of a totally centralized system.

6.1.2 PROCESSOR-BASED TERMINAL SYSTEMS

A form of the pdp11 based terminal has been assembled on an experimental basis for use with a large information retrieval system. The main data base resides on MULTICS (Mass. Inst. of Tech.) and is accessed through the ARPA net node at the Center for Advanced Computation on campus.

The hardware configuration is a pdp11/05 with 22K of memory, parallel plasma display, keyset, touch panel and DL11 programmable serial

communications interface. A dual DEC tape drive is used for program
storage.

The design goal of the system is to demonstrate the advantages of
a local processor and graphics display on an information retrieval system.
Once the system is initialized, the touch panel is the only input device.
Part of the data base is loaded from the host and stored locally. This
local data base is automatically updated as needed. If the link to the main
system is lost, the local program can continue to format and display all of
the local data base, while also informing the user of the status of the
communications link. When the link is restored, the program can return to
using the entire data base without reinitialization.

Work is continuing on the feasibility of local word storage to
increase text writing speeds. It had been decided to analyze the PLATO
system output stream to determine character and word frequencies. The pro-
gram to determine character frequencies has been completed, and the one to
determine word frequency distributions is near completion.

While it is still not clear how much would be gained in visual
speed improvement by storing words at the terminal, a number of inefficiencies
in the current method of sending text have been quantitatively analyzed. For
example, both the need for a null character, and the advantage of keeping
more local positioning information such as margins has been found to be quite
significant.

More work will be done to improve the character by character sending
of text, both from the standpoint of display speed and in reducing the amount

of processing needed to convert from the system's internal character representation to the terminal format.

A modification of the PLATO IV terminal simulator is currently running under a version of RT11, Digital Equipment Corporation's disk operating system for the pdp11. This system now uses the RK-05 cartridge disk, but will convert to floppy disk as soon as the necessary software arrives from DEC. The main emphasis of this system is image trapping, which allows a user to create a display on PLATO, send it to the pdp11 as a stream of terminal commands, which are then stored and regenerated locally. The combination of image trapping of text and diagrams, plus local area erasure (block erase) are being used with a medical information system that the user can interact with at acceptable speeds. (1/3 sec. for a full screen rewrite.)

Many applications which involve sending data to PLATO IV have been found. For example, sending grey scale picture information that has been digitized elsewhere to PLATO for use in lessons there, or adding binaries assembled for the pdp11 on a more convenient system to those currently stored on PLATO. Also, laboratory terminals need to send experimental results. We now have two programs which do this, with enough error checking to prevent data loss. One dumps a core image, the other accepts data from the serial communications line, buffers it as necessary and sends it to PLATO.

Sending data back to PLATO in this manner is non-trivial since the problem of low bandwidth is compounded by the system wide assumption that most input is hand time slices. We are encouraging a system level change both in priority structure and in the TUTOR language to help alleviate this problem.

6.2 DISPLAY TECHNOLOGY

The primary objective of the display technology project is to enhance the performance and minimize the cost of the display systems which are used in PLATO system terminals. At present, there are two principle activities:

1. Advanced plasma display system research.

2. A study of basic display device principles.

6.2.1 PLASMA DISPLAY

During this period, a study of second generation PLATO terminal display design alternatives was continued. It is expected that this activity will continue throughout the next period.

6.3 TACTILE INPUT SYSTEMS

Since CAI is necessarily a highly interactive environment, the PLATO system draws much of its instructional power from the graphics oriented plasma display terminal. The efficiency of the system relies, in part, on the efficiency of the man-machine interface provided for at the terminal. The keyset has always served as the standard tactile input to a computer terminal. However, manipulation of graphically formated display material is particularly tedious when the keyset is the only means of data entry available. This is a distinct disadvantage when the effects of limited student attention span are considered. A more direct means of addressing display

material can be had by incorporating a position sensitive device overlaid on the display surface.

A crossed light beam position encoder, developed at CERL, has successfully met the PLATO IV system requirements of low cost and simple user operation. This touch panel has a resolution of four bits per axis (16 x 16 touch sensitive areas) and a limited rate of data generation as constrained by the low bandwidth return path of the PLATO IV communications network. While the crossed beam technique affords absolute resolution (i.e. the beams are fixed in space), this resolution is limited by the physical size of the discrete transducers used to emit and to detect the light beams.

The development of a minicomputer based intelligent terminal at CERL that has local computing capability and storage stimulated interest in designing a second generation graphics input device that could more fully utilize this increased data handling capacity. Greater resolution of eight bits per axis (256 x 256 touch sensitive areas) and position encoding rapid enough to follow hand drawing in real time were major changes in design objectives. It was felt important, however, that the additional touch capability not be gained at the expense of operational simplicity. During the reporting period a prototype transparent conducting glass touch entry system was designed and built in an effort to meet these specifications.

Initially, attempts were made to adapt an existing commercial product into the design in order to more quickly expose a working graphics tablet to the CERL courseware staff. This was done primarily to create constructive feedback from those who could use the device. Although the resulting unit

worked well enough to demonstrate the principles of operation, performance of the hybrid system proved unsatisfactory. Emphasis was then shifted toward designing a completely in-house prototype that could be more easily modified to experimental specifications.

The graphics encoder is built around a glass substrate coated with a conducting thin film that exhibits linear planar resistive properties. The thin film is typically composed of stannous oxide applied with well established vapor deposition processes. A major step in the proposed design evolution is the integration of the thin film with the plasma display itself, the display glass serving as the substrate. This step will provide for a minimum of parallax and attenuation in the resulting display device.

A significant feature of this design is the use of a transparent metalized membrane closely overlaid above the active area of the graphics encoder. The conductive membrane acts as a two-dimensional probe, thus eliminating the need for an active hand-held stylus and connecting wire. Additionally, the overlay acts as a barrier against adverse environmental conditions, preventing oil and dirt accumulation on the active surfaces and protecting the more expensive coated glass from scratches. It should be noted that resolution is not limited by the contact area between the membrane and thin film coating. There is the future possibility of back coating the plastic polarizer, already required for plasma displays, thus increasing the transmission efficiency of the composite system. These advantages are particularly suited to the requirements of operating ease and low maintenance.

To visualize how position is determined, consider current flowing through one axis of the thin film coating. This current will create equipotential lines that are orthogonal to the current flow. A probe touching the conducting surface at some point will assume a voltage that is directly proportional to the position of the probe on the axis parallel to the current flow. This voltage is then digitized to provide a binary representation of the (x,y) position. This scheme offers high resolution inherent in the continuous nature of the thin film.

The control logic in the encoder accepts mode select and variable length comparator commands from the terminal under program control. The mode may be chosen either to cause the hardware to generate a single coordinate per touch or to generate a stream of coordinates as long as the overlay is in contact with the resistive surface. The digital comparator checks the last converted coordinate with the newest, preventing the transfer of data to the terminal in the event that the two data words are equivalent. Comparator precision is program selectable, allowing the graphics encoder to operate at reduced resolution while still eliminating the need for the programmer to check for redundant data.

At this time the unit has not been fully tested due to a delay in the acquisition of high quality coated glass. Work yet to be completed includes fabrication of a suitable mechanical frame, cost and performance conscious modifications and evaluation of the fully operational encoder. Of particular interest in performance tests are linearity, long term stability and the effects of noise on the system. These tests are important because accuracy and absolute resolution depend on these factors.

6.4 AUDIO INPUT AND OUTPUT SYSTEMS

The terminal technology research group has two current programs in audio input/output systems. One activity deals with the investigation of a terminal-based speech recognition scheme which will lend itself to low cost production, and which can be used with the low bandwidth return path to PLATO. The second activity deals with the evaluation of a commercially available tape cassette system which can be used in conjunction with a standard PLATO terminal.

6.4.1 VOICE INPUT

The major emphasis of our audio input work has been on the implementation and evaluation of modifications to our existing speech recognition hardware and software, in an attempt to both improve recognition reliability and reduce the amount of information sent to the PLATO computer.

A considerable amount of time was spent trying to correct inconsistencies that were noted in the results of our initial performance evaluation tests. It was hypothesized that keys were being dropped due to automatic interrupts occurring during key processing, resulting from the high CPU usage of the recognition program. To guard against this possibility, it was decided to utilize a handshaking scheme between the voice input and the CYBER 70. The system utilizes an external output word (rather than the terminal) to generate a data resume. To check for keys being dropped, the finish key was modified to send a count of the number of keys generated to

be compared with the number of keys received. It has been found that keys are still being dropped at about a one percent rate, which is probably low enough to leave performance relatively unimpared. Nevertheless, minor inconsistancies are still being noted probably due to inherent statistical variation.

A number of modifications have been implemented but evaluation of their effect has been delayed due to the performance evaluation difficulties mentioned.

First implemented was hardware to allow different thresholds for different measurement types. It does appear that varying individual thresholds can improve performance. A series of tests will be run to determine an optimal set of threshold values.

Second was a system that causes keys to be generated only if the difference threshold is exceeded on two consecutive sampling passes (rather than one with current system). Initial results indicate that relatively significant savings do occur without serious reduction in recognition ability.

The third modification implemented is a "finish key" that is generated at the end of an utterance (.5 seconds after the input signal falls below the noise threshold). This key eliminates the need of a speaker to remain quiet until all the keys are transmitted as is currently the case, and it contains a six bit measurement of the duration of the utterance, providing a more accurate duration indication than is currently possible.

Some exploration of software improvements was also carried out. A series of tests were run to evaluate the effect of using different sets of

b-weights for different vocabularies. The results we obtained did not indicate that there were significant gains in recognition with the b-weights calculated by our correlation methods.

Some exploration of the difference between linear and hyperbolic prediction methods was also carried out. There was not sufficient difference between these two methods, though, to warrant further efforts in this area.

Our current work involves implementing further modifications and evaluation of the existing ones.

6.5 AUXILLIARY MEMORY SYSTEMS

In the consideration of micro and mini-computer-based terminal systems on PLATO, a natural requirement is that of additional low-cost, terminal-based memory for storage of expanded character sets, storage of image frames, storage of local programs for management of lab and office systems and storage of terminal operating systems for multi-host operation. Current activity in this area is concentrated on evaluation of floppy disk technology and low cost solid state shift-register memory systems.

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T. Agler
D. Brown
J. Oppenheimer
M. Stone
J. Suste
P. Van Arsdall
L. Weber
P. Lamprinos

7. OPERATIONS

The PLATO IV Operations Group has responsibilities in the following areas: installation, maintenance, microwave and data line communications. The group also supplies, on occasion, technical support for demonstrations.

7.1 INSTALLATIONS

During this period, equipment from Ft. Monmouth was transferred and the site at Stanford University was closed. The installation of four terminals and associated 4800 baud equipment at Ft. Belvoir, Virginia on May 1, 1975 and at Maxwell AFB on June 9, 1975 completed the original ARPA 98 terminal system. In the coming months, we anticipate reinstallations as presently installed equipment is reassigned.

7.2 MAINTENANCE

The maintenance operations consist of two separate but interconnecting areas: the physical repairing of non-working terminals and the repairing of the parts that have been replaced. The diagnosis of a particular problem is either done by personnel at the site or in consultation with engineers at CERL. This interexchange of information, either by terminal or telephone, has proven to be a valuable means of reducing the down time of equipment as well as improving the ability of on-site personnel to do their own troubleshooting. This has menat that the physical repairing of the terminals can be accomplished by sending replacement parts to the site, where physical replacement is then made. The number of trips required by

CERL personnel to the sites has been greatly reduced, thus lowering the cost of maintenance. This has worked particularly well at San Diego, Aberdeen and Sheppard, where extremely helpful and qualified personnel exist. We are continuing to supply all the maintenance for Chanute AFB.

As was reported earlier, a new repair program was put into service on June 1, 1975. Figure 7.1 shows an actual report. The first section contains all the information needed to identify the terminals and locations. Section 2 gives the reporter's diagnosis of the problem. On observing this report a CERL engineer contacts the site and follows through until the terminal is confirmed as being operational. This procedure is noted in Section 3, repair comments. The checklist in Section 4 is used to call attention to specific areas of trouble. Should the problem be related to the plasma panel or power supply, then notations are made in the report as shown in Fig. 7.2. Once the terminal is verified as operational, the status is changed to "Finished" at which point the down time clock stops. The total down time is recorded just below the checklist. The status change as well as other types of changes are made by use of Section 5. When the defective component is repaired at CERL, the final report comments are made by the repairman in a section shown in Section 6, which appears in place of Section 5. The new repair program has proven much more satisfactory than its predecessor, however, we are presently updating it to provide for easier entry of comments by repair personnel. These changes will be reported in a future report.

rin =
10372

Updated-F report from Remote site
Terminal 502
From bldg 501,rm3, maxwell afb   Phone - 2052936122
Reported by bl abbott   of mto site 25 stn. 18
Reporter comments:

everything that appears on the screen. also appears on
either lines 29 and 30 (cg) all garbled up. doesnt appear
to be keyset but maybe in the screen electronics. happen
at this terminal only

Repair comments:

terminal has a bad md30 panel, verified bad. pp430254

new panel will be sent jhk 6/27/75/packed 6/30/sent 7/3 lb

sent pp430110. def unit rec cerl 7/21/75 jhk

CHECKLIST
a) plasma panel *   b) panel power   c) logic card
d) logic power   e) terminal elec. f) keyset
g) slide sel.   h) touch panel   i) audio .
j) phone line   . k) cmr4   l) other
Reported on 26 Jun 1975 at 7.76 hours   Total Down Time
Completed 14 Jul 1975 at 15.40 hours   18.32 days

Repaired In Field   OI (CERL)
a. voltage adjustment d. display electronics
b. fuses & components e. power supply
c. other   f. glass

press NEXT for Can Not Verify (CNV)
>

FIG. 7.2

SECTION 1

Updated-F report from Remote site

Terminal 502

From bldg 501,rm3, maxwell afb   Phone - 2052936122

Reported by bl abbott   of mtc site 25 stn. 18

rin =
10372

SECTION 2

Reporter comments:

everything that appears on the screen.also appears on
either lines 29 and 30 (cg) all garbled up. doesnt appear
to be keyset but maybe in the screen electronics. happen
at this terminal only

SECTION 3

Repair comments:

terminal has a bad md30 panel, verified bad. pp430254

new panel will be sent jhk 6/27/75/packed 6/30/sent 7/3 lb

sent pp430110, def unit rec cerl 7/21/75 jhk

SECTION 4

CHECKLIST
a) plasma panel ←   b) panel power   c) logic card
d) logic power   e) terminal elec.   f) keyset
g) slide sel.   h) touch panel   i) audio
j) phone line   k) cmr4   l) other

Reported on 26 Jun 1975 at 7.76 hours   Total Down Time
Completed   14 Jul 1975 at 15.40 hours   18.32 days

SECTION 5

1 = New   2 = Complete   3 = Finished
4 = Incomplete   5 = Info only   6 = Updated Finished

SECTION 6

Final Report Comments:

replaced ic 3672 and diode in pulser package-gls

Updated-F report from Remote site

Terminal 502

From bldg 501,rm3, maxwell afb   Phone - 2052936122

Reported by bl abbott   of mtc site 25 stn. 18

rin =
10372

Reporter comments:

everything that appears on the screen.also appears on
either lines 29 and 30 (ce) all garbled up. doesnt appear
to be keyset but maybe in the screen electronics. happen
at this terminal only

Repair comments:

terminal has a bad md30 panel, verified bad. pp430254

new panel will be sent jhk 6/27/75/packed 6/30/sent 7/3 lb

sent pp430110, def unit rec cerl 7/21/75 jhk

CHECKLIST

a) plasma panel ←   b) panel power   c) logic card
d) logic power   e) terminal elec.   f) keyset
g) slide sel.   h) touch panel   i) audio .
j) phone line   . k) cmr4   l) other .
Reported on 26 Jun 1975 at 7.76 hours   Total Down Time
Completed   14 Jul 1975 at 15.40 hours   18.32 days

P   s - alter status   .←DIAl TO UPDATE REPORT←
R   t - alter terminal number   NEXT for next report
E   p - alter location   BACK for index
S   r - write/rewrite repair comments HELP1 to delete
S   o - to set problem checklist   LAB1 for OI Checklist

FIG. 7.1

Table 7.1 shows an analysis of the repair program for the last reporting period. It also shows that the following repairs and trips were made at the ARPA sites. When examining the table, one should be aware that a typical time for shipping a part and installing same is 9 days and a terminal is considered down (according to PLATO Operations people) from the time it is reported in repair until it is verified as operational by someone at the site. The down times, therefore, include the time to ship and install the defective part. Table 7.1 also shows higher down times for those sites where no personnel are available for troubleshooting and repair. The second greatest time builder is time required to send a man to a site for repairs. Finally, telephone line problems on weekends and lack of available part replacements add to the down time for terminals. It is hoped that the telephone line analyzer described later in this report will decrease the time needed to diagnose line problems and thus reduce the total down time.

7.3 MICROWAVE SERVICE

On April 5, 1975, the temporary microwave system on MDS Channel 1 was replaced with a permanent system operating on MDS Channel 2A. This six mhz. change required replacement of the transmitter and down converters.

To effectively monitor the microwave system performance, a combination software/hardware fault reporting system has been developed. Every fifteen minutes a software routine checks the transmission errors for each microwave site. If the error rate exceeds 10 errors per 1000 keys, a signal from the computer is sent to a visual display connected to the computer operator terminal. The operator will then notify repair personnel.

TABLE 7.1

Location	Number of Terminals	Number of Reports	Down Time Term Days	Number of Trips Required
Aberdeen, MD	14	2	22.15	0
ARPA Headquarters, Rosslyn, VA	2	4	2.00	2
Chanute AFB[1], Rantoul, IL	22	40	21.09	22
Educational Testing Service, Princeton, NJ	2	1	13.11	1
Electrical Engineering[1], Urbana, IL	2	13	5.80	11
Ft. Belvoir[3], VA	2	5	26.10	2
Ft. Monmouth, NJ	4 (2)	0	0.00	0
HumRRO, Alexandria, VA	2	2	0.00	1
ISI (USC)	1	0	0.00	0
Maxwell AFB[2], Montgomery, AL	4	5	19.53	1
Orlando, FL	4	16	130.13	0
San Diego, CA	12	11	58.34	1
Sheppard AFB, Wichita Falls, TX	20	18	143.41	1
UCSB, Santa Barbara, CA	1	1	16.85	1
Stanford University, Stanford, CA[2]	4	3	0.66	1
USC, Los Angeles, CA	3	3	3.80	0
	95	123	462.31	44

[1]Chanute AFB and Electrical Engineering are serviced by CERL personnel and are shown for comparison purposes.
[2]Maxwell AFB has those terminals which were previously at Stanford.
[3]Two of Ft. Belvoir's terminals came from Ft. Monmouth.

Available Terminal Days = 17,195   Percentage Down Time = 2.69%

7.4 COMMUNICATIONS

The Operations Group is responsible for all communications connections between CERL and PLATO IV terminals. In the case of ARPA installation, all telephone lines are ordered through Washington, however, in fact, the information as to specifications comes from Urbana.

The storing of information pertaining to telephone lines and locations has become a burden of such magnitude as to cause the creation of a computer program to keep track of all the information needed. This program is nearing completion and will be described in a later report.

7.5 DEMONSTRATIONS

The Operations Group provided support for two ARPA demonstrations during the last quarter, however, no trips were required.

7.6 EQUIPMENT DESIGN

Although designing of equipment is not the principal function of the Operations Group, we have, in the past, developed test equipment to assist in the maintenance operation. The keyer described in a previous report has been modified and an additional unit constructed. A fault reporting system was developed and constructed as described in the section on microwave service. Also designed and under construction is a communications line analyzer and a time-shared data switch which is constructed and operational.

7.6.1 LINE ANALYZER

An inexpensive test instrument has been recently designed which will allow remote PLATO users to monitor and test their data lines. The test instrument called the PLATO Line Analyzer consists of a digital frequency counter, an A.C. digital voltmeter and test tone oscillator. The frequency counter will measure from zero to 9,999 Hz. The A.C. voltmeter will measure levels from 40 mv (-29 dbm) to 6v (+9 dbm). The test oscillator is preset to 1 KHz at 0 dbm. It is hoped that the cost can be kept low enough so that all sites can obtain this unit to assist in communication problems troubleshooting.

7.6.2 TIME-SHARED DATA SWITCH

There are occasions where it is advantageous to be able to serve more than four terminals with one 4800 baud modem multiplexer. To solve this problem, a data switch has been designed. The switch permits the operation of either a local terminal (one in the same vicinity as the multiplexer), and/or a remote terminal. The remote terminal can be connected by either a dedicated telephone line or an auto answer modem. Although they effectively share the same port, the local terminal always has priority of use. The design is being modified to allow the local user to know if the remote terminal is operating. The data switch is shown in Fig. 7.3.

7.7 COPIER MAINTENANCE

Varian electrophotographic hard-copy devices have been installed and placed in operation at the following ARPA sites:

Aberdeen Proving Grounds

Lowry A.F.B.

San Diego Naval Station

Sheppard A.F.B.

Chanute A.F.B.

Orlando Naval Training Center

At each site an operator has been trained by CERL to perform required maintenance. These people have an excellent record of keeping the copiers producing high quality copies with minimum down time.
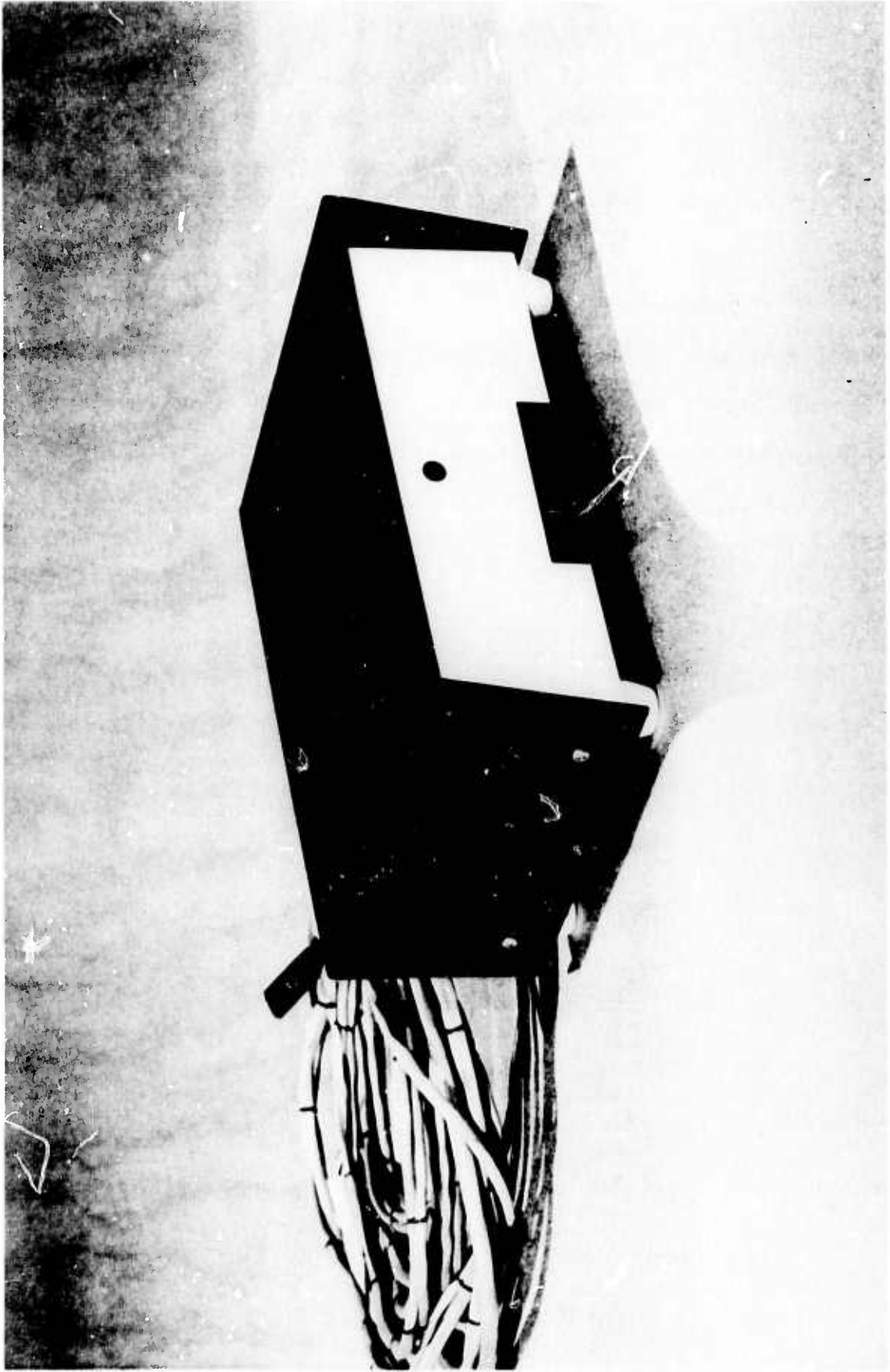
G. Burr
J. Knoke
M. Williams

FIG. 7.3 TIME SHARED DATA SWITCH