DEPARTMENT OF COMMUNICATIONS

CANADA

MINISTÈRE DES COMMUNICATIONS

VOLUME 4

Time Shared System Terminal Hardware

- Terminal Hardware Requirements -
- Terminal User Requirements -

by

John deMercado

Terrestrial Planning Branch
Department of Communications

June 1972

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Acknowledgements

The purpose of these notes is to promote dialogue within the Terrestrial Planning Branch and serve as a basis for our computer-communication systems implementation program.

The notes are only in first draft form and borrow heavily from the references. They should be read in conjunction with the attached reference papers.

As a revised version is planned the author would appreciate any corrections or omissions in the text that were brought to his attention. He also wishes to thank Messrs. John Harris, S. Mahmoud and Kalman Toth for their valuable contributions.

Miss Gail Widdicombe and Miss Yollande Chartrand typed them in record time from an almost unreadable handwritten manuscript.

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Terminal Hardware Requirements

Terminal Hardware Requirements

Introduction

The following is a preliminary discussion of the operation and characteristics of character display terminals as elements of time shared systems. These terminals have a number of characteristics listed below which are interrelated and of interest to designers of Time Shared Systems, these characteristics are

- speed (baud or character rate)
- transmission mode (synch or asynch)(parallel-serial)
- code
- pollability (addressability)
- peripherals - paper tape, cassettes, local printing
- display type (hard copy or CRT display)

The following schematic shows the relationship and interdependence between these various characteristics as shown in Figure 1.

Code Requirements

Most terminals in a time-sharing environment communicate in either BCD or USASCII communications codes and operate in a serial, asynchronous transmission mode. The internal representation of these codes is given in the tables attached at the end of these notes.

The BCD Code

Internally, BCD is a 6 bit code that is made up of a 4

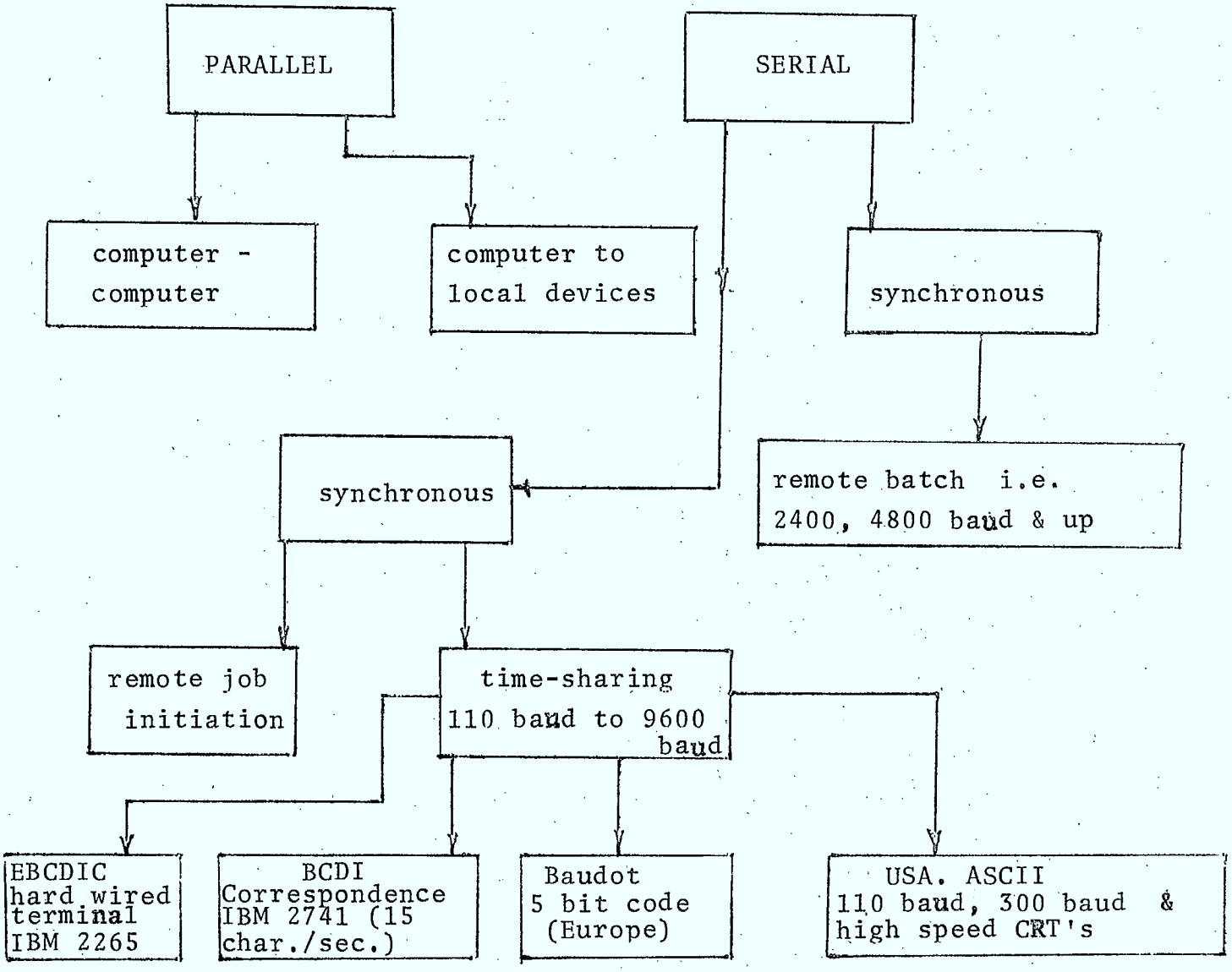

PARALLEL
SERIAL
computer - computer
computer to local devices
synchronous
synchronous
remote batch i.e. 2400, 4800 baud & up
remote job initiation
time-sharing 110 baud to 9600 baud
EBCDIC hard wired terminal IBM 2265
BCDI Correspondence IBM 2741 (15 char./sec.)
Baudot 5 bit code (Europe)
USA. ASCII 110 baud, 300 baud & high speed CRT's

Figure 1

bit byte plus two zone bits. For transmission, an additional data bit, the parity bit is used plus one start and one stop bit. This is called a 7 level 9 unit code. A variation on BCD is what IBM calls correspondence communications code. This is a code that varies from BCD only in the representation of a few characters.

As only 64 characters may be represented by the 6 real data bits, the convention used to include upper and lower case characters in the set is to assign two special characters for upper and lower case shifts, i.e. - Once an upper case shift character is received, the hardware decodes all characters that follow as the upper case representation of the character - (see Coding Chart). For example, the IBM 2741 terminal* and compatable devices have been designed to handle this code.

This code has two basic character sets - one is 6 bit ASCII code which has 64 characters and the 7 bit ASCII code which has 128 characters. The 7 bit ASCII code has the advantage that both upper and lower case characters may be represented by a single data word. Most of the time-sharing systems that exist have been designed to handle the 64 character ASCII code. In any case, for transmission, either 7 level, 10 unit code or 8 level, 11 unit code is sent. In each code word, 1 bit is included for parity and one start and 2 stop bits are sent for activating and deactivating the mechanical action of the terminals.

Terminals that are designed for communication in ASCII codes are called teletypes, and include portable terminals like the Execuport which offers 10, 15, 30 character per second

---

* Terminal cost if about $5,000 and rental about $130 per month.

full or half duplex operation through an acoustic coupler. The cost of this terminal in Canada is about $4,500.

Low Speed Communications Terminals

These devices are restricted to rates from 110 baud to 300 baud (some manufacturers claim up to 120 characters per second (say 600 baud)). They are hard copy devices that require hammers or other electromagnetic devices to print on paper. There are however some terminals that print by burning the paper or print by exposing heat sensitive paper to intersive beams of electrons or light.

The reason for the start and stop bits mentioned above on the transmitted data is two fold.

The electro-mechanical action has to be initiated to start the printing process and then signalled to stop the printing process, and return the terminal to some neutral status.

Since data is being received and transmitted serially, the device must detect the beginning of a data word, assemble the serial characters into (out of) a buffer, detect the end of this seriallization (parallelization) and then initiate the transponders to begin the printing action.

The speed of the TTY terminal is limited by the speed at which characters can be displayed/printed by the electro-mechanical devices, that is, since only single character buffering occurs, if the received serial data comes faster than the physical limitations of the device, characters will be either completely lost, or meaningless characters will be displayed. For transmission to the computer the contraints on speed are not severe as the user is invariably much slower than even the mechanical speed limitation of the terminals.

These terminals, almost without exception, can support peripheral equipment in the form of paper tape readers and punches.

High Speed Communications Terminals

Higher speed ASCII devices (and some BCD types) that are capable of displaying characters at speeds in excess of 1200 baud are available. These so called CRT's, (cathode ray terminals), use electron gun methods to achieve these high speed display capabilities. CRT's can be divided, in general, into three broad types:

- teletype compatible terminals (T.T.Y.)
- pollable terminals
- programmable terminals that also have the above capabilities

T.T.Y. Terminals: The most elementary terminals in this group behave exactly like the more primitive keyboard teletype terminals except that they are capable of switch selectable speeds of from 100 baud through 600 baud to as high as 9600 baud.

Most of these devices, however, have additional control logic that permits local functions like

- roll up
- homing to any of the four corners of the screen
- rub out
- cursor positioning where the cursor makes the
- next displayable position

The Datapoint 3300 and Hazeltime 2000 are examples of this type of terminal. Typical costs are of the order of $3000.

Pollable Terminals: These terminals are usually much more versatile and more expensive than those above. The speeds at which they can communicate are again switch selectable but they have read-write refresh memory capabilities that can be line controlled. In addition these terminals can provide status information on their "status". That is the host computer can check the terminal and determine whether or not they have a character ready for transmission or whether they require some special service. Special service from the host computer takes the form of the transmission of control characters to initiate some internal or external action (such as drive a printer) by the terminal.

Some other actions that these terminals can perform are:

- transmitting a block of data from the terminal to the host computer, which could typically be a line or several lines from the screen;
- receiving a block of data from the host
- transmitting a block of data to a local device like cassette tape or local printer.

-receiving a block of data from local devices at the request of the host computer.

These terminals in essence can permit the host computer to remote control other tasks. An example of this type of terminal is the Hazeltime 3000, which costs about $4,000.

Programmable Terminals: These terminals can be considered mini-computers in their own right. They have their own memory, cpu and associated peripherals like cassettes, printers, disc etc. These devices are capable, in general, of communicating in parallel to local devices or in serial (both asynchronous and synchronous) to remote devices including the host computer. Their data rates are only restricted by the communications peripherals that are connected to it (modems, DAA, telephone lines). Code conversions can be programmed so that the device can communicate in BCD, ASCII or another code. Special functions can be built into the terminal resident software that recognizes line control characters to effectively speed up on line functions. These devices can in general, without hardware modifications, support other terminals of their own type or of lesser intelligence. An example of these terminals that are used in the Department of Communications system is the Datapoint 2200 CRT made by Computer Terminal Corporation (a subsidiary of TRW). These terminals are available with from 2K to 16K of memory and cost corresponding from $7000 to $15,000 (for the 16K machine).

The characteristics which serve to classify CRT terminals are

- screen size (number of lines and screen width)
- clarity of characters (eye fatigue)
- display and transmission rates (switch selectable or programmable)
- character set (may require upper and lower case)
- pollability (can character buffers be stored)
- programmable features (hardware line control or software control)
- asthetic qualities (does it "look" nice?)

CODING CHARTS

EBCIDIC Coding Chart

Left or zone half of byte in hexadecimal

Right or digit half of byte in hexadecimal	0	1	2	3	4	5	6	7	8	9	A	B	C	D	E	F	
0	NULL		·		Δ	&	-									0	0
1							/		a	j			A	J		1	1
2									b	k	s		B	K	S	2	2
3									c	l	t		C	L	T	3	3
4									d	m	u		D	M	U	4	4
5									e	n	v		E	N	V	5	5
6									f	o	w		F	O	W	6	6
7									g	p	x		G	P	X	7	7
8									h	q	y		H	Q	Y	8	8
9									i	r	z		I	R	Z	9	9
A					¢	!		:									A
B					.	$	,	#									B
C					<	*	%	@									C
D					(	)	_	'									D
E					+	;	>	=									E
F					|	¬	?	"									F

EBCDIC coding chart.

U.S.A. ASCII Coding Chart

Left half of byte in hexadecimal

Right half of byte in hexadecimal	0	1	2	3	4	5	6	7	8	9	A	B	C	D	E	F	
0	NULL	DLE			Δ	0					@	P			`	p	0
1	SOH	DC1			!	1					A	Q			a	q	1
2	STX	DC2			"	2					B	R			b	r	2
3	ETX	DC3			#	3					C	S			c	s	3
4	EOT	DC4			$	4					D	T			d	t	4
5	ENQ	NAK			%	5					E	U			e	u	5
6	ACK	SYN			&	6					F	V			f	v	6
7	BEL	ETB			'	7					G	W			g	w	7
8	BS	CAN			(	8					H	X			h	x	8
9	HT	EM			)	9					I	Y			i	y	9
A	LF	SUB			*	:					J	Z			j	z	A
B	VT	ESC			+	;					K	[			k	{	B
C	FF	FS			,	<					L	\			l	¦	C
D	CR	GS			-	=					M	]			m	}	D
E	SO	RS			.	>					N	~			n	~	E
F	SI	US			/	?					O	_			o	DEL	F

USASCII coding chart.

APL & BCD Coding Charts

Figure II. 5 CALL/360: BASIC CODE

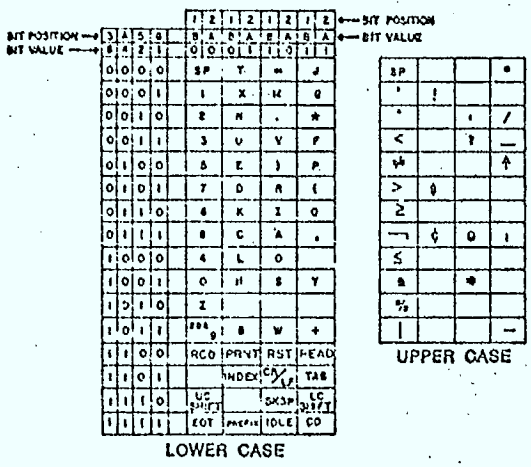
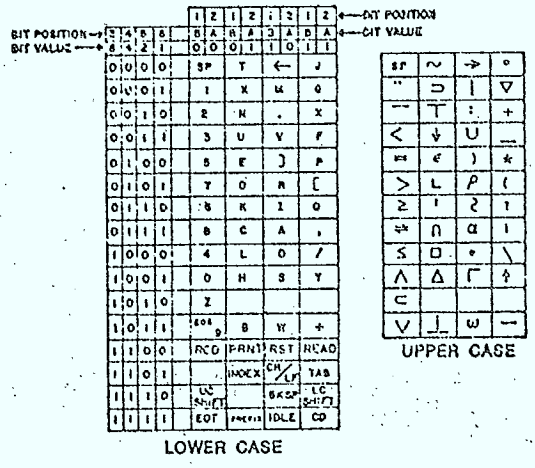
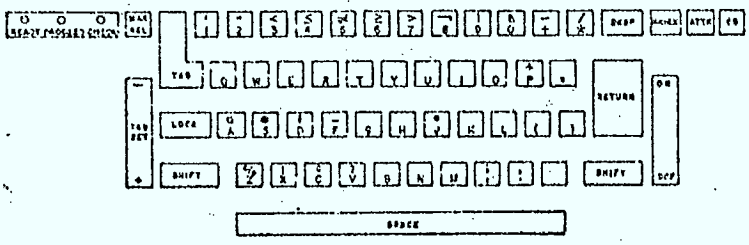


Figure II. 6 A.P.L. (CORRESPONDENCE)





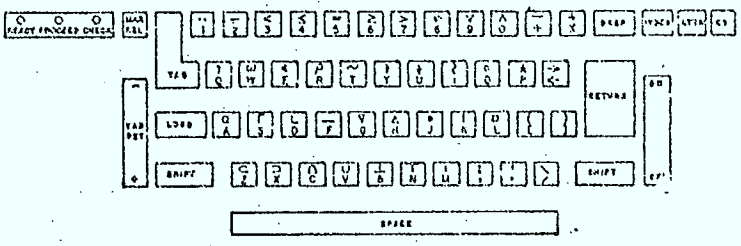


Figure II. 7 A.P.L. (EBCD)

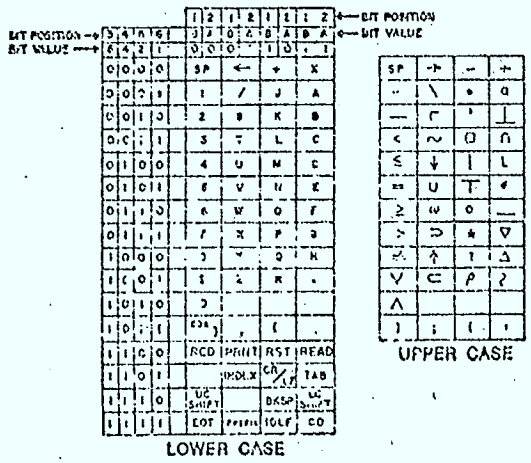
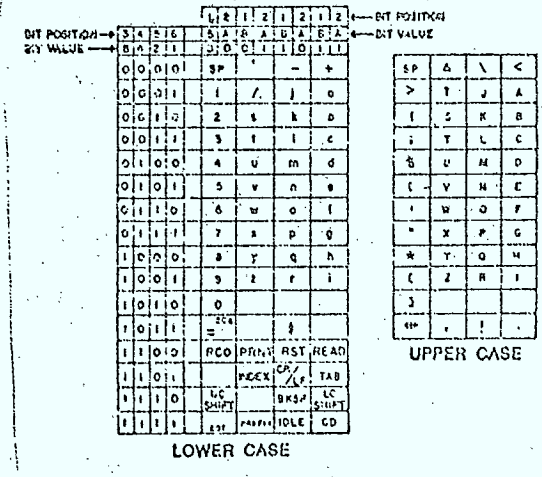
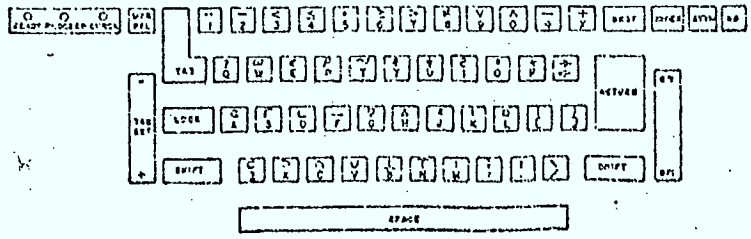
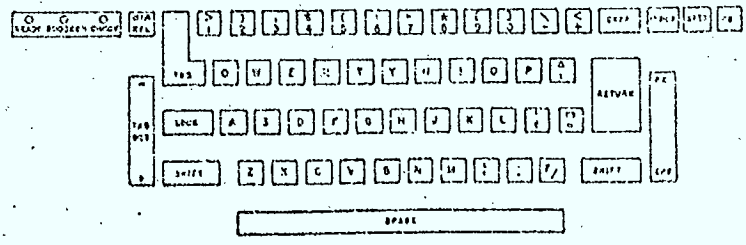


Figure II. 8 BINARY CODED DECIMAL (BCD)



0 - 01 2 4
1 - 00 4 0
2 - 0 2 0
3 - 0 1 6 0
4 - 0 1 0
5 - 0 1 5 0
6 - 0 1 3 0
7 - 0 7 0
8 - 0 0 4
9 - 0 1 4 4





Terminal User Requirements

Terminal User Requirements

Introduction

In what follows an outline of relative merits of the various means for doing time-sharing is presented. The basic terminal requirements for doing it effectively including the choice and evaluation of terminals is also presented.

Time Sharing Modes

There are basically four modes in which a computer can be time shared, namely through

- Interactive timesharing; that is through the use of small terminals such as teletypes, etc. that are connected to the computer through various types of communication lines. Programs are prepared and run interactively in this mode.

- Batch submissions; that is through the user programs and data that have been prepared on cards, tapes or some other medium. A Volkswagen or some such vehicle delivers the program/data to the computer. The output from the computer is usually returned to the user in a similar manner.

- Remote batch; where user programs and data are prepared as in the case of batch submissions but a given job is initiated from a remote terminal, usually a card reader and printer utilizing high-speed synchronous communication lines.

- Remote initiation of batch; here user programs and data are already at the computer center. A job may be remotely initiated from a small terminal

and its progress monitored.

The relative merits of the above four methods are:

- Interactive timesharing, is particularly useful in program development, "one-shot" problem solving, and information retrieval.

- Batch submission, is cheaper, and when time is of little importance also quite convenient. For large scale production programs the cost factor gives batch a firm advantage over timesharing. However, program production can be awkward because of the slow turn-around time.

- Remote batch, while more expensive than manual batch has the same advantages. The turn-around time factor is considerably improved.

- Remote initiation of jobs, provides further flexibility for program development, and usually ensures timely completion of the task. It also provides a progress monitoring capability, which can prove useful in the case of large jobs (large program and/or large data sets).

Factors Affecting Selection of Terminals

To do timesharing effectively, the user should select the best terminal for use with his timesharing system. In making this selection, the three main factors to be considered are

- The nature of the interaction required
- The physical constraints
- The financial costs

Nature of Interaction

This is essentially dependent on the task at hand. Problem solving for example, requires only an adequate character set for the computer language to be used, regardless of application (whether statistics, engineering, etc.).

Information retrieval usually demands a terminal capable of producing good quality output, and having some peripheral control capability for semi-permanent storage of the output.

On-line data entry which is economical only for small quantities of data or for small dedicated systems requires good display or hard-copy or CRT screen and control capabilities for editing and verification.

Off-line data entry and unattended data transmission require terminals with peripheral controls and some communications control capability such as automatic dialing to the time-shared computer.

Special output characteristics are necessary in three different kinds of applications: Text-editing requires very high quality output. Simulations, PERT, and CPM cannot be used to advantage without special character sets, when the rough output will be copied by a draftsman. Cartography and other plotting work may need an X-Y plotter, which can either be a terminal or serve as a peripheral to another terminal.

This brief survey only covers some of the most important points; often it is necessary for interaction to be modified according to what is available; availability being defined by other factors.

Physical Constraints

The most important physical constraints are those of telephones and computers.

Telephone capabilities vary widely, by country, area and, of course, by cost. Generally, low speeds (110, 134, 150, 300 baud) transmissions can be supported on voice-grade lines. These lines can suffice to handle many or most timesharing applications. As timesharing usually involves asynchronous operation, a terminal which provides optional higher speeds and/or synchronous transmission may not be worth the extra cost. Additional telephony considerations are those which dictate the types of modems or acoustic couplers that are required.

The timesharing computer itself places other constraints on terminal selection. Choice of transmission code (ASCII, BCD, etc.) must coincide with that allowed by the computer, as must line speed. Certain intelligent terminals such as the Datapoint 2200 series may allow almost universal access to any computer, but this must be balanced against cost (typically, $7,000 and up per intelligent CRT terminal).

If the nature of interaction, described above, requires peripheral control then, this must be regarded as a physical constraint; for example, if hard copy and CRT output are required simultaneously, then since most printers will only

operate at 30 cps, a 60 cps terminal and line may not be useful. Other physical criteria affecting the choice of a terminal are

- Portability and size
- Ruggedness
- Does it have buffers to prevent "falling behind"?
- Is there tabulation for I/O speed?
- Is there an interrupt capability?
- Are there other features pertinent to a class of terminal, such as brightness of CRTs, ease of paper handling for hard-copy terminals, etc.?

Financial Costs

The third and too often the most important consideration in choosing terminals are those of costs and other administrative matters. These may easily be quantified, and the most important are:

- Basic Cost
- Service Agreement Cost
- Rent/Lease/Purchase Costs vs. expected life of terminal
- Service Availability
- Mean Time Between Failines, etc.

Evaluation of terminals

In evaluating terminals various scoring methods have been used. Such a method is due to Kamman, and his paper is included as a reference. Two brief case studies will now be presented which will show the selection of two different types of timesharing terminals. The selection method involves eliminating various terminals by considering interaction and physical factors, and then making the final selection on a

cost basis. Interaction and physical factors are graded as YES/NO. One or more occurance, of NO results in rejection. These studies are presented in a tabular fashion.

Case Study 1

This application involved low speed (up to 30 cps) communication in BCD or Correspondence coding for information retrieval. Hard copy, upper-lowercase, and off-line data entry capabilities were also required. Ease of moving was desired, but not "suitcase" portability. Good service arrangements were necessary with a purchase agreement. Initially, we consider terminals for interaction capabilities:

TERMINAL	U-L Char. Set	Peripheral Control	Ease of Interface	Off-line Data Entry	Screen Size (for CRT)	(if CRT) Hard Copy AV?	Display Quality Output
Teletype ASR/33	NO	Y	Y	Y	na	na	N
IBM 2741	Y	N	Y	N	na	na	Y
IBM 1050	Y	N	Y	Y	na	na	Y
IBM 2265	Y	N	N	N	Y	N	Y
Hazeltime 2000	NO	Y	Y	Y	Y	Y	Y
Hazeltime 3000	Y	Y	Y	Y	Y	Y	Y
Novar 540-2	Y	Y	Y	Y	na	na	Y
Datapoint 3300	N	Y	Y	N	Y	Y	N
Datapoint 2200	Y	Y	Y	Y	Y	Y	Y
Burroughs B9353	Y	Y	Y	Y	Y	Y	Y

From this list of ten terminals we are now left with five:

- Hazeltine 2000
- Hazeltine 3000
- Novar 540-2
- Datapoint 2200
- Burroughs B9353.

Proceeding to tabulate physical constraints we have:

TERMINAL	Tranmit Code/Speed	Modem/ Coupler Req.	"Pro-gramm-able"	Size	Rug-ged-ness	Tabu-lation	Inter-rupt Capabi-lity
Hazeltine 2000	N	Y	N	Y	Y	N	Y
Hazeltine 3000	Y	Y	Y	Y	Y	Y	Y
Novar 540-2	Y	Y	Y	Y	Y	Y	Y
Datapoint 2200	Y	Y	Y	Y	Y	Y	Y
Burroughs B9353	N	Y	Y	Y	Y	Y	Y

Three terminals now remain, and cost considerations are inspected. As no service was available in this city (Ottawa), the NOVAR 540-2 was eliminated, and we are left with the Datapoint 2200 and the Hazeltine 3000.

A final choice was made of the Datapoint 2200, as specific pricing information was not available on the 3000.

Case Study 2

This application involved low speed (110 baud) communication in ASCII for statistical problem solving. Character sets were required to support Basic and FORTRAN. Dependability, good service and low purchase costs were the other prime factors. CRTs were inspected only if they also offered hard copy. The tables below show the process. Note that only two qualities need be considered under interaction. Output from thermal printers did not pass as acceptable.

TERMINAL	I/O Char. Set	Output Quality
Teletype ASR/33	Y	Y
IBM 2741	Y	Y
IBM 1050	Y	Y
Hazeltine 2000	Y	N
Hazeltine 3000	Y	N
Novar 540-2	Y	Y
TI Silent 700/720	Y	N
Datapoint 2200	Y	Y
Datapoint 3300	Y	N
Burroughs B9353	Y	N
IBM 5028	Y	Y
GE Datanet 730	Y	Y
DEC LA30	Y	Y
Olivetti TE308	Y	N

PHYSICAL CONSTRAINTS

TERMINAL	Transmit Code/ Speed	Modem/ Coupler Req.	Interrupt Capability	Inter-face Req.
Teletype ASR/33	Y/Y	Y	Y	Y
IBM 2741	N/N	Y	Y	N
IBM 1050	N/N	Y	Y	N
Novar 540-2	Y/N	Y	Y	N
Datapoint 2200	Y/Y	Y	Y	Y
IBM 5028	Y/Y	Y	Y	Y
GE Datanet 730	Y/Y	Y	Y	Y
DEC LA30	Y/Y	Y	Y	N

Costs, etc.

TERMINAL	MTBF acceptable	Service available	Cost ($U.S)	Service Cost ($U.S)	Total(incl. 1 yr maint.) ($U.S)
Teletype ASR/33	Y	Y	$1025.	$20.	$1265.
Datapoint 2200	Y	Y	?	?	$9000.
IBM 5028	Y	Y	$2240.	$46.	$2792.
GE Datanet 730	Y	Y	$1200.	$30.	$1560.

The final choice in Case Study 2 was the ASR/33 made by the Teletype Corporation.

Disks

In a number of systems, such as the one in the Department of Communications, disks are being used with time shared terminals to support such functions as high speed off line data entry, for local data storage etc.

Although the first commercially-used disk appeared in 1956 this method of data storage caught on comparatively slowly and it was not until the appearance of drives with interchangeable packs - IBM's 1311 was the first, with a maximum capacity of two million 6-bit characters - that the concept began to catch on. Today it is unusual to find a

reasonably sized configuration without any disk storage at all, and even programmable calculators and the small visible record computers are being offered with disk storage capability.

Early systems, comparatively small-capacity disk packs, meant that users could carry out processing far more quickly and frequently than had been the case with a tape-only system and even tele-processing was carried out with remarkable success.

The demand for larger and faster disk storage was increasing and in 1970 came the IBM 3330, with a capacity of 100 million bytes per pack and a data transfer rate over 8 times that of the 1311.

One of the aspects of the design of the 3330 which permits such high performance is the height at which the read/write heads "fly" over the disk surface . This can be compared to the size of ash particles suspended in smoke, some of which are over twice as big as the gap between the 3330 head and the disk surface - which is passing at over 100 miles per hour.

Each time speed and capacity are increased there is a corresponding demand for greater reliability, otherwise we would only succeed in generating more errors more quickly. With the increasing dependence on continuous computer operation and the more complex applications of the 1970's, users require not merely the same but greatly improved standards of reliability .

The demand for increased performance and reliability and the fact that it is only in the peripheral market that IBM

has any real competition, has kept manufacturers on their toes. The makers of IBM-compatible disk drives are continually striving to produce models that are as good, if not better, than those marketed by IBM, which sometimes has the effect of forcing IBM to push things out on to the market sooner than they would have done. Nevertheless independent manufacturers are only one step behind.

In the plug-to-plug compatible market activity and competition is comparatively fierce. Most of the independent peripheral manufacturers are concentrating on IBM replacement equipment, although one or two are scratching at Univac. IBM is, of course, the biggest market and although it hit back at its competitors by introducing a fixed term rental plan, and increased its profit-margin period to 36 months instead of 24, the independent companies instantly undercut IBM. The profit-margin is now around 25%, but if IBM cuts its prices by 15% quite a lot of people would go out of business. Hamstrung as it is by anti-trust laws, IBM is not likely to indulge in a price war of this kind and is a sitting duck for the competition.

Disks are likely to increase their ascendancy over tapes steadily. In today's cut-throat, commercially orientated world, a company which hopes to market its product successfully must be able to react rapidly to market changes and forecasts and in this connection disk storage becomes essential. With their advantages of rapid, random access and the promise of high speed MOS memories to accommodate swifter transfer rates, it is forecast that magnetic tapes, as a storage medium, will have virtually gone out of use in another ten years, except as a backup store. Although tapes are still considerably cheaper than disks, the price of the

latter is continually decreasing while the reliability and length of life of both the disks and the hardware associated with them constantly increases. Disks are now available for as little as $6000.

Disk software presents few problems and has the advantage over tape that it provides for more detailed handling procedures to be recorded on the control console log than is the case with tapes. It is therefore possible for the activities of the operators to be checked with ease, and a high level of system security to be maintained. This provision has had to be built in because of the nature of destructive updating of disks.

The paper in the References by C. Smythe on What To Look For In Disk Drive Data Systems contains a good summary of some of the disk systems available as well as design and selection criteria for choosing them in time shared systems applications.

References for Terminal User Requirements

Special

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WHAT TO LOOK FOR

The design criteria for disk drives in the 1970's must specify not only high performance but also characteristics which will ensure that the user obtains a very high level of availability. **Clare Smythe**

IN THE TABLES THAT FOLLOW are given the basic specification of the large number of disk drives and packs at present on the market and designed for various 'host' computer systems. A disk sub-system generally speaking consists of a controller and one or more disk drives capable of carrying either fixed or removable disks of several kinds. The rôle of the controller is to select the appropriate disk drive and control its operation. The disk drive is addressed through the controller, which also generates a parity bit during the write operation and check parity when reading.

When IBM introduced the 370/135 and 145 they also announced the Integrated File Adaptor which meant in simple terms, that half the control unit was integrated in the central processor and the rest of the control circuitry was in the same cabinet as the new drive (the 2319, a modification of the 2314). IBM competitors say that this was to foil the competition offered by the independent peripheral manufacturers: IBM say it was to keep down costs. However, the opposition quickly bounced back with their IBM-compatible versions of the 2319—BASF introduced their 6219 last month—designed to be connected to IBM's Integrated File Adaptor.

A controller can handle a varying number of drives. Often manufacturers offer so many on line and one off line. Modern disk drives are usually separately connected to the control unit and are therefore completely interchangeable by means of address plugs and a service address plug, which allows a drive to be taken off line for servicing without disturbing the operation of the rest.

On the earlier drives the disks were invariably fixed, and fixed drives today usually have heads which are positioned over each track on the disk. The advantage of this is, of course, speed of access but fixed disks also have their disadvantages and are most suitable in applications where there is only a fairly small volume of data to be stored, but which needs to be accessed rapidly and must be continually on line. Some models of fixed disk drives operate only on a dedicated line from the central processor.

Exchangeable packs

Generally, however, the interchange of the file-carrying component on the peripheral is essential and therefore most users prefer exchangeable packs of stacked, disks. These are accessed by moving heads on a comb of arms, with a read/write head for every side in the pack. Electronic methods are normally used for locking the access comb at the point it reaches, and are much to be preferred to mechanical methods. On the older models there is only one read/write head, which moves up and down a pillar beside the stack of disks and has to poke in and out between the disks seeking the appropriate area. Obviously this has severe disadvantages in the time it takes to access the required data.

The efficiency of the drive will determine the access time—the time it takes to position the head over the required data, measured from the moment of executing an instruction to call for the data to the moment when the data is stored in the specific location. Search time indicates the average time required to identify an item of data. Effective search time may sometimes be lengthened because the selector channel from the CPU is flagged against interruptions until the search is ended. Rotational delay indicates the time the disk takes to execute a half turn.

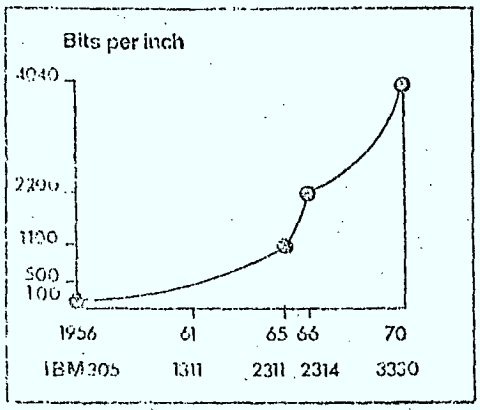
To most people seek and search time are synonymous. IBM, however, use somewhat different terms, explained here by Jack Llewellyn, Product Line Manager:

'One of the inherent characteristics of disk storage is the time lag in locating the required record. This "access" time is made up of two parts—"seek" time required to position the heads over the required track and "search" time to locate the record on the track.

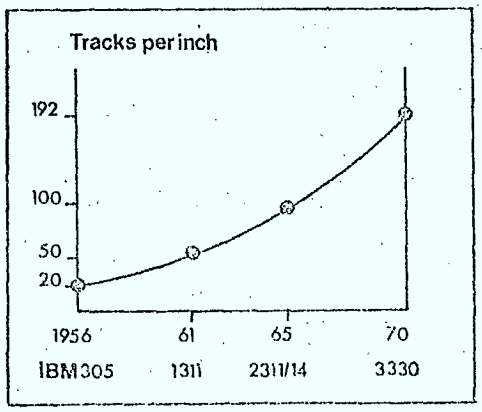
'Since 1964 it has been possible to overlap the seek times with other operations on the channel (including seeks on other disk drives). However, until the advent of the 3330/3830, the search time, which on average the time for half a revol of the disk, has tied up the channel.

'The 3830 Control Unit uses a "look ahead" techinque which locates the record on the track without tying up the channel. This technique allows all eight 3330s on one 3830 to be seeking or searching for data concurrently, reducing contention and increasing systems throughput.'

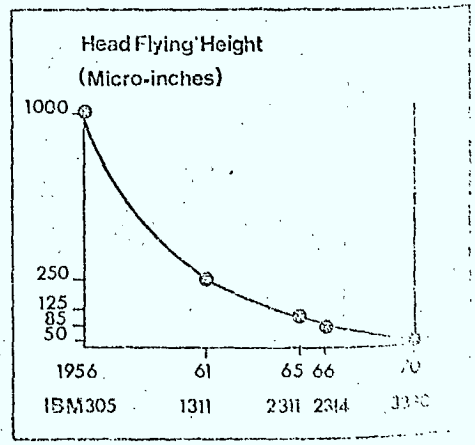
The transfer rate is the time taken for



More than 40 times the number of bits per inch in 1970 than in 1956—one of the many examples of rapid advances in computer technology in the past decade.



The track density has increased by a factor of nearly 10 since IBM's first commercial disk in 1956. The most recent development is almost a two-fold increase over the previous density of 100 tracks per inch.



The graph gives a good idea of the ... ing reduction in head clearance—... thousandth of an inch in 1956 ... millionths of an inch in 1970. Even in ... it looked as if the heads touched the ... —without a magnifying glass. Now need a microscope to see the gap

a byte of information to be transferred from the disk to the channel of the system. The destination of the information is important: if the CPU store has a slow cycle speed as on earlier systems, the transfer rate may be too fast, causing problems of over-run. The speed of the drive and the packing density of the information recorded on the disk both govern the transfer rate.

The disk drive and the disk pack are complementary to each other and equally important to efficient operation. The disk pack may have from one to several disks which are made of a thin aluminium alloy with a magnetic coating of iron oxide or nickel cobalt compound.

Constant speed

The top and bottom disks are supported by a cover disk, and are only used for recording on the inner surfaces. The bottom cover disk usually has a number of radial slots which monitor the speed of the drive by inducing a pulse in a sensor as the disk rotates—it is essential for the disk to spin at full speed to keep the read/write heads floating—and which also indexes the recordings. An air filter attached to the opening at the base of the stack prevents coarse particles of dirt from entering, and also at the base are attached weights to keep its balance true.

Cartridges or cassettes contain one single disk within a plastic cassette. The read/write heads may be already mounted within the disk or may come in from outside. The advantage of a disk cartridge is the degree of protection it enjoys, but it is only suitable for small volumes of data.

There are two ways of organizing data on disk—by sector and by cylinder. The cylinder concept is a hangover from the days when actual cylinders were used, and for some unimaginable reason the disk is looked upon as if it were a cylinder. Thus on a pack with ten recording surfaces each with twenty tracks similar to the closed groove on a gramophone, the space is first of all filled on the first track on side one, then to the first track on side two, then to the same track on side three and so on until side ten is filled. Then control is given to the second track on side one and the process repeated.

The sector method is to divide the surface of the disk into wedge-shaped sectors, so that when reading or writing information the disk, track and sector is specified. This allows for greater precision in seeking during rotational position sensing. The more tracks and sectors the more precise can be the placing and finding of data and the shorter the search time, also the more tracks there are the more data can be packed in. If the packing density rather than the number of tracks is doubled, the transfer rate is also doubled which may lead to problems, and the software is also more complex. Telex claims to be the only manufacturer which markets a double-track density disk in this country.

Variable life

Obviously the manufacture of disks is a highly precise operation and the length of their life varies from manufacturer to manufacturer—for example the balance weights on the lower disk may start to come off and the pack begin to wobble. It is therefore essential that disk packs should come from a reliable maker. (A list of the major companies making disks is given at the end of this article.)

The IBM 3330 is regarded by some people as the ultimate in disk storage and it certainly meets the requirements of high performance and a very high level of availability. Jack Llewellyn of IBM describes here the capabilities and operation of these units.

Reliability and Serviceability

'When System/370 was launched it was apparent to many computer users that the more powerful processors used in this range were fully complemented in performance characteristics by the new 3330 disk storage drive. In the last few months the installation experience of 370 users with 3330 disk units has confirmed the performance advantage of the new duet between processor and store. However, the final verdict on the 3330 will probably dwell on the greatly increased reliability and serviceability of the product.

'In many senses the complete picture presented by the 3830 disk controller and 3330 disk drive unit represents an inversion of people's experience with advanced technology. It is usual to associate large increases in performance with rather higher risks of failure and unavailability. But the 3830-3330 technology story tells not only of "outperforming", but also of "sweeter running".

'The essence of the new approach to disk drive performance starts on the 20th surface of the 3336 disk pack. The other 19 surfaces are available to the user; the 20th is turned into a control surface during manufacture. It has become known as the 'servo surface' because of the way in which it feeds back signals to the disk drive head positioning actuator. Through this feedback technique the heads follow the tracks and receive maximum signal strength. A further effect of the servo system is to allow track following to take place even though the track does not run precisely true. In this way, a completely new order of reliability is gained and, at the same time, the recovery procedures can be improved on although the servo system is not the first line of defence against error. Before the system comes to a halt, the error correcting codes ensure that any error of up to 11 continuous bits of information can be corrected on the fly. The next stage, if the error is spread over more than 11 bits, is initiated by the control unit without consuming processor time and consists of a number of re-tries. In many instances, the error disappears or can be put right by the correction code. To prevent a build-up of malfunctions in

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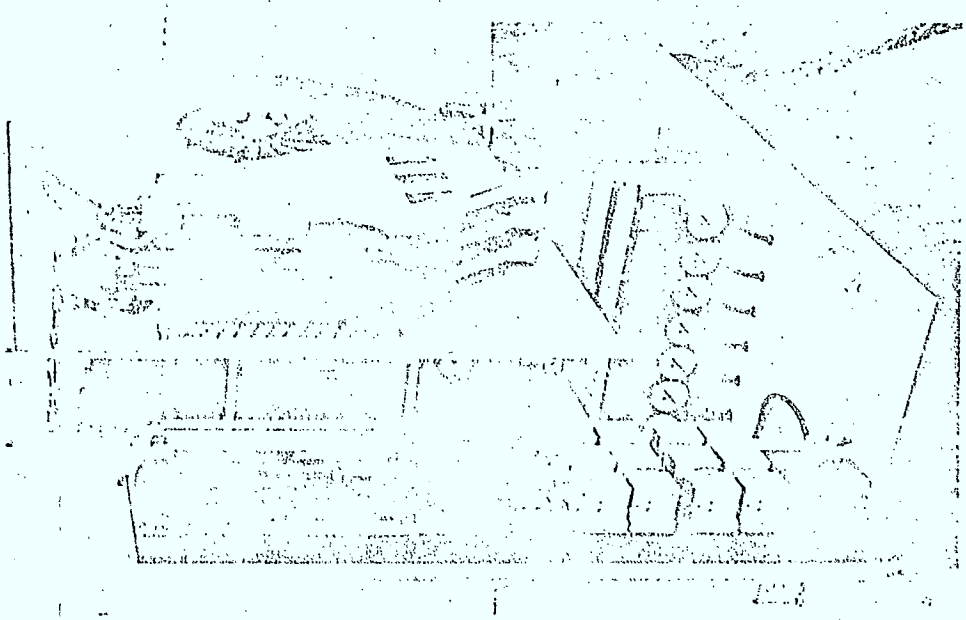

'The manufacture of disks is a highly precise operation and the length of their life varies from manufacturer to manufacturer . . .'

Company	Ampex Great BritainLtd, Acre Road, Reading, Berks.	BASF United Kingdom Ltd, 197 Knightsbridge, London S.W.7.				Burroughs Mach... Ltd, Heathrow House, Bath Road, Cranford, Mddx.
Type	Disk file system	6111 disk drive	6114 disk drive	6214 disk drive	6230 disk drive	B 9370–2 system memory
Storage medium	IBM 2316 or equivalent pack	BASF 616, IBM 1316 or similar pack	BASF 621, IBM 2316 or similar pack	BASF 621 pack or similar	BASF 626 disk pack	Fixed head per track disk
Host system	IBM System/360	IBM	IBM 360/30 upwards		IBM 370	B 2500/3510/4700/6700
Control unit	DC-314	IBM 2841	BASF 6014 or similar	BASF 6014 or similar	BASF 6030	B 371
Drive	DM-312	6111	6114	6214	6230	B 9370-2
Number of disks per control unit	Up to 8				Up to four	1–2
Surfaces/pack	20	10	20	20	19	—
Tracks/surface	20	200	200	200	404 plus 7 spare	100
Sectors/track	—	—	—	—	—	100
Heads						100
Capacity: mega-bytes/pack	29·17	7·25	29·17	58·34	100	2
Access time (av)	32 ms	10 ms	12 ms	12 ms track to track	30 ms	17 ms
Seek time (av)						
Rotational delay (av)		12·5 ms	12·5 ms	12·5 ms	8·3 ms	34 ms
Transfer rate (bytes/sec)	312,000	156,000		312,000		291,000
Specimen configuration						B 371 + B 9370-2
Monthly rental for this config.						£245

Company	Digital Equipment Co. Ltd, Arkwright Road, Reading, Berks.	Feedback Data Ltd. Bell Brook, Uckfield, Sussex		Friden Ltd. 101 Blackfriars Road, London, SE1.		He... 22... Slough, Buc...
Type	RP Series	111	114/1014	Model 40 disk drive	Model 42 twin pack	7900A
Storage medium	RP Packs	10 surface disk pack (IBM 2311)	2316	Model 40 disk drive	41A or 41B disk pack	DISC
Host system	DEC system-10	S 360/370 Varian 620, PDP 11, PDP 10, SPc 16 etc.	S360/370	System 10	System 10	2100 and 3000 series
Control unit	RP control	Feedback 016, IBM 2841	1014	9220 in CPU	9220 in CPU	13210A
Drive	RP series	111	114 or 214	Model 40	Model 42	7900A
No. of disks per control unit	1–8	1–8 + 1 SP	1–8 + 1SP	1–9 + 1 spare	1–9 + 1 spare	8
Surfaces/pack	20	10	20	10	4	2
Tracks/ surface	200 and 400	200	20	20	200	203
Sectors/track	10	20	20	50	50	24
Heads	Movable	Movable	Movable	Movable	Movable	—
Capacity: megabytes/ disk	30 million or 60 million	7·25	29·17	10 m. chs.	4 m. chs.	2·4
Access time (average)	47·5 ms or 41·5 ms	35	45	60·5 ms	60·5	47·5 ms
Seek time (average)	35 ms or 29 ms	7·5	12·5	12·5 ms	12·5	35 ms
Rotational daily average	12·5 ms	25	25	12·5 ms	12·5	12·5 ms
Transfer rate (bytes/sec)	400 bytes/sec	156,000	312,000	229,000 cps	229,000 cps	312k
Specimen configuration	RPO3G Disk subsystem (140 m. bytes)	9 + 1 CTLR	9 + 1 CTLR	2 drives + 1 control	1 drive + control	1 × 7900 + 1 13210A
Monthly rental for this config.	£1800/month		£1,600	£342 3 yr. basis	£200 3yr. basis	On application

						Control Data Ltd. Control Data House, 22a St. James's Sq., London, SW1				Data Recording Instrument Co. Ltd., Hawthorne Road, Staines, Mddx.	
B9372	B 9372	B 9376-2	B 9974-1	B 9974-2	B 9974-2	821 data file	841 multiple disk drive	7638 disk file	844 disk storage unit	Series 4000 (4091 & 4043)	Series 30 310 and 312
Fixed head disk	Fixed head disk	Fixed head disk	Disk pack	Disk pack	Disk pack	fixed disk	871 pack	fixed disks	872 pack	IBM 5440 cartridge	IBM 2315 cartridge
B 2500/3500/ 4700/6700	B 2500/3500 4700/6700	B 2500/3500/ 4700/6700	B 4700/ 6700	B 4700/ 6700	B 4700/ 6700	3000 series or CYBER 70	3000 series or CYBER 70	CYBER 76	3000 series or CYBER 70		
B.373	B 373	B 373	B 387	B 388	B 388	3553	3553	(included)	7054	OEM	OEM
B 9372	B 9371-2	B 9371-4	B 9487 2 or 3	B 9488-1	B 9488-2	821	841	7638	844		
1-5	1-5	1-5	1-16	1-16	1-16	—	3-8 + 1 spare	1	up to 8	Single	Single disk cartridge
—	—	—	20	20	20	20	20	—	20	2 and 4	2
100	100	100	406	406	406	—	—	—	404	203 + 3 spare	203 + 3 spare
100	100	100	—	—	—	—	—	—	—	—	—
100	100	100	—	—	—	20	20	—	—	2 and 4	2
10	20	20	121 or 181	121	242	419 or 838 m.chs	36 m.chs	800 m.chs	109 m.chs	25 and 50M bits	12 and 24M bits
20	23	40	42·5	42·5	42·5	87·5 ms	75 ms	87·5 ms	30 ms	38 ms	60 ms
0	0	0	30	30	30	75 ms	60 ms	75 ms	20 ms	—	—
40	46	80	25	25	25	12·5 ms	15 ms	12·5 ms	10 ms	12·5 ms	20 ms
208,000	377,000	400,000	312,000	625,000	625,000	420,000 cps	420,000 cps	42m cps	880m cps	2·5MHz	781 and 1562kHz
B373 + 9371-1 + 9372-5 (50MB) £1460	B373 + 9371-2 + 3 × 9372-7 (60MB) £1370	B373 + 9371-4 + 3 × 9376-2 (60MB) £1060	B387 + 9487-2 £889 £1435	B388 + 9488-1 £1332	B388 + 9488-2 £1805	821 + 3553 £1000	3 × 841 + 3553 £1000	7638 £4000	844 + 7054 £900		

Information ead, dix.							IBM United Kingdom Ltd, 389 Chiswick High Road, London, W.4.
Changeable Drive	272 and 273	277	DSU 167	DSU 270	DSU 180	DSU 190	5444
Removable Disk pack	Removable disk	Removable disk	Removable disk	Fixed disk	Removable disk	Removable disk	5440 disk cartridge and fixed-disk
Model 58	Series 200/2000	Series 200/2000	Series 6000	Series 6000	Series 6000	Series 6000	System/3
DSU 050	257/260	Integral	DSS 167	DSC 270	DSS 180	DSS 190	In cpu
DSU 162	272 or 273	277	ADU 167	DSU 270	DSU 180	DSU 190	—
2	8	8	8 (+1)	20	16	16 (32 dual crossbarred)	1 or 2
10	10	20	20	8	20	19 (+1)	2 or 4
203	200	200	200	150 (3 zones)	200	404	200 or 50
	Variable	Variable	10	34 (Av.)	18	30	—
10	1	1	20	head/track	20	19 (+1)	2 or 4
5,760,000	9·2 or 18·4 ms chs.	64 chs.	15 chs.	15 chs.	27·5 chs.	133 chs.	2·45 and 4·9
72·5 ms.	62·5 ms.	46·5 ms.	98 ms.	26 ms.	46·5 ms.	38·3 ms.	269 and 153 ms.
60 ms.	50 ms.	34 ms.	85·5 ms.	none	34 ms.	30 ms.	—
12·5 ms.	12·5 ms.	12·5 ms.	12·5 ms.	26 ms.	12·5 ms.	8·3 ms.	20 ms.
156,000	208 kc/s	714	108 kc	273 kc (Av.)	416 kc.	1.078 kc.	199,000
	Control unit + 2 drives	control unit + 2 drives	5 drives	5 drives	10 drives	12 drives	2 fixed plus 2 removable
	£744–£900	£744–£900	£1,861 (5 yrs.)	£2,942 (5 yrs.)	£3,236	£5,410	£280

								ICL ICL House London, [illegible]15
Type	5445	2311 Model 1	2314 (B series)	3330	2319	2305 model 1	2305 model 2	2813
Storage medium	2316	1316	2316 disk pack	3336	2316 disk pack	Fixed disks	Fixed disks	EDS 30 disk cartridge
Host system	System/3	360 and 1800	360–370	370	370, 135/145	370	370	1902A up
Control unit	In cpu	2841	2314 B1	3830	In cpu	2835 model 1	2835 model 2	2812/2 (buffered)
Drive				3330 (2 spindles)	—	—	—	2813
Number of disks per control unit	2	1 to 8	3 to 8 + 1 spare	2, 4, 6 or 8	3 to 8	1 or 2	1 or 2	1–9
Recording surfaces/pack	20	10	20	19	20	12	12	20
Tracks/recording surface	20	200	200	44	200	32	64	203
Sectors/track								15
Heads	20	10	20	19	20	—	—	Movable
Capacity/megabytes/pack	20·48	7·25	29·17	100	29·17	14,136	14,660	30·7
Access time average	60 ms.	75 ms.	60 ms.	30 ms.	2·5 ms.	2·5 ms.	2·5 ms.	72·5
Seek time average	—	—	—	—	—	—	—	60
Rotational delay (average)	12·5 ms.	12·5 ms.	25 ms.	8·33 ms.	8·33 ms.	10 ms.	10 ms.	12·5
Transfer rate (bytes/sec)	312,000	156,000	312,000	806,000	312,000	3 million	1·3 million	416,[illegible]
Specimen configuration	2 × 5445	8 × 2311 plus 2841	9 drives + control	4 × 3330 + 3830	8 drives + control	2 drives + control	2 drives + control	9 drive[illegible]
Monthly rental for this config.	£600	£1,950 on 2 yr. fixed term plan	£1,870 on 2 yr. fixed term plan	£3,120 on 2 yr. fixed term plan	£1,230 on 2 yr. fixed term plan	£5,480 on 2 yr. fixed term plan	£4,620 on 2 yr. fixed term plan	

Itel International supply Models 714 and 715 disk drives in competition with the IBM 2314 drive, and the 7330 in competition with the IBM 3330.

Company		Potter Data Products Ltd, Station House, Harrow Road, Wembley, Middx.		Racal Thermionic Ltd, Hythe, Southampton, Hants.	Rank Zerox Ltd, RXDS Division, York House, Empire Way, Wembley, Middlesex.			
Type	655	4314/4314	5330/4330	Singer Librascope.	7202	7203	7204	7212
Storage medium	955 disk pack	2316 IBM disk pack or equiv.	IBM 3336 disk pack or equiv.	Fixed disk	Disk	Disk	Disk	Disk
Host system	NCR Century	IBM 360-370	IBM 370		Sigma 3–9	Sigma 3–9	Sigma 3–9	Sigma 5–9
Control unit	625-101	DC 5314	DC 4330		7201	7201	7201	7211
Drive	655-101/102/201	DD 4314-1	DD 4330	Fixed	7202	7203	7204	7212
No. of disks per control unit	Up to 8 (4 dual)	2 — 8 + 1 spare	2–9	—	1–8	1–8	1–8	1–4
Surfaces/pack	6	20	20		1	2	4	4
Recording surface	192	200	400		128	256	512	64
Sectors/track	8	20	—	Customer specified	16	16	16	32
Heads	12 movable	20 movable	Movable.	Up to 256	Fixed	Fixed	Fixed	Fixed
Capacity megabytes/disk	4·19	29·17	100	18 × 10^6 Bits	0·75	1·5	3·0	5·3
Access time (av)	44·7	27 ms	25 ms	10 ms	17	17	17	17
Seek time (av)	—	6 ms	3·5 ms	NA	0	0	0	0
Rotational delay (av)	20·8	12·5 ms	8·33 ms	Included in access time	17	17	17	17
Transfer rate (bytes/sec)	108,000	312,000	806Kb	80K	188,000	188,000	188,000	3,000,000
Specimen configuration	4 spindles + control	DC 5314 + 9 DD 4314	DC 5330 + 8 × 4330		1 + CTL	1 + CTL	1 + CTL	1 + CTL
Monthly rental for this config	Not available	On application	On application	From £1500	£285	£345	£465	£870

					Memorex Corporation, St. Ives House, St. Ives Road, Maidenhead, Berks.			The National C Register Co. Ltd. 206 Marylebone Road, London, NW1
2815	2802	4420	4425	2815	620 storage drive	630	660 storage drive	657
EDS 60 disk cartridge	EDS 8 disk cartridge	EDS 30 disk cartridge	EDS 8 disk cartridge	EDS 60 disk cartridge	1316 or equivalent	Memorex Mark 1, IBM 1316	Memorex Mark VI, IBM 2316	957 disk pack
4–50 up	All 1900	4–50 up	4–50 up	1902A up	IBM system 360–20	360/25 up	IBM 360/30 up	NCR century
4312/2	2802/0	4312/0	4310	2812/3	—	2841 or in cpu	661	625–201
2815	2802/3	4425	4425	2815 (buffered)	2311 model II	IBM 2311–1		57–101/102
3–9	1–8	1–9	1–8	3–9	4	6	11	Up to 8 spindles (4 dual spindle units)
20 406 variable	10 200 8	20 203 variable	10 203 variable	20 406 15	10 203 20 or 32	100 200 + 3 spare —	20 200 + 3 spare —	20 203 (+ 3 spares) 1 or 8
movable	movable	movable	movable	movable	movable			
58·34	8·19	29·17	7·25	61·4	7·25	7·25	29	29
47·5 35·0 12·5	97·5 85·0 12·5	87·5 75·0 12·5	97·5 85·0 12·5	47·5 35·0 12·5	50 ms. — 25 ms.	50 ms. — —	50 ms. — —	60 ms. — 12·5 ms.
312,000	208,000	312,000	156,000	416,000	156,000	156,000	312,000	315,000
2815/9 + 4312/2	8 drives + CTL	4420/9 + 4312/0		9 drives + CTL			*Model 670 also available	4 spindles + control Not available

				Sintrom Electronics Ltd., 2 Arkwright Road, Reading, Berks RG2 0LS		Tally Ltd, Cremyll Road, Reading, Berks.	Telex Computer Products (UK) Ltd., 213 Oxford Street, London, W.1.	
7232	7242	7246	7242B	Moving head disk system	Fixed head disk system Series 1700	EDP 2000/3000/4000 series	5314 storage system	5311
Disk	Disk pack	Disk pack	Disk pack	2315 type cartridge	Data disk 7200	Single disk	IBM 2316 pack	1316 disk pack
Sigma 3-9	Sigma 3-9	Sigma 3-9	Sigma 3-9	Most minicomputers	Most minicomputers	Most minicomputers	IBM 360/370	IBM 360
7231	7240	7240	7240	2923/3110	Data disk 1200		Telex 5328	IBM 284-1
7232	7242	7246	7242B	DRI Series 30/33	7200		5312	5311
1–4	1–8	1–8	1–8	4–8	1–4 (depends on computer)	1–4	1–9	1–9
4 512 12	20 200 6	20 200 6	20 200 6	2 203 8, 12, 16, 24 standard	2 4–64 at customer demand	8–128 — To customer requirement	20 203 —	10
Fixed	Movable	Movable	Movable	2	One per track	One per track	20	10
	49·2	24·6	98·3	12/24 (single/double density)	up to 2·2	0·4–6·0 M. bits	29	7·25
17 0 17	87·5 75·0 12·5	87·5 75·0 12·5	87·5 75·0 12·5	80 60 20	20 — 20	8·5 ms, 17 ms, 17 ms resp. — 8·5 ms, 17 ms, 17 ms resp.	30 ms	30 ms
384,000	312,500	312,500	312,500	195k	500k	3 m, 1·5 m, 2·54 m (bits)	312,000	156,000
1 + CTL	1 + CTL	2 + CTL	1 + CTL	8 packs + controller + interface to PDP-8 or 11	4M words store + PDP8 i/F		C + 5 drives	3 × 5311
£715	£655	£730	£950	£650	£1,650	From £1,500	From £820	£516

WHAT TO LOOK FOR

cont. from p 37

the system, all instances of re-try attempts are logged within the control unit for engineering investigation. This means that incipient errors can be recognized and corrected, during scheduled maintenance, before they cause failure of the unit.

However, there are occasions when the re-tries fail to recover from the error and it is in these instances that the track following system is used after converting it into a track deviating system. One of the likely causes of persistent error rests with minute damage or dirt on the track. By reading deliberately to one side or the other of the track path, enough signal is normally collected to enable a correct reading to be obtained.

It should be emphasized that most of the error recovery procedures are controlled by the disk channel and the 3830 control unit. In these 370 control units every advantage has been taken of the relatively low cost of integrated circuits today. The increased density of components which can be mounted within a single circuit package has created the opportunity for speeding up the process of fault finding. The trick is to try to put a complete logical function in a single electronic pack. The diagnostics help with locating the faulty function and the more lucid layout of circuit package helps to simplify the curative process. Using micro-programs, the control unit acts as a data logger and process monitor over all drive and channel activity. Quite apart from keeping track of transient or soft errors, the control unit diagnostics are invaluable to the user when a hard error finally occurs. And because the various disk drives are attached to the 3830 like the spokes of a wheel, servicing one drive does not affect the availability of the others to the axious central processor.

The last point emphasizes what we mean by availability. The availability of a product to the user is a combination of reliability and serviceability aspects of design and production. The 3330 has achieved a much higher standard of reliability by being a disk drive which effectively driven from any disk pack. The approach assures the user of full interchangeability and true backup facilities from any 3330 equipped installations. □

Disk suppliers

BASF United Kingdom
197 Knightsbridge,
London S.W.7.

Control Data,
22a St. James Square,
London S.W.1.

Dataset Ltd.,
Arena House,
Broadway, Letchworth,
Herts.

Fenn Continuous,
New Continuous House,
Burslem,
Stoke-on-Trent, Staffs.

Friden Ltd,
101 Blackfriars Road,
London S.E.1.

General Automation
Victoria Road,
Burgess Hill, Sussex.

Hewlett Packard,
224 Bath Road,
Slough, Bucks.

Honeywell Ltd,
Computer Control Division,
Great West Road,
Brentford, Mddx.

IBM UK Ltd,
389 Chiswick High Road,
London W.4.

International Computers,
ICL House,
Putney, London S.W.15.

Mastertape (Magnetic)
Blackthorne Road,
Pyle Trading Estate,
Colnbrook, Bucks.

Memory Magnetics,
Alder House,
1 Aldersgate Street,
London E.C.1.

Minnesota Mining &
Manufacturing,
3M House,
Wigmore Street,
London W.1.

The National Cash
Register Co.
202/216 Marylebone Rd,
London N.W.1.

Precision Data Co.
Angel Road Works,
London N.18.

Rank Xerox Data Systems,
York House,
Empire Way,
Wembley, Mddx.

Viatron Computer Systems
928 High Road,
London N.12.

Xycom Ltd,
41 Grays Inn Road,
London W.C.1.

Zonal Films Ltd,
Holmethorpe Avenue,
Redhill,
Surrey.

Company	Telex Computer Products (cont.)		Transworld Data Systems Ltd, 1 West Ruislip Station, Ickenham Road, Ruislip, Mddx.	Univac Division Sperry Rand Ltd, 106 Euston Road, London, N.W.1.			
Type	5600	6330	IOMEC 2000 series	8411 disk sub system	8414 disk sub system	8440 disk sub system	8405 sub system
Storage medium	2316 pack	IBM 3336 pack	Interchangeable cartridge/disk system	Moving head interchangeable disk pack	Moving head interchangeable disk pack	Moving head interchangeable disk pack	Fixed head disk
Host system	IBM 360/370	IBM 370	I0 mec	9200 Mk 2, 9300 Mk 2, 9380, 9400, 9700	9200 Mk 2, 9300 Mk 2, 9380, 9400, 9700, 1106, 1108, 1110, 413/8, 494	9700, 1106, 1108 1110, 418/3, 494	Univac 9700
Control unit	Telex 5650	Telex 6830	Iomec 2001 and 2002				
Drive	5625	6316	Man. 4	8	8	8	4
No. of disk/control unit	1–9	1–9					
Surfaces/pack	20	19 (& 1 control)	2	10	20	19	
Tracks/surfaces	406	400	203 (3 spare)	203	203	406	
Sectors/track	—		24	Non sectorized	Non sectorized	Non sectorized	Non sectorized
Heads	20	19	2 (2001) or 4 (2002)	10	20	20	—
Capacity: megabytes disk	58	100	3 M or 6 M	7	29	1,110	3
Access time (av)	29 Ms	30 ms	75 ms	87.5	72.5	47.5	8.34
Seek time (av)			35 ms track to track	75	60	35	0
Rotational delay (av)			20 ms	12·5	12.5	12·5	8·34
Transfer rate (bytes/sec)	312,000	806,000	200 K-bytes/sec	156,000	312,000	624,000	624,000
Specimen config.	C + 5 drives	C + 5 drives				Control + 1 drive	Control + 1 drive
Monthly rental for this config.	£1621	£2087	£5,300	£357 on 5 yr. basis	£342 on 5 yr. basis	£842 on 5 yr. basis	£802 on 5 yr. basis add. drives £249 p.m.

8. In many cases real - time extraction of information from huge files can be replaced by a small file extracted off - line and introduced via punched cards and 1050 into a few workspaces.

A Survey of APL Compatible Terminals

Harley P. Macon
Senior Operations Research Specialist
American Can Company

In the absence of APL program products from manufacturers other than IBM, the terminals described are those which interface APL/360 and APL/370. In some cases additional equipment is required for such interfacing (i.e., the Memorex 1270 controller when using Memorex 1240, 1241, 1242 terminals or the Teletype model 38).

APL compatible terminals are now available in a wide variety of types and capabilities. The devices described fall into two broad categories.

1. Keyboards with printers.
2. Keyboards with video displays.

Several devices which do not have (at present) the APL font are included because they may serve well in special applications where program execution only is required.

Where terminal costs are a primary concern the TELETYPE Model 38 is certain to have a significant impact. It is one-half the cost of the least expensive terminals available today. An appropriate font wheel is not currently offered but is certain to be forthcoming.

Those interested in computer graphics will take special interest in the IMLAC PDS-1 which has a full graphics capability, can display the APL character set (in fact any character set), and readily interfaces to APL.

Finally several devices not fully described but which may interest users in the APL community would include:

1. The TSP-212D plotter which is readily interfaced to a storage tube display.
2. The Hewlett-Packard model 7201A plotter.
3. Image Systems random access mass storage device (microfilm) which operates in conjunction with an APL terminal. Maximum time for retrieval and display is 4 seconds.

Chart I is a list of manufacturers, their addresses, and the abbreviations used in the tables.

Table I is a descriptive list of all devices producing hard copy.

Table II is a descriptive list of video devices.

CHART I

PRINTERS

Manufacturers	Abbreviations
Anderson Jacobsen 2235 Mora Drive Mountain View, Calif. 94040 415-968-2400	A.J.
Computer Transceivers Systems, Inc. 317 Route 17 Paramus, New Jersey 07652 201-261-6800	C.T.C.
International Business Machines Corp. Data Processing Division 1133 Westchester Ave. White Plains, New York 10604	I.B.M.
Itel Information Products Division 2585 East Bayshore Palo Alto, California 94303	ITEL
Memorex Corporation San Tomas at Central Expressway Santa Clara, California 95052 408-246-6200	MEM
Novar Corporation 2370 Charleston Road Mountainview, California 94040 415-964-3900	NOV.
Omnitec 903 N. 2nd Street Phoenix, Arizona 85004 602-258-8246	OMNI
Teletype Corporation 5555 Touhy Avenue Skokie, Illinois 60076 312-676-1000	TT
Texas Instruments, Inc. Digital Systems Division PO Box 66027 Houston, Texas 77006	TI
University Computing Company 1300 Frito-Lay Tower Dallas, Texas 75235 214-350-1211	UCC

VIDEO DISPLAYS

Computer Communications, Inc.
701 W. Manchester Blvd.
Inglewood, California 90301 — C.C.

Computer Terminal Corporation
9725 Datapoint Drive
San Antonio, Texas 78229 — C.T.

Incoterm Corporation
Hayes Memorial Drive
Marlborough, Mass. 01752 — INCO

Imlac Corporation
296 Newton Street
Waltham, Mass. — IMLAC

MISCELLANEOUS

Hewlett-Packard
1501 Page Mill Road
Palo Alto, Calif. 94303

Image Systems
30 E. 40th Street
New York, New York
212-685-2120

Time Share Peripherals Corp.
Box 361
Wilton, Conn. 06897
203-762-3348

TABLE I

MFG.	MODEL	PRINT METHOD	PRINT SPEED(CPS)	TRANS. CODES	LINE LENGTH	WGT. LBS.	APL FONT	TRANS. SPEED (BAVD)	STANDARD FEATURES	OPTIONAL	NOTES	INTERFACE CAPABILITY
A. J.	841	I	14.9	1,2,3	130, 156	54	Yes	134.5	4,5,10,34,40	3,12,31,32,35,3		
C. T. C.	300	T	10,15,30	4	80	30	No	to 300	3,4,5,25.32.	21,26	(1)	
IBM	1050	I	15	2	130	N.A.	Yes	134.5	5,37	4, 7, 22, 23, 24, 54, 46, 50, 52, 31, 53, 51		
	2741	I	15		130/156	N.A.	Yes	134.5		4, 12, 31, 40, 42, 44, 48, 51,		
	2740-1	I	15		130/156	N.A.	Yes	134.5	5	4,7,12,36,37,46, 40,42,43,44,33, 51		
ITEL	1021	I	15		156	87	Yes	134.5	40			EIA RS232
	1051	I	15		156	92	Yes	134.5	22,40			EIA RS232
MEM.	1240	I	10,15,30 60 (0)	4	120	150	Yes (0)	to 600	6, 44, 40,	2,3,4,5,7,8,9,11, 37,41,45,46	(1)	EIA RS232
	1241	I	10,15,30 60 (0)	4	120	150	Yes (0)	to 600	6, 36, 45, 40,	2,3,4,5,7,8,9, 11,37,41,46,47	(1)	EIA RS232
	1280	I	10,15,30	4	120	150	Yes (0)	to 1200	6,13,21, 44,40.	2,3,4,5,7,8,9,11, 37,41,45,46	(1)	EIA RS232
	1242	I	10,15,30, 60 (0)	4	120	150	Yes (0)	to 1200	2,6,8, 14, 37,40	3,4,5,7,9,11, 41,46,47.	(1)	EIA RS232
NOV.	5-40-1	I	15	2	130		Yes	134.5 or 300	2,5,6,7,8,12, 40,42,44	3,4,11,31,36,37 43,45,47		EIA RS232
	5-40-2	I	15	2	130		Yes	134.5 & 300 or 600 or 1200 or 1800	6,8,12,40,42, 44	3,4,14,31,36,37, 38,39,45,47,48		EIA RS2[illegible]

TAB I

MFG.	MODEL	PRINT METHOD	PRINT SPEED CPS	TRANS CODES	LINE LENGTH	WGT. LBS.	APL FONT	TRANS. SPEED (BAVD)	FEATURES STANDARD	FEATURES OPTIONAL	NOTES	INTERFACE
NOV.	5-41	I	15	2,3	130	48	Yes	134.5	5,6.42.40	3,4,31,32,33,45,49		EIA RS232
	5-50	I	15	2,3,4,	130	85	Yes	to 2400	5,6,8,12,14,21, 40	1,2,3,4,36,37,45		EIA RS232
	5-51	I	15	2,3,4,	130	100	Yes	to 2400	5,6,8,12,14,21, 40	1,2,3,4,36,37,45	(3)	EIA RS232
OMNI	800A	I	15	1	N.A.	26	No	134.5	3,4,32,40		(4)	N.A.
T. T.	38	I	10	4	132	85	No	110	22,31,40	4,21,36,38	(5) (1)	EIA RS232-C
T. I.	710	T	14.8 30(0)	2	80	38	No	to 300	5,14,36,40	4,8,22,23,24,25		EIA RS232-B
	715	T	14.8 30(0)	2	80	38	No	to 300	5,14,36,42,40	4,8,22,23,24,25		EIA RS232-B
	725	T	10,15,30	4	80	35	No	to 300	3,4,6,32	22,25	(1)	N.A.
U.C.C.	30	I	15	2,3	130/156	54	Yes	134.5	5,10,12,40,42, 35	3,4,31,32		RS232-B
	31	I	15	2,3	130/156	55	Yes	134.5	5,10,21,35,40 42	3,4,31,32,33		

TABLE I

HARD COPY SEVICE FEATURES

1. Binary synchronous transmission
2. Automatic correction of transmission (line) error
3. Acoustic coupler
4. Modem
5. Parity check
6. Buffer 2 char.
7. Automatic EOB, EXT
8. Extended buffer
9. Split buffer (allows due preparation while simultaneously transmitting).
10. Repeat function
11. Numeric key cluster
12. Typamatic
13. Tape editing capability
14. Keyboard editing
21. Tape cassette
22. Paper tape
23. Card reader
24. Card punch
25. Peripheral interface
26. Video display
31. Pin feed for paper
32. Carrying case
33. Terminal to terminal communications
34. Local/Communications switch
35. Reverse break - allows computer to lock keyboard
36. Polling and Addressing
37. Record checking (LRCC)
38. Special document handling
39. Header control
40. Dial up capability
41. Remote tab sef
42. Receive interrupt
43. Transmit control
44. Transmit interrupt
45. Tractor feed
46. Unattended operation
47. Vertical forms control
48. Buffer receive
49. Print inhibit
50. EOT suppression (continuous transmission)
51. Audible alarm
52. Shared line capability
53. Auto fill character generation
54. Programmed keyboard
55. Additional printers

TABLE II

VIDEO DISPLAYS FEATURES

1. Upper case only
2. Upper and lower case
3. Character size
   a. 4/32 x 3/32 - 5x7 dot matrix
   b. 0.14 x 0.1 - 7x10 dot matrix
   c. Variable - program defined
   d. N.A. - a function of display size
4. Numeric keyboard
5. Tapes
6. Modem
7. Rollup
8. Characters displayed are software determined
9. Automatic polling
10. Printer
11. IBM compatible tape drive
12. Multiplexer
13. Paper tape
14. Software
    a. Assembler
    b. Test editor
    c. Graphics
15. Tape cartridge drives
16. Lightpen
17. Tablet
18. Jaystick
19. Card reader
20. Acoustic coupler
21. Synchronous communications
22. Memory word size
    a. 8 bits
    b. 16 bits
23. APL characters (note characters are program defined)
24. Line sharing
25. Multiple cursors

MFG.	MODEL NO.	CRT SIZE	CHARACTER SIZE	NO. CHARACTER	CHAR/LINE //No. Lines	CHARACTER DISPLAY	TRANS MISSION CODE	GRAPHICS CAPABILITY	TRANS RATES CHAR/SIZE	MEMORY SIZE	STD. OTHER EQUIPMENT	OPTIONAL
C.C.	CC-30 with CC-301	*Note 1	3D	800	40//20	2,23	Any	Yes	to 500,000	1K	22A	9,10,12,16, 19, 21
C.T.	2200	7x2½	3A	960	80//12	2	Any	No	10-960	2K-8K	22A, 9, 4, 15, 7, 24	6, 10, 11
IMLAC	PDS-1	7.5x8.5	3C	1200	80//40	2,23	Any	Yes	to 500,000	4K-32K	14A, 14B, 14C, 22B	1, 5, 10, 11, 12, 13, 16, 17,18,19,21
INCO.	10-20	9½x7	3B	1920	64//80	1	Any	No	10-960	1K-2K	7,9,22B 14A	5,10,12,13, 15,21,24,6

*Note 1 – determined by the user in the selection of TV to be used.

This is your terminal!

TRANSMISSION CODES

1. Correspondence = Selectric
2. BCD = PTTC/BCD
3. EBCDIC = EBCD
4. ASCII

PRINTING METHODS

Impact - I
Thermal - T

GENERAL NOTES

1. Requires ASCII to EBCDIC conversion of incoming data using a device such as the Memorex 1270 Terminal Control Unit.
2. Cannot use public telephone networks.
3. Has second tape cassette drive
4. Uses strip printer
5. The availability of an APL font on the print wheel would make this the most economical terminal for APL.

DISPLAY TERMINAL STATISTICS

	Terminal X To be Compared	Alphacom Inc. DW-33	American Data Systems ADS-780	Atlantic Technology 200 (ATC 2000)	Beehive Medical Electronics Model III	Burroughs B 9353	Bunker Ramo 2206/17	Control Data Corp. 214-11, 12	Computer Terminal Corp. Datapoint 3300	Conrac Corp. 201	Corning Data Systems Photochromic Display	Courier Terminal-Systems Executerm 65	Data 100 Corp. Model 73-2	Delta Data Systems Teterm II	Entrex, Inc. 480 Data-Scope
1. Cost per unit	$6,600	$3,450	$1,900 - 3,900	$8,500 (Est.)	$2,987	$8,250	$1,825	$6,250	$4,000 (Est.)	Factory Quote	$19,650	$5,150	$4,750	$3,500	$3,660
2. Display area size (hxwxd-inches)	6-3/4 x 9-1/4	6 x 8	5-1/2 x 7-1/4	7 x 9-1/2	9 x 6	9 x 12	6-1/4 x 8-3/4	6 x 8	8 x 6	7.5 x 11	11 x 8½	11.5 x 5.5	6 x 9	5½ x 11	2½ x 5
3. Spot diameter (mils)	30	12	NA	15	NA	20 - 25	25	36	25	20	18	35	UN	9	20
4. Character generation technique	7 x 10 dot	5 x 7 dot	9 x 14 stroke	Cursive stroke	5 x 7 dot	Stroke	5 x 7 dot	5 x 7 dot	9 x 14 dot	5 x 7 dot	Dot	7 x 8 dot	5 x 7 dot	7 x 9 dot	5 x 7 dot
5. Deflection method	M	M	M	EM & ES	M	EM	EM	M	M	EM	EM	M	EM	EM	EM
6. Brightness (Foot-Lamberts)	30	To 40	UN	75	40	50	52	30	75	50	15	50-100	UN	75	UN
7. Characters per line	64	72,80 (0)	32 - 80	40 - 80	40 80 (0)	80	80	50 - 80 (0)	72	80H, 40V	72	40 - 80	72, 80	80	40
8. Lines	30	25	4 - 30	3 - 48	20	25	24	20 - 13 (0)	25	12H, 24V	64	6 - 12	24	27	12
9. Maximum displayable character positions	1,920	1,800, 2,000 (0)	2,400	1,920	8,00 - 1,600 (0)	1,024	1,920	1,000 - 1,040 (0)	1,800	960	4,608	960	1,920	2,169	480
10. Size of character (hxw - inches)	.14 x .10	0.16 x 0.07	3/16 x 9/32	.33 x .33	0.1 x 0.2	.15 x .12	.13 x .25	.25 x .13	18 x .11	.09 x .13 (H)	125 x 90 mils	.14 x .11	.14 x .08	.16 x .09	.25 x .13
11. Is controller separate?	No	No	No	Yes	No	Yes	Yes	Yes	No	No	NA	No	No	No	Yes
12. Type of memory	Core	Delay, MOS/LSI	MOS/451	Delay	MOS/LSI	Core	Delay	Delay	MOS	Delay	NA	MOS/LSI	MOS	MOS	MOS/LSI
13. Characters in memory	2,040	1,800, 2,000 (0)	2,400	1,920	800, 1,500 (0)	1,024	960	1,000 - 1,040 (0)	1,800	960	NA	240 (0) - 960	1,920	500 - 2,500	480
14. Rate (Baud or bps)	110 - 4,800	110 - 4,800	75 - 9,600	1,200 - 4,800	110 - 2,400	4,800	1,200 - 2,400	2,000 - 4,800 (0)	110 - 2,400	0 - 2,400	110 - 300	1,200, 2,400	110 - 2,400	All serial ranges	All serial ranges
15. Code for output	ASCII	ASCII	ASCII	ASCII	ASCII	ANSI	ASCII	BCD, ASCII (0)	ASCII	ASCII	ASCII	ASCII	ANSI	ASCII	EBCDIC
16. Size of terminal, incl. keyboard (hxwxd-inches)	18/19/27	17/18/21	13/18/18	16/16/29	14/16/21	18/19/29	15/15/21	17/18/29	14/18/18	10/18/30	UN	18/21/26	14/19/23	16/24/27	10/17/22
17. Is keyboard detachable?	Yes	No	No	Yes	No	Yes	Yes	No	No	No	No	No	No	Yes	Yes
18. Controller, if separate (hxwxd-inches)	NA	NA	NA	25/22/16	NA	27/19/14	25/23/14	19/6/24	NA	NA	NA	NA	NA	NA	5/19/23
19. Character typeover?	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	No	Yes	Yes	Yes	Yes
20. Character insert?	Yes	Yes	O	Yes	Yes	O	Yes	No	No	No	No	Yes	No	Yes	Yes
21. Character delete?	Yes	Yes	O	Yes	Yes	D	Yes	No	No	No	Yes	Yes	No	Yes	Yes
22. Line insert?	Yes	No	O	0	Yes	0	No	No	No	No	No	No	No	Yes	Yes
23. Line delete?	Yes	No	O	0	Yes	0	No	No	Yes	No	No	No	No	Yes	Yes
24. Roll-up feature?	Yes	Yes	Yes	0	Yes	No	No	No	Yes	No	No	Yes	Yes	Yes	Yes
25. Roll-down feature?	Yes	No	No	0	No	No	No	No	Yes	No	No	No	No	Yes	Yes
26. Tabulating feature?	Yes	Yes	Yes	Yes	Yes	Yes	Yes	No	No	Yes	Yes	Yes	Yes	Yes	Yes
27. Vector generation?	Partial	No	No	No	No	UN	Partial	No	No	No	Yes	No	No	Y (line)	No
28. Type of cursor?	4 Vert. lines	CU/B	CU/B	CU/B	CU	HB	Square	CU	B	Blinking	Flashing cross	CU/Steady	U/End	CU/B	Square/0
29. Split screen capability?	Yes	Yes	O	Yes	Yes	No	Yes	Yes	No	Yes	NA	Yes	Yes	Yes	Yes
30. Partial transmit capability?	Yes	Yes	O	Yes	Yes	Yes	No	Yes	CT	Yes	No	Yes	Yes	Yes	Yes
31. Audible alarm for incoming messages?	O	Yes	O	No	No	No	0	Yes	Yes	Yes	No	No	Yes	Yes	Yes

B = Cursor Blinking
CT = Transmission is Character at a Time
CU = Cursor Underlined
EM = Electromagnetic
ES = Electrostatic
H = Horizontal Unit
HB = Horizontal Breckots
M = Magnetic
O = Optional
U/End = Underline from Given Position to Right-most End of line
V = Vertical Unit

Line insert—with the cursor at the beginning of a line, pressing a "line insert" key moves that line and all subsequent lines down.

Line delete—with the cursor at the beginning of a line, pressing a "line delete" key causes the line below to replace that line and all subsequent lines to move up.

Roll-up—on a 20-line screen, typing a 21st line causes the first line to disappear, all other lines to shift up, and the 21st line to appear at the bottom.

Roll-down—assuming roll-up capability, can a special key cause line one to reappear and line 21 to disappear, reversing the roll-up characteristic?

Tabulating feature—can tabs be set so that pressing a "tab" key will move the cursor to a predetermined position, to the right or down?

Vector generation—is a true generation technique used to draw lines on the screen? Or can the dots that normally form dot matrix characters also create vectors such as curves or lines.

Cursor type—blinking, character-underlined, etc.

Split screen capability—one part of the screen can display variable data, while the rest contains a fixed format.

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By reducing data logically, Alan B. Kamman of Arthur D. Little Inc. implements a selection technique for crt terminals that is equally valid for other types of equipment

How to pick crt terminals

"How should I select a crt terminal?" Ask that question to ten people and you'll get ten different answers. And each will have impressive collections of statistics with which to back up their contentions. The prospective buyer may, himself, have access to sophisticated and expensive services which provide a great deal of data, most of which is updated periodically. Or he may rely on computer periodicals for similar information.

A sound method of data reduction is particularly important when selecting a crt terminal because there are now over 40 U.S. manufacturers producing between 60 and 70 models, and using from 20 to 40 different specification categories. The simplified method described here reduces all data into summary tabular form. Final analysis may then be made with confidence, based on that summary.

The procedure divides into four operations: data collection and tabulation (gather all up-to-date material, define terms, list the information, and note inconsistencies for later analysis if needed), calibration of specifications (form weightings based on the application or on expert opinion), scoring the matrix (organize data, calculate the weighted values, and compare), and analysis (study, in depth, all the equipment scoring higher, and a few which score lower but seem comparable).

The first step in any selection procedure is collecting information to form a current data base. Many computer shops have outdated equipment comparisons published by various services. Often, the companies subscribe to a service for a year or two, drop the subscription, and rely on the old data. Most offices also have collections of suppliers' brochures picked up at various conferences. Both of these situations can cause mistakes. So to eliminate this risk, new data should be requested from potential suppliers—and in a specified form.

Since semantic difficulty is always a constant problem in the edp field, the user must do some research before comparing peripherals. He must set the definitions and specifications that are meaningful to him and request precisely that information.

For this article, a technical questionnaire—designed to be filled out easily—was sent to 37 crt display terminal manufacturers. All information in the tables was obtained directly from the producers via the questionnaire.

The following definitions apply to crt terminals:

Unit cost—basic retail sale price of one unit, excluding quantity discounts, optional features, installation fees, and maintenance contracts.

Display area—height and width, in inches, of the area of screen used to display characters.

Spot diameter—diameter of the focused spot on the screen, in mils.

Character generation technique—dot matrix (5x7, 9x11, etc.), stroke, monoscope, or other.

Deflection method—magnetic, electrostatic, or other.

Brightness—in foot-lamberts. If crt model uses a screen (colored or polaroid), give brightness with screen in place.

Characters per line

Lines

Maximum displayable character positions—characters per line multiplied by the number of lines. Does not include characters stored in memory.

Character size—height and width, in inches, of the character font used.

Controller separate—is the controller logic built into the terminal?

Controller size, if separate— height × width × depth, in inches.

Memory type—delay line, core, MOS/LSI, etc.

Characters in memory—number of characters which can be held in storage at one time.

Rate—speeds (basic and optional) in baud at which the model can operate. List optional as well as basic data.

Output code—USASCII, EBCDIC, etc.

Terminal size, including keyboard—height × width × depth, in inches, assuming that the keyboard is attached to, or flush with, the crt case.

Detachable keyboard?—answer YES, NO, or O for optional.

Character typeover—with the cursor over a character, pressing a key replaces the character with a new one.

Character insert—with the cursor over a character, pressing an "insert" key displaces that character, and moves others one space to the right.

Character delete—with the cursor over a character, pressing a "delete" key causes the character under the cursor to disapper and everything to the right shifts one space to the left.

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DISPLAY TERMINAL COMPARISON *

	Weight	Alphacom DW-33	Amer. Data Sys. ADS-760	Atlantic Technology 200	Beehive Model III	Burroughs B9353	Bunker Ramo 2206/17	CDC 214-11, 12	Datapoint 3300	Conrac 201	Corning Photochrome	Courier Executerm 65	Data 100 Crop. 73-2	Delta Data Telterm II	Entrex 480 Data-Scope	IBM 2265	Raytheon DIDS 401-3	RCA 8755-200	Sanders 620	DatagraphiX SD 1110/360R	SYS Editerm 100/200	TEL DST-50	Ultronic Videomester 7000	UNIVAC Uniscope 100
1. Cost per Unit																								
2. Display Area Size (hxwxd-inches)	2	–	–	+	–	+	–	–	–	+	+		–	–	–	–		–	–		–	–	+	–
3. Spot Diameter (mils)	2	+		+		+	+	–	+	+	+	–		+	+	+	+	–	+		–	+	+	
4. Character Generation Technique	3	–	+	+	–	+	–	–	+	–			–		–	+	+	+	+	+	–	–	–	+
5. Deflection Method	1			+																				
6. Brightness (Foot-Lamberts)	3	+		+	+	+	+		+	+	–	+		+		–	+	+		+	–	–	+	–
7. Characters per Line	3	+	+	+	+	+	+	–	+	+	+	+	+	+	–	+	+	+		+	+	–	+	+
8. Lines	3	–		+	–	–	–	–	–	–	+	–	–	–	–	–	–	–	+	+	–	–	–	–
9. Maximum Displayable Character Positions	3		+		–	–		–	–	–	+	–		+	–	–	–	–	+	+		–	–	–
10. Size of Character (hxw-inches)	2		+	+		+	+	+	+	–	+				+	+	+		–	–	–	+	–	+
11. Is Controller Separate?	3			–		–	–	–							–	–	–			–			–	
12. Type of Memory	1	–	+	–	+		–	–	+	–		+	+	+	+	–	–	–	–	–	+	+	–	
13. Characters in Memory	3		+	–	–	–	–	–	–	–		–	–	+	–	–	–	+	–	–		–	–	–
14. Rate (Baud or bps)	2		+	–	–		–	–	–	–	–	–	–	+	+	–	–	–	–	–	+	+	–	+
15. Code for Output	2														–									
16. Size of Terminal, Incl. Keyboard (hxwxd-inches)	1	+	+	+	+		+		+				+		+	+	+	+	+	+	+	+	+	+
17. Is Keyboard Detachable?	1	–	–		–			–	–	–	–	–	–	–							–			
18. Controller, If Separate (hxwxd-inches)	1			–		–	–	–							–	–	–			–			–	
19. Character Typeover?	3										–													
20. Character Insert?	3		–			–		–	–	–	–		–			–			–				–	
21. Character Delete?	3		–			–		–	–	–			–			–			–				–	
22. Line Insert?	2	–	–	–		–	–	–	–	–	–	–	–			–	–		–	–			–	
23. Line Delete?	2	–	–	–		–	–	–		–	–	–	–			–	–	–	–	–			–	
24. Roll-up Feature?	1			–		–	–	–		–	–					–	–	–	–	–	–		–	–
25. Roll-down Feature?	1	–	–	–	–	–	–	–		–	–	–	–			–	–	–	–	–	–		–	–
26. Tabulating Feature?	1							–	–									–						
27. Vector Generation?	1	–	–	–	–	–		–	–	–		–	–	+	–	–	–	–	–	–	–	–		–
28. Type of Cursor?	1																							
29. Split Screen Capability?	2		–			–			–							–		–	–				–	
30. Partial Transmit Capability	2		–				–		–		–													
31. Audible Alarm for Incoming Messages?	1	+		–	–	–		+		+	–	–	+	+	+	–	–		–		–	+	–	
Total Plus Score		10	18	20	8	15	11	3	15	11	15	7	6	19	9	11	14	13	12	16	7	9	11	11
Total Minus Score		16	19	18	20	29	26	41	28	31	21	21	26	6	24	37	24	21	26	19	20	21	36	17
Net Score		-6	-1	+2	-12	-14	-15	-38	-13	-20	-6	-14	-20	+13	-15	-26	-10	-8	-14	-3	-13	-12	-25	-6

Key to Code: + = Probably superior to Terminal X
– = Probably inferior to Terminal X

* Based on weightings from 60 users' applications

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comparison *technique,* and is not intended as an absolute ranking of display terminals. It is based on only 24 of the models for which information was supplied, and therefore does not reflect the total universe of products supplied by these vendors. Also, nine manufacturers did not reply, and a user interested in a true and total comparison would have to persist until he received suitable replies from all sources.

To illustrate the scoring matrix, compare the technical specifications of Terminal X with those of the Alphacom DW-33 in the statistics chart. In the second category, display area size, Alphacom provides fewer square inches than Terminal X. Therefore, a minus is placed in that position in the comparison table. Comparing spot diameter, Alphacom's focus point is smaller (offering a potentially crisper character image), so it rates a plus in the appropriate column.

When all comparisons are finished, all the plusses and minuses—multiplied by their weightings—are added and the net result listed. Alphacom for example scored +10 and —16, netting a —6.

Scoring matrix results indicate that terminals with a net plus score are probably superior overall to Terminal X from the viewpoint of the people responsible for the weightings, while those with a negative score are probably inferior. Since the weightings reflect the specific application, or the biases of the users asked for their opinions, they are usually valid only for a current study. Comparisons of terminals for other applications would probably produce different weighting systems, which, in turn, would generate different net scores.

SCORING MATRIX RESULTS *

Rank	Company	Terminal	Score	Price
1	Delta Data Systems	Teiterm	+13	$ 3,500
2	Atlantic Technology	200 (ATC 2000)	+ 2	8,500 (est).
3	American Data Systems	ADS-760	— 1	3,900 (est.)
4	Stromberg DatagraphiX	SD 1110/360R	— 3	8,500 (est.)
5	Alphacom	DW-33	— 6	3,450
6	Corning Data Systems	Photochromo	— 6	19,650
7	Univac	Uniscope 100	— 6	3,545
8	RCA	8755-200	— 8	8,325
9	Raytheon	DIDS 401-3	—10	4,350
10	Beehive Electrotech	Model III	—12	2,987
11	TEC	DST-50	—12	2,363
12	Computer Terminal	Datapoint 3300	—13	4,000 (est.)
13	SYS Computers	Editerm 100/200	—13	2,995
14	Courier	Executerm 65	—14	5,150
15	Sanders	620	—14	5,670
16	Burroughs	B 9353	—14	8,250
17	Entrex	480 Datascope	—15	3,660
18	Bunker-Ramo	2206/17	—15	1,825
19	Data 100	73-2	—20	4,750
20	Conrac	201	—20	8,000 (est.)
21	Ultronic Systems	Videomaster 7000	—25	4,980
22	IBM	2265	—26	14,000 (est.)
23	CDC	214-11, 12	—38	6,250

* Based on weightings explained in text

FINAL SUMMARY *

Rank	Company	Terminal	Price
1	Alphacom	DW-33	$ 3,450
2	Delta Data Systems	Teiterm II	3,500
3	Univac	Uniscope 100	3,545
4	American Data Systems	ADS-760	3,900 (est.)
5	Terminal X		6,600
6	Atlantic Technology	200 (2000)	8,500 (est.)
7	Stromberg DatagraphiX	SD1110/360R	8,500
8	Corning Data Systems	Photochromo	19,650

* Based on weightings explained in text

All candidate terminals should be listed in descending order of their scores; a selection is made consisting of all those with a positive score, and several with negative scores but which seem to have qualities similar to those offered by Terminal X. A final listing can now be made, by cost, and analysis of the remaining candidates can begin.

Corning Data Systems' terminal, at $19,650, caters obviously to a different market and need not be considered further. Also note that the questions raised earlier about the Bunker-Ramo and IBM terminals do not need to be answered since neither made the final list.

Only six terminals remain that compare closely with Terminal X. Atlantic Technology and Stromberg DatagraphiX are similar but cost $1,700 more. Further investigation shows that they are compatible with IBM mainframes. If the application requires an IBM computer, and if Terminal X doesn't offer this feature, these terminals might be worth the additional cost.

Assuming that Terminal X is made by a fairly new company, it corresponds in that respect to all of the remaining terminals with the exception of Univac's. The Uniscope 100, at half the price of Terminal X, must be considered prime competition for two reasons. First, many users prefer the security of purchasing from an established firm, and second, Univac maintains a competent nationwide service organization. So salesmen from the other candidate companies must be questioned in detail about their maintenance facilities and procedures. The remaining three terminals, Alphacom, Delta Data Systems, and American Data Systems, all seem to offer comparable or superior features at a lower cost than Terminal X. But Terminal X, which happens to be Incoterm's SPD 10/20, is programable, making it more flexible than the others. All of these should rank behind Uniscope in the summary chart.

The result of this evaluation has been to reduce the original 24 models to four. If the application requires extreme emphasis on one or two terminal characteristics, such as editing functions, the field can be reduced even further.

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Of course, our other features match those offered by other video terminals, with one big difference: we've put the best of all into TelTerm. Like the most readable upper/lower case character set you can buy. And addressable cursor, blinking, underlining, formatting and line drawing capabilities. With more too. There's also a long list of useful accessories, such as a light pen, built-in acoustic coupler, hard copy printers, cassette recorders and multiplexers.

End the disappearing data act now. Ask for more information, demonstration, or applications assistance. Or ask about our Delta 1 color display. DELTA DATA SYSTEMS Corporation, Woodhaven Industrial Park, Cornwells Heights, Pa. 19020; telephone (215) 639-9400.

△ Delta Data Systems

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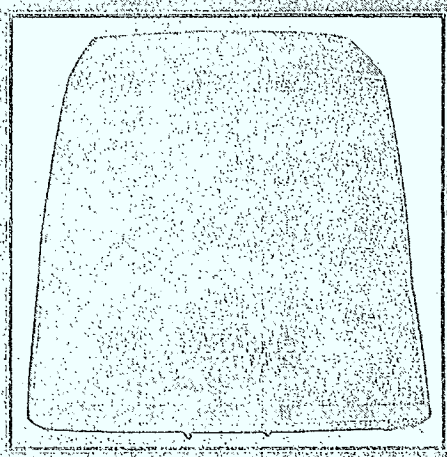


	IBM 2265	Raytheon Co. DIDS 401-3	RCA Corp. 8755-200	Sanders Data Systems 620	Stromberg Datagraphix SD1110/360R	SYS Computer Corp. Edterm 100/200	TEC, Inc. DST-50/20/02/01 100/01/01	Ultronic Systems Corp. Videomaster 7000	UNIVAC Uniscope 100
	$340/Mo.	$4,350	$8,325	$5,670	$8,500(Est.)	$2,995	$2,363	$4,980	$3,645
	10 x 5	7 x 9	8 x 5.6	7 x 0.3	8 x 8	8 x 5	6½ x 9	7⅛ x 9⅝	5 x 10
	20	15	38	20	NA	50	15	20	NA
	Stroke	Monoscope	Monoscope	Stroke	Charactron	5 x 7 dot	5 x 7 dot	5 x 7 dot	Stroke
	EM	M	M	M	M	M	EM	M	EM
	13	50	50	30	40	40	27	40	22
	60, 64	40 - 80	64-61	64H, 52V, 64H (0)	80	80	50	60, 64	32, 64, 80
	12, 15	12 - 16	20 - 14	82H, 48V	36	24, 12 (0)	20	12, 15	6, 12, 16
	960	10,40, 1,472 (0)	1,134, 1,782 (0)	2,688	2,880	1,920	1,000	960	1,024
	.13 x .18	.21 x .16	.14 x .10	.13 x .08	.13 x .09	.10 x .08	.19 x .13	.12 x .08	.15 x .12
	Yes	Yes	No	No	Yes	No	No	Yes	No
	Delay	Delay	Delay	Delay	Delay	MOS	MOS	Delay	Core
	960	1,040	2,268	780	1,100	2,048	1,000		1,024
	1,200 (0), 2,400 (0)	1,200, 2,400	300 - 2,400	100 - 2,400	2,000, 2,400	600 - 9,600	All rates	1,200, 2,400	110 - 9,600
	ASCII	ASCII	ASCII	ASCII	ASCII	ASCII	ASCII	ASCII	ASCII
	16/18/26	15/19/24	14/17/30	19/16/26	16/14/30	16/20/21	12/14/17	15/14/19	12/18/28
	Yes	Yes	Yes	Yes	No	No	Yes	Yes	Yes
	27/15/26	15/20/25	NA	NA	14/12/23	NA	NA	12/17/12	NA
	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
	No	Yes	Yes	No	Yes	Yes	Yes	No	Yes
	No	Yes	Yes	No	Yes	Yes	Yes	No	Yes
	No	No	Yes	No	No	Yes	Yes	No	Yes
	No	No	No	No	No	Yes	Yes	No	Yes
	No	No	No	No	No	0	Yes	No	No
	No	No	No	No	No	0	Yes	No	No
	Yes	Yes	0	Yes	Yes	Yes	Yes	Yes	Yes
	No	No	No	No	No	No	No	Partial	No
	CU/Stead6	Inverted L	CU/Steady	UB	Square-B	CU/Steedy	CB	CU	Rt. Angle
	No	Yes	0	No	Yes	Yes	Yes	No	Yes
	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
	No	No	0	No	0	No	Yes	No	UN

Partial transmit capability—data in various parts of the screen can be transmitted without sending the entire display.

Audible alarm for incoming messages—an incoming message, or a code asking the operator to interrogate the computer, activates an audible alarm such as a buzzer or a bell.

Of the terminal makers polled, 26 responded, and the information was tabulated. The tabulation such as the Display Terminal Statistics chart, shown on these pages, should be performed directly by the user so he gets a feel for the data, and recognizes inconsistencies which he may eventually question. Some apparent inconsistencies were noted during the tabulation of this study. In the Display Terminal Statistics chart, for example, the price of the Bunker-Ramo terminal is listed as $1,825. This seems exceptionally low for the qualities provided, and for the pricing history of its manufacturer. Perhaps the price applies only to the display terminal, and the controller (absolutely necessary to make any terminal work) is priced separately. In another instance, IBM replied with monthly rentals for their terminal and controller. But the user must have the actual purchase price in order to compare properly. He must also know, either from experience or by questioning the vendor, that "factory quote" for the Conrac terminal means that it can be bought only as OEM equipment, and that an end-user must make arrangements through another vendor.

One major advantage of this comparison system is that such inconsistencies as those just described don't have to be resolved immediately. They become meaningless if the terminal doesn't qualify for the Final Summary table on page 45. So they are noted and set aside until needed.

Having collected all pertinent data, the next step is to weight each of the specifications. The user can do this if he knows his application well, and understands the relative importance of each category. If the comparison is being made by a vendor testing his product against others, or by a corporate staff member—who might be unfamiliar with the details of the application—opinions should be collected from users, and the weighting system formed from these factors.

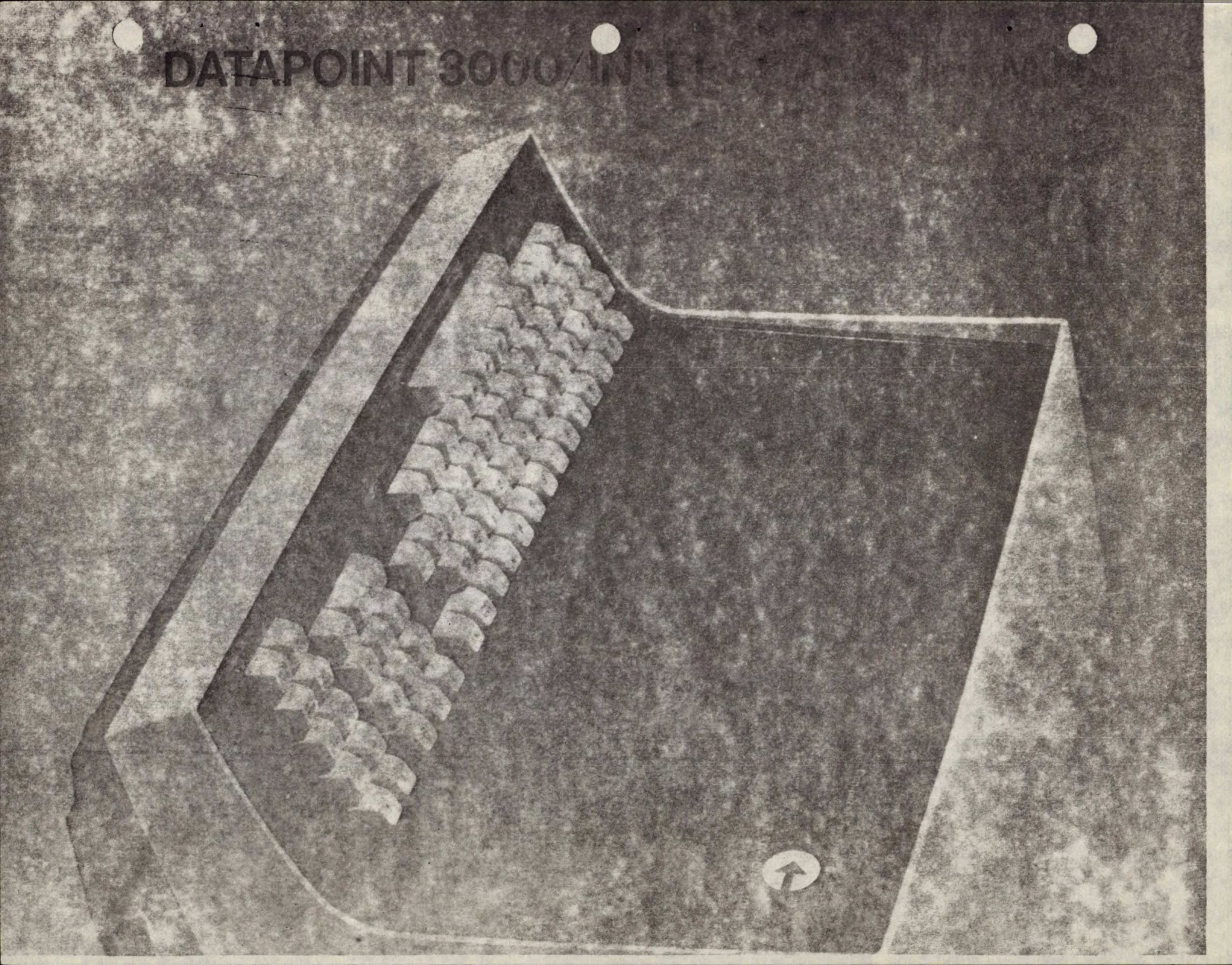
A simple weighting system has proved quite adequate to reduce the matrix. A weight of three was applied to very important factors, two for less important factors, and one for unimportant features.

These weightings, which are listed under the appropriate columns in Display Terminal Comparison chart on page 44, reflect the collective opinion of over 80 display terminal users throughout the country. To form effective weightings, the user must know which technical methods are best. Using character generation as an example, a 7x9 dot matrix is generally superior to a 5x7 matrix since the resulting character is clearer. Furthermore, since a stroke technique probably produces an even sharper character, a terminal with this method would rate higher than either of the dot matrix terminals.

To illustrate the comparison process, the name of one vendor has been deleted without his knowledge, and the designation "Terminal X" substituted.

Terminal X will be compared to every other terminal for each of the defined specifications. Where the terminal feature under comparison is superior to Terminal X, a plus (+) sign is placed in the table; where the subject feature is considered inferior, a minus (—) sign is entered in the table.

Remember that the information here illustrates a


DATAPOINT 3000/

DATAPOINT 3000/INTERACTIVE TERMINAL

The Datapoint 3000 was developed to provide the time sharing user with an inexpensive, interactive display terminal with full-screen teletypewriter compatability. The terminal is attractively styled and quiet enough to fit the most critical office environment.

The Datapoint 3000 operates at data rates of 110, 150, 220, and 300 bits/second (10, 15, 20, and 30 characters per second), and can be used with a Datapoint 3300 Thermal Printer for hard copy. A separate eleven-key number pad and ten function keys provide a functional keyboard arrangement.

FUNCTIONAL CHARACTERISTICS

Screen Size
12 inch rectangular tube

Character Size
0.16" x 0.11"

Number of Characters
1800

Characters Per Line
72

Number of Lines
25

Refresh Rate
60 frames per second

Character Set (ASCII)
27 alphabetic
10 numeric
26 special

Controls
Cursor: up, down, right, left, home up, home down
Erase: to end of line, to end of frame
Frame roll: up, down
Power: on, off
Mode: remote/local
Transmission: full duplex/half duplex
Rate: 110, 150, 220, 300 bits/second

PHYSICAL CHARACTERISTICS

Dimensions
Width: 18 inches
Height: 14 inches
Depth: 19 inches
Weight: 48 lbs.

POWER REQUIREMENTS

115 v.a.c., 60 Hz, 130 watts

Model Codes
3000-100 Interactive CRT Terminal
3300-102 Answerback option (factory-installed only)
3300-110 Telegraph Loop Keyer
3300-111 230 v.a.c., 50 Hz option (factory-installed only)
3300-112 Auto carriage-return/line-feed deletion kit
3300-113 Coded Cursor Key Kit
3300-114 Backspace Coding Kit
3300-115 Escape Key Coding Kit
3300-116 Space Over-write Latch Kit
3300-200 80 Column Printer
3300-201 Print Control option for 3300-200
3300-400 Data Coupler

Computer Terminal Corporation

9725 Datapoint Dr • San Antonio, Texas 78229 • Phone 512/696-4520

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