PROPOSAL

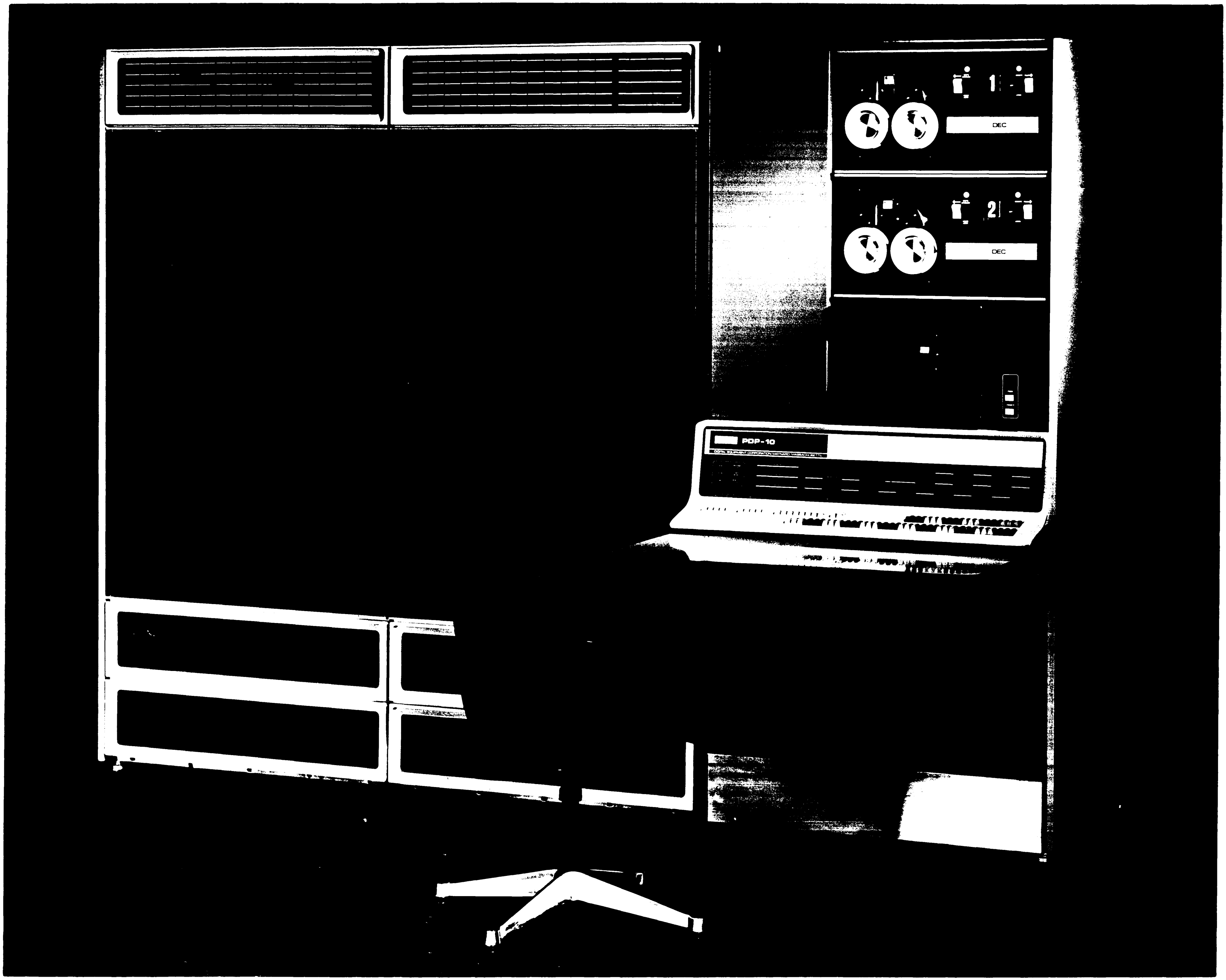
TO

UNIVERSITY OF QUEENSLAND

BRISBANE

MULTI-USER, TIME SHARED PDP-10 SYSTEM

DIGITAL EQUIPMENT AUSTRALIA PTY. LTD. • SYDNEY, N.S.W.


1
DEC
2
DEC
PDP-10

UNIVERSITY OF QUEENSLAND

TENDER FORM

for the

SUPPLY AND INSTALLATION OF ONE (1) AUTOMATIC DIGITAL COMPUTER SYSTEM

*~~I~~/WE the undersigned do hereby tender to provide the materials and perform all works for the full and proper supply, delivery, installation, setting to work and maintenance of one (1) automatic digital computer system at the University of Queensland, St. Lucia, Brisbane, in accordance with the Specification issued by the University and as priced in the accompanying signed Schedule numbered I and as described by the documents referenced in the accompanying signed Schedule numbered II at the time or times stated and subject to the General Conditions of Contract and Conditions of Tendering issued by the University.

Dated at: Sydney this Thirty-First day of January, 1967.

(Signature and address of person, firm or company tendering)

DIGITAL EQUIPMENT AUSTRALIA PTY. LTD.
89 Berry Street,
North Sydney, N.S.W.

(Signature and address of witness)

89 Berry Street,
North Sydney, N.S.W.

* Strike out whatever is not applicable to the tender submitted.

Five copies supplied.

SCHEDULE I

SCHEDULE OF RATES AND PRICES

Prices (in Australian currency) are to be entered against each item tendered for.

Specification Section	Description	Quantity	Total Price (f.o.b.)	Monthly Rental	Monthly Maintenance Charge	Import Charges	Reference in Tender
	PDP-10/50 System comprising:						
5	Type KA10 Central Processor	1	72,000)				
4	Type MB10A Core Memory	2	129,600)				
4	Memory Processor Access Type MC10	2	2,700)				
6	Type TD10 DECtape Control	1	13,800)				
6	Type TU55 DECtape Transports	2	4,230)				
5.5	Type KP10 I/O Bus and Priority Interrupt	1	2,800)	-	690	14,000	Section 2
4.6	Type KT10 Memory Protection and Relocation	1	4,170)				
5.5	Type KE10 Extended Order Code	1	10,800)				
6.3	Type MS10 Multiplexer/Selector Channel	1	15,300)				
6.3	Type RC10 Disc File Control	1	10,800)				
6.3	Type RD10 Disc File	1	29,390)				

Signature of Tenderer ..R. Frost.........

Date ..31st January, 1967.

Witness ......[signature].....

Five copies supplied.

SCHEDULE I

SCHEDULE OF RATES AND PRICES

Prices (in Australian currency) are to be entered against each item tendered for.

Specification Section	Description	Quantity	Total Price (f.o.b.)	Monthly Rental	Monthly Maintenance Charge	Import Charges	Reference in Tender
6.3	Type RD10 Disc File	3	87,870	-	162	2,000	Section 2
5.6	Type KM10 Fast Registers	1	8,100	-	16	100	"
6.3	Type CR10B Card Reader	1	24,770	-	97	2,000	"
6.3	Type CP10 Card Punch	1	27,000	-	90	2,000	"
6.3	Type LP10C Line Printer	1	45,000	-	158	2,000	"
6.3	Type TU55 DECtape Transports	2	4,230	-	24	1,000	"
6.3	Type TM10B Magnetic Tape Control	1	19,800	-	43	1,500	"
6.3	Type 3029 Magnetic Tape Transports	2	32,400	-	330	2,000	"
6.3	Type 565 Plotter	1	8,100	-	22	500	"
6.3	Type DC10 Data Communications:						
	DC10A	1	8,100	-	) 33	) 1,000	"
	DC10B	1	4,500	-	)	)	
6.3	Type KSR-33 Teletypes	8	6,500	-	200	2,000	"

Signature of Tenderer ....R. Pratt....

Date 31st January, 1967.

Witness ....[signature]....

Five copies supplied.

SCHEDULE I

SCHEDULE OF RATES AND PRICES

Prices (in Australian currency) are to be entered against each item tendered for.

Specification Section	Description	Quantity	Total Price (f.o.b.)	Monthly Rental	Monthly Maintenance Charge	Import Charges	Reference in Tender
	Alternative equipment as follows:						
4.1	Type MB10B Core Memory	1	55,700		215	1,200	Section 2
4.1	Type MA10 Core Memory	1	44,000		100	1,200	"
6.3	Magnetic Tape Transport Type TU20	1	10,800		70	1,200	"
6.3	Magnetic Tape Control Type TM10A	1	16,200		38	1,000	"
6.3	Type LP10A Line Printer	1	29,200		120	2,000	"
6.3	Type CR10A Card Reader	1	13,500		75	800	"
6.3	Teleprinters Type ASR-33	1	1,080		30	200	"
6.3	Teleprinters Type KSR-35	1	2,250		22	300	"
6.3	Type 338 Display	1	55,000		180	2,500	"
6.3	Type 340 Display	1	36,000		66	1,500	"
6.3	Type DA10 PDP-8 Interface	1	4,500		10	100	"
6.3	PDP-8 Computer	1	17,000		117	1,000	"

Signature of Tenderer ...[signature]...

Date 31st January, 1967.

Witness ...[signature]...

Five copies supplied.

SCHEDULE II

REFERENCES TO PARTICULARS OF EQUIPMENT TENDERED

Specification Section	Item	Reference in Tender
5	PDP-6 Handbook F-65 and Change Notice #3	Page 3
6.3 (b)	Card Reader Type 461B	Page 5
6.3 (c)	Card Punch	Page 5
6.3 (h)	Incremental Plotter Type 350B	Page 5
6.4	DECtape Transport Type TU55 and Control Type TC01	Page 9
6.4	Programmed Buffered Display Type 338	Page 10
6.4	Data Communication System Type 680	Page 5
7.3	MACRO Assembly Language Programming Manual	Page 31
7.3	Fortran IV and Fortran II Programming Manuals	Page 31
7.3	Compact Cobol Language	Page 31
7.3	LISP Programmer's Manual	Page 31
7.3	SIMPLE Manual	Page 31
7.3	Desk Calculator Programming Manual	Page 31
7.6	DDT Programming Manual	Page 32
7.6	Time Sharing TECO	Page 32
7.6	Batch Control Processor	Page 32
7.6	Multiprogramming System Manual	Page 32
7.6	DECtape Editor	Page 32

Signature of Tenderer ....R. Frett....

Date ..31st January, 1967.

Witness ......[signature]

Five copies supplied.

SCHEDULE II

REFERENCES TO PARTICULARS OF EQUIPMENT TENDERED

Specification Section	Item	Reference in Tender
7.6	Type 338 Programming Manual	Page 32
7.6	Fortran IV Library Routines	Page 32
7.6	User Programs	Page B.1
-	DECUS brochure	Page 17
-	DECUS Proceedings, Spring 1966	Page 17
-	DECUS Proceedings, Fall 1966	Page 17
-	DECUS Proceedings, European Spring Seminar, 1966	Page 17
-	Small Computer Handbook	Page 10
-	PDP-10 Systems Philosophy and General Characteristics	-

Signature of Tenderer ..R. Frith..

Date 31st January, 1967.

Witness ....

PROPOSAL TO

UNIVERSITY OF QUEENSLAND, BRISBANE

FOR A

MULTI-USER, TIME SHARED PDP-10 SYSTEM

Prepared by

DIGITAL EQUIPMENT AUSTRALIA PTY. LTD.

January 1967

TABLE OF CONTENTS

digital

SECTION 1

INTRODUCTION

Digital Equipment Australia Pty. Ltd. has pleasure in submitting this proposal for the supply and installation of an Automatic Digital Computer System for the University of Queensland.

We have proposed an advanced multi-programming system including remote user terminals. The hardware is a third generation design incorporating compatible software with its predecessor, the PDP-6. This ensures completed, tested and proven operating systems. The software has been developed over the past two years to meet the systems needs of a sophisticated group of users, who have in turn contributed substantially to the DECUS Library.

The equipment proposed is a PDP-10 Model 50, with a core/disc swapping monitor. Current development of this monitor (as well as of the PDP-10/40 monitor) will provide re-entrant operation of the Compiler, Assembler and Text Editor, and will provide a conventional Batch Processing function, in parallel with multi-user operation.

We look forward to supplying the University with this advanced Time Sharing system and contributing to its subsequent development, through our special capability in the fields of on-line communications, displays, small satellite computers and special input/output devices constructed from our circuit module products.

SECTION 2

PROPOSED CONFIGURATION

2.1 Component Parts

1 only PDP-10/50 configuration consisting of the following elements:

Central Processor Type KA10
I/O Bus and 7-level Priority Interrupt System Type KP10
Memory Protection and Relocation Type KT10
Extended Order Code Type KE10

32K words Core Memory, 1.0 microsecond cycle time, Type MB10A
2 additional Memory-Processor Access Ports, Type MC10
Paper Tape Reader, 300 ch/sec
Paper Tape Punch, 50 ch/sec
Console Teleprinter

DECtape Control Type TD10
2 DECtape Transports, Type TU55

Selector/Multiplexer Channel Type MS10
Disc File Control Type RC10
Disc File Type RD10

Plus the following options:

3 additional Disc Files, Type RD10

Fast Memory Type KM10

Card Reader, 800 cards per minute, Type CR10B

Card Punch, 100 cards per minute, Type CP10

Line Printer, 1000 lines per minute, Type LP10C

Magnetic Tape Control, Type TM10B

2 Magnetic Tape Transports Type 3029

Calcomp Plotter Type 565

Type DC10 Data Line Scanner, 8 lines operating

8 User Consoles

2 additional DECtape Transports, Type TU55

2.2 Description

Central Processor - The PDP-10/50 computer system has as the major control element the Type KA10 Arithmetic Processor. The 36-bit word length of the KA10 allows for the direct addressing of 262,144 core memory locations, 15 index registers, 16 accumulators, and an indirect bit for multi-level indirect addressing. It provides for up to 512 operation codes, of which 365 are currently implemented. An additional 64 of these codes may be arbitrarily assigned by the programmer. Included in the PDP-10 instruction repertoire are important groups of instructions for byte manipulation, list processing, floating point operations, and logical manipulations. The full list of the PDP-10 instruction codes is shown in Appendix 1 of the PDP-6 Handbook, F-65. In the proposed configuration, the Central Processor is equipped with full memory protection and relocation and a 7-level priority interrupt system for input/output transfers.

Primary Storage - 32,768 words of core storage are provided in two modules of 16,384 words each. Memory cycle time for the proposed core storage is 1.0 microseconds. The average cycle time of the proposed configuration, however, is improved approximately 25% by the interleaving of memory addresses. Each of the 16K memory banks operates asynchronously to the Central Processor and to each other.

Fast Memory - The 16 accumulators and/or index registers are normally located in the lower 16 addressable locations of core memory. We have proposed that the fast memory option be supplied, which reduces the access time of the accumulators and index registers from 1.0 microseconds to virtually 20 nanoseconds. As on the average every second memory reference is to an accumulator, the increase in overall operational speed is very significant.

Secondary Storage - The proposed magnetic disc system provides for storage of 10.56 million characters on four separate disc files. Rotational delay of the disc file system is 34 milliseconds, giving an average access time of 17 milliseconds. Transfer rate to the PDP-10 is 15 microseconds per 36-bit word, or 2.5 microseconds per 6-bit character. The disc is a fixed head system, so that there is no increase in access time due to head movement. Each disc file has a capacity of 440,000 words or 2.64 million characters. Data is transferred to and from the disc file system control through the Selector/Multiplexer Channel. This controller occupies one of the four ports into the core memory of the system. The Selector/Multiplexer Channel can handle up to four high speed device controllers requiring direct core memory access.

Tertiary Storage - Four DECtape Transports are provided for "carry away" user file storage, library program exchange and data storage. The DECtapes have a character transfer rate of 15 Kc/s, with each reel of tape holding 443,900 6-bit characters. The two IBM compatible Magnetic Tape Transports have a maximum transfer rate of 60 Kc/s. These transports are provided for communication with existing systems and for larger capacity off-line storage.

Paper Tape Reader - The Paper Tape Reader on the PDP-10 is supplied as standard. It is designed to read 8-channel fanfold paper tape photoelectrically at 300 characters per second.

Paper Tape Punch - The Paper Tape Punch is supplied as standard with the basic PDP-10 configuration. It punches 8-channel paper tape at 50 characters per second.

Console Teleprinter - The Console Teleprinter provides operator communications with the Central Processor and monitor at 15 characters per second. When not required for operator control, the Console Teleprinter may be used as a separate user station.

Card Reader - The Card Reader reads 80 column punched cards photoelectrically at 800 cards per minute. It reads in either alpha-numeric or binary modes.

Line Printer - The Line Printer offered has a sustained printing rate of 1000 lines per minute, 132 columns per line.

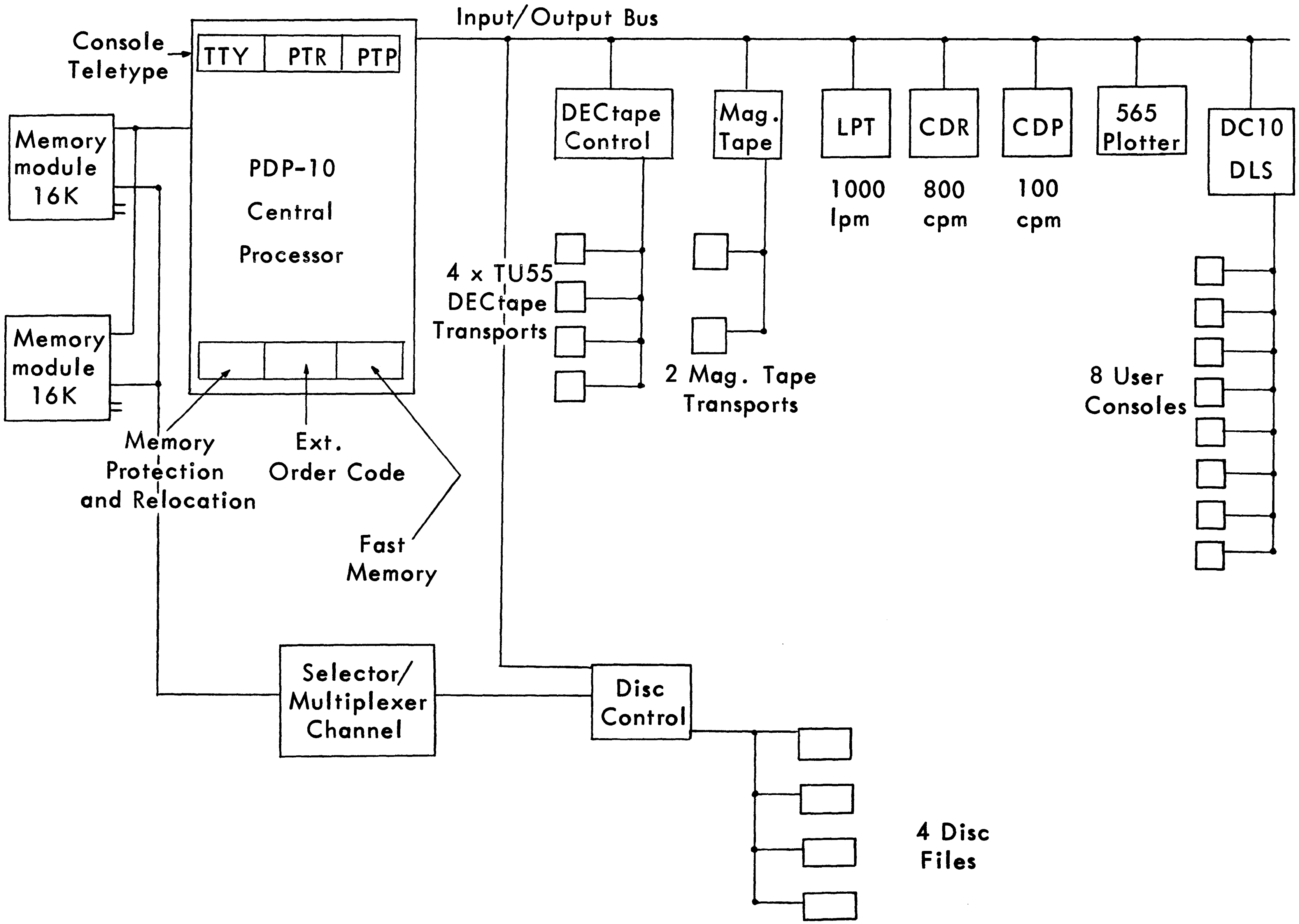
Plotter - The Type 565 Plotter has a maximum stepping frequency of 18,000 per minute with a step size of .01 inches. It has a paper width of 12 inches.

Card Punch - The Card Punch offered punches 80 column cards at 100 cards per minute.

User Consoles - The User Consoles (Teletype Model KSR-33) provide keyboard and printing facilities at 10 characters per second. The user stations may be used either in close proximity to the computing centre or at distances of up to ten miles on a leased line, or at any distance with the aid of Modem equipment via the PMG's network.

DC10 Data Line Scanner - Communications between the PDP-10 and its users are provided by the DC10 Data Line Scanner. This equipment buffers and controls serial input and output information required for communicating with the PDP-10. This information may be either 5 or 8-bit characters, from local or remote lines, or via switched communications networks. It is expandable in groups of 8 lines up to 64 lines. Each group of 8 may have up to 3 different speeds of transmission.

PROPOSED CONFIGURATION



2.3 Additional or Alternative Equipment

Type KA10 Central Processor

1.65 microsecond 16K Core Memory Module Type MB10B

1.0 microsecond 8K Core Memory Module Type MA10

1.0 microsecond 16K Core Memory Module Type MB10A

DECtape Transports Type TU55

Magnetic Tape Transport Type TU20, 36 Kc/s

Magnetic Tape Control Type TM10A

Line Printer, 600 lpm, 132 column, Type LP10B

Line Printer, 300 lpm, 132 column, Type LP10A

Card Reader and Control, 200 cards per minute, Type CR10

Optional Teleprinters:

- Type ASR-33 (with reader and punch, light duty)
- Type KSR-35 (without reader and punch, heavy duty)

Type 338 Programmed Buffered Display

Type 340 Display System

Type DA10 PDP-8 Interface Control

PDP-8 Computer

Type 680 Data Communications System

All PDP-8 Options (see Small Computer Handbook).

2.3.1 Type MB10B Core Memory Module - Type MB10B is the memory presently used on the PDP-6 system. It has a cycle time of 1.65 microseconds, and an access time of 900 nanoseconds. Delivery of this memory is available in December 1967.

2.3.2 Memory Module Type MA10 - This is a 1.0 microsecond 8K core memory module similar to the proposed. Delivery could not be effected until April 1968.

2.3.3 DECtape Transports Type TU55 - This transport is the same as is used as standard on the PDP-10/50 configuration. The DECtape Control will control up to 8 transports.

2.3.4 Magnetic Tape Transport Type TU20 - The Type TU20 is an IBM compatible magnetic tape system with a maximum transfer rate of 36 Kc/s. This transport must be used with the Control Type TM10A. Each TM10A will control up to 8 TU20 transports.

2.3.5 Line Printers - Line Printers are available in 300, 600 and 1000 line per minute versions with 120 and 132 columns. Character spacing is 10 per inch, with lines 6 per inch. The line printers operate on a 64 character set. The interface is designed to handle 7-bit ASCII code, thus line feed, carriage return, form feed, horizontal and vertical tabs etc. are treated by the program as printable characters rather than control functions. They are packed in the output data, five to a computer word, and interpreted by the printer control hardware.

2.3.6 Card Reader and Control - The optional 200 card per minute reader reads either alpha-numeric or binary codes photo-electrically at 200 cards per minute.

2.3.7 Optional Teleprinters - All the remote user teleprinters operate at 10 characters per second with an 8-bit ASCII code set. The ASR teleprinter is equipped with a 10 character per second 8-level reader and punch for either off-line tape preparation or on-line reading of data via the monitor system.

2.3.8 Type 338 Program Buffered Display - The 338 includes a PDP-8 computer as the core storage buffer for a very powerful graphical display system. Full details on the 338 are included in the attached literature.

2.3.9 Type 340 Display System - The Type 340 is a graphical display system which plots points and lines on a 16 inch tube with data drawn directly from the PDP-10 system. The display itself is unbuffered.

2.3.10 PDP-8 Computer - The PDP-8 is perhaps the most popular small computer in the world today. Designed for scientific and engineering control systems, it may be used in this system as the control element for a teletype line multiplex system. However, with its wide range of standard peripheral equipment that includes A/D and D/A converters and multiplexers, display systems and communications systems, and the facilities for easy interfacing to any non-standard devices, the PDP-8 is ideal as the peripheral computer on a PDP-10 system.

For full details of the PDP-8, please see the Small Computer Handbook.

2.4 Purchase Prices

2.4.1 Proposed Equipment:

	Total $A
1 only PDP-10/50 configuration, comprising:	
Central Processor	
I/O Bus and 7-level Priority Interrupt	
Memory Protection and Relocation	
Extended Order Code (Byte and Floating Point)	
32K words Core Memory, 1.0 microsecond cycle time	
2 additional Memory-Processor Access Ports	
Paper Tape Reader, 300 ch/sec	
Paper Tape Punch, 50 ch/sec	
Console Teleprinter	
DECtape Control	
2 DECtape Transports	
Selector/Multiplexer Channel	
Disc File Control	
Disc File	295,590
3 only additional Disc Files Type RD10 @ $29,290	87,870
1 only set of 16 Fast Accumulators Type KM10	8,100
1 only Card Reader Type CR10B, 800 cpm	24,770
1 only Card Punch Type CP10, 100 cpm	27,000
1 only Line Printer, 1000 lpm, 132 column	45,000
2 only DECtape Transports Type TU55	4,230
Magnetic Tape Control for 60 Kc/s Transport, Type TM10B	19,800
2 only Type 3029 Transports @ $16,200, 60 Kc/s	32,400
1 only Calcomp Plotter and Control Type 565	8,100
Data Communications System Type DC10, 8 local lines:	
DC10A Control Unit	8,100
DC10B 8 Line Group Unit	4,500
8 only User Consoles, Type KSR-33	6,500
	$571,960

2.4.2 Alternative Equipment Prices

	Total $A
Type KA10 Central Processor	72,000
Type MB10B Core Memory, 16K at 1.65 microseconds per word	55,700
Type MA10 Core Memory, 8K at 1.0 microseconds per word	44,000
Type MB10A Core Memory, 16K words of 1.0 micro-seconds	64,800
DECtape Transport, Type TU55	2,115
Magnetic Tape Transport Type TU20, 36 Kc/s	10,800
Magnetic Tape Control Type TM10A	16,200
Line Printer, 300 lpm, 132 column, Type LP10A	29,200
Line Printer, 600 lpm, 132 column, Type LP10B	31,500
Card Reader and Control, 200 cpm, Type CR10A	13,500
Teleprinters: ASR-33	1,080
KSR-35	2,250
Type 338 Programmed Buffered Display with Character Generator	55,000
Type 340 Unbuffered Display with Character Generator	36,000
Type DA10 PDP-8 Interface Control	4,500
PDP-8 Computer, including CAB-8B	17,000
Type 680 Data Communications System Control for 16 local lines	8,150
Each additional local line	90
Additional control for up to 32 long lines	3,080
Each long line implemented	100

2.5 Maintenance Prices

2.5.1 Proposed Configuration - The following prices are for a single shift maintenance contract for the proposed PDP-10 equipment.

	A$/Month
PDP-10/50	690
Disc Files, 3 @ $54	162
Fast Accumulators, Type KM10	16
Card Reader, 800 cpm, Type CR10B	97
Card Punch, 100 cpm, Type CP10	90
Line Printer, 1000 lpm, 132 column, Type LP10C	158
Magnetic Tape Control Type TM10B	43
Magnetic Tape Transport, 2 @ $165	330
Calcomp Plotter and Control Type 565	22
Data Communications System Type DC10	33
User Consoles, Type KSR-33, 8 @ $25	200
	$1,841

2.5.2 Alternative Equipment

		A$/Month
Type MB10B Core Memory		215
Type MA10 Core Memory		100
DECtape Transport, Type TU55		12
Magnetic Tape Transport, Type TU20		70
Magnetic Tape Control, Type TM10A		38
Line Printer, 600 lpm, 132 column, Type LP10B		133
Line Printer, 300 lpm, 132 column		120
Card Reader and Control, Type CR10A		75
Teleprinters:	ASR-33	30
	KSR-35	22
Type 338 Display		180
Type 340 Display		66
PDP-8 Interface Type DA10		10
PDP-8 Computer		117

2.6 Freight and Insurance

Because of the delicate nature of computing machinery, Digital prefers to air freight the system to Australia.

* Estimated cost of Air Freight and Insurance for the proposed system (Section 2.4.1) is $30,000.

This cost is approximate only, and the University would be charged for the actual shipping costs.

SECTION 3

GENERAL INFORMATION

Delivery Schedule

Delivery of the complete system including software is May 1968 or twelve months from receipt of order, whichever is the later. Installation and acceptance at site is estimated to take another six weeks. If the optional Type MB10B Core Memory is suitable for your requirements, delivery may be effected in January 1968. These delivery times are valid for sixty days from the date of this proposal.

Warranty

The PDP-10 system is warranted to be free from manufacturing defects for three months from date of acceptance. This includes repair and replacement of defective parts at no additional charge for this period of time. All parts, labour, travel, shipping charges, etc. for replacement items are included in this warranty. No consequential damages or other secondary liabilities of any kind are covered by this warranty. Digital will supply its standard time shared swapping monitor which will efficiently operate the proposed equipment.

Inspection of Similar Equipment

A similar configuration to that proposed is available for inspection at the University of Western Australia. This machine is a PDP-6 system, which is the predecessor to the PDP-10 and is program compatible, i.e. it uses the same Time Sharing Monitor System as the PDP-10 Model 40. Existing PDP-6 installations and their configurations are shown in Appendix A.

Development State of the System

The first PDP-10 prototype computer is expected to be in operation in February/March. Delivery of the first production PDP-10 is scheduled for September 1967. Digital's time sharing monitor system was first placed in general use in May 1965. Since that time it has been undergoing continuous program development in all phases of operation. The time sharing swapping monitor has been in operation since May 1966. The Fortran IV compiler and operating system has been in operation since June 1966 at all installations of the PDP-6 system, including the University of Western Australia. All other programs listed in the PDP-10 program library (see Appendix B) have been in general use for many months. All software systems are, however, under continual revision, and as suggestions are received from the existing users, they are evaluated and incorporated into the system where appropriate.

Reliability and Availability

The following figures were derived from the PDP-6 system at the University of Western Australia for the period 31st March 1965 to 1st February 1966. Faults were recorded on the complete system, but not including the remote teleprinter units.

Total hours switched on:	6,020
Total faults recorded:	31
Mean time between failures:	194 hours

Percentage availability over the ten month period was 99.2%.

Due to the increased reliability of Digital's FLIP CHIP logic modules, the PDP-10 is expected to provide greater reliability in addition to substantially increased performance.

Maintenance

The PDP-10 computer is equipped with provision for marginal checking by varying the voltage to individual racks of logic modules in the system. These checks are performed just prior to acceptance and the results recorded. The checks are subsequently performed every 1000 hours after acceptance and the trend of the voltages at point of failure is noted. If the margins fall below certain limits the cause of the failure is determined and corrected. Estimated maximum time involved for each of these 1000 hour checks is 15 hours. It is recommended that maintenance diagnostics be run for half-an-hour prior to each day's operation. These may be carried out by unskilled operators. Electro-mechanical equipment requires periodic lubrication of components at intervals not exceeding 300 hours.

To perform these tasks and to provide a local contact for software support, Digital will place a qualified engineer near or at the University of Queensland, both during warranty and for the period of the maintenance contract. The engineer will have had a period of training, if not on your actual system, then on a similar one. As back-up, Digital has three engineers in Australia with considerable PDP-6/-10 experience, both in Australia and overseas.

Post-Installation Support

Digital will provide a telex connection either at Queensland University or at any location in Brisbane yet to be decided. This will provide rapid communication between all our Australian offices and with our factory in Maynard. As the systems programs are under continual development, revised copies of the programs are distributed to all installations at regular intervals. Programs developed by other users are available through our users group, DECUS. For full details of users in the PDP-6 and PDP-10 group, see Appendix A, and for details of DECUS see the attached brochure. To provide post-installation support for programming staff, the maintenance engineer will have some familiarity with the software system and will provide a local interface to more experienced software support people. Our Australian staff includes people who have participated in the development of the time sharing system from its concept, and will be available for consultation by the University.

Installation

Minimum area of floor space to house the proposed equipment is 1000 square feet, not including the user consoles. All equipment associated with the computer is designed to operate directly from multiple 220-250V 50 cps power outlets. No conversion equipment is necessary. Heat dissipation of the proposed equipment is shown in Appendix C.

Training

Digital will provide, free of charge, three programmer training courses totalling approximately 3 week's duration. These courses can be tailored to emphasise any special requirements of the University. However three basic areas would be covered:

* PDP-10 system operation. Including start-up, local and remote console operation, peripheral device operation (and routine cleaning).

* PDP-10 programming, including MACRO-10 and the common systems programs.

* Time sharing monitor design and the hardware/software interfacing to special I/O devices.

Conditions of Sale

Digital's normal Terms and Conditions are shown on the next page. These include the following provisions:

(a) Digital shall not be liable for any damages or penalty for delay in delivery.

(b) Terms are net thirty (30) days from date of invoice. The University will be invoiced at the time of delivery of the system.

(c) There is no provision in the terms for the payment of a security deposit on receipt of an order for the system. This may be subject to further discussion in the event of Digital being awarded the contract.

TERMS AND CONDITIONS

The following are the terms and conditions under which Digital Equipment Corporation, hereinafter called DEC, sells its products.

PRICES — Prices are exclusive of all federal, state, municipal, or other government, excise, sales, use, occupational, or like taxes now in force or enacted in the future and, therefore, are subject to an increase equal in amount to any tax DEC may be required to collect or pay upon the sale or delivery of the items purchased.

DELIVERY — 1. Delivery will be made F.O.B. DEC's plant, Maynard, Massachusetts. The time of delivery is the time when the product to be delivered is ready for pickup by the carrier.

2. DEC shall not be liable for any damages or penalty for delay in delivery or for failure to give notice of delay when such delay is due to the elements, acts of God, acts of the purchaser, acts of civil or military authority, priorities, fires, or floods, or epidemics, quarantine restrictions, war, riots, strikes, differences with workmen, accidents to machinery, car shortages, delays in transportation, delay in delivery by DEC's vendors, or any other causes beyond the reasonable control of DEC. In any such event, the delivery date shall be deemed extended for a period equal to the delay.

3. Title to the products shall pass to the purchaser upon delivery thereof by DEC, and upon delivery the purchaser shall be responsible for and bear the entire risk of loss or damage to the products.

4. Products held for the purchaser or stored for the purchaser shall be at the risk of the purchaser. The purchaser shall also be liable for the expense of holding or storing products at the purchaser's request.

SHIPMENT — In the absence of specific instructions DEC will select the carrier.

TERMS — Terms are net cash with order except where satisfactory open account credit is established, in which case the terms are net 30 days from the date of invoice. DEC will issue invoices on delivery in the case of all products.

DATA AND PROPRIETARY RIGHTS — DEC normally supplies all the necessary data for the proper installation, test, operation, and maintenance of its products. Portions of this data are proprietary in nature and will be so marked, and the purchaser agrees to abide by the terms of such markings. DEC retains for itself all proprietary rights in and to all designs, engineering details, and other data pertaining to any products specified in the contract, all discoveries, inventions, patent rights, etc., arising out of the work done in connection with the contract or with any and all products developed as a result thereof, including the sole right to manufacture any and all such products.

PATENTS — The purchaser agrees to notify DEC of all claims that any DEC equipment infringes a United States patent.

If notified promptly in writing of any action (and all prior claims relating to such action) brought against the purchaser based on a claim that the equipment infringes a United States patent, DEC will defend such action at its expense and will pay the costs and damages awarded in any such action, provided that DEC shall have had sole control of the defense of any such action and all negotiations for its settlement or compromise. In the event that a final injunction shall be obtained against the purchaser's use of the equipment or any of its parts by reason of infringement of a United States patent, or if in DEC's opinion the equipment is likely to become the subject of a claim of infringement of a United States patent, DEC will, at its option and at its expense, either procure for the purchaser the right to continue using the equipment, replace or modify the same so that they become noninfringing, or grant the purchaser a credit for such equipment as depreciated and accept their return. The depreciation shall be an equal amount per year over the lifetime of the equipment as established by DEC. DEC shall not have any liability to the purchaser under any provision of this clause if any patent infringement, or claim thereof, is based upon the use of the equipment in combination with equipment or devices not made by DEC, or in a manner for which the equipment was not designed. No costs or expenses shall be incurred for the account of DEC without the written consent of DEC. The foregoing states the entire liability of DEC with respect to infringement of patents by the equipment or any part thereof or by their operation.

WARRANTY — 1. **FLIP-CHIP MODULES** — All Flip-Chip modules (shown in Catalog C-105, as revised from time to time), are unconditionally guaranteed against defects in workmanship and material under normal use and service for a period of ten years from date of shipment. DEC will repair or replace any Flip-Chip modules found to be defective in workmanship or material within ten years of shipment for a $5.00 per unit handling charge. Handling charges will not be applicable for one year after delivery.

Flip-Chip modules must be returned prepaid to DEC. Transportation charges covering the return of the repaired Flip-Chip modules shall be paid by DEC. Please ship all units to:

Digital Equipment Corporation
Module Service Department
146 Main Street
Maynard, Massachusetts 01754

No modules will be accepted for credit or exchange without the prior written approval of DEC.

2. **SYSTEM MODULES, LABORATORY MODULES, HIGH CURRENT PULSE EQUIPMENT** — All System Modules, Laboratory Modules and High Current Pulse Equipment are guaranteed against defects in workmanship and material under normal use and service for a period of one year from date of shipment. DEC will repair or replace any System Module, Laboratory Module or High Current Pulse Equipment found to be defective in workmanship or material within one year of shipment.

System Modules, Laboratory Modules and High Current Pulse Equipment must be returned prepaid to DEC. Transportation charges covering the return of the repaired System and Laboratory Modules shall be paid by DEC. Please ship all units to:

Digital Equipment Corporation
Module Service Department
146 Main Street
Maynard, Massachusetts 01754

No modules or High Current Pulse Equipment will be accepted for credit or exchange without the prior written approval of DEC.

3. **COMPUTERS, COMPUTER OPTIONS, AND OTHER DEC SYSTEMS** — All of this equipment is warranted free from defects in material and workmanship for the period of time applicable to the type of equipment:

PDP-6 — 6 months
PDP-7 — 3 months
PDP-8 — 3 months
LINC — 6 months
MEMORY TEST SYSTEMS — 6 months

The warranty period begins on the date of installation. Any component which fails during this period will be either repaired or replaced at DEC's option.

4. All above warranties are contingent upon proper use in the application for which the products were intended and do not cover products which have been modified without DEC's approval, or which have been subjected to unusual physical or electrical stress or on which the original identification marks have been removed or altered. These warranties will not apply if adjustment, repair or parts replacement is required because of accident, neglect, misuse, failure of electric power, air conditioning, humidity control, transportation or causes other than ordinary use.

5. The foregoing warranties are in lieu of all other warranties expressed or implied, and of all obligations or liabilities on the part of DEC for damages, including but not limited to consequential damages arising out of or in connection with the use or performance of the equipment.

ACCEPTANCE TESTS FOR COMPUTERS, COMPUTER OPTIONS AND OTHER DEC SYSTEMS — Prior to shipment, DEC will place the equipment in good working order including successful operation of the equipment using test procedures and/or programs, established by DEC, which are applicable to the equipment. All acceptance tests will be run by DEC personnel at the DEC factory upon five days' written notice to the Purchaser, in order to allow a representative of the Purchaser to witness the acceptance tests. The acceptance test report signed by the DEC representative (and by the Purchaser's representative if he attends and witnesses the acceptance tests) will be sufficient to establish that the equipment has satisfactorily completed the acceptance tests.

INSTALLATION OF COMPUTERS, COMPUTER OPTIONS AND OTHER DEC SYSTEMS — The equipment will be installed and placed in good working order including successful operation of the equipment using test procedures and/or programs, established by DEC, which are applicable to the equipment. The Purchaser shall make available a suitable place of installation with all facilities as specified in DEC's Installation Manual. The Purchaser shall furnish all labor required for unpacking and placing the equipment in the desired location.

FIELD INSTALLATION OF OPTIONS — Standard field installation charges are 5% of the option's list price with a $200 minimum and $5,000 maximum plus travel expense.

SUBSTITUTIONS AND MODIFICATIONS — DEC assumes the right to make substitutions and modifications in the specifications of equipment designed by DEC providing that such substitutions or modifications will not materially affect the performance of the equipment.

TOOLS — DEC shall retain title to and possession of any models, patterns, dyes, molds, jigs, fixtures, and other tools made for or obtained in connection with this contract.

CONTRACT — A valid contract binding upon DEC will come into being only as of the time a formal written contract signed by an authorized agent of DEC at Maynard, Massachusetts is dispatched to the purchaser by DEC.

CHOICE OF LAW — This contract is made in, governed by and shall be construed in accordance with the laws of the Commonwealth of Massachusetts.

ERRORS — Stenographic and clerical errors are subject to correction.

DEVIATIONS — Deviations from these terms and conditions are not valid unless confirmed in writing by an authorized agent of DEC at Maynard, Massachusetts.

SUPPLEMENTARY TERMS AND CONDITIONS OF SALE

Applicable to the Sale of Products (excluding developmental, experimental, and research types) for U.S. Government End-Use

The following terms and conditions of sale apply to sales for U.S. Government end-use when the Government contract number is specified on your order.

1. **INSPECTION** — DEC agrees that such products will be subject to inspection and test by the Government under the same arrangements that apply to contracts between DEC and the Government for directly supplying the same or similar products.

2. **BUY AMERICAN ACT** — To the extent required by the Buy American Act (41 U.S. Code 10a-d), DEC agrees to deliver only such products as have been manufactured in the United States substantially all from supplies mined, produced, or manufactured, as the case be, in the United States.

3. **WALSH-HEALY AND EIGHT HOUR LAWS** — In the performance of work under your order, DEC agrees to comply with the applicable provisions of the Walsh-Healy Public Contracts Act (41 U.S. Code 35-45) or the Work Hours Act of 1962 as amended (40 U.S. Code 327-332), whichever is applicable, and official regulations and determinations thereunder, and will save you harmless from any claim or liability because of DEC's non-compliance.

4. **NONDISCRIMINATION IN EMPLOYMENT** — In the performance of work under your order, DEC agrees not to discriminate against any employee or applicant for employment because of race, creed, color, or national origin in accordance with Executive Orders 10925 and 11114 as amended.

5. **TERMINATION** — You may, by written notice to DEC, terminate any order, in whole or in part, to the extent that such termination is made necessary by a termination in whole or in part, or modification, by the Government of the prime contract upon which your order is based. In such event, the respective rights and duties of DEC and the Purchaser will be in accordance with the provision of ASPR, Section 8-706.

6. **RENEGOTIATION** — DEC agrees to abide by the applicable provisions of the Renegotiation Act of 1951 (P.L. 9, 82nd Cong.) or the Vinson-Trammel Act as amended and extended (34 U.S. Code 496, and 10 U.S. Code 311), which is applicable, with respect to orders containing notice that either of said Acts is applicable, and agrees to insert in sub-contracts thereunder the provisions required by the applicable Act.

7. **MILITARY SECURITY REQUIREMENTS** — The provisions of the "Military Security Requirements" clause in ASPR, Section 7-104.12 will apply to any order involving access to classified information.

10/10/65

SECTION 4

SYSTEM DESCRIPTION

In writing this description we have followed closely the system requirements stated in your Specification. Paragraph numbers used in your Specification are given opposite the related description in our proposal.

3.0 General

3.1 Most of the existing PDP-6 installations are oriented towards technical computation, in research or teaching institutions. PDP-10 interest is in this same direction, and our programming development is oriented to serve this area. The major role of PDP-10/50 then, is a time shared technical computing facility with multi-user (local and remote) and on-line capability. Teaching, research and the University's administrative work are very effectively handled on such a facility.

3.2 The teaching load, consisting of large numbers of small programs, can be handled as a batch, with minimum operator intervention. Compilation rates of the order of several hundred statements per minute (for the proposed configuration) would limit the throughput to a little under card reading speed (800 cpm). If compilation listings (source statement plus assembly level listing) were required, this would generally control the throughput, even at 1000 lines per minute. The special advantage of Digital's system is that the higher level students (particularly post graduates) can be exposed to advanced computing techniques using our standard products, e.g. not only time sharing, but the use of displays, remote terminals, peripheral processors and special purpose (home made) interfaces.

3.3 Sophisticated program development is generally best handled by an on-line user, who is able to originate, edit and compile his source files, then load, run and debug his object program, all in direct contact with the computer from a user station. This approach allows the programmer to work at his own rate, with interruptions arising from turn-around essentially removed. The proposed monitor (the PDP-10/50 system) provides a disc/core swapping system to accommodate large user programs. Futhermore, the Fortran IV compiler, the MACRO-10 assembler and TECO editor are being made re-entrant in the time sharing environment, to reduce core requirements for these common operations.

3.4 A Compact Cobol Compiler has been written by Digital's Australian staff, to provide PDP-6/PDP-10 with a facility for handling data processing applications. This compiler was produced initially for university administrative data processing.

3.5 and 3.6 The proposed 10/50 installation is a general multi-user time sharing system, including batch processing. It is well recognised that Digital is the leader in this field, having implemented time sharing with its PDP-6 before the principle was generally accepted by the industry. Although other companies are now proposing very large time sharing systems, Digital has a very significant accumulated experience with installed systems. Most PDP-6 systems include, in addition to remote user stations, an assortment of on-line equipment for data collection and control. The documentation supplied with our systems enables the monitor to be adapted to local requirements. Typically this includes the addition of service routines for specialised on-line devices, alterations to the scheduler etc. The benefits of our experience in operating these systems in "the field" enable new installations to get into a solid production state without a protracted settling-in and debugging delay.

3.7 The PDP-10 system is specially designed for expansion. The 10/50 configuration can be built up from a smaller configuration by the addition of hardware, while retaining program compatibility at both source and object level, as well as file compatibility. The basic 10/50 configuration can be expanded by the addition of core memory and additional processors (up to four PDP-10 processors total, including I/O processors), each with direct addressing capability up to 262,000 words of core. Additional core memory can be of different speeds because of the asynchronous memory system of the PDP-6/PDP-10. Additional and future peripherals can be added to the I/O bus to adapt the configuration to the University's needs from time to time. Peripheral processors, e.g. PDP-8, 8/S, -9, can be added to the PDP-10 via the I/O bus or via data modulation equipment from remote locations.

The faster processors (PDP-8, PDP-9) can be connected directly to the memory bus via the Type 165 option, through which their memories are addressable from the PDP-6/PDP-10. Expected development of mass storage options will also provide a direction of expansion towards faster or larger file storage. The PDP-6/ PDP-10 software system, in which I/O calls are handled symbolically through the monitor, simplifies the inclusion in the system of new peripheral equipment both standard and non-standard.

4.0 Store

4.1 The direct access store proposed has a capacity of 32,768 words, each of 37 bits, 36 information bits plus one parity. Memory cycle time is 1.0 microsecond.

4.2 Core memory is expandable up to 262,144 words, all directly addressable.

4.3 Prices for additional core memory modules are shown in Section 2.

4.4 Details of the core memory modules are as follows:

Type MA10 and Type MB10A -	1.0 microsecond cycle time, access time approximately 0.6 microseconds.
Type MB10B -	1.65 microsecond cycle time, access time 0.9 microseconds.

Each core memory module has its own individual control and memory buffer, and is fully asynchronous with the Central Processor. Memory is connected to the Central Processor by means of a memory bus structure, which allows each core memory module to plug into the bus without modifying the Central Processor or the other associated memories. Address selection circuitry in each memory module determines the address range over which this memory module works. Thus with appropriate address selection circuitry, the memory locations may be interleaved in any number of ways. They are normally arranged such that successive addresses fall in different memory modules.

Details of the major registers of the central processor, and cable connections on the input/output and memory busses, are shown on Page 16 of the PDP-6 Handbook, F-65.

4.5 The memory protection features of the PDP-10 have been described elsewhere in this proposal.

4.6 A user program swapped into core occupies a contiguous protected block. The monitor includes the facility for shuffling down programs to leave contiguous space for new jobs. This approach, which is described in the Multiprogramming Manual addendum, has proved very effective in practice.

5.0 Central Processor

5.3 The PDP-10 Central Processor operates in two modes, Executive and User modes. In Executive mode, all 365 defined instructions are legal, and will be executed by the Central Processor. The 64 programmed operator group are trapped out. The programs are not relocated and the memory is not protected. In User mode, all input/output instructions and the instruction that causes the Central Processor to halt are illegal, and are trapped out along with the 64 programmed operator instructions. When the trap takes place, the control returns to Executive mode and the monitor may take any action required. When in user mode, the relocation constant is added to the running program and each memory reference is checked to ensure that it does not exceed the bounds specified by the memory protection register.

5.4 A full list of the instruction codes for the PDP-10 is shown in Appendix 1 of F-65. Multiple precision arithmetic is provided for by having the arithmetic unit set a flag for program sensing if there is either an underflow or an overflow during an arithmetic operation. The ability to specify bytes of any size provides the programmer with the ability to manipulate character oriented data. All user programs written for the PDP-10 are designed to occupy from location 0 upwards. As each user program is run in user mode, a relocation constant is added to each memory reference in the program. The monitor thereby relocates programs to optimise the use of the core storage. The Central Processor may be interrupted externally by any peripheral device or by the attempted execution of an illegal instruction, or internally be setting one or more of the processor flags. The processor uses a 7-level priority interrupt system. Each peripheral device is assigned a priority level by program, as are the processor flags. Each priority level, j, where $1 \leqslant j \leqslant 7$, has associated with it two words of core memory. These are 40 + 2j and 40 + 2j + 1. When a device on channel j requests an interrupt, the currently running program is suspended and the instruction at location 40 + 2j is executed. This instruction may be a block-in instruction, which would fetch the next word of data and transmit it to the device automatically. Such an interrupt does not change the active registers of the computer. That is, the interrupted program is frozen and no special action is required. This requires three memory cycles, or approximately 3 microseconds per interrupt. Alternatively, the instruction stored at location 40 + 2j might be a jump to the device's service subroutine. This subroutine might check for error indications and perform other housekeeping operations. Any accumulators required by the service routine would be restored prior to leaving the subroutine. The subroutine operates, of course, in executive mode. On completion of the subroutine, the processor will revert to user mode if it had been in user mode when interrupted. Time taken by interrupts of this type is just whatever time the service subroutine requires. During this interrupt time the lower priority channels will not succeed in interrupting, although their requests will of course be remembered and honoured when possible. The maximum length of time between an interrupt and processor reaction occurs when the processor has just been committed to a fixed point divide instruction, and would not be greater than about 10 microseconds. Full details of these facilities are shown in F-65 and the Change Notice #3. The facilities are all standard in the PDP-10/50 configuration.

5.6 The PDP-10 is provided with fifteen index registers. The effective address of an instruction is calculated by adding the contents of the specified index register to the address portion of the instruction. If the indirect operation is specified, the calculated address is used to locate the new effective address. Multi-level indirect addressing is provided.

5.7 The following table shows sample instruction times for some of the commonly used operations.

TYPICAL PDP-10 INSTRUCTION TIMING*

	Interleaved** Operation	Non-Interleaved*** Operation
MOVE A, E (Move the contents of location E to location A)	1.9 μs	2.7 μs
MOVEM A, E (Move the contents of location A to location E)	2.1 μs	2.9 μs
ADD A, E (Add the contents of location E to location A)	2.1 μs	2.9 μs
MPY A, E (Multiply the contents of location A by location E)	9.1 μs	9.9 μs
FMPY A, E (Floating point multiply the contents of location A by location E)	8.8 μs	9.6 μs
DIV A, E (Divide the contents of location A by location E)	11.0 μs	11.8 μs
FDIV A, E (Floating point divide the contents of location A by location E)	10.2 μs	11.0 μs
FADD A, E (Floating point add the contents of location A to location E)	5.1 μs	5.9 μs
JUMP A, E (Jump to location E)	1.0 μs	1.0 μs

* This assumes a configuration of interleaved 1.0 μs core memory, and fast accumulators.

** Instruction stored in one memory module and operand in the other.

*** Instruction and operand in the same memory module.

5.8 The PDP-10 system is a multi-programming swapping system. That is, as many users as possible are held in core storage and the scheduler allocates running time to each of the users in turn. If the total core storage required by the number of users exceeds that available, one or more of the inactive users is swapped out onto the high speed disc system to make room in core. All the hardware, including a real time clock to control this multiprogramming system, is provided in the standard PDP-10/50 configuration.

5.9 The PDP-10 , having only just been announced, is a state of the art computer, and is unlikely to be superceded for a few years. The PDP-10 memory system, with its four processor ports, allows up to four processors to address the one core memory bank. Later processors developed for the PDP-6/PDP-10 system can be added to the available memory ports, to build up a multi-processor system.

6.0 Peripheral Units

6.1 Details and prices of the peripheral units proposed with this configuration are shown in Section 2.

6.2 The PDP-10 is provided with three methods of data transfer between peripheral devices and the central processor and/or memory system.

(a) Direct memory transfers: Blocks of data are transferred directly to and from fast peripheral devices (discs, drums, etc.) into core memory via the selector/multiplexer channel. The selector/multiplexer channel steals core memory cycles from the PDP-10 when necessary to write or read memory. This takes no processor time unless during that cycle the processor is accessing the same memory module.

(b) Block Transfers via the I/O Bus: If a block transfer instruction (BLKI or BLKO) is placed at the priority interrupt trap location, data may be transferred directly to or from core memory locations according to a pointer word pointed to by the instruction. This method of transfer requires three memory cycles.

(c) Programmed Data Transfers: Data may be transferred from peripheral devices by means of the data transfer instructions (DATAI and DATAO). Transfer rates using this method are determined by the program loop required to control the transfer.

Details of the I/O bus structure are shown on Page 16 of F-65, and the details of the control provided with each device are shown in Chapter 4 of F-65.

6.4 Details of the additional peripheral equipment available with the PDP-10 are shown in Section 2.

Digital does not supply Modem equipment for high speed data transfers over communications networks, but can interface to the units becoming available in Australia. In particular, a suitable Modem for private voice grade lines is the system supplied by STC called the GH2011. This system provides for full duplex transmission at 1200 baud. Estimated cost is $1,700 per terminal.

7.0 Programming Support

7.1 The PDP-10 software is an extension of the PDP-6 software, which has been going through evolutionary development since 1964, in university and research oriented environments. In addition to the advanced systems programs, MACRO-10, Fortran IV, TECO, DDT and the very general Time Sharing Monitor provided by Digital, there are a number of more specialized programs provided by or in conjunction with our users. For example, Compact Cobol, Simple (simulation), Fordesk (desk calculator).

7.2 Full details of the established conventions and information on the use of the Time Sharing Monitor system are shown in the accompanying Multiprogramming Manual and other Digital literature.

7.3 The following languages will be supplied by Digital or by DECUS for the PDP-10 system:

* MACRO-10
* Fortran IV
* Compact Cobol
* Lisp Processor
* Simple
* Fordesk
* Desk

Manuals and language specifications relating to these are enclosed. Additional documentation will be available at a later date.

7.4 The Fortran IV Compiler provides highly efficient object code, and compiles at approximately 600 statements per minute, with source on magnetic tape. Fordesk, a Fortran-like desk calculator routine (an interpreter) is provided for problem solution at a user console. Desk is another desk calculator system oriented towards Macro language.

7.5 Full details of the operating system are shown in the Multiprogramming Manual attached to this proposal. Details of the present Batch Control Processing system are shown in Appendix D. A more conventional Batch Control Processor is being developed for the PDP-10.

7.6 The PDP-10 library of programs and routines is shown in Appendix B. These programs include line and context editors, a program for media conversion and transfer called PIP, a sophisticated desk calculator routine and a dynamic debugging program called DDT. In addition, for their own environment, the University of Western Australia developed programs for interactive remote console use as shown in Appendix B. Attached is a listing of the Fortran library subroutines taken from the current systems tape. These routines are fully described in the attached literature.

7.7 The basic PDP-10/50 or 10/40 configuration will run all the software provided. The core requirement of individual programs is listed in Appendix B.

7.8 All programming systems offered are available now.

7.9 The programming system is under continual revision by our programming section in Maynard, and as each new revision is checked out it is forwarded to the customer. A software maintenance group including six programmers is responsible for this function.

7.10 As stated in Section 3, Digital is prepared to offer three training courses during or shortly after installation of the machine. In addition, we have personnel in Australia experienced on the time sharing system, available for consultation on the use and development of the system.

7.11 Digital's users' society, DECUS, is one of the most active societies in computing. Details of this society are shown in the attached DECUS brochure. Some idea of the sophisticated work being done by our users is shown in the DECUS Proceedings.

8.0 Power Supply

8.1 All the equipment tendered is designed to operate on a power supply of 240 Volts $\pm$ 10%, and a frequency of 50 cycles per second $\pm$ 2%.

8.4 No motor alternator set is required.

9.0 Air Conditioning

9.1 Appendix C shows the approximate heat dissipation for all items tendered in this equipment. Ideal conditions for the computer are 72°F, and between 30% and 70% Relative Humidity. However the equipment operates satisfactorily between 60° and 90°F and 10% to 90% Relative Humidity.

9.2 All the equipment, including the discs, are provided with a means of dust control. The requirements for dust control of the system should be as afforded by the filtering system in the average air conditioning installation provided for offices and similar applications.

10.0 Installation and Layout

10.2 Appendix E shows the proposed layout of the equipment tendered in this proposal. This layout is very flexible and is given as a rough indication only.

10.4 Details required in Section 10.4 will be provided on acceptance of the contract. However, it is anticipated that the only special requirement for the PDP-10 configuration would be some cable ducts beneath the Central Processor.

11.0 Finish and Colour

11.1 Digital does not offer alternative colour schemes for the PDP-10 system. It will be provided in the colours of blue and black with a small amount of white.

12.0 Spares

12.1 A full spares list for the PDP-10 is not immediately available. For budget purposes however, the approximate cost would be $18,000 or 3% of the system cost.

13.0 Consumable Stores

13.1 The following items are available from Australian suppliers:

Fanfold line printer paper: Lamson Paragon
Line printer ribbons: Caribonum
Teletype ribbons: Remington Rand, Type 171/100, Black

Teletype print roll: Percy Boyden, $8\frac{1}{4}$" x 4-3/8"
Rolled oiled paper tape: Percy Boyden, 1000 ft rolls
Fanfold paper tape: Digital
DECtapes: Digital
Magnetic tapes: IBM, 800 bpi, certified
Cards: IBM.

15.0 Arrangements for Maintenance

15.1 Prices for a single shift maintenance contract to cover the proposed configuration are shown in Section 2. This contract provides for the repair and replacement of all defective parts and the cost of all parts, labour, travel and shipping charges associated with them.

16.0 Arrangements for Training of Personnel

16.1 Courses offered for the training of programming and operating personnel are covered in Section 3. Maintenance training, if required, would be provided on site by our maintenance engineer, over a period of a few months.

17.0 Instruction Manuals

17.1 A fixed quantity of instruction and programming manuals will be supplied prior to the delivery of the computer, with the balance being supplied at time of installation of the computer.

17.3 As new manuals are printed for the machine, Digital will guarantee to supply reasonable quantities of these to the University.

17.4 The University may reproduce material from the programming and system manuals, provided the source is acknowledged. Hardware drawings, however, are proprietary and may not be reproduced without specific approval.

18.0 Inspection of Identical or Similar Equipment

18.1 Appendix A lists existing PDP-6 installations and their configurations. As mentioned previously, the PDP-6 is a program compatible predecessor to the PDP-10 system. Any of these installations may be inspected by arrangement.

18.2 Most PDP-6 systems are primarily used for technical computation.

18.3 The University of Western Australia have had a PDP-6 time sharing system in operation since February 1965. Inspection of this equipment may be made by arrangement with the University or with Digital.

19.0 Acceptance Tests

19.1 The PDP-10 system will undergo acceptance tests in Maynard (including heat tests) and these tests will be repeated after installation at the University. The duration of these tests will be subject to negotiation after the letting of the contract.

The acceptance tests will be carried out with the normal maintenance programs supplied with the system. The University may take the liberty of writing additional test programs, but their use shall not be admitted as part of the acceptance tests.

20.0 Delivery

20.1 Delivery of the complete system including software is May 1968 or twelve months from receipt of order, whichever is the later. If the optional Type MB10B Core Memory is suitable for your requirements, delivery may be effected in February 1968. These delivery times are valid for sixty (60) days from the date of this proposal.

SECTION 5

PDP-10 SYSTEM SUMMARY

5.1 Multi-User Operations

(a) The PDP-10 provides initiation of any number of jobs (up to system limit) from one console. These jobs are scheduled to run for up to 300 milliseconds before switching to the next job. Thus, response times to commands are dependent on the number of active users rather than the compute time required by active jobs. Each console has apparent sole use of the system. The scheduling algorithm is described in Appendix F. Provision is made for adapting the scheduler to your particular requirements.

(b) The proposed system contains eight remote consoles and the operator's console. Expansion of the data communications equipment to accommodate up to sixty-four consoles is implemented by plugging in additional modules and user stations.

(c) The maximum number of active jobs allowed in the proposed system is a parameter which may be specified at monitor assembly time. Any reasonable number may be used, each job requiring four words of core store to record its status, and twenty-seven words for each data block.

(d) Jobs are scheduled to run by the scheduler routine, which may be called every $1/50^{th}$ of a second. Scheduling algorithm for allocation of computing time is described in Appendix F.

(e) Interference between jobs is prevented by the use of protection and relocation registers, described in PDP-6 Handbook F-65, Change Notice #3. Each user operates as though he were in the lowest address block of core store. Before he is allowed to run the monitor loads the protection and relocation registers with his highest legal address relative to zero and his base address respectively. If the user attempts to refer to memory above that assigned to him, that reference is prevented and the monitor is called to stop his job and type out an appropriate message to him.

(f) Four categories of user programs exist as follows. Their storage between computation slots is described:

Category 1: Inactive jobs are usually stored on disc, the only exception being where the available core memory is sufficient to hold all active and some inactive jobs. No needless swapping occurs.

Category 2: Jobs which are awaiting teletype input and output are also stored on the disc. On input, information is transferred to the teletype buffer in the monitor. When the message is terminated the job is re-scheduled, and the stored information copied across to the job's own buffer. Thus users who type slowly or who leave a job waiting for input will not decrease the efficiency of the system.

Category 3: Jobs which are currently awaiting input or output on devices other than a teletype remain in core but are transferred from a processor queue to the I/O wait queue, thus minimising the time required for the scheduler's search routine.

Category 4: Jobs which are currently runnable, that is, have no reasons for not running, are stored in the processor queue and are allowed to run as the scheduler permits.

(g) Communication between user programs and the monitor is effected by the use of user operation codes (UUO codes). When a UUO is obeyed in the user program, the program traps and the monitor is immediately called. The monitor interprets the particular UUO required and then returns control to the user program.

(h) I/O requests are also effected by UUO's. User programs are not allowed to refer to I/O devices directly, and attempts to do so will result in a trap to the monitor. When a user's job has assembled information for an output device, it issues an output command. If the device is being operated in a buffered mode, the monitor advances the user's buffer pointed to the next buffer, resets a buffer count, initiates a physical transfer to the output device, and allows the user to resume. If output is not buffered, the monitor initiates a physical transfer, places the user in an I/O wait state, and schedules the next job. When the transfer is complete, the device service routine will remove the job from its I/O wait state, thereby allowing it to be re-scheduled in the normal way.

(i) Assignment of core and I/O devices to user jobs. Core may be assigned explicitly by console command or implicitly by the system reading the amount of storage required for the user program from the directory associated with that program. For example, the command RUN F4 will assign 10K of core, load the program into that area, and start it. I/O devices may be assigned either explicitly or implicitly, that is by console command or by programmed instructions. An explicitly assigned device will remain assigned to a job until a de-assign or KJOB command is given, and in this state may not be addressed by any other job. Implicitly assigned devices are released as soon as the program issues a release or an exit UUO, or a KJOB command is typed.

(j) Queuing of requests for non-storable devices. Devices such as the line printer and plotter may not be queued. Normally programs would be written to perform general purpose I/O to a retrievable device such as DECtape, disc or magnetic tape, and this device could be called a line printer or plotter if this were available at the time the program was run. If not available, the program would store its output as a file on disc or DECtape from where the operator could retrieve it when the requested device became available.

(k) A full message switching system is provided between operator console and user consoles and between user consoles. By use of the TALK command, any console may communicate with any other console.

5.2 Queued Jobs

Use of the Batch Control Processor (BCP) allows the operator or any other user to control the processing of a number of jobs sequentially. Commands to the BCP may be either typed into the processor directly, or stored as a separate command file. This command file may be a card in the card reader or files on magnetic tape or DECtape. The processor will access this file and run the jobs in sequence until all jobs have been completed, directing error messages to the user or to the operator if the user has so directed. Each user may generate his own Batch Processor queue. To direct a job to the operator's queue, it is necessary to transfer the job's command string to the operator, who will append it to his command list. The control language for the Processor is described in Appendix D. A Fortran IV compiler has a built-in Batch Control Processor with the same command structure, but does not use the BCP user program.

5.3 On-Line Entry of Experimental Data

Experimental monitoring is most easily handled by small 1024 word user programs coupled with an I/O service routine for the experimental devices. Experimental devices would be provided with a control interface connected to the PDP-10 I/O bus system or to the PDP-8 I/O bus system. The interface would scan all the input lines, accept a character from an experiment and pass the data and line number via the I/O service routine in the monitor to a buffer associated with the small user program. When this buffer becomes full, the user program transfers the information to a file on secondary or tertiary storage.

5.4 Programming Aids

Details of programming languages available in the PDP-10 system are given in the manuals which accompany this proposal. Briefly, they include:

* A very powerful assembler which includes an extensive MACRO processing facility, MACRO-10.

* A sophisticated Fortran IV compiler which produces a binary object program directly, that is without an intermediate MACRO file, and produces very tight object

code. This compiler also incorporates a batch compilation feature allowing, for example, all the programs in the card reader to be compiled without operator intervention.

* A separate Batch Control Processor which supervises the sequential execution of several jobs such as tape copying, Fortran compilation, MACRO assembling, load and go operations, or any other combination.

* A Fortran compile and execute system, Fordesk, designed to speed the debugging of Fortran programs.

* A Lisp Programming language which utilises the list structure storage scheme for both program and data.

* Compact Cobol; a summary of the facilities available in the language is given in the attached literature.

* Utility programs operating from each console include:

  DDT Dynamic Debugging Technique, which allows the user complete control of the execution and monitoring of his program,

  PIP, a Peripheral Interchange Program, which allows the user to copy information in almost any form from any input device to any output device,

  Editor, a program which allows users to create and modify text files such as source programs, A Context Editor, TECO, which is a powerful text editor with facilities for editing on a character, line, or variable character string basis. A summary of TECO commands is shown in Appendix G.

Desk Calculator, a powerful conversational problem solving system which gives the computer user direct access to the arithmetic functions within the PDP-10 science library.

A simulation language, SIMPLE, developed by the University of Western Australia.

5.5 Disc File System

The proposed system allows for a total disc storage of 1.76 million words, of 10.76 million characters.

The allocation of this storage during normal system operation might be as follows:

	Characters	Words	
Operating System Programs (compilers, etc.)	500,000	80,000	System space 450K
Active User Jobs	1,000,000	160,000	
Library Programs	1,000,000	160,000	
Scratchpad	300,000	50,000	
Editing Space	1,000,000	160,000	
Inactive User Jobs	4,000,000		
	7,800,000		

digital

APPENDIX A

EXISTING PDP-6 INSTALLATIONS AND CONFIGURATIONS

1. Physikalisches Institut der Technischen Hochschule Aachen

Quantity	Description
1	Type 136 Data Control
2	Type 161C Core Memory (16K - 5 μs)
1	Type 166 Arithmetic Processor
1	Type 461 Card Reader
1	Type 516 Magnetic Tape Control
1	Type 521 Magnetic Tape Control Interface (for 570)
1	Type 551 DECtape Control
2	Type 570 Magnetic Tape Transports
1	Type 626 Console Printer Keyboard and Control
1	Type 630 Data Communications System
1	Type 646 Line Printer
1	Type 760 Paper Tape Reader
1	Type 761 Paper Tape Punch
2	Type 555 Dual DECtape Transports

2. University of Western Australia

Quantity	Description
1	Type 166 Arithmetic Processor
1	Type 760 Paper Tape Reader
1	Type 626 Console Printer Keyboard and Control
1	Type 163C Core Memory (16K - 1.7 μs)
1	Type 162 Fast Memory
1	Type 551 DECtape Control
4	Type 555 Dual DECtape Transports
1	Type 136 Data Control
1	Type 646 Line Printer
1	Type 461 Card Reader
1	Type 346 Incremental Display
1	Type 630 Data Communications System

3. University of California, Berkeley Division

Quantity	Description
1	Type 166 Arithmetic Processor
1	Type 626 Console Printer and Keyboard Control
1	Type 760 Paper Tape Reader
1	Type 136 Data Control
1	Type 163C Core Memory (16K - 1.7 μs)
1	Type 461 Card Reader
1	Type 551 DECtape Control
2	Type 555 Dual DECtape Transports
1	Type 646 Line Printer
1	Type 346 Incremental Display

4. University of California, Lawrence Radiation Laboratories

Quantity	Description
1	Type 166 Arithmetic Processor
1	Type 760 Paper Tape Reader
1	Type 626 Console Printer and Keyboard Control
1	Type 136 Data Control
2	Type 163C Core Memory (16K - 1.7 μs)
1	Type 516 Magnetic Tape Control
1	Type 522A Interface for IBM
1	Type 162 Fast Memory

5. Der Universitat Bonn

Quantity	Description
1	Type 136 Data Control
2	Type 161C Core Memory (16K - 5 μs)
1	Type 166 Arithmetic Processor
1	Type 346 Incremental Display
1	Type 461 Card Reader
1	Type 516 Magnetic Tape Control
1	Type 521 Magnetic Tape Control Interface (for 570)
1	Type 551 DECtape Control
2	Type 570 Magnetic Tape Transports
1	Type 626 Console Printer Keyboard and Control
1	Type 630 Data Communications System
1	Type 646 Line Printer
1	Type 760 Paper Tape Reader
2	Type 555 Dual DECtape Transports

6. Brookhaven National Laboratories

Quantity	Description
1	Type 166 Arithmetic Processor
2	Type 163C Core Memory (16K - 1.7 μs)
1	Type 162 Fast Memory
1	Type 551 DECtape Control
4	Type 555 DECtape Transports (Dual)
1	Type 760 Paper Tape Reader
1	Type 136 Data Control
1	Type 646 Line Printer
1	Type 516 Magnetic Tape Control
1	Type 521 Magnetic Tape Control Interface (for 570)
3	Type 570 Magnetic Tape Transports
1	Type 626 Console Printer Keyboard and Control
1	Type 761 Paper Tape Punch
1	Type 630 Data Communications System

7. Applied Logic Corporation

Quantity	Description
1	Type 166 Arithmetic Processor
1	Type 626 Console Printer Keyboard and Control
1	Type 760 Paper Tape Reader
1	Type 761 Paper Tape Punch
1	Type 136 Data Control
2	Type 163C Core Memory (16K - 1.7 μs)
1	Type 551 DECtape Control
1	Type 555 Dual DECtape Transport
1	Type 646 Line Printer
1	Type 630 Data Communications System

8. University of Rochester

Quantity	Description
1	Type 166 Arithmetic Processor
2	Type 555 Dual DECtape Transports
1	Type 136 Data Control
1	Type 551 DECtape Control
1	Type 163C Core Memory
1	Type 165C Memory Interface
1	Type 165B Computer Interface

9. Massachusetts Institute of Technology, L.N.S.

Quantity	Description
1	Type 166 Arithmetic Processor
1	Type 626 Console Printer Keyboard and Control
1	Type 760 Paper Tape Reader
2	Type 136 Data Control
1	Type 551 DECtape Control
1	Type 516 Magnetic Tape Control
1	Type 520 Magnetic Tape Control Interface (for Potter Transport 50)
1	Type 163C Core Memory (16K - 1.7 μs)
2	Type 555 Dual DECtape Transports
1	Type 461 Card Reader
1	Type 348 Interface for Display
1	Type 630 Data Communications System

10. Massachusetts Institute of Technology, Project MAC

Quantity	Description
1	Type 166 Arithmetic Processor
1	Type 161C Core Memory (16K - 5 μs)
1	Type 162 Fast Memory
1	Type 136 Data Control
2	Type 170 16K Memory
1	Type 340 Precision Display
1	Type 344 Display Interface
1	Type 626 Console Printer Keyboard and Control
1	Type 551 DECtape Control
1	Type 760 Paper Tape Reader
1	Type 761 Paper Tape Punch
1	Type 555 Dual DECtape Control
1	Type 163 Core Memory (16K - 1.7 us)

11. Rand Corporation

Quantity	Description
1	Type 136 Data Control
1	Type 162 Fast Memory
2	Type 163C Core Memory (16K - 1.7 μs)

cont'd.

11. cont'd.

Quantity	Description
1	Type 166 Arithmetic Processor
1	Type 516 Magnetic Tape Control
1	Type 520 Magnetic Tape Control Interface (for Potter Transport 50)
1	Type 551 DECtape Control
1	Type 626 Console Printer Keyboard and Control
1	Type 630 Data Communications System
1	Type 760 Paper Tape Reader
1	Type 761 Paper Tape Punch
2	Type 555 DECtape Transport (Dual)
1	Type 50 Magnetic Tape Transport
1	Type 270 Disc Control
40	Type 616 JOSS Consoles

12. Rutgers University

Quantity	Description
1	Type 166 Arithmetic Processor
1	Type 760 Paper Tape Reader
1	Type 761 Paper Tape Punch
1	Type 626 Console Printer Keyboard and Control
1	Type 179 Memory (8K - 6 μs)
1	Type 136 Data Control
1	Type 551 DECtape Control
2	Type 555 Dual DECtape Transports
1	Type 346 Precision Display

13. United Aircraft

Quantity	Description
1	Type 166 Arithmetic Processor
1	Type 626 Console Printer Keyboard and Control
1	Type 760 Paper Tape Reader
1	Type 136 Data Control
1	Type 163C Core Memory (16K - 1.7 μs)
1	Type 162 Fast Memory
1	Type 551 DECtape Control
3	Type 555 Dual DECtape Transports
1	Type 630 Data Communications System

14. Stanford University

Quantity	Description
1	Type 166 Arithmetic Processor
1	Type 626 Console Printer Keyboard and Control
1	Type 760 Paper Tape Reader
1	Type 761 Paper Tape Punch (wired panel only)
2	Type 136 Data Control
1	Type 551 DECtape Control
1	Type 162 Fast Memory
2	Type 163C Core Memory (16K - 1.7 μs)
4	Type 555 Dual DECtape Transport
1	Type 646 Line Printer
1	Type 165 Computer Intercommunication System
1	Type 630 Data Communication System
1	Type 167 Drum Processor

15. University of Pennsylvania

Quantity	Description
1	Type 166 Arithmetic Processor
1	Type 760 Paper Tape Reader
4	Type 164 Core Memory (16K - 1.7 μs)
1	Type 162 Fast Memory
1	Type 136 Data Control
1	Type 551 DECtape Control
1	Type 516 Magnetic Tape Control
2	Type 555 Dual DECtape Transports
1	Type 646 Line Printer
1	Type 346 Incremental Display and Character Generator
2	Type 570 Magnetic Tape Transports
1	Type 461 Card Reader

16. Oxford

Quantity	Description
1	Type 166 Arithmetic Processor
1	Type 162 Fast Memory
4	Type 164 Core Memory (16K - 1.7 μs)
1	Type 136 Data Control

cont'd.

16. cont'd.

Quantity	Description
4	Type 545 Magnetic Tape Transports
3	Type 555 Dual DECtape Transports
1	Type 646 Line Printer
1	Type 30 Display
1	Type 348 Interface for 30 Display
1	Type 370 High Speed Light Pen Display
1	Type 630 Data Communications System
1	Type 516 Magnetic Tape Control
1	Type 760 Paper Tape Reader
1	Type 761 Paper Tape Punch
1	Type 551 DECtape Control

17. Yale University

Quantity	Description
1	Type 163 Core Memory (16K - 1.7 μs)
1	Type 161 Core Memory
1	Type 136 Data Control
1	Type 30 Display and Interface
1	Type 551 DECtape Control
2	Type 555 Dual DECtape Transports
1	Type 516 Magnetic Tape Control
1	Type 461 Card Reader

18. Imperial

Quantity	Description
1	Type 166 Arithmetic Processor
1	Type 162 Fast Memory
4	Type 164 Core Memory (16K - 1.7 μs)
1	Type 136 Data Control
1	Type 551 DECtape Control
2	Type 555 Dual DECtape Transports
1	Type 516 Magnetic Tape Control
4	Type 545 Magnetic Tape Transports
1	Type 761 Paper Tape Punch
1	Type 461 Card Reader

18. cont'd.

Quantity	Description
1	Type 646 Line Printer
1	Type 30 Display
1	Type 370 High Speed Light Pen Display
1	Type 348 Interface for 30 Display
1	Data Communications System

APPENDIX B

LIST OF CUSP PROGRAMS

Common User Service Programs (CUSPS) available to users at remote consoles:

Name	Size	Function	Described
F4	10K	Fortran compiler	Manual
MACRO	9K	MACRO assembler	Manual
Loader	1K	Linking loader	Multiprogramming System Manual
DDT	$1\frac{1}{2}$K + symbol	Dynamic Debugging Technique	Manual
PIP	1K, 2K	Peripheral Interchange Program	Multiprogramming System Manual
Editor	1K	Edits ASCII files	Multiprogramming System Manual
Desk	2K	Desk Calculator	Manual
Forlib	$<$2.7K	Fortran library and operating system	Manual
BCP	2K	Batch Control Processor	Appendix E
TECO	3K	Edits ASCII files	Appendix H
FUDGE	2K	File updating generator	Multiprogramming System Manual

In addition, the following user programs are of interest:

Name	Size	Described
Solutions of Linear Equation	3K	Attached Program Information Sheets
Matrix Inversion	7K	"

Name	Size	Described
Matrix Inversion Subroutine		Attached Program Information Sheets
Matrix Inversion TTY Service Routine	3K	"
Solution of Linear Equations	7K	"
χ^2 TTY Service Routine	3K	"
Polynomial Curve Fitting TTY Service Routine	3K	"
Chebyshev Polynomial Evaluation TTY Service Routine	3K	"
Chebyshev Polynomial Evaluation		"
Gaussian Integration		"
FORPIP	1K	"
Correlation TTY Service Routine	3K	"
Correlation Subroutine		"
Correlation	4K	"
Correlation and Factor Analysis	5K, 8K	"
General Cross-Tabulation Program	8K	"
Polynomial Roots Solver - TTY Service Routine	4K	"
Reservoir Behaviour Program	7K	"
VMAX	6K	"
Matrix Inversion, Linear Equations, Determinant Evaluation Subroutine		"
Bounded Context Translator for Desk Calculation	2K	"
Steady State Magnitude, Phase and Phase Delay of a Network Function	4K	"
Multiple Regression	7K	"
2 x 2 Contingency Table	4K	"
BIPRO	3K	"
Pipe Network Analysis	5K	"

Name	Size	Described
Slope Stability Analysis	5K	Attached Program Information Sheets
Simulation Problem-Oriented Language for Engineers (SIMPLE)	9K	"
Transient Response of Network Function	6K	"
Matrix Multiply on TTY (MATTY)	3K	"
Display Subroutines		"
Memory		"
Three Chebyshev Polynomial Subroutines		"
Numeric Integration	3K	"
CHIP		"
Analysis of Variance Two-Way Classification AVCD	5K	"

APPENDIX C

HEAT DISSIPATION OF THE PDP-10 SYSTEM

Equipment	No.	Heat Dissipation (BTU/hours)	Power Dissipation (KW)
Central Processor and Options	1	9,900	2.900
Core Memory	2	9,800	3.000
DECtape Control	1	1,200	0.345
DECtape Transports	4	1,160	0.344
Disc File Control	1	1,200	0.345
Disc Files	4	20,400	6.000
Fast Memory	1	2,150	0.635
Card Reader (800 cpm)	1	4,950	1.450
Card Punch	1	9,420	2.750
Line Printer	1	2,710	1.560
Magnetic Tape Control	1	1,564	0.460
Magnetic Tape Transport	2	19,600	5.800
Total		84,054	25.589

APPENDIX D

BATCH CONTROL PROCESSOR

General Specifications

The Batch Control Processor is a CUSP program that performs routine supervision of other jobs with a minimum of operator intervention. Instructions to the BCP may come from the operator who initiates the batch and handles unusual conditions via a time sharing console (TTY), or from the programmer in the form of a command file.

BCP exercises control over subject jobs by means of a pseudo-time-sharing console (PTY). BCP output to the PTY is treated by the Time Sharing Monitor as input from a TTY. Time Sharing Monitor, and subject job output to the TTY, is input to the PTY. Error responses from the Time Sharing Monitor and the subject job are prefixed with a ? (ASCII 277). The operator may select either completely unattended operation or pausing for operator correction at certain of these error responses.

Job Interpreted Strings

All strings that are output by BCP to the device PTY are Job Interpreted Strings. These strings are limited to one teletype line. Each line of output on PTY requires a response by the job which is received as BCP input on PTY. Lines whose first character is "are output (not including") to PTY with no translation by BCP.

Operating Instructions

Assign the conventional device names to the source device and scratch tapes to be used during the batch; for example, type to the Monitor:

ASSIGN MTA1:BIN
ASSIGN MTA2:LIST
ASSIGN CDR:SOURCE

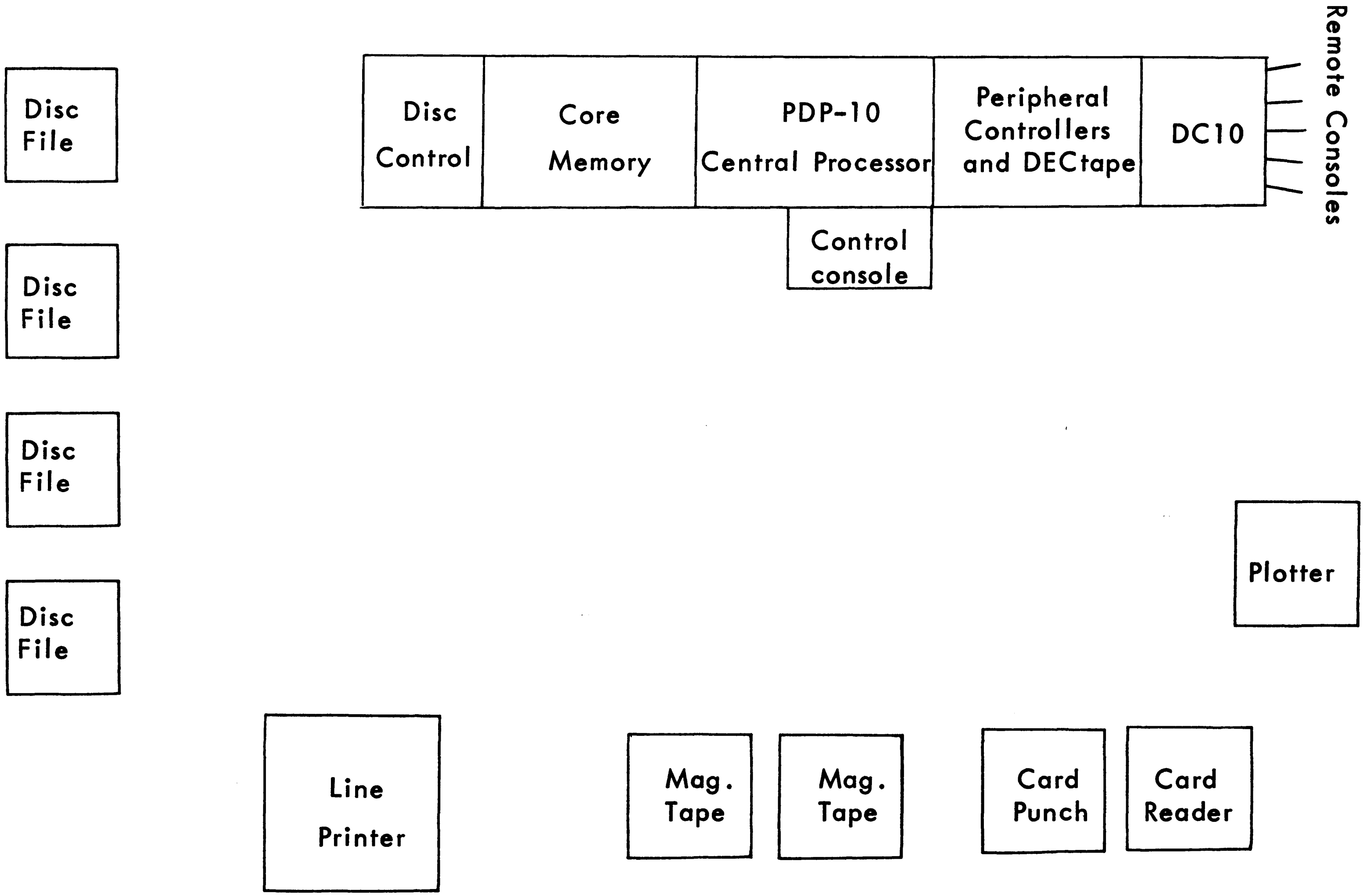
The binary device must be a retrieval device such as DECtape, magnetic tape or disc. There are no restrictions on the other devices.

Obtain 2K of core, GET BCP and START. BCP will respond by typing the word "BCP". The BCP commands G and S cause the BCP to take further commands from the command file.

If an error occurs which is not resolved, BCP types question mark three times, carriage return and "bell" three times. BCP then waits 30 seconds for the operator to respond by typing a line of text (carriage return is sufficient). If the operator does not respond, BCP skips to the next job. If the operator does respond, BCP takes commands from the TTY until a G or S command is given.

APPENDIX E

LAYOUT OF EQUIPMENT



APPENDIX F

DESIGN OF THE PDP-10 TIME SHARING SWAPPING SYSTEM

For the purpose of time sharing, think of a computer as composed of four parts, each of which must be allocated or continuously reallocated to its various current users:

1. The Processor

2. Core Memory

3. "Assignable" I/O devices:

   These devices are explicitly (through console commands or program UUO calls to the monitor) requested by the user, assigned (if free) by the monitor and finally released by the user. The list of such devices includes:

   (a) Teletype consoles
   (b) Display consoles
   (c) Line printer
   (d) Paper tape reader and punch
   (e) Card reader and punch
   (f) DECtape and magnetic tape transports

4. "Sharable" I/O devices:

   These devices are implicitly requested by the user or his program and are automatically assigned and released by the monitor. They include:

(a) Data control

(b) DECtape control

(c) Magnetic tape control

(d) System tape (the DECtape drive used for the CUSP tape)

(e) Device allocation routine for disc storage

(f) Monitor queue routine for disc storage

(These last two examples are monitor routines which are in effect software extensions of the disc hardware.)

The "scheduler" allocates (schedules) the processor. One form of time sharing assumes all users to be in core so that the scheduler need only "switch" the use of the processor between the various programs in core. This scheme also allows simultaneous use of assignable I/O devices since, once started, data transfer does not require the job (the user's program) to be scheduled or "run". However, since core is expensive, this system limits the number of simultaneous users.

A second method supplements core storage with cheaper mass storage (e.g. drum or disc) when the scheduler decides a different job should be run. The current job is saved out of core in the mass storage and the new job to run is brought into core - thus, only one job is in core at a time. This "swapping" scheme lifts the limit on the number of simultaneous users but does not allow the degree of parallel I/O possible in the previous scheme and wastes the processor during the time needed to effect the "swap".

The routines to be described implement a scheme incorporating both approaches - combining their individual advantages and cancelling most of their disadvantages. By allowing several jobs to reside in core and providing compatible swapping software and hardware, swapping overhead can overlap the use of the processor and I/O devices. The following problems arise in such a system:

1. There is a certain degree of independence between the scheduler and the swapper, i.e. who should use the processor and who should use core. It is not complete independence, of course, since using the processor implies being in core. The ideal swapper would "anticipate" the scheduler - continually seeing to it that only those jobs the scheduler is likely to want to run are in core.

2. Current hardware and software require a job to be composed of consecutive storage. Thus, it is only practical (at least at present) to swap whole jobs at a time. Since jobs are of different lengths, swapping soon produces many small unusable gaps in the occupied regions of core. A third monitor routine, a "shuffler", is needed to continually relocate jobs in core such that all free core is concentrated in one large block.

3. Both scheduling and swapping affect the allocation of assignable I/O devices. Certainly a job must be run for I/O initialization. For all devices (except teletype) data is transmitted directly to or from the user's program, thus the job must remain in core until I/O runs to completion or is forcibly stopped. An inherently slow transfer rate and user reaction time and "head scratching" makes this I/O exceedingly slow. Buffering independent of the user program allows the swapper to make better use of core occupied by the program while it waits for completion. On the other hand, practical use of a teletype console requires short response time between input and output so that swapping overhead must be taken into account.

4. Many of the sharable I/O devices are often demanded by several users at once. Since only one job at a time can use a particular device, the waiting users are "wasting" core and should be swapped out. However, it is also desirable to keep such a heavily demanded device busy, which in turn requires minimizing swapping overhead for its users.

5. Finally, a time sharing system is, in one light, an attempt to make most of the people happy most of the time. Happiness is measured to a large extent by the emphasis placed on the various allocation problems. As demonstrated, this emphasis is directly affected by scheduling and swapping. Certainly a satisfactory compromise demands some amount of "tinkering" with both the scheduler and swapper. In addition, the best blend probably varies from installation to installation. Both considerations require routines that can be clearly and easily modified to make changes in emphasis.

The scheduler is a closed subroutine which returns the number of the next job to run. It, in effect, answers the question: "Who, at this moment, should use the processor?"

In a similar manner the swapper, each time it is called, checks to see if any jobs should be swapped in or out. If so, it picks the most pressing case and initiates its transfer. The swapper is device (disc, drum) independent - i.e. it decides "who" but not "how".

The scheduler is designed to facilitate swapping, however it does not physically or logically depend on the swapper, so that it can be used in a non-swapping system.

Both the scheduler and swapper (and shuffler) are driven by the clock - that is, the clock interrupt service routine, on every clock interrupt, calls the shuffler, swapper and scheduler. The job indicated by the scheduler is then set to run until the next clock interrupt.

The scheduler and swapper must interact to some extent. In addition, both routines must choose one job from many possible candidates, but they cannot afford the time needed to poll all jobs. Both considerations are met by queuing all jobs in a manner which reflects their current state or priority to the scheduler. The scheduler simply returns the first job in the queues and need not perform any polling (in the swapping system this is not quite true, but the general idea is valid). Now, through the queue-ordering of the jobs, the swapper has a means of anticipating (or at least co-operating with) the scheduler.

Job queuing has another advantage. It provides easy visualization of current job states and their relation to scheduling, swapping, I/O, etc. The movement of jobs between queues and the manner in which these queues can easily be directed by tables. These two properties allow easy and meaningful modification of the scheduling and swapping functions. Indeed, it is feasible to monitor and modify scheduling and swapping concurrent with regular time sharing, providing an easy means to "tune" or optimize the monitor itself.

Queues and Queue Servicing

Both the scheduler and swapper are very simple routines. The structure of the decisions they perform lies in the queuing system.

Four parts compose this system: queue storage, a routine to transfer a job from its present queue to another, a routine to scan the queues, and a series of tables to direct these routines.

Storage

For this system, think of a queue as a string of elements with a beginning and end. Any element may be removed from the queue regardless of its position in the queue, however, elements may enter the queue only at the beginning or end. The system incorporates many such queues. The elements are job numbers which obey the restriction: at any moment, every job (or more precisely its number) is a member of one, and only one, queue. This restriction minimizes the storage needed to accommodate the queues and simplifies their servicing.

Transferring

One routine provides all queue to queue transferring of jobs. A call to this routine provides the job number and a function code which will determine to which queue the job is to be transferred (and whether the insertion is at the end or beginning).

Three functions are available:

1. New queue is fixed (predetermined).

2. New queue depends on current queue.

3. New queue depends on size of the job being transferred.

The latter two functions are defined with tables giving the queue-queue or size-queue correspondence. The "flow" of jobs between queues is modified by changing the function codes and/or the correspondence tables.

The routine also (if requested) resets the jobs "quantum time" based on the function it uses to determine the new queue. This is a variable used by the scheduler to aid in determining job running priority.

Scanning

Both the scheduler and swapper call a common routine to scan the queues. A specified table determines which, in what order and manner the queues are scanned. Each queue may be scanned in four possible ways:

1. "Forward" - from beginning to end.

2. "Backward" - from end to beginning.

3. Only first member (if any).

4. Backward but omitting the first member.

Again, modification of scanning is accomplished by altering the appropriate table.

Queue Flow

Whenever a job changes its status, with respect to the scheduler or swapper, it is transferred to a queue which reflects its new state. For example, the scheduler causes a transfer when it decides the currently running job has run too long, and jobs needing unavailable sharable devices are transferred to specific waiting queues. This "flow" of jobs between queues affects the scheduler and swapping process and determines many overall characteristics of the time sharing system.

Processor Queues

This subset of the queues forms a nucleus for the queue system as a whole. A job enters one of the processor queues when it can (and desires) to run or use the processor and leaves these queues whenever it becomes "unrunnable". The scheduler scans only these queues to pick the next job to run.

When a job enters one of the processor queues, it is assigned a "quantum time" which determines how long this job is allowed to run before it is interrupted in preference for another job. The simplest form of scheduling, "round-robin", uses one queue with new members entering the end. The scheduler runs the first job in the queue until its quantum time has elapsed, then transfers it to the end of the queue and resets its quantum time.

Such a scheme is not adequate for a large and varied class of users because:

1. Many jobs (especially those interacting with a user's teletype) demand short but immediate attention when they enter the runnable state.

2. Long running jobs should run and wait for longer periods of time

since any rescheduling overhead is wasted on them. Also, swapping becomes inefficient if the run-wait cycle is much shorter than the time needed by the job.

3. In swapping systems it is necessary to reflect the job's size (which is proportional to its swap time) in the scheduling process.

These problems are met by using several queues, to each of which is associated a priority. The scheduler scans the queues in the order of their priority until a job is found. A quantum time is also associated with each queue, with lower level queues having longer quantum times. When a job uses its current quantum time, it is dropped down to the end of the next lowest level or queue and assigned that queue quantum time. Note that now the quantum time determines how long a job remains at one level rather than how long it will run without interruption. The overall effect of such a scheme is such that jobs initially entering the high level queues are given immediate attention, but as they run longer, they "filter" down to lower level queues where they run for longer times with longer intervals between runs. The high level queues tend to be populated with short running I/O or user interactive programs while lower levels are occupied by long running, compute programs.

Furthermore, the initial attention given a job just entering the runnable state may be varied by varying the level at which it enters the processor queues. In particular, job size can be taken into account.

Stop Queue

Jobs are transferred to this queue when they become "unrunnable" (e.g. the monitor detects an error or the user types "control C"). Here the queue serves only to group these jobs together - the actual order in the queue is not important. Jobs may enter the stop queue from any other queue (e.g. "control C" may be typed anytime). Transfer out of the stop queue usually depends on where the job entered the stop queue (this information is retained in a status bit word associated with each job).

Sharable Device Queues

One queue for each device holds jobs waiting for that device when it is unavailable (being used by some other job). The queuing is first in - first out, or "first come - first serve". All entries into these queues are from the processor queues (or stop queues if the job was previously stopped while in a sharable device queue) since these devices are allocated when the user or his program initiates various I/O activity. When the device becomes available, the first job in the queue will be transferred to the processor queues where it will be scheduled and hence assigned the device. To what level (and whether beginning or end) processor queue the transfer is made, determines the utilization of the device. The transfer - hence utilization - may be tailored to each device.

I/O Wait Queues

The buffering and servicing of assignable devices is designed to allow overlapping computation and data transfer. Whenever the program "catches up" to I/O, the monitor prevents the job from running until the I/O terminates or progresses far enough for the program to continue. Two queues hold jobs in this I/O Wait State, one for teletype only, the second for all other assignable devices. In this second queue (as in the stop queue) the order is irrelevant and the grouping is the desired effect. The I/O data transfer for the devices represented by this queue is directly to or from the user's program area with no intermediate buffering in the monitor. Therefore, these jobs cannot be swapped (there is a means for forcing the I/O activity to stop, i.e. a job in the I/O Wait queue could be swapped out if it is decided that its core could be used to better advantage than keeping an assignable device busy). The job is transferred on termination of I/O Wait to the processor queues, and here again, as for sharable devices, the destination determines device utilization.

As mentioned before, the teletype is a special case, hence a separate queue is provided for the teletype I/O wait state. Rate of input is determined by the console operator and is, by the monitor's standards, painfully slow. To make matters worse, there is nothing to prevent a user from stopping in the middle of his input to get a cup of coffee. Therefore, a swapping system must provide for swapping jobs in teletype I/O wait. This is possible by buffering teletype I/O through the monitor.

As with other I/O wait, the job is transferred to the processor queues when the restricting input (or output) is complete and allowed to continue. If, however, it was swapped out while in I/O wait, any response to the received input must wait until the program is swapped back into core. The balance between response and core utilization can be adjusted to some degree by specifying how the scan for swap-out, swap-in is done and where in the processor queue a job is transferred when it comes out of I/O wait.

APPENDIX G

SUMMARY OF BASIC TECO COMMANDS

$ means ALT-Mode (< control-shift >K)

Input-Outake Selection

ER dev: name .ext$	Select Device dev, file name .ext for READING
EWdev: name .ext$	Select Device dev, file name .ext for WRITING
EF	Close out the output file.

Input-Outake Commands

Y	READ the first page
P	WRITE out the current page, go to the next
PW	WRITE out the current page, don't go to the next.

Line Editing (commands with n missing: Assume n = 1)

n is a number; it may be negative

nT	TYPE n lines
nK	KILL n lines
nL	Move the pointer n lines (ØL moves pointer to beginning of current line)

Character Editing (commands with n missing: Assume n = 1)

n is a number; it may be negative

nC	Move pointer forward n characters

nR	Move pointer reverse n characters
nD	Delete n characters at pointer (delete to the right if positive, left if negative)

Character Strings (all terminated by ALT-Mode)

S test $	Search for "text" from pointer to end of page. If found, move pointer immediately after text.
N text $	Search as above. If not found, do P command (write this page, read next page) and continue searching.
I text $	Insert "text" at the pointer.
Goodies	n = B beginning of Buffer
nJ	Move the pointer n = Z end of Buffer
<S text $; commands>	For each occurrence of "text" from pointer to end of buffer, execute commands.

APPENDIX H

SUMMARY OF MONITOR COMMANDS

The following list of Monitor commands, control functions and CUSP commands is sufficient to allow a remote user to time share the PDP-6/10. A complete glossary of commands is available in the Multiprogramming Manual and addendum.

TELETYPE CONTROL FUNCTIONS

User Types:	Monitor Echoes:	Function:
<CONTROL> C	↑C	To return to monitor command level, suspends execution of user's current job.
<CONTROL> Z	↑Z	Acts as an "end of file" from a teletype.
<CONTROL> U	↑U	Erase the current line being typed in its entirety.
<RUBOUT>	\	Erases one character each time; may be continued until the entire line is erased.

Special Characters

.	Typed by Monitor to indicate that it is awaiting a command.
*	Typed by a Common User Service Program (FORTRAN IV Compiler, Macro Assembler, etc.) to indicate that it is awaiting a command.

MONITOR COMMANDS

Command	Options	Function
R NAME	(CORE)	Loads and starts the program "NAME" from the system library device. *
RUN DEV:NAME	(CORE) [PROJ-PROG NO] **	Loads and starts program "NAME" from device "DEV". User may specify more than the required memory by typing "CORE" for the total number of 1K blocks of core required.*
CORE N		Request that "h" 1K blocks of core be made available. This CORE command requires one argument, a decimal integer, specifying the total number of 1024-word blocks of core memory needed to run his program. The core assigned becomes inaccessible to all other users.

SAVE DEV:NAME	(core) [proj-prog]	"SAVE" the user's program as file "NAME" on device "DEV", such that it may be loaded later by a "GET" command. The file name extension created by the SAVE command is "DMP"; the monitor response after successful completion is: JOB SAVED
GET DEV:NAME	(core) [proj-prog]	Load the user's core area from device "DEV" with a core image named "NAME" that was previously "SAVED". (A file name extension of "DMP" is assumed unless some other extension is supplied.) This command is used both for loading CUSP programs from the system library and for retrieving previously "SAVED" user programs. Upon completion of loading the program, the monitor types: JOB SETUP The job is fully loaded but not started. Other messages indicate error conditions. These are: NO CORE ASSIGNED — The user has 0 blocks of core N 1K BLOCKS OF CORE NEEDED — The user has not assigned enough core to load his program. He must now type CORE N and retype the GET command. FILE NOT FOUND — The file name typed is not found in the directory for the specified device. DEVICE NOT AVAILABLE — Another user has control of the specified device. TRANSMISSION ERROR — A parity or other error condition occurred during data transmission.
START	(loc)	START the user's program. The program will be started at

(LOC) after START.

DDT	Start the user's debugging program, DDT. The starting address of DDT, the user's debugging program, is a parameter kept in the user's job data area. When the DDT console command is typed, the monitor starts the user's program at the starting address of DDT. The console is taken out of the monitor mode and placed in the user mode so that input is directed to DDT. Error messages are: NO CORE ASSIGNED — The user has no blocks of core. NO DDT — The starting address of DDT, as stored in the job data area, is 0; therefore, DDT is not loaded.
ASSIGN	ASSIGN I/O devices to this job. This command requires one or two arguments. In the form: ASSIGN DEV the physical device DEV is reserved for the exclusive use of this job. (See Table 4-1 for a complete list of devices and their physical names.) In the form: ASSIGN DEV NAME device DEV is reserved, and in addition, NAME (called the logical name) is made synonymous with DEV. If NAME happens to be the same as the physical name of some other device, the logical name takes precedence. With the ability to rename devices, a user may write his programs to use arbitrarily named devices which he assigns to the most convenient physical devices at run time. For multiple devices such as DECtape or magnetic tape, the physical name consists of a 3-letter device-type mnemonic followed by the unit (transport) number. For example, DTA3 means DECtape (DTA) transport number 3. To locate a free transport, use only the first three characters of the

physical device name as argument DEV. For example:

User types:	ASSIGN DTA
Monitor responds:	DEVICE DTA4 ASSIGNED
Then user types	ASSIGN DTA
Monitor responds:	DEVICE DTA5 ASSIGNED

In the example above, the monitor is asked to find two free DECtape transports. Transports 4 and 5 were free and are now accessible only to the user typing the ASSIGN command. The monitor may type back one of the three following error messages:

LOGICAL NAME ALREADY, DEVICE DEV ASSIGNED	The logical name specified is the same as a logical given in a previous ASSIGN command. Nevertheless, the device is reserved but without a logical name specified.
ALREADY ASSIGNED TO JOB N	Another user is using the device.
NO SUCH DEVICE	Either the physical device name is misspelled or (in the case of searching for a multiple device) all transports are in use.

Examples

User types:	ASSIGN DTA, ABC	
Monitor responds:	DEVICE DTA6 ASSIGNED	(successful)
User then types:	ASSIGN DTA, DEV	(find another transport)
Monitor responds:	NO SUCH DEVICE	(all in use)
User then types:	ASSIGN PTP, ABC	(reserve the paper tape punch)
Monitor responds:	LOGICAL NAME ALREADY IN USE DEVICE PTP ASSIGNED	(punch is reserved but ABC still refers to DTA6)
User then types:	ASSIGN DTA1, DEV	
Monitor responds:	ALREADY ASSIGNED TO JOB 2	(another user has reserved DTA1)

See the DEASSIGN console command for relinquishing devices.

DEASSIGN

Return I/O devices to the common pool. This command cancels device reservations made via the ASSIGN command. The DEASSIGN command may be typed alone or with one argument. When an argument is typed, it must be the logical or physical name of some device that was previously reserved by the ASSIGN command. If no arguments are typed, all devices currently reserved by user via ASSIGN commands are affected. The

DEASSIGN command may be typed even though the user's program continues to use the devices affected.

Error messages are:

NO SUCH DEVICE	The specified device does not exist.
DEVICE WASN'T ASSIGNED	The specified device was not reserved by the ASSIGN command.

KJOB — KILL the JOB. This console command does the following:

1. Deassigns and stops all I/O devices connected to the job.
2. Returns all the user's core allotment to the monitor.
3. Places the console in the detached state.
4. Makes the job number assigned to the killed job available to the next user who initializes a job.

CONT — CONTinue execution. When a user's program (including DDT) is stopped by typing '<CONTROL> C (C while holding down the 'control' key), execution may be resumed by typing the CONT console command. If the user's program stops running because of an error condition or if the user's program deliberately stops by calling "EXIT," the CONT command does not restart the job.

Error messages are:

NO CORE ASSIGNED	
CAN'T CONTINUE	Either the program was never started or it was stopped by other than 'control' C.

SPECIAL DEVICE NAMES

SYS:	The Systems Library device, initially DECtape Ø (DTAØ) or DISC if present. May be changed to any directory device by the "ASSIGN" command.
TTY:	By convention the teletype being typed upon
CTY:	Console Teletype
OPR:	Any teletype designated as the Operator's Console (via "ASSIGN" command)

such as FORTRAN or assembly language source statements. These CUSP's require that a command be typed to identify the devices from and to which this information will be transmitted and to uniquely identify this information when the devices specified may contain other data.

The general format of the command is:

BIN, LIST ←—— SOURCE(S)

where "BIN", "LIST" and "SOURCE" are file descriptions as described below:

DEVICE NAME:FILE NAME.FILENAME EXTENSION

where "device" is the logical or physical name of the desired device, "filename" is a 1- to 6-character file name, and "extension" is an optional 1 to 3 character file name extension.

For the convenience of the user, the command format may be abbreviated as follows. The file name extension need not be typed, in which case the period should also be omitted. For devices other than DECtape or the disk, no file name is required; only a device name followed by a colon need be typed. If the device name is omitted, the most recently typed device name is used. Thus to specify more than one file from the same device, the user types:

PTR:,,	(three paper tape files)
PTR:,	(two files)
PTR:	(one file)
DTA3: file1, file2, file3	(three DECtape files)

When a CUSP requires more than one output file, the first file on the left is the binary file and the second file is the listing file.

Most CUSPs allow the user to select several options or modes and to perform certain device-manipulation functions (such as rewinding magnetic tape). These options, called switches, are selected by typing a single letter preceded by a slash or by typing several letters enclosed in parentheses. Each letter selects an option as determined by the particular CUSP being used. For example, to command PIP to copy a binary paper tape, the user types:

PTP:/B <-- PTR:

where "B" selects binary mode for PIP. To copy a card file, the user might type:

DTA2:CARDS(CS)←—CDR:

[illegible]

Mnemonic	Device
CTY:	Console Teletype
TTY1, TTY2, . . . , TTY27:	Teletype
PTR:	Paper Tape Reader
PTP:	Paper Tape Punch
LPT:	Line Printer
CDR:	Card Reader
DTAØ:, DTA1: . . . , DTA7:	DECtape
DSK:	Disc
DIS:	Display
MTAØ:, MTA1:, . . . , MTA7:	Magnetic Tape

USE OF THE DISC SYSTEMS

There are currently two systems operating on the PDP-6 in Maynard which allow access to the 6 million word type 270 DISCFILE. When either of these systems is operating, there is an added parameter required to limit access to authorized users. The system will initially type:

LOGIN PLEASE

The user must then type "LOGIN" followed by a carriage return. The LOGIN CUSP will [illegible] automatically, and is now waiting for the user to identify himself, [illegible] types:

[illegible] PROJECT-PROGRAMMER NUMBER

random part of the user's identification

DEMO2 (CR)

The overprinted lines typed by the system after the user has entered the PROJECT-PROGRAMMER NUMBER serve to obscure the user's secret access name ("DEMO2") when it is then typed over the garbled text.

All monitor commands may be abbreviated by typing just enough letters to identify them uniquely. The following is a list of commands and shortest abbreviations:

ASSIGN	AS
ATTACH	AT
CCONT	CC
CONT	CON
CORE	COR
CSTART	CS
D	D
DAYTIME	DA
DDT	DD
DEASSIGN	DEA
DETACH	DET
E	E
FINISH	F
GET	G
HALT	HA or <CONTROL> C
IJOB	[illegible]
KJOB	K
LOGIN	L
NULTIME	N
PJOB	P
R	R
REASSIGN	REA
REENTER	REE
RUN	RUN
RUNTIME	RUNT
SAVE	SA
SHFTIME	SH
START	ST
TALK	T