Communications Research Centre

DATA TERMINAL TECHNOLOGY - PRESENT AND FUTURE
VOL. I - STATE-OF-THE-ART

BY

STAFF OF URWICK, CURRIE & PARTNERS LTD.

EDITED BY

R.G. FUJAROS

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DEPARTMENT OF COMMUNICATIONS

CANADA

DATA TERMINAL TECHNOLOGY – PRESENT AND FUTURE
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R.G. Fujaros

(Communication Systems Research and Development Directorate)

(Technology and Systems Branch)

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The information contained in this report is essentially in the form prepared for the Communications Research Centre (CRC) by Urwick, Currie & Partners Ltd., with the exception of minor changes to report format and presentation as mutually arranged. This report represents the views and conclusions of Urwick, Currie & Partners Ltd. The publication of the report by the CRC does not necessarily imply the agreement of CRC with these views and conclusions.

PREFACE

The Department of Communications (DOC) of the Government of Canada includes under its mandate a number of broad objectives. One of these to "promote the orderly evolution and growth of efficient and effective communication systems and services for Canada". Towards this general objective the Department has in recent years carried out studies directed specifically at fostering the optimum development of the Canadian computer/communications industry — including the communications common carriers, the manufacturing industry and the service industry.

Thus the DOC Computer/Communications Task Force under Dr. H.J. von Baeyer in its report "Branching Out"* and in subsequent studies, addressed this question and presented a number of specific recommendations. In particular the Task Force cited the proliferation of data communications terminals as posing a problem and proposed that research be conducted on the use of hardware to overcome problems of incompatibility. Further the Task Force stressed the desirability of an indigenous hardware supply role, particularly with regard to data terminal devices and computer peripherals. In addition to suggesting that component and systems research and development should be performed primarily by private industry, the Task Force indicated that government research laboratories also had a role to play in the research and development activity with the ultimate objective of appropriately transferring the results of this research activity to industry. "Branching Out" also addressed other subsidiary but relevant points, such as the role of government in the field of standardization and the use of government procurement practices to support Canadian industry.

Responding to these objectives, recommendations and policy proposals, the Communications Research Centre (CRC) of the Department of Communications initiated a broad research and development program in the area of computer/communications. Specific projects covering many aspects of the subject were undertaken. One of these projects is the "Data Terminal Research and Development Project"**, of which the study reported herein is a part. The broad objective of this project is to explore the use of hardware development as a vehicle to support government policy with respect to computer/communications systems and services relevant to future Canadian requirements. In particular a data communications terminal is to be developed to meet existing or near-term user needs. The data terminal design is to include features which will encourage the evolution of a coherent data communications system for Canada. The area selected for study is that of interactive data terminals, on the premise that its future impact on data communications is expected to be high, both in terms of number of terminals and terminal data traffic, and that this area represents a viable opportunity for Canadian activity in the overall field of computer/communications. Though the Data Terminal Project has restricted its initial research activities to interactive data terminals, the project results are generally applicable to a wider area, for example to remote job entry systems, and to local computer peripheral devices.

The work on the Data Terminal Project during the fiscal year 1973/74 constituted a feasibility study phase, with work carried out primarily by means of industrial contracts. To establish feasibility and to define the project in greater detail for subsequent phases of the project (also to be carried out mainly by industrial contracts), a series of studies was commissioned by CRC as follows:

a) A survey and assessment of user requirements and relevant market factors;

b) A survey and assessment of research and development, manufacturing, and marketing and servicing capabilities of Canadian firms in the data terminal area;

c) A survey and assessment of the state-of-the-art of data terminal equipments;

d) A forecast and assessment to 1985 of the technologies relevant to the data terminal field; and

e) A study of standards and protocols relevant to data terminal technology and their influence on the design and use of data terminal equipments.

* *Branching Out, Report of the Canadian/Communication Task Force, Department of Communications, Ottawa, May, 1972.*

** *Project initiated in April, 1973.*

This report summarizes the work carried out with respect to topic c) under the title "State-of-the-Art". It should be noted that this report complements the report for the companion study under topic d) entitled "Technology Forecasting and Assessment", the former being Volume I and the latter Volume II. The first section of this report is the EXECUTIVE SUMMARY which highlights the major findings of the study. The remaining sections and appendices cover the details of data gathering and data analysis undertaken for the study.

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ABSTRACT

*Data Terminal products currently available within Canada and those not yet available which have potential for significant future impact on the Canadian terminal market are surveyed. The products are classified according to major terminal types for each of which the approximate number installed in Canada and the price range are presented. The products are examined with respect to their physical and functional implementation, and the cost and extent of use of the various underlying technologies for the different terminal types are presented.**

1. EXECUTIVE SUMMARY

This study, one of a series commissioned by the Communications Research Centre to foster research into interactive terminals, constitutes a survey of the state-of-the-art of available interactive data terminal products and their component technologies. The work was carried out by Urwick, Currie & Partners Ltd and associated consulting specialists.

The major findings of this state-of-the-art study are summarized in this section with supporting details presented in the following sections.

* *Study conducted from November, 1973 to March, 1974.*

1.1 There is a good representation of interactive data terminal products of all categories now available in Canada. Certainly, there are no obvious omissions as to current commercial products representing new or unique functions or technologies.

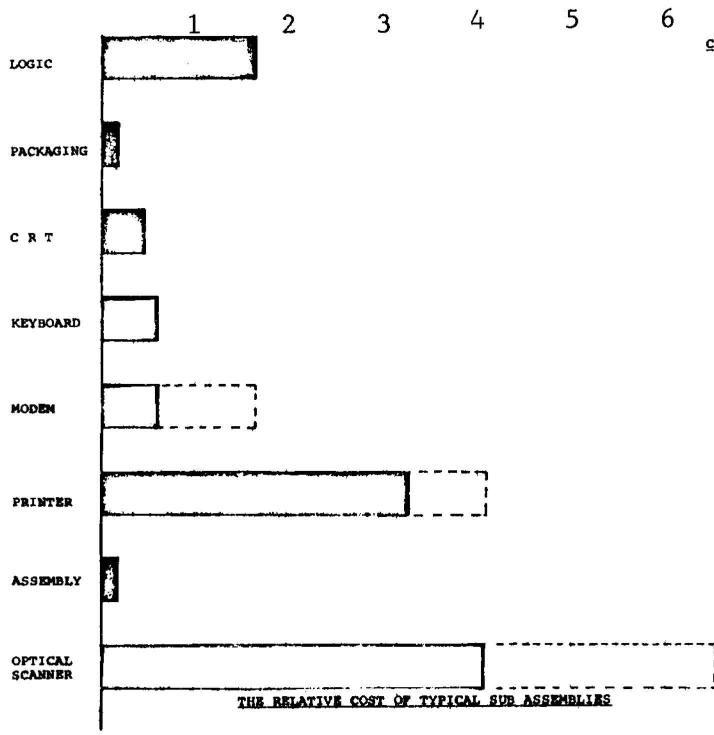
1.2 The terminal population appears to be dominated by products provided through U.S. Suppliers. We estimate that greater than 90% of those currently installed are of U.S. origin. The significant manufacturers of terminals in Canada are subsidiaries of U.S. firms, assembling predominantly U.S. manufactured components and, ironically, exporting a substantial portion of their product.

1.3 The actual fabrication of a terminal is essentially the assembly of pre-manufactured components and represents on the average only 8% - 10% of the total manufacturing costs.

1.4 Most of the current products have integrated circuit memory and logic and this constitutes a major cost component of typical terminal products. Although IC component costs are decreasing, the trend is to maintain terminal cost and provide more function/dollar.

1.5 Printer mechanisms and optical scanners constitute the major cost component when employed in a general purpose terminal. The accompanying chart illustrates approximate relative costs of various sub-assemblies. This chart is not representative of special purpose devices such as point of sale and limited data entry terminals.

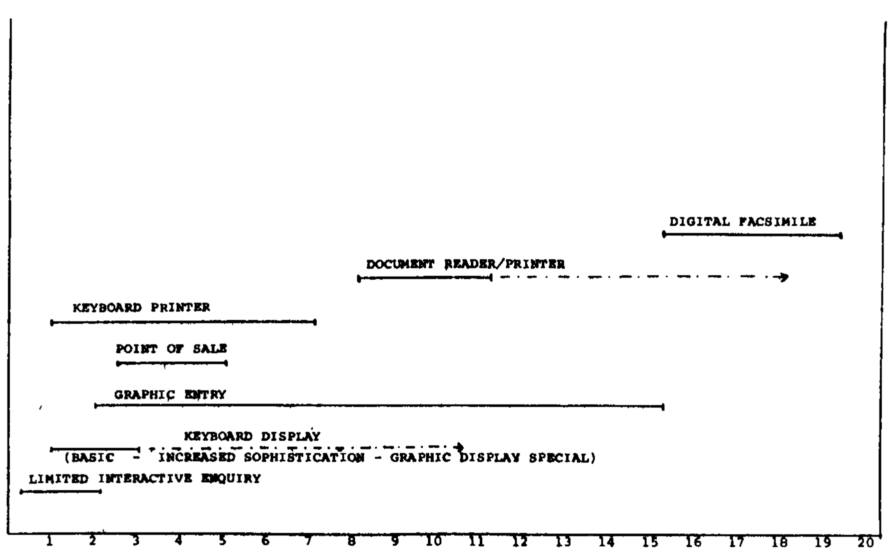
CHART NO. 1



THE RELATIVE COST OF TYPICAL SUB ASSEMBLIES

1.6 The interactive data terminal classes surveyed cover a wide price range, as shown in the chart below. The price range is indicative of the range of sophistication in the terminals.

CHART NO. II

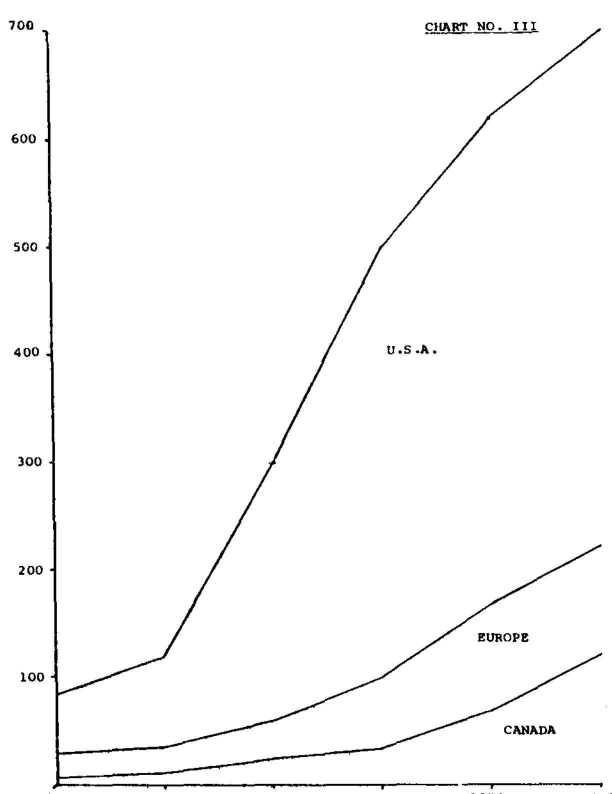


TYPICAL PRICE RANGES FOR TERMINAL CLASSES

1.7 The cost of manufacture is extremely volume sensitive due to the quantity/unit cost relationships of the components as well as the volume thresholds at which large scale integration can be justified. Several integrated circuit manufacturers have stated that 50,000 to 100,000 chips is the minimum quantity of units to be cost effective.

1.8 The major technologies identified are all at the component or sub-assembly level. Manufacture of components or sub-assemblies is a highly specialized game. Generally it is dominated by a few firms in each technology and these concentrate their expertise in a narrow range. Even the larger integrated companies manufacturing data terminals tend to have OEM contracts for significant components.

1.9 The terminal population in Canada is currently less than 7% of the U.S. but the percentage growth rate in Canada is currently higher.



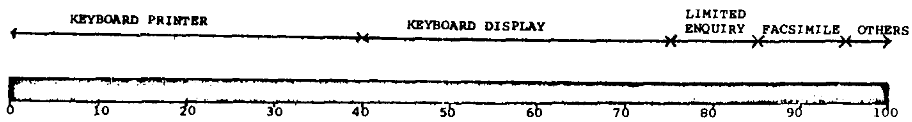
Figures do not include T.W.X./TELEX printers

TERMINAL POPULATION (000's)

1.10 The predominant classes of interactive terminals are the TTY (Keyboard/low speed printer) type and the Keyboard/Display. These two categories represent over 70% of the units currently employed.

1. Percentages do not include TWX/TELEX printers
2. Facsimile equipment includes non-digital units

CHART NO. IV



% DISTRIBUTION OF TERMINAL POPULATION

1.11 The dominant display of the keyboard/display terminal is still a CRT with a very insignificant population of plasma display. This is partly due to the short time that the plasma products have been on the market. Opinions indicate that eventual competition will come from crystal displays.

1.12 With respect to printers, about 75% currently employ some form of impact technology, but the field that seems to be receiving the most development attention is the non-impact technology, particularly the thermal technique. This is influenced by current activity in the calculator market.

1.13 In the OCR market the current technology generally employs a photo-diode scanner. Various charge coupled device (CCD) scanners appear to be the potential replacement in the next generation of terminals, but a major cost breakthrough is not indicated.

1.14 In the case of facsimile equipment, the indication is that digital data transmission will become the dominant mode with significant transmission time reductions, although present digital equipment costs are higher than conventional facsimile.

1.15 Point of sale terminals are still in the initial development stage with no evident technological trends. Costs however should be decreasing as manufacturers improve production techniques.

In a more general sense we find the distributor market somewhat volatile. Out of the approximately 80 Canadian suppliers only about 15 are major firms with a broad range of products. There is also a tendency for suppliers to change product representation on a frequent basis, which indicates some instability in the supplier field, but is not necessarily a reflection on the terminal market.

2. INTRODUCTION

2.1 GENERAL

As a result of the work done by the Computer/Communications Task Force and the recommendations expressed in its report "Branching Out", a series of studies has been commissioned by the Communications Research Centre of the Department of Communications. The broad objective of this series is to provide the Government of Canada with a basis for planning and evaluation of computer/communications services and systems, relevant to future Canadian requirements. The area selected for these studies was that of interactive data terminals, on the premise that this represents a significant and viable opportunity for Canadian activity in the overall field of computer/communications.

As one of the series, the State-of-the-Art study covered herein has as its specific objectives to survey data terminal devices presently available in Canada and elsewhere, to classify them and to identify and assess the technology that they represent.

Taken on their own, the findings of this study are useful in documenting the wide range of products available, the considerable number of suppliers, and the predominant types of terminals and technologies in this fast moving segment of the broadening computer industry. It should be understood, however, that the observations made serve an equal purpose as base data in the companion study, Technology Forecasting and Assessment, and that it is the group of studies combined which will be used in evaluating policy to encourage the development of the data terminal industry in Canada.

As a note to the reader, since the subject is quite technical and unavoidably lapses into the jargon, we have endeavoured to give simple explanations where we have felt it appropriate and have included a Glossary of Abbreviations as Appendix F. On the other hand, it is obviously beyond the scope of the study to satisfy the serious technical student and we have therefore included a list of technical references for further reading.

2.2 SCOPE AND OBJECTIVES

The state-of-the-art study has been commissioned to examine currently available data terminal equipments from the aspects of cost, population, features and underlying technologies. The emphasis was to be on those products commercially available in Canada with the potential impacts of trends originating in other countries to be identified. The study was also to set the basis for the identification of significant future data terminal technologies by the companion research of the "Technology Forecasting and Assessment" study.

The specific goals of the study are set forth in the following:

a) Identify and classify data terminal equipment, their costs and country of origin, availability to Canadian Users, and establish approximate installed quantities.

b) Identify and classify data terminal equipment, their costs and country of origin which have the potential for significant future impact on the Canadian market, but are not presently available to it.

c) Establish the functional features available in data terminal equipments and categorize the approximate quantities according to these uses.

d) Ascertain the underlying technologies, their costs, and extent of usage in the various data terminal classifications.

e) Identify the significant terminal assembly and component fabrication techniques currently in use.

3. METHODOLOGY

It is important to understand that information for this study has been accumulated through a combination of methods with the intent that as much as possible the result is an aggregate of facts and opinions acquired through the most relevant and reliable sources.

3.1 INFORMATION SOURCES

The major source for the reported information has been questionnaires that were sent to all known Canadian suppliers of data terminal products and all U.S. manufacturers or suppliers thought to have commercially available products on the market.

Two types of questionnaires were used. One requesting detailed information on terminal products and the second, where appropriate was used to obtain more extensive information with respect to subassemblies or components. Summaries of the questionnaire's content and the response may be found in Appendix B.

With regard to overseas manufacturers and suppliers we contacted, wherever possible, the North American representative of the firm. As a further source of information, however, we used the overseas offices of our associated firm, Coopers & Lybrand, to obtain relevant information from the United Kingdom, France, Germany, Italy, Sweden and Japan.

To this data base we have added information from a number of published articles on data terminals and technology, product brochures of supppliers, as well as other studies and surveys such as Eurodata, Auerbach, A.D. Little, and Frost & Sullivan. A complete reference list can be found in Section 6.

3.2 INFORMATION RESPONSE

In general, we believe that the information response is sufficiently reliable and adequate such that appropriate conclusions can be drawn for purposes of this study.

In assessing the response, we should emphasize that we have been careful to make sure that no major terminal classification has been excluded, and that all significant current technologies were represented. In addition, personal interviews were conducted where specific technological information was required, particularly with respect to components and this included a number of interviews with manufacturers of keyboards, displays, semiconductors, scanners, printers, etc.

4. STATE-OF-THE-ART

The results of the study are presented below under three major headings, Interactive Terminal Products, which addresses the State-of-the-Art at the full terminal level, Major Sub-Assemblies, which addresses the technologies involved at the component level, and the Terminal Population estimates giving the terminal base which is currently installed.

4.1 INTERACTIVE TERMINAL PRODUCTS

4.1.1 Classification

As a first task, a classification of terminals was developed in order to be able to group terminals appropriately and to be able to present meaningful statistics on terminal types.

The objective was to reflect significant functional differences in the use of terminals, or to group those where a common technological requirement exists. It should be pointed out that whereas two classifications represent by far the majority of the installed terminals in the present state-of-the-art, we were, in our final selection, influenced by the relationship of this study to the companion study on Technological Forecasting. In this regard, it was decided that whereas some of the classifications were only sparsely represented in the current market (e.g. POS, limited data entry, and graphic input), they should be recognized due to their future potential.

It is also significant to note that we have not, by classification, differentiated as to the attribute of intelligence or storage attached to a terminal. Our survey shows that, in most cases, a discrete distinction is not practical, as virtually all products have some of these attributes and the variation is only by degree.

4.1.1.1 Keyboard/Display

This is a common type of terminal which has an alphanumeric keyboard with some form of electronic display but no hard copy provided. Alphanumeric and graphical display capability are both included in this classification as the technology employed is not significantly different. These units are typically employed in word processing applications.

4.1.1.2 Keyboard/Printer

This type of terminal represents either the standard teletypewriter device or the more current replacement products, and is used typically in the interactive time sharing environment. The technologies of producing hard printed copy are distinct enough to make this a separate category from the first.

4.1.1.3 Keyboard/Printer-Plotter

This classification is a variation of the last, where the printing capability is not limited to just normal type, but can also produce hard copy graphic display, diagrams, etc. The printer-plotter is generally a refined version of one of a limited number of printer technologies. The type of terminal classified herein is not the large flat-bed type of plotter used for computer output but typically limited to a 8½" x 11" page with keyboard entry.

4.1.1.4 Document Reader/Printer

The distinctive characteristic of this class of terminal is that the input is read by scanning a typed, or marked, document. This type of terminal can read the previously prepared documents including graphic data but is limited to alphanumeric hard copy output.

4.1.1.5 Point-of-Sale

This class of terminal has a greater capability than the Limited Interactive Enquiry class and represents a device capable of completing a full transaction. In order to do this, there is some combination of attributes, such as reading coded price tickets, identification cards, keyboard entry, coupled with printed and/or display output.

4.1.1.6 Limited Interactive Enquiry Systems

This classification includes any simple key and/or identification card entry terminal, with some combination of limited digital display, magnetic stripe update or audio response. Several different types of technologies may be involved here, but they are to some extent competing in a particular functional environment. Typical applications include order entry, credit verification and inventory control.

4.1.1.7 Graphic Entry

The key characteristic of this classification of terminal is the use of a coordinate reference to initiate the enquiry rather than using keyboard or character input. Typically, this would include terminals involving the use of light pen, finger touch or drawn (tablet type) input with either hard or soft copy display for response.

4.1.1.8 Digital Facsimile

This classification depicts a terminal with the digitized image being transmitted as input from or output to the terminal station. It would typically be used as a "frame grabber" providing hard copy in conjunction with the CRT display. It differs from straight graphic display and document reader in that it is capable of gray scale (or ultimately colour) differentiation.

Other categories such as two-way cable TV terminals were considered but not included in this report since they do not represent current readily available commercial products. However, there is every indication that such terminals will be in widespread use within 5 to 10 years.

4.1.2 Survey Results

A detailed listing of interactive data terminal products, as obtained from our survey, is included as Appendix C. For purposes of comparison, the various terminals have been grouped by classification defined above, together with information on price, features and technologies which are relevant. Observations made as to the state of the art in each category follows.

4.1.2.1 Keyboard/Display

The keyboard/display terminals listed are essentially all interactive data terminals, although some terminals are suited for both batch entry as well as interactive operation.

As may be seen in the present products available, the CRT display is very predominant as there are only a few examples of a non-CRT display. The only alternative display employed at the present moment is the plasma panel.

There are a large number of manufacturers in this category (approximately 100) and although the manufacturers generally concentrate their development on either the basic terminal or the "intelligent" terminal, there are so many products available that the distinction in levels of "intelligence" is almost indiscernable.

The manufacturer of keyboard/display terminals is generally an assembler of sub-assemblies. The assembly techniques are relatively difficult to automate, requiring instead hand-assembled wiring harnesses to inter-connect the sub-assembly modules. However, labour costs only contribute about 5 percent to the total terminal cost.

i. Display

The display technologies are completely dominated by the CRT with approximately 95% of the terminals by manufacturer, and greater than 99% by volume, employing this display device. The only present alternative is the plasma panel although some other technologies are in the advanced experimental stage. The plasma panel costs approximately 7 to 8 times the price of a CRT display of equivalent panel size, moreover, the number of addressable points on a plasma panel can approach that of a CRT, but present costs are prohibitive. Although plasma panel costs are expected to decrease, the general industry consensus is that liquid crystal displays (LCD) will provide the first solid state flat panel display to be cost competitive with CRT's. The LCD should be able to compete on a cost and performance basis within three to four years. It will have a major advantage over both CRT's and plasma panels in multi-media terminals. The LCD can be made transparent, to act as a projection screen for slide or photograph display.

The CRT display generally has capability of displaying between 500 and 3,000 characters with the average number being approximately 2,000 characters. The non-CRT displays are presently limited to about 250 characters but this number is expected to increase significantly in the near future, to approach that of a CRT display. The CRT display package is generally purchased as a package by the terminal manufacturer and presently constitutes approximately 12 to 15 percent of the total component cost of the terminal. The most important display parameters are user readability and cost.

ii. Keyboard

Both reed switch and Hall-effect keyboards are widely used with only a small percentage of mechanical contact or other technologies being employed. This predominance of two technologies is a reflection of the manufacturer's policy of incorporating only long-established proven designs with good reliability. Only about 40% of the Keyboard/Display manufacturers supplied information on the keyboard technology but the results present a realistic profile with 60% employing reed switch, 30% Hall-effect, and 10% other forms of keyboard. Of these keyboards, approximately 75% employ MOS encoders and 25% employ Bipolar encoders. From the present state of the art in keyboard encoders, the trend is towards the MOS technology, so that the MOS portion of the market will increase in the future. It is expected that the type of keyboard technologies employed will continue to be predominatly reed switch and Hall-effect.

The keyboards employed have a range of 55 to 70 keys, with complete alphanumeric key input plus various functional key inputs, such as line feed, carriage return, etc., and optional editing key inputs, such as cursor control, erase, page transmit, etc. In this type of terminal, the keyboard package, including printed circuit board and encoders, constitutes approximately 20 percent of the total component cost. The terminal manufacturers generally buy this as a pre-assembled package. The most important performance parameter of the keyboard is reliability, with cost being of secondary importance.

iii. Logic/Memory

Semiconductor memory circuits are almost 100% MOS devices in display terminals presently in the market. Although considerable development activity is being concentrated, by semiconductor manufacturers, in both Bipolar and MOS memories, the MOS units are more cost advantageous than the higher speed Bipolar memories, for data terminal applications. One further note regarding memories is that, although present terminals employ MOS units almost exclusively, a large proportion of the installed base of Keyboard/Display terminals employ magnetostrictive delay lines as memory units.

In the category of logic, the ratio of Bipolar to MOS circuitry is approximately 60:40. Logic circuit design presently favours Bipolar technology but, with the rapid advances in MOS microprocessors and programmed logic arrays (PLA) the trend in future data terminals will be to provide more local processing power for the user through the greater and greater application of MOS LSI. As with memories, MOS circuitry has sufficient speed for interactive data terminal purposes and provides more circuitry, and therefore more processing power, for a given price than does Bipolar circuitry.

The present logic control/memory package generally constitutes 55 to 60 percent of the complete terminal component cost. Although the integrated circuits are not manufactured by the companies that build terminals, the actual employment of IC's, and the design and assembly of the PC board, to form the complete subassembly package, is generally done "in-house". The primary objective of the terminal manufacturer is to provide the functional objectives of the product at minimum cost. With the rapid developments in the semiconductor field, the cost-effective lifetime of a given logic control/memory subassembly is relatively short, being, at best, no more than two years.

iv. Prices

The price range of terminals in this category is quite wide (from $1,000 to $25,000). This broad range reflects the degrees of sophistication available in Keyboard/Display products. The simple terminal has, essentially, no local data manipulation capability. A basic device has memory capacity to store only one page of data, provide a minimum amount of editing features, and low speed (300 baud) data transmission capabilities. As the "intelligence" or local processing power of the terminal is increased, with the addition of expanded editing features, formatting, code conversion and generation features, error correcting, high speed (up to 9600 baud) data transmission rates, etc., the cost of the terminal increases. There appear to be no discrete levels of intelligence with a number of terminals all providing the same features so that determining a price range for a standard degree of intelligence is not significant. The "average" basic terminal price is in the range of \$1,500 - \$2,000 with indications that this will decrease over the next one to two years to approximately \$1,200 - \$1,500. There are also a number of terminals in the \$3,000 - \$4,000 price range with a limited degree of intelligence although no clear-cut "standard" features. The newer designs in this category feature programmable capabilities by employing one of a growing number of microprocessors.

v. Data Transmission

Almost 100% of the Keyboard/Display terminals surveyed employed an Electronic Industries Association (EIA) RS232 standard interface or the European CCITT V24 quivalent. This standard interface permits the user to select the modem best suited to his requirements. Less than 10% of the terminals had a Teletype[R] compatible current loop either as standard or as an option. This method was more common in basic terminals where the manufacturers' purpose is to supply a low-cost teletypewriter "replacement" albeit with soft-copy rather than hard-copy output.

The RS232 type interface is almost a negligible cost contribution component to the terminal. If a modem is provided with the terminal, it may constitute 5 to 15 percent of the total component cost and is generally

R - registered trade-mark

purchased as a subassembly by the terminal manufacturer. Modem prices are decreasing and it is expected that, at the low speed end (less than 300 baud) these will be increasingly incorporated in the low cost basic Keyboard/ Display terminal. However, it is not expected that the higher cost high speed modems will be incorporated as a hard-wired terminal component.

4.1.2.2 Keyboard/Printer

As with the Keyboard/Display, it is often difficult to determine whether a terminal is employed for batch or interactive data entry, but all terminals which are potentially interactive, are listed.

A wide mix of printing technologies are employed although the present installed base of terminals predominantly employs some form of impact printing. Although the manufacturers of Keyboard/Printer terminals purchase some sub-assemblies, the printing mechanism is generally of "in-house" design and assembly. Labour costs contribute 10-20 percent of the total terminal cost.

i. Printer Mechanism

The present ratio of impact printing to non-impact printing techniques is approximately 2:1 for the terminals on which information was supplied. The ratio would favour the impact methods to a greater extent if Telex/TWX equipment was included. However, the trend, as exemplified by the more recent introductions to the marketplace, is to non-impact dot matrix printers, particularly to the thermal technology. It is expected that this trend will continue as printing methods that are simple, reliable and where labour costs are minimal, will eventually predominate over the electromechanical methods which have poor reliability, high maintenance costs and where the manufacturing process is highly labour intensive.

The printing mechanism provides the largest single cost factor in the terminal, ranging from 55 to 60 percent of the total component cost. The absolute cost of the printing mechanism is expected to decrease as more non-impact printer developments take place. The printers are generally capable of printing 80 to 132 columns of alphanumeric data with the average being close to the low-end. The two most important features of the printing mechanism are cost and reliability with readability being of somewhat lesser importance.

ii. Keyboard

For the limited amount of response in this sub-assembly area, conclusions are not warranted although it would appear that, rather than one or two dominant technologies as with Keyboard/Display terminals, there are a wider range of keyboard technologies employed. It is expected that the trend will be towards the same technologies predominant in Keyboard/Display terminals.

The keyboards have approximately the same configuration as in Keyboard/Display terminals with 55 to 70 keys. A complete alphanumeric input plus some functional and editing key inputs are provided. The keyboard is generally purchased as a sub-assembly and, although the absolute cost is the same as for the units employed in Keyboard/Display terminals, the percentage cost contribution is only 7 to 8 percent due to the relative cost of the printing mechanism. As with Keyboard/Display terminals, the most important feature of the keyboard is its reliability.

iii. Logic/Memory

Generally, the Keyboard/Printer terminal employs less control circuitry than does the Keyboard/Display terminal. These terminals, with hard-copy output, do not lend themselves to the editing features of the soft-copy display terminal so the electronic circuitry for such features is not included. Of the circuitry employed, there does not appear to be a strong commitment to one or the other semiconductor technologies (Bipolar or MOS) although the trend appears to be towards MOS LSI circuitry such as microprocessors and programmed logic arrays.

The logic control/memory sub-assembly is a relatively lower cost component in Keyboard/Printer terminals, for the following reasons:

a) fewer editing features and therefore less logic control
b) no refresh memory is required
c) higher cost of output medium

The logic/memory sub-assembly is approximately 20 to 25 percent of the total component cost. The absolute cost of the sub-assembly will probably remain the same as manufacturers incorporate more functional features per dollar.

iv. <u>Price</u>

The low end of the price range is set by the $1,000 - $1,500 teletypewriter equipment but most printers presently available fall into the $3,000 - $4,500 price range, featuring reliability and low maintenance costs when compared to the electromechanical teletypewriters.

The price trend is towards increased costs in the more labour intensive impact printing technologies and towards decreased costs in the non-impact technologies.

v. <u>Data Transmission</u>

Approximately 60% of the terminals featured an EIA RS232 data transmission interface with the remaining 40% providing assorted options such as: -

- teletypewriter-compatible current loop
- built in acoustic coupler
- parallel TTL compatible interface

The data transmission sub-assembly contributes only about 1 or 2 percent to the total component cost.

4.1.2.3 Keyboard/Printer-Plotter

There are less than 10 manufacturers of terminals in this category at present. Interactive graphics requirements are more suitably fulfilled by a soft-copy output media such as a CRT display as the user often wants to make a modification or update to a drawing. The equipment available in this category are special types of Keyboard/Printers with graphic capabilities. The size of the plotting area is generally limited to a standard page width of 8½ inches but may be longer than the standard page length of 11 inches.

i. Printing

The types of printer/plotters that can produce acceptable graphics are limited to dot-matrix type (both impact and non-impact) and full page electrostatic machines. Impact dot-matrix units are employed in approximately 30%, thermal dot-matrix in 60%, and magnetostatic dot-matrix in 10% of those terminals surveyed. The non-impact technologies generally produce better resolution because the number of selectable points in the dot-matrix is usually larger (up to 10 x 14) than the conventional 5 x 7 matrix available with impact technologies.

The resolution with the dot-matrix type of plotting is generally limited to 30 - 40 points per inch. With the thermal printing techniques, the "print" heads are fabricated by standard semiconductor photographic procedures so that better resolution should be possible. Better resolution with impact technologies would involve considerable expense. Cost and reliability are the chief selection factors in choosing a printing technique. The percent cost contribution of the printing-plotting mechanism is in the same range as for Keyboard/Printers, namely 55 to 60 percent.

ii. Keyboard

As with Keyboard/Printer terminals, there were no predominant keyboard technologies. The configuration, trends etc., which applied to Keyboard/Printers, also apply to this type of terminal.

iii. Logic/Memory

The terminals employ a mix of both Bipolar and MOS technology. As graphics requires more logic control than alphanumerics, the terminal manufacturers should incorporate MOS LSI devices in increasing numbers. The relative sub-assembly cost is generally 3 to 5 percent higher than for Keyboard/Printers.

iv. Price

The price spectrum covered by Keyboard/Printer-plotter terminals surveyed is from $3,000 to $6,000 with a predominance in the lower range. It is expected that terminal costs will decrease in the near future as more products become available and printer costs decrease.

v. Data Transmission

Over 70% of the data terminals in this category employ an EIA RS232 interface with the remainder incorporating some form of built-in modem or parallel TTL-compatible data input/output. As with Keyboard/Printers, the data transmission sub-assembly costs are minimal so that any sub-assembly cost decreases are not expected to significantly affect the user terminal cost.

4.1.2.4 Document Reader/Printer

The market for this type of equipment is quite small due, to a large extent, to the present high cost. The optical reading facility lends itself more to batch applications orientation where information may already be available in printed form and the technique avoids duplication of effort. There are, however, specific products, such as the Canadian produced T-Scan, which provide a commercially feasible interactive terminal and indicate potential for such applications-oriented devices.

Document readers employ scanners which have a resolution capability of 50-60 lines per inch but the computer programming is not presently sophisticated enough to accept wide variations in character shape and size.

No cost comparison data were available for this type of terminal although it is expected that the logic control/ memory sub-assembly would constitute the largest single cost factor.

i. Scanner

Approximately 75% of the Document Reader terminals employ an optical photodiode scanner for reading the marks or characters on a document. Of the terminals surveyed, the only other technology employed was a unique thick film resistance scanner for mark sense reading. It is expected that, with the introduction of production CCD scanners in 1973, new terminal designs will incorporate this technology. Cost and resolution are the two primary selection factors for a scanner.

ii. Printing

For those terminals on which information was available, impact printers were used exclusively. There are two reasons for this; namely, that printing is generally done on standard paper or cards, thus ruling out the use of most non-impact techniques, and often there is a requirement for printing the output in OCR print font. The printer itself is generally a limited alphanumeric type used to output verification data or requests for further operator input.

iii. Price

There is a wide range of prices in this terminal category, ranging from $8,000 - $12,000 OMR equipment to $300,000 document reader equipment. There are no indications at present that the price of even a simple optical mark reader terminal will approach that of a keyboard entry terminal. However, in certain applications the higher terminal cost is justified by the elimination of redundancy in data input.

iv. Data Transmission

The predominant data transmission interface is the EIA RS232 which permits user attachment of a modem best suited to his requirements.

4.1.2.5 Point of Sale Terminals

This category is a relatively new one in the industry in the sense of electronic systems although the cash register industry as a whole is relatively old. However, despite the fact that the number of firms is approximately 10, with two or three dominant firms, the resources necessary to establish a reasonable-sized, profitable operation in this highly competitive field would be prohibitive, even in light of the potentially large market. At present, costs are stable while manufacturers recover some development costs. There are no Canadian firms manufacturing POS terminals although some U.S.-based firms have indicated possibilities of doing so in the future.

Although the maximum benefit from Point of Sale (POS) equipment is achieved with a fully integrated system for inventory control, credit verification and customer sales, the present installed base in Canada utilizes only the customer sales features. Merchants are wary of setting up a complete on-line system until equipment reliability has been established, however the new store installations, which comprise the present installed base entirely, are generally being set up to utilize the full POS system capability in the future.

Only two firms supplied information on their POS terminals so broad conclusions covering the entire industry are not justified. Terminals are in the first generation stage so no strong trends or directions are evident, although MOS LSI logic and memory circuitry would appear to be an obvious choice to satisfy the requirements of programmability, to meet individual merchant needs, and memory to provide tax and merchandise price data.

POS terminals generally employ a full numeric keyboard in addition to 10 - 20 special function keys. As no sub-assembly cost breakouts were available, the percent cost of the keyboard is not known. However, it is expected to be a minimal cost factor, within the price range of $30 to $50. The display on a POS terminal is generally a numeric display with some limited alphanumerics capability. The displays are generally 5 or 6 digits, of LED or LCD technology and constitute a cost in the $20-$25 range. Two of the principal factors in the selection of any sub-assemblies are cost and reliability.

4.1.2.6 Limited Interactive Enquiry Terminals

There are no present commercially available products manufactured in Canada although Northern Electric is scheduled to start production of a terminal in 1974. There is a wide range of terminals available generally designed to suit a particular application. The market size is also quite appreciable but in low cost products, as with the current example of the very competitive calculator market, and the profit margins are very small.

Terminals in this classification typically employ highly automated assembly techniques in a effort to reduce the total terminal cost.

Limited Interaction/Enquiry terminals are applications oriented terminals used in credit verification, order entry and inventory control.

i. Keyboard

The cost of the terminal dictates the use of low cost keyboards. The dry contact keyboard predominates with approximately 75% usage with the remainder divided between conductive elastomer and reed switch keyboards. The trend is towards conductive elastomer switches which are potentially the lowest cost keyboard. The keyboard is typically a numeric only keyboard although a few special function keys may be provided. The keyboard constitutes one of the major cost items in the limited Interaction/Enquiry terminal, contributing to 25-30 percent of the total component cost. The principal selection factor is cost.

ii. Display

In those terminals for which information was available, LED displays were used exclusively although, in view of the display type and price similarities with the calculator market, LCD displays could also be cost-effective.

Displays are generally not available in terminals costing from $70-$100 but in higher priced equipment the display would contribute to 10-15 percent of the component cost. The display is usually a limited alphanumeric configuration with 5 to 10 displayable digits plus one or two special function displays. Again, cost is the principal selection factor.

iii. Logic/Memory

The low terminal cost restricts the amount of circuitry that can be incorporated but MOS LSI is presently employed in 60 to 70% of the terminals and this percentage is expected to increase to meet the demand to minimize the parts count yet maximize the functional power of the terminal.

The logic control/memory sub-assembly is approximately 30 percent of the total component cost. The trend is towards LSI devices as this reduces the component count, thereby reducing assembly costs. The amount of terminal functional capability is directly proportional to the cost of the terminal. The low cost devices have little or no logic control circuitry whereas, the higher cost terminals employ more logic and therefore feature more functions.

iv. Price

The limited interactive enquiry terminal price ranges from $70 to $3,700 depending upon the specific features provided. It is expected that the low priced terminal will drop to $25 to $30 in the next few years as the devices receive wider acceptance.

v. Data Transmission

Eighty to ninety percent of the terminals surveyed employ a touch-tone or acoustic coupler compatible FSK signal transmission method. In the low cost ($<$\$200) terminal touch tone signaling is the only economically viable method but in higher cost units the acoustic coupler method of data transmission is cost competitive. Both methods are expected to continue in widespread use in the future.

4.1.2.7 Graphic Entry

There are only a few examples of this type of terminal presently available and only one Canadian manufacturer. Although the potential applications appear to be quite large, the demand for such terminals does not reflect this feeling. These terminals have also been listed in the Keyboard/Display category as the graphic input facility is generally an add-on option to the basic Keyboard/Display terminal.

The graphic input terminals surveyed either employed a light pen (60%) or an acoustic surface wave touch sensitive screen (40%) for data input. Prices ranged from \$2,000 to \$12,000 for units with alphanumeric capability and the only example of a terminal with full graphics capability cost \$25,000. All units employ a CRT display and utilize an EIA RS232 interface for data transmission. It is expected that more terminals of this type will be available in the future, employing predominantly CRT displays although plasma panels and LCD's are expected to find increasing application.

4.1.2.8 Digital Facsimile Terminals

Most terminals presently installed in the marketplace employ relatively old technologies. This is perhaps the reason for the failure of facsimile to live up to early market growth forecasts. Digital facsimile itself is only in the first generation stage although if referenced to the overall field of facsimile, it is in the third generation stage. Only one manufacturer of digital facsimile equipment responded to the questionnaire and, it would appear that most manufacturers of conventional facsimile terminals do not presently have a digital unit on the market although they are developing units for introduction in the near future. The amount of data manipulation necessary would indicate that MOS LSI circuits should predominate once this terminal field matures. Also it appears that manufacturers are changing from the helical wheel-electrosensitive printing technique used in conventional facsimile terminals to the higher resolution electrostatic printing technology. The only digital facsimile terminal available utilizes a photodiode scanner although newer designs will probably employ CCD scanners. The present price range is quite high ($10,000-$20,000) relative to the price of older generation facsimile equipment but these prices will decrease in the future.

4.1.3 Cost of Assembly

It was found that the actual cost of assembly for the terminals under investigation was only a small percentage of the total terminal cost. For the very low cost Limited Data Enquiry Terminal, the manufacture consists of a highly automated assembly of a limited number of components and assembly costs constituted only 5-8% of the total terminal cost. For Keyboard/Display terminals, the assembly costs were approximately 8-10% of total terminal costs.

For Keyboard/Printers the assembly costs were a greater proportion of the total terminal costs, ranging from approximately 15% for simple non-impact printers to 25% for electromechanical impact devices.

4.1.4 Assembly Techniques

No new or unique assembly techniques were revealed in the examination of terminals. In the majority of cases, plug-in printed circuit boards were employed for mounting the integrated circuit logic devices with the trend to putting as much logic as possible on the least number of boards. In smaller volume productions, some wire wrap techniques were employed but this is generally a more expensive operation on any scale above 400 - 500 boards. The trend is towards using medium scale and large scale integrated circuits (MSI and LSI respectively) as standard circuits become readily available (which usually implies second-sourcing). Incorporation of MSI and LSI circuits reduces the component count thereby reducing assembly costs although it might increase maintenance costs. Custom LSI circuits have limited applications at present because of the relatively high volume (>50,000) required in order to justify development costs. In fact, MOS LSI devices such as programmable logic arrays (PLA) and microprocessors are expected to price custom LSI out of contention in future terminals. Manufacturers generally employ a modular construction approach in order to facilitate assembly during production and for ease of maintenance.

4.2 MAJOR SUB-ASSEMBLIES OR COMPONENTS

The classes of terminals listed in 4.1 are each composed of a number of subsystem "modules", as illustrated in Fig. 1, representing the modes or input, output or other functional features of the model interactive data terminal. Using this model as a guideline,

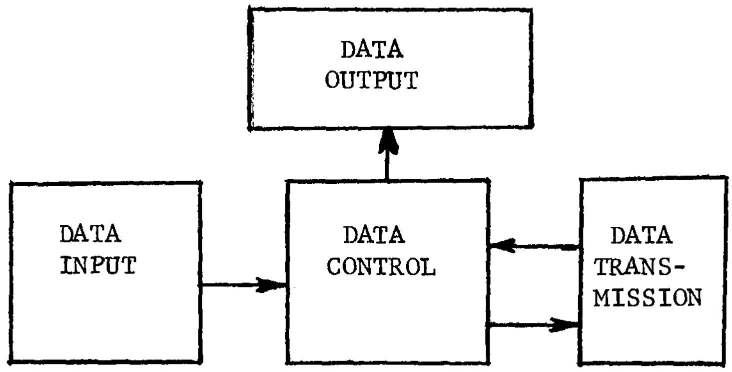


Fig. 1. Interactive Data Terminal Block Diagram

sub-assemblies were selected to provide the desired function of one of the modules. Some types of sub-assemblies are employed in more than one class of terminal. However, the predominant technologies for a particular sub-assembly may not necessarily be the same for different classes. Since individual technologies are related to this subsystem level rather than the complete data terminal product, a list of the significant technologies is given with each category listed below.

a) Displays
b) Printers
c) Keyboards
d) Logic Circuitry
e) Memory
f) Readers
g) Badge/Card Update
h) Data Transmission

The competing technologies are manufacturing methods that are currently available or under development for commercial usage in the particular category of sub-assembly. Some technologies listed may not presently be widely available but are included since they are relevant to the "Technology Forecast" study.

4.2.1 Displays

There are various methods of displaying information on interactive terminals. The following brief descriptions apply to what is described as "soft" display, implying there is no "hard" paper copy involved. Hard copy output is classified in the domain of printers and described elsewhere. The technologies described are:

(a)	cathode ray tube	vacuum tube display methods
(b)	gas discharge	
(c)	plasma	
(d)	vacuum fluorescent	
(e)	filament	
(f)	light-emitting diode	solid-state display methods
(g)	liquid crystal	
(h)	electroluminescent	
(i)	miscellaneous displays	

4.2.1.1 Cathode Ray Tube (CRT) Displays

This particular display medium is the least expensive and probably the most versatile. One advantage to the CRT is that it is widely used as a display in the high volume television receiver market and therefore cost and technological improvements are passed on to the data terminal display market.

The complete display sub-assembly is generally referred to as a TV Monitor, consisting of a CRT, a power supply, scanning and synchronization circuits and a video input stage. The CRT itself, consists of a vacuum tube with a phosphor coating on a flat display surface. The coating will phosphoresce when a high speed beam of electrons is incident upon it. There are two main types of CRT displays: random scan and raster scan.

The Random Scan technique is generally employed in the graphic data terminal because of the better visual quality compared to the Raster Scan technique. The visual quality is a very subjective comparison but based on resolution, jitter, intensity variation, etc. The random scan technique controls the position of the electron beam to form a specific character, line or curve on the display screen. Storage type CRTs are frequently used to simplify the circuitry by eliminating the need for refresh memory; however this slows down the interaction time. The storage CRT employs a phosphor coating which has a long decay time so that a particular spot will continue to fluoresce for several seconds or even minutes after the exciting electron beam has ceased bombarding the screen.

The Raster Scan technique operates on the same principle as the television receiver. Rather than directing the electron beam to form a particular character or line, the beam scans the entire screen with the electron beam intensity, and therefore the light intensity, being varied to form a character. (See Fig.2.)

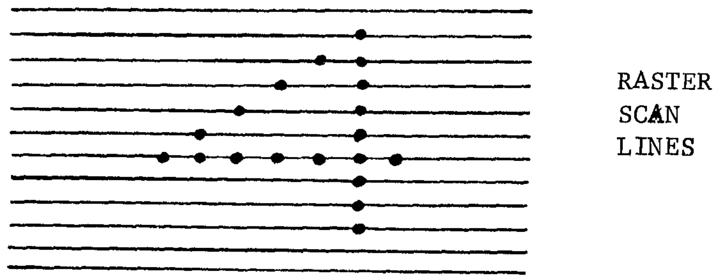


Fig.2. CRT Display

The Raster Scan CRT does not have as good visual quality as the Random Scan CRT but the overall cost is lower and the display signal can be mixed with a conventional television signal. Both types of CRT display have cost advantages over other types of displays but their disadvantages include physical size, high voltage requirements and relative fragility.

Colour CRT displays have advantages in bringing particular blocks of data to the attention of the operator. The conventional colour television employs three separate electron beams to produce three distinct and separate coloured dots on the screen. From a distance the three dots appear as a single spot, the colour of which is dependent upon the relative intensities of the individual dots. This technique has poor resolution because of the requirement for three dots rather than one. One new technique called the colour penetration principle overcomes the resolution problem by employing one electron beam and a multi-layer phosphor screen. Each phosphor emits a different colour when bombarded by the electron beam.

A relatively low speed electron beam will cause one phosphorous layer to illuminate, a higher speed beam will cause the second layer to illuminate, as illustrated in Fig.3.

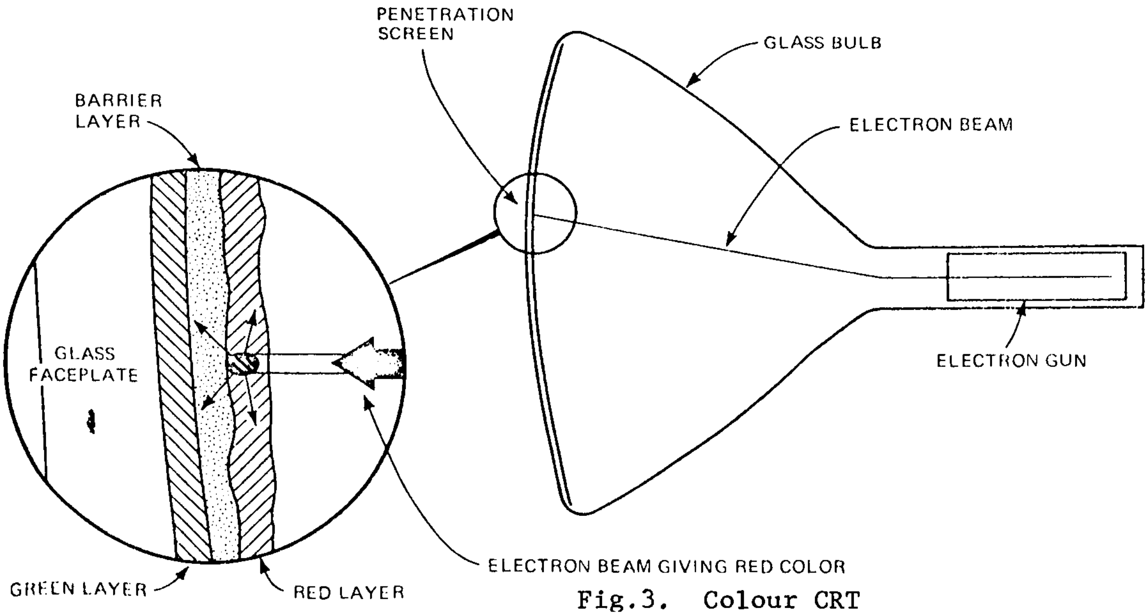


Fig.3. Colour CRT

Although production of the CRT, whether it be black and white or colour, is generally a highly-automated process, the assembly of the display "package" with power supplies, high voltage drive circuits etc, presently requires a high level of manual labour. Furthermore, although the television receiver provides a high volume market for CRTs, the data terminal market demand is low and there have been no so-called "industry standard" tubes developed. Perhaps future pressure from solid state display technologies will force CRT manufacturers to develop standards so that their product will remain cost-effective.

4.2.1.2 Gas Discharge Display

The gas discharge display is generally referred to as a cold cathode device. This can take the form of the familiar Burroughs "NIXIE"[R] tube, where a number of discrete cathode shapes (e.g. numerics 0 - 9) are mounted one behind the other, with a common anode in a hermetically sealed glass envelope containing an inert gas (neon usually).

The anode of this device is normally connected to DC voltage of approximately 175 volts. The cathode, which is energized by connecting it to ground through the control circuits, will cause the surrounding gases to ionize, and if the physical shape of the cathode is that of, say, a figure "2", the ionized gases will display this figure.

A very similar type of display consists of straight segments, in place of shaped cathodes. The most common form of segmented display is the "Seven Segment" display, illustrated in Fig.4.

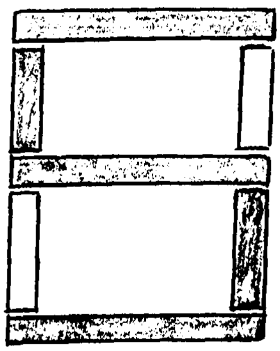


Fig.4. Seven Segment Display

By selecting different combinations of segments the 0 - 9 numeric set can be displayed.

R - registered T.M.

The advantages of these devices are their ruggedness and relatively low cost. Typical disadvantages are the limited viewing angle obtainable with "stacked cathode" and the need for a high voltage (175 volts) supply, creating a compatibility problem when used with computer logic which normally has a 5 volt supply.

4.2.1.3 Plasma Display

These displays are direct descendants of the above types. The major difference being that a "dot matrix" is used to form characters. The display consists of vertical and horizontal conductors of fine wire arranged in a gas "sandwich". The conductors effectively form the anode and cathode of a gas discharge display at each cross point. Depending on which horizontal and vertical electrodes are energized, a pattern is created by a matrix of light dots generally 5 x 7. (See Fig.5)

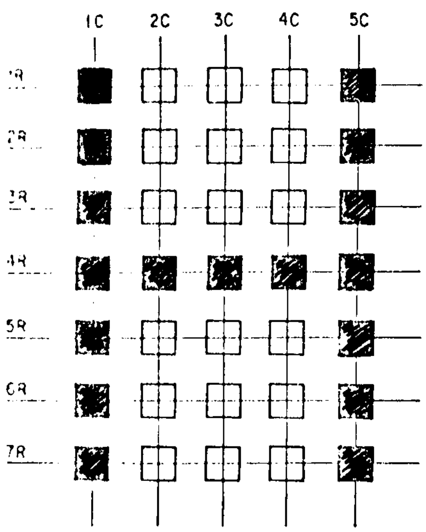


Fig.5. 5 x 7 Dot Matrix Display

These panels are versatile, but expensive to produce. Also, the associated logic necessary for controlling the X and Y selection (character generation), is expensive because of the high voltage requirements and the necessity of selecting a number of dots to form one character.

4.2.1.4 Vacuum Fluorescent Tube (VFT)

A vacuum fluorescent tube consists of a vacuum tube glass envelope, a low voltage filament and the usual seven segments which act as anodes. Electrons are emitted by the filament, and are attracted to the phosphor coated anodes which have a positive voltage applied to them. The anodes glow with a blue/green light. These devices usually operate with either a D.C. or A.C. filament voltage, and approximately 12v. D.C. for the anode supply making it MOS compatible. The major advantages are ease of reading (less operator fatigue), low power, reasonable cost. The major disadvantage is the use of a fine filament structure making its ruggedness questionable.

4.2.1.5 Filament Display (FD)

This display is based on the normal hot filament incandescent lamp. The hot wire filaments are segmented and placed near the front of a vacuum tube package for direct viewing. The filaments are normally at half voltage to provide long life, and reduced heat. The segments to be lighted are selected by the usual 7 segment decoders. There are a number of variations of filament displays, for example, in some cases the lamp is located remotely and light is conducted to the viewing area by fibre optic packages.

The advantages of FDs are extremely high brightness, any colour available by filtration, and TTL compatibility. Some disadvantages are relative fragility, high power requirements, long on/off delays.

4.2.1.6 Light Emitting Diodes (LED)

The light emitting diode readout is most usually in the form of a "seven segment" display. It utilizes the properties of Gallium Phosphide (GaP), Gallium Arsenide (GaAs), or Gallium Arsenide Phosphide (GaAsP) which emit light when a current flows across the semiconductor junction. The normal device emits a red light, but recent advances have made possible green, yellow, and, in experimental devices, blue. The LED fabrication techniques are similar to most semiconductor manufacturing methods and the devices are compatible with computer logic. The light output in most types is proportional to the forward current, up to the point of burnout, with the average current for most applications being relatively high. The LED segments are generally mounted in a standard integrated circuit package, which can also contain BCD to 7 segment converters for direct actuation of the segments. These devices are rugged and have a long life. They are most suitable for applications on consoles and calculators, where the calculator has sufficient current capability to provide proper illumination (i.e. batteries can be a problem).

4.2.1.7 Liquid Crystal (LCD)

The liquid crystal display is considered to have the most optimistic future for providing a low cost, low power, high performance display. Liquid crystals differ from most other displays in that they are not in themselves a light source, and depend on external light sources for their operation.

In its simplest form a liquid crystal display consists of two parallel glass plates with conductive coatings on their inner surfaces and a liquid crystal compound, called nematic, is sandwiched between them. In the dynamic scattering display the clear organic material becomes opague and reflective when subjected to an electric field. The current required to create this effect is extremely low and generally these devices operate in the micro-watt region. As in other displays the characters are normally built up from segments and driven by BCD to 7 segment converters.

The advantages of LCDs are low power requirements, good readability, computer logic compatibility and potentially low cost. Liquid crystal panels are very simple to construct, although there are presently some quality control problems involved in large volume production. There are limitations on the operating temperature range, but this presents no problems at normal room temperatures and researchers feel this will be overcome in the near future.

4.2.1.8 Electro-Luminescent (EL)

Eletroluminescence is a phenomenon whereby light is emitted from a semiconductor material under an applied electric field.

An EL cell consists of a transparent conductive glass substrate to which a phosphor/dielectric layer is applied, with a second electrode applied to the opposite surface of the substrate. The electrodes can be segmented as in other types of displays to form the required data readout. EL cells are designed to operate on several hundred volts A.C. and are therefore difficult to interface with computer logic. The main advantage of EL is the simplicity of fabrication, its present disadvantages are: high A.C. voltages, relatively low light output and short lifetime.

DISPLAY COMPARISON

DISPLAYS	COMPETING TECHNOLOGIES	MAJOR APPLICATION AREA	NO. OF CHARACTERS	MAIN CHARACTERISTICS	LOGIC COMPATIBILITY	EXTERNAL REQUIREMENTS	COST PER CHARACTER*	REMARKS
ALPHANUMERIC/GRAPHIC DISPLAYS	Cathode Ray Tube (CRT)	Display for interactive terminals Monitors	500-3,000	Display versatility Low cost Colour capability	No	High voltage for tube operation Refresh memories Character gen	$ .05 - $ .10	CRT displays are the lowest cost at present Physical bulk is a disadvantage Will continue to lead for low cost terminals
	Gas discharge (PLASMA)	Relatively small area displays Usually used for alphanumeric displays but have graphic capability	Up to 250	Flat compact display Digital scanning	No	X - Y drivers Relatively high voltages Read only memory	$3.00 - $3.50	These displays have been slow to impact the market place due to manufacturing problems creating high costs. Newer techniques are bringing costs down
NUMERIC - ALPHANUMERIC	Liquid crystal (LCD)	Monitors Calculators Instrument readouts	1-10 (per assy.)	Low power requirement Well defined display TTL/MOS compatible	Yes	Requires external light source read only memory	$4.00 - $5.00	This device has the most promise for challenging CRT in Alphanumeric use from a cost standpoint Normally grouped single character display
	Light emitting diode (LED)	Calculators Monitor panels Touchtone terminal displays	1-5 (per pack)	TTL Compatible Pleasant light display Low voltage Various colours	Yes	Read only memory TTL drivers	$3.00 - $3.50	Can be used aa dot matrix or segment displays. Bell labs currently involved in cost reduction for low power versions
	Electro luminescent EL	Aircraft panel display Monitors	1-5 (per pack)	Reliability Flat display large area	No	High A.C. voltage	$4.00 - $5.00 (est.)	Not very popular due to high voltages and limited light emission Normally used only in specific situations
	Gas Discharge (NIXIE)	Instrument readouts Monitors Calculators	1-15 (per assy.)	Defined characters No external character Generation reqd.	No	175 volts D.C. Normal drivers	$4.00 - $4.50	Very popular over a great number of years - Poor viewing angle performance due to paralax
	Vacuum Fluorescent	Computer consoles Small displays	1-15 (per assy.)	Low power Clear display Reliability	Yes	1.5v. AC/DC 12 v. DC	$3.50 - $4.00	Excellent viewing display - but hot filament limits physical abuse
	Filament	Any display which has to operate under high ambient light conditions	1-10 (per assy.)	High brightness Versatility Easy viewing	Yes	12 - 24 v. lamp drivers	$4.50 - $5.00	Any colour display can be obtained by filtration Hot filament requires careful handling

* based on 100 qty. CAN price.

4.2.1.9 Miscellaneous Displays

There are several other types of displays which are neither in the present nor in the future considered to be cost-effective data terminal readouts. These displays are usually a limited alphanumeric unit with a small number of characters and generally employed for special purpose applications. The types have been listed below for reference purposes only.

- magneto-optic drum (Magneline)
- rear projection (IEE)
- magneto-optic dot matrix (Ferranti-Packard)
- stencil-image CRT (IEE "Nimo")

4.2.2 Printers

Printer mechanisms may be divided into two distinct types: impact and non-impact.

Each type has several sub-classifications or technologies which may be employed to achieve a hard copy output. Basically the differences between the two types are as follows:

	Impact	Non-Impact
Multiple Copies	Yes	No
Noise level	High	Low
Speed	Low*	High
Special paper	No	with some types
Reliability	Moderate	High

Note: *Some high speed impact printers are available in non-interactive data terminals.

4.2.2.1 Impact

The common impact printing methods are described below.

i. Typewriter-style printwheel. This type of printer may employ:

- a series of arms with a single character imposed on the end of each arm, similar to the conventional typewriter.
- a ball on which the entire character set is embossed, similar to the IBM Selectric (R) typewriter.
- a vertical drum on which the entire character is embossed, similar to the Teletype (R) typewriter.

Various mechanical means are used to select the desired character. Once selected, an inked ribbon is sandwiched between the printwheel and the paper and the character is imprinted upon impact. This type of printer can only accept serial data input and so is limited in speed (generally the upper limit is 30 characters/second). However the unit is low in cost and features a simple change of character font. Crude graphics are possible with this method of printing but the limitations are rather severe.

ii. Hammer-style printer. This type of printer has the character set embossed on a "fixed" wheel or chain. The desired character must be selected but rather than the character moving to impact the paper from the front, as in i., a hammer strikes the back of the paper, forcing it against the selected character. A printwheel such as described in i.,may be employed for low speed printers.

R - Registered T.M.

For higher speed printers, the embossed characters may be fastened to a continuously moving chain. There is an individual hammer for each column of the page. When the desired character is aligned with the desired column the hammer solenoid is actuated, causing the character to be imprinted. This type of printer has a much higher printing speed, typically 200 to 1500 lines/minute for a 132 character/line output. Both the printwheel and chain type printer are considerably more expensive than the typewriter-style unit.

iii. Dot-Matrix Impact Printer. Characters may be composed from a matrix of dots with common arrangements being 5 x 7 and 7 x 9. The greater the number of dots, the more legible the character, however this also entails greater complexity and therefore higher cost. In a 5 x 7 dot matrix printer, for example, five solenoid actuated pins impact the paper at each character position. However seven "rows" must be printed in order to form the complete character. This method of forming a character is similar to that used in dot-matrix displays, described in section 4.2.1.3. The necessity for multiple impacts to generate a single character increases wear and therefore lowers the printer lifetime. However this type of printer is relatively simple and therefore less expensive than the hammer style printer. Relatively high resolution graphics may be printed with this style of printer and non-standard characters are simple to generate.

Higher printing speeds in the hammer-style and dot-matrix printers may be achieved by employing multiple character set wheels or chains or multiple rows of dot matrix pins. However, this naturally involves higher cost.

4.2.2.2 Non-Impact

i. Electrostatic. The most common example of the electrostatic printing technology is the Xerox machine. For electrostatic dry printing on ordinary paper, a charged latent image of an entire page is stored on a web or drum of semiconductor material. A toner-powder adheres to this charged image and is then transferred to the paper. The paper is then heated to fuse the toner and create a permanent image. Line by line electrostatic printing can be accomplished but this is usually done with special paper coated with a non-conducting dielectric material. Line printing is usually done in a dot-matrix format. Available electrostatic page printers provide full graphic capabilities, multiple copies and the ability to produce fixed-format overlays.

ii. Electromagnetic. Similar to the electrostatic printer, the line data is recorded on a magnetic tape loop which then picks up a magnetic toner. This toner is transferred to the paper and fused to it through heating. The only model of this type of printer is a line version although page versions would be possible.

iii. Thermal. A special heat sensitive paper is required for this type of printing. Generally employing a dot-matrix format, dots or pins similar to those employed in the dot-matrix impact printer, are heated by electrical pulses. The paper turns black in the locally-heated area with a number of individually heated dots forming the desired character. Considerable research is being done in this field at present, with the goal of supplying the high volume demand of the low-cost printing calculator market. Integrated circuit fabrication techniques are being employed to produce potentially low-cost, high reliability, compact printing units.

PRINTER COMPARISON

PRINTERS	TECHNOLOGY UTILIZED	APPLICATION/ SPEED	CHARACTERISTICS	COST	REMARKS
Impact	Typewriter-Style	Char. by Char.	Noisy	Low Cost	Long Established - some reliability problems
	(Printwheel Drum or Ball	Usually not over 30 CPS	Mech. Maintenance variable font if ball		
	Dot Matrix	Any range but normally 30 - 120 CPS	High Speed High Resolution Variable font by Circuitry Some Graphics	Mod Cost	Wear can cause maint. problems
	Hammer Style (Chain, Drum, Daisy)	Med. to High Speed Usually Line Printer 200 - 1500 LPM		Higher Cost	Long Established
Non-Impact	Electrostatic	Can be page by page	Analogue or digital input Limited gray scale	Very High Cost	Regular Paper or Special
	Electromagnetic	150 CPS Med	Has potential for Graphics	Moderate Cost	Special Paper
	Thermal	Usually char. by char. Limited columns	Compact High Reliability, Simple to produce	Low Cost	Becoming popular for other products Special paper
	Ink Jet	200 - 250 CPS	Requires Cleaning	High Cost	Regular Paper
	Electro Sensitive	Facsimile Type (Full page)	Simple construction Graphics, gray scale, Analogue imput, Limited resolution	Moderate Cost	Special Paper

iv. Ink-jet. The ink-jet system operates in a manner similar to the cathode ray tube (CRT). A high velocity stream of charged ink droplets is directed towards the standard bond paper by horizontal electrostatic deflection plates. The ink drop generator mechanically scans the page width while the changing voltage on the deflection plates directs the droplets to form the dot-matrix character. Periodic maintenance is required with this type of printer because of clogging of the jet nozzle, but its advantages include moderate speed (200-250 characters/second) and the potential for full graphics capability.

v. Electrosensitive. This printing technique requires a special chemically-treated paper containing minute iron particles which when exposed to an electric field become opaque. This type of printing is generally employed in the facsimile field. The method of printing employs a helix mounted on a drum. The paper is sandwiched between this helix and a page-width bar. Varying electrical fields between the helix and the bar produce varying degrees of opacity (or grey-scale) on the paper. The method is simple and the technique provides full graphics capability but resolution is limited. Characters of the size used on this page would be quite difficult if not impossible to read with the electrosensitive printing technology commonly used in facsimile equipment.

4.2.3 Keyboards

In present interactive data terminals, the most common method of data input is the keyboard. Several technologies are employed in the manufacture of keyboards; a brief description of some of the switch technologies are given under the following classifications, and illustrated in Fig.6.

a) Dry Contact
b) Electromechanical
c) Flexible Layer
d) Snap Action Disc
e) Capacitance
f) Reed
g) Hall-Effect
h) Magnetic Core
i) Magnetic Repulsion
j) LED/Phototransistor
k) Conductive Elastomer

Keyswitches are generally rated as to contact bounce and number of operations (lifetime). When a keyswitch is actuated, the switch does not instantaneously make a solid switch closure but, similar to a rubber ball dropped on a solid surface, the switch may open and close several times before final closure is achieved. Although the bounce time may appear to be relatively short (1 to 2×10^{-3} seconds) in human terms it may appear, on a logic circuit timescale, to be several switch actuations rather than one. Some switch technologies do not inherently have contact bounce. Those technologies that do have contact bounce may require some additional circuitry, and therefore additional cost, to filter out the effects of bounce. Although the manufacturers state that individual keyswitch lifetime is of the order of 10^7 to 10^8 operations, this does not necessarily relate to the failure rate of the complete keyboard. Some studies have indicated that with "average" usage, based on a forty hour week, the most frequently used keyswitch, rated at $5\ 10^7$ cycles, would fail in approximately 2 years. The keyswitches most commonly used are the space bar and some vowels.

With the wide usage of keyboards for data entry, semiconductor manufacturers have designed keyboard encorders which transform a particular keyswitch input into a unique code that the computer or terminal will recognize, thus permitting use of single contact switches rather than multi-pole units. Most commercially available keyboard encoders are MOS ROMs which feature, besides code generation, elimination of the effects of contact bounce, n-key rollover or lockout, and multi-level encoding. Rollover correctly encodes data for all keys that are depressed and is useful in burst typing applications such as word data entry terminals. Lockout blocks data from all but the first key that was selected, until it is released. This feature is preferable in accounting type applications. Some keyboards have as many as four levels of coding for each keyswitch thus enabling the manufacturer to supply more codes for a given number of keyswitches but, perhaps, at the expense of decreased operator efficiency.

Keyboards are typically constructed of a single pc board on which are mounted the keyswitches and the encoder. The more recent keyboard designs include a metal framework to support the keyswitches. Earlier units relied on the pc board for keyswitch support but the mechanical stresses created reliability problems.

4.2.3.1 <u>Dry Contact Mechanical Switch</u>

This switch is a simple mechanical contact of metal conductors. This type of switch is one of the lowest cost keyboards, but the lifetime is relatively low (typically 10^7 operations).

4.2.3.2 <u>Electromechanical Switch</u>

This type of switch is a variation of the dry contact type in that an electrical contact is established upon switch actuation but the actuation mechanism is more elaborate. This type of keyboard is an obsolete design but it is described here for reference purposes as it is widely employed in teletypewriters. It is used for complete keyboards rather than individual keys and involves a mechanical matrix which, most commonly, provides 8 separate possible contact closures, with a unique combination for each key. Although the design was a reasonable solution, before the introduction of solid state encoders and a wide variety of switch technologies, the highly mechanical design is unreliable and costs will increase in the future. No lifetime figures are readily available but the number of operations is probably of the order of 10^5.

4.2.3.3 <u>Flexible Layer Mechanical Switch</u>

A flexible conducting metal disc contacts a rigid conductor pad when the keyswitch is actuated. The two conductors are normally separated by an insulating washer. This type of switch has a typical lifetime of 3×10^7 operations. One main feature is the low profile.

4.2.3.4 <u>Snap-Action Disc Mechanical Switch</u>

This switch employs a small cup-shaped metal disc. When the key is actuated, the disc is pressed flat to create an electrical path between two conductors. Lifetime is approximately 10^7 operations.

4.2.3.5 Capacitance Switch

A change in the capacitance coupling between two metal plates is translated into a switching action. This type of switch may be fabricated so that there are no moving parts, therefore producing a switch with a high lifetime (typically 10^8 operations).

4.2.3.6 Reed Switch

Two cantilevered magnetic reeds (encapsulated in a sealed glass tube) are actuated by a permanent magnet attached to the key. Typical contact rating is 10^8 operations.

4.2.3.7 Hall-Effect Switch

This type of switch employs a semiconductor device which develops an output voltage proportional to the surrounding magnetic field strength. (Hall-effect). The magnetic field is varied by a permanent magnet attached to the key. Reliability is extremely high (typically greater than 10^8 operations) but this is presently one of the most expensive types of keyboard switching.

4.2.3.8 Magnetic Core Switch

Two sets of windings are placed on a ferrite core which acts as a transformer. An oscillator is connected to the primary winding and coupling to the secondary winding is varied by moving a magnet attached to the key. An amplifier is required on the secondary circuit to produce a positive switching action. Because there is no mechanical switch contact, reliability is high (5×10^7 operations).

4.2.3.9 Magnetic Repulsion Switch

One floating magnet is attached to an electrical conductor. A second magnet is attached to the key. When the key magnet is actuated it moves close to the floating magnet, the like poles on the two magnets cause a repulsive force to move the floating magnet and associated conductor. This conductor contacts a second conductor producing a switch closure. Because of the mechanical contacts, lifetime is typically 10^7 operations.

4.2.3.10 LED/Phototransistor Switch

The light from a light-emitting diode (LED) source is directed towards a phototransistor. When the key is actuated, a mask moves out of the path of the light, permitting the light to act on the phototransistor. The phototransistor conducts current when exposed to light, thus producing a switching action. These switches have a very high lifetime of approximately 10^8 operations.

4.2.3.11 Conductive Elastomer Switch

This type of switch may employ an actuating plunger on the end of which is a flexible conductive material or it may employ a sheet of the material. In either case the material is silicone or some such flexible organic compound that is impregnated with carbon, silver, or gold particles. When the key is actuated the conductive elastomer contacts and compresses against two conductors, establishing a firm low resistance electrical path between the conductors. Although some fabrication problems have been encountered, the manufacturers feel that the sheet type conductive elastomer keyboard has the projected potential cost of approximately 25% of that of the dry contact switch. Presently, lifetime is rated at approximately 10^8 operations.

KEYBOARD COMPARISON

A listing for the rated lifetime, logic compatibility and price for competitive technologies in keyboards. The price given is representative of a complete keyboard assembly, with pc board and encoder, in quantities of 1000, for a manufacturer's standard product in the range of 50-70 keys.

KEYSWITCH TYPE	KEYSWITCH LIFETIME NO. OF OPERATIONS	LOGIC COMPATIBLE OUTPUT	COST/KEY CAN $ FOR COMPLETE ASSEMBLY
DRY CONTACT	10^7	Yes	1.25
FLEXIBLE LAYER	10^8	Yes	1.50
SNAP ACTION	10^7	Yes	1.50
CAPACITANCE	10^8	Not Directly	$1.80
REED	10^8	Yes	$1.50
HALL-EFFECT	10^8	Not Directly	$2.00
MAGNETIC CORE	$5X10^7$	Not Directly	1.90
MAGNETIC REPULSION	10^7	Yes	2.00
LED/PHOTOTRANSISTOR	10^8	Yes	1.65
CONDUCTIVE ELASTOMER	$2X10^7$	Yes	0.65*

* based on 16 key keyboard without encoder

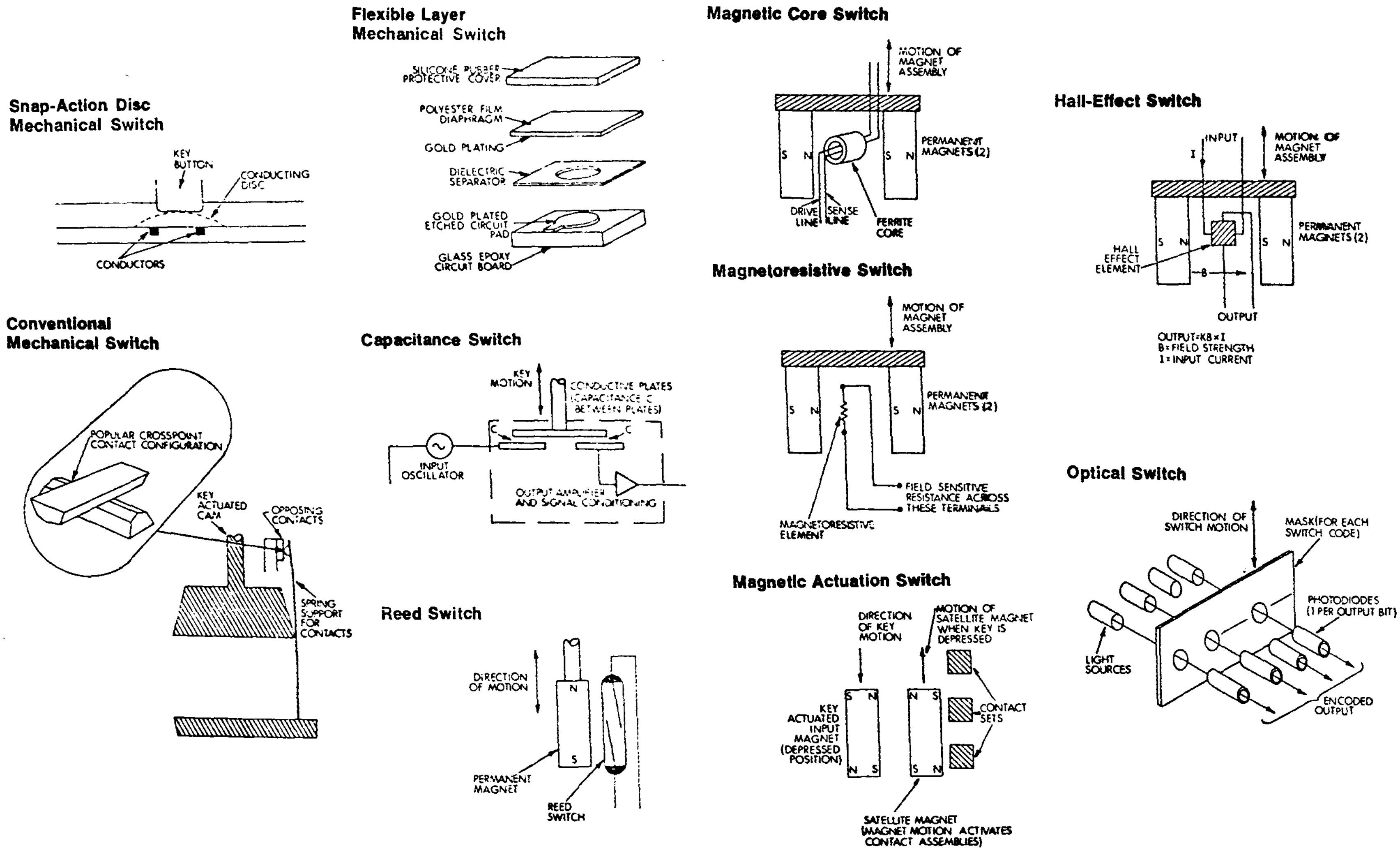


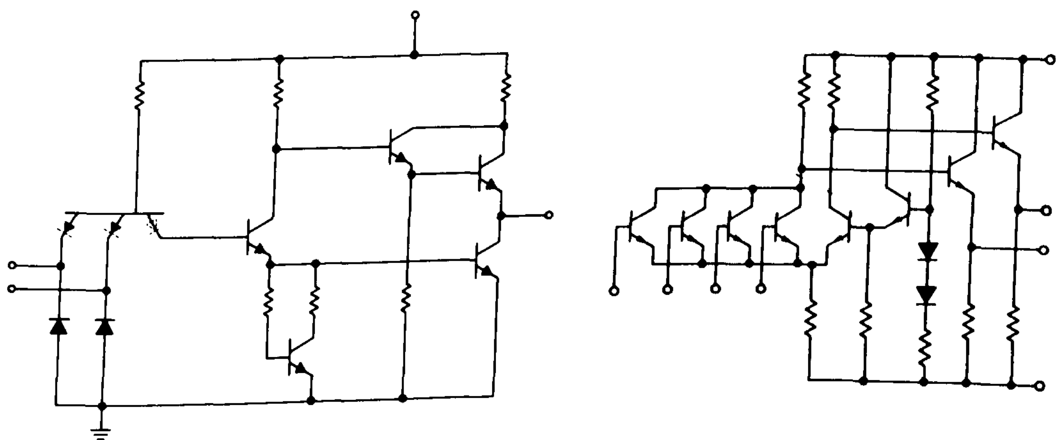
Fig. 6. Typical Switch Configurations

4.2.4 Logic Circuitry

From the invention of the transistor in the late 1940's through the development of the first, simple integrated circuits (with several transistors on a single chip) in the early 1960's to the present day large scale integrated circuits (LSI - with several hundred transistors on a single chip) increasingly complex electronic circuits have become available at increased reliability levels and with steadily decreasing costs. During this electronic revolution, two distinct major circuit technologies have developed, namely, Bipolar and MOS. Bipolar transistor operation depends upon the interaction of two types of charge carriers in the semiconductor material - holes and electrons. The MOS (metal-oxide-semiconductor) field effect transistor is a unipolar device in which the operation is basically a function of only one type of charge carrier. Although the first decade of transistor development was concentrated mainly on bipolar transistor technology, the greatest advances in the last decade have been made in the field of MOS devices. The $30 pocket calculator and the digital wristwatch of today were only possible through the development of MOS LSI circuits.

4.2.4.1 Bipolar Technology

Bipolar transistors are inherently faster than MOS transistors and so, even though improved manufacturing processes have allowed some MOS device speeds to approach those of some bipolar devices, when maximum system speed is required, certain types of Bipolar logic must be employed. Bipolar logic circuits have developed into several subsets or families. One major division occurs between the non-saturating and saturating logic circuits. A saturating transistor has an excess charge build-up in the base region when the transistor is switched on. This excess charge must be discharged before the transistor can be turned off, an operation which may take a relatively long period of time (although in reality it may be of the order of a few nanoseconds - 10^{-9} seconds). A non-saturating transistor does not have this excess charge build-up so it can operate at higher speeds. The non-saturating logic circuit family is called emitter-coupled logic (ECL). The two popular examples of saturating logic circuitry are called transistor-transistor logic (TTL) and diode-transistor logic (DTL). Schottky TTL logic is a variation of conventional TTL which operates at speeds approaching those of ECL but is simpler to fabricate. The present drawback to ECL is its more complex manufacturing process and therefore higher production cost. TTL is by far the most popular bipolar logic family because of low cost and the wide range of circuit functions that are available. TTL logic is at a relatively mature state and prices have reached a "bottoming-out" level. In fact the trend appears to be towards increasing prices in the future.



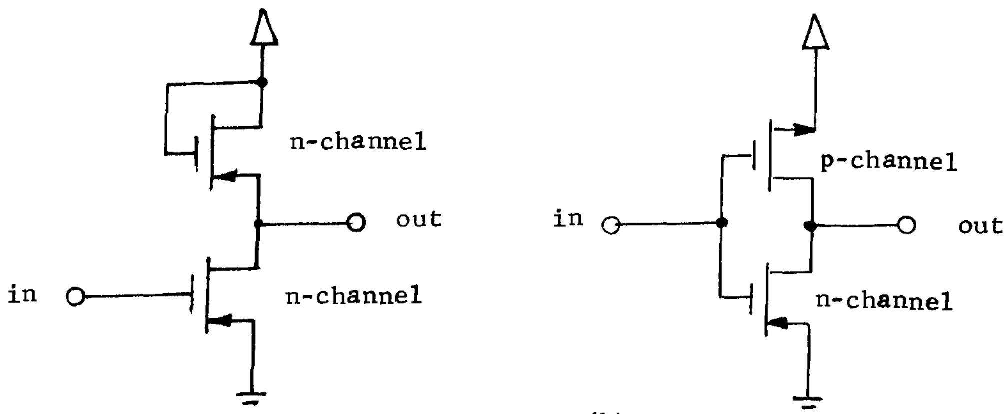
(a) Typical TTL gate (b) Typical ECL gate

Fig.7.

4.2.4.2 <u>MOS Technology</u>

MOS circuitry has also evolved into several distinct families. First of all, there are two basis types of MOS transistors; The depletion type and the enhancement type. In the depletion type transistor, applying a signal voltage to the gate turns the transistor off. In the enhancement type device, the operation is complementary to the deletion type. Current flow in the transistor increases, turning the transistor on, when a signal voltage is applied to the control gate. Further separation of types is made, depending upon whether current flow is due to electrons (n-channel) or holes (p-channel). Because electron mobility is greater than hole mobility, n-channel devices are inherently faster than p-channel devices. Most early MOS logic circuits employed p-channel enhancement technology, because of simpler manufacturing processes. However, most significant new circuits introduced within the last year have been n-channel devices, as the semiconductor manufacturers have now mastered the complexities of n-channel technology. Some semiconductor manufacturers are now putting all their research and development (in MOS) into n-channel and phasing out p-channel development altogether. N-channel and p-channel logic circuit families have not been developed on the small scale integrated circuit (SSI) level such as with Bipolar logic. The main advantage of MOS technology is its high packing density and low power requirements. In LSI circuits where a large number of gates are required, MOS technology is widely employed. Such devices as microprocessors and programmed logic arrays (PLA) are finding increasing applications in interactive data terminals as well as a large number of other electronic equipments. The terminal manufacturer can realize considerable assembly cost and physical size savings by employing one or two MOS LSI logic chips in place of upwards of 100 SSI chips.

The major MOS logic family is complementary-symmetry MOS or CMOS. In CMOS both n-channel and p-channel transistors are employed with one transistor forming the load for the other complement transistor. One transistor is turned on while the other is turned off. Because of the high off impedance of MOS transistors the load current is extremely low except during switching. It should be noted that it is possible to make complementary bipolar logic but only with discrete transistors. Present manufacturing processes mitigate against the fabrication of complementary bipolar transistors on the same substrate. More manufacturing steps are required in the fabrication of CMOS logic than for TTL but CMOS logic circuitry is still a relatively new development so that, while TTL prices have "bottomed out",the manufacturers are still improving the manufacturing process and yields with CMOS so costs are expected to continue downward for some time. CMOS logic costs may not exactly equal TTL logic costs, for equal functions, but overall system costs will be lower because power requirements are three orders of magnitude lower for CMOS. Most indications are that CMOS logic will grow rapidly over the next few years and eventually displace TTL as the most widely accepted logic family.



(a) Typical MOS inverter (b) Typical CMOS inverter

Fig. 8.

Some newer developments in the field of MOS are the MNOS metal-nitride-oxide semiconductor and the fabrication of circuits on a sapphire base, commonly referred to as SOS (silicon on sapphire). MNOS development has been concentrated on memory circuits because of the non-volatile storage capabilities and electrical field alterability of the devices. The technology provides no real advantages for logic circuitry and no "family" of MNOS logic circuits are commercially available. The MNOS structure is essentially the same as the p-channel MOS structure except that the gate insulator is composed of a thick layer of silicon nitride and a thin layer of silicon dioxide rather than a single layer of silicon dioxide. The SOS method of fabricating MOS circuits consists of growing the silicon wafer on a sapphire substrate. Sapphire forms a better insulator than the conventional silicon dioxide so it is possible to reduce the interdevice spacing and thereby increase the packing density. The first commercially available SOS devices have just been introduced so fabrication techniques are still ripe for improvement and improved yields will produce lower cost devices over the next few years. There are indications that silicon-on-sapphire technology may give way to silicon-on-spinel. There are manufacturing problems involved in producing spinel but its atomic structure more closely matches that of silicon so there should be fewer structural flaws at the junction of the two materials than between sapphire and silicon. The one major SOS device on the market is a LSI microprocessor. As with MNOS circuitry no real "family" of logic devices is presently available.

4.2.4.3 Semiconductor Logic Comparisons

The various major families of semiconductor logic circuits have been listed in the following chart with a graded relative comparison under several performance parameter categories. The grading is from 1 (best) to 6 (worst) and, in the case of more than one family exhibiting relatively equal performance, the chart shows equal grading. It should be emphasized that 1 denotes best performance which, for example, means the highest packing density however, it refers to the lowest in terms of cost/gate. It should be noted that, with the constant development work in the field of semi-conductors, there may currently be evidence of superior performance of one family over another, in a particular category, in contradiction to the table below.

The grading was determined from readily available, commercial products, and not the latest laboratory developments.

PARAMETER	ECL	BIPOLAR SCHOTTKY TTL	TTL	MOS CMOS
PROPAGATION DELAY	1	2	3	4
POWER CONSUMPTION	4	3	2	1
PACKING DENSITY	2	2	2	1
COST/GATE	3	2	1	2

SEMICONDUCTOR LOGIC COMPARISON

4.2.5 Memory

In the low speed "basic" interactive data terminal it is not absolutely necessary for the equipment to have any internal memory, as all data is transmitted or received at rates that the circuitry and the human operator are able to accept. However, there are some advantages in transmitting data at higher speeds, where it becomes necessary to have some buffer storage in the terminal. There are several means of providing a buffer store or memory, some of which are listed below:

a) Magnetic tape memory
   - "IBM-compatible"
   - cassette
   - cartridge

b) Magnetic disc or drum memory
   - rigid disc or drum
   - flexible disc

c) Semiconductor memory
   - bipolar
   - MOS

d) Ferrite Core Memory

All of the types listed above have been included because they form major categories in the present state-of-the-art of terminal memories. However some types will not be described because the present pricing structure of these subassemblies does not render them cost-effective in terms of the types of data terminals under examination. Such types as the "IBM-compatible" magnetic tape memory and the rigid disc or drum memory are only cost-effective for applications requiring very large memory capacity. They are often employed with batch entry type of data terminals but not with interactive data terminals.

There are two main functional divisions in memories, one is the read/write memory and the other is read only. All types listed above have both read and write capabilities, the read only memories are merely a limited subset of the particular memory in question.

Read/write memories are employed as buffer or "scratch-pad" memories to temporarily store data. One principal application is to act as an interface between the relatively slow operating speed of the human user and the fast nanosecond operating speeds possible in the data terminal and computer.

Read only memories are employed as character generators, keyboard encoders, and code converters in the main but they may also be employed in the intelligent terminal for such tasks as table lookup and microprogramming.

4.2.5.1 Magnetic Tape Memory

A thin layer of a material which exhibits magnetic properties such as iron oxide, or nickel cobalt is deposited on a film or tape of acetate or, more commonly, mylar. During the write operation, the tape is passed through the magnetic field under a recording head and the iron oxide particles are permanently polarixed in accordance with the direction of the magnetic field. The magnetic field is produced by a drive current in a coil wound around a roughly U-shaped core. The magnetic field bridges the gap between the two ends of the core. When the tape is passed under the tape head during the read operation, the magnetic field associated with the individual particles on the tape, induces a signal in the head producing data output. Magnetic tape memory is generally employed for mass storage where a large amount of data is to be stored. The "IBM-compatible" magnetic tape memory is capable of storing 10^7 bits or greater, it has a relatively long access time and costs in the range of $4,000 to $7,000. The large storage capability is more than that necessary for an interactive data terminal and the cost is relatively high.

Low cost magnetic tape storage can be obtained with the use of a cassette or cartridge. The cassette package now accepted as an industry standard is the Philips unit, widely used in home entertainment audio equipment. The typical cartridge is the 3M-type cartridge. Both types of memory have similar advantages in low cost ($700-$1200), small package with ease of handling, and sufficient storage for most interactive data needs (typically 10^6 bits). There is very little performance difference in the "packaged tape" concept between the two units although the cassette has received wider acceptance.

4.2.5.2 Magnetic Disc or Drum Memory

This type of memory is very similar to Magnetic Tape Memory in employing microscopic particles of materials exhibiting magnetic properties. However, instead of having the particles bonded to a mylar tape, they are bonded to the surface of a drum or disc, so that, essentially, the drum or disc is a short but very wide piece of magnetic tape. The net result of that, although the total bit storage capability of the drum or disc may approach that of magnetic tape, (although it is typically 10^5 to 10^6 bits) the access time is much lower.

The rigid drum or disc, as with the IBM compatible tape, is a high cost item and so is commonly found only in the "intelligent" batch-type of data terminal.

The flexible disc, or so-called "floppy" disc, is cost-competitive with the cassette or cartridge memory and, in fact, forecasts indicate that it will soon displace these tape memories in low cost bulk memory applications. The floppy derives its name from the very thin and flexible construction of the disc.

4.2.5.3 <u>Semiconductor Memory</u>

Monolithic semiconductor technology has, by developments in large scale integration (LSI), provided increasing density of chip elements, and higher reliability. These improvements and a continual reduction of per bit costs for stored digital data have made semiconductor memories cost competitive with core memories in small (< 64K bit) systems. Semiconductor memories have several advantages when compared to other memory types:

- high speed
- circuit compatibility with logic circuitry
- addressing and decoding electronics may be incorporated on memory chip
- semiconductor manufacturing technologies are still at an early development stage so further price reductions and performance improvements will be realizable.

The main disadvantage of most semiconductor memories is their volatility wherein data are normally lost whenever there is a power failure. Several systems utilize a standby power source for critical applications.

Regardless of the specific technology of the semiconductor memory, the general operation is similar. A matrix of memory cells, as illustrated in Fig. 9, are arranged with "X" and "Y" address decoders so that any specific memory cell may be addressed.

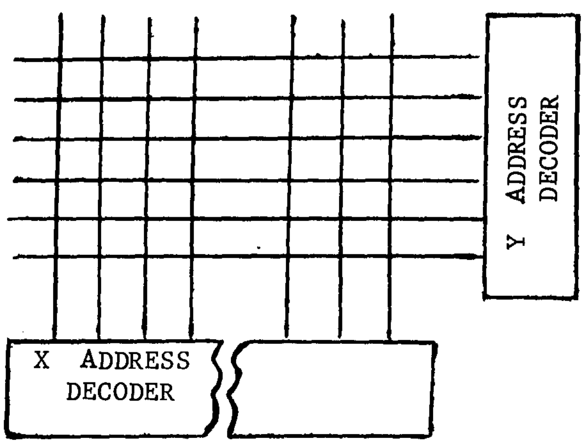


Fig. 9. Memory Matrix

During write operation, a particular memory cell is addressed and a data bit is transferred to that cell. Similarily, during read operations, the data bit is transferred from the addressed cell. In read only memories (ROM) permanent data are recorded in each memory cell and no write circuitry is provided. In programmable read only memory (PROM) the data may be altered or reprogrammed but in normal applications it is used as a ROM. The PROM devices are generally employed in the pre-production stage of terminal development so that changes may be made without excessive cost. Once the design is finalized, the lower cost ROM can be employed.

ROM's are typically employed as code converters such as keyboard encoders or to convert from the code employed in the computer on the data transmission medium. ROM's are also employed as character generators to address the specific dots in a dot matrix character or the specific bars in a seven segment character, for display or printer output.

Random access memory (RAM) is used in applications where data must be written and read at some later time, such as in a refresh memory for a keyboard/display terminal or as a memory buffer between the terminal and the data transmission medium. ROM's are actually a random access memory also, except that they are read only as opposed to the read/write capability of RAM. Serial access memories such as shift registers were employed, for example, as refresh memories in older keyboard/display terminals but are not presently cost-effective with RAM. Type groupings are:

i. Bipolar memories employ versions of the common transistor flip-flop to store data. These are faster than MOS memories but are more expensive to manufacture and consume more power. Bipolar memories are either manufactured as saturating TTL circuitry or as non-saturating ECL.

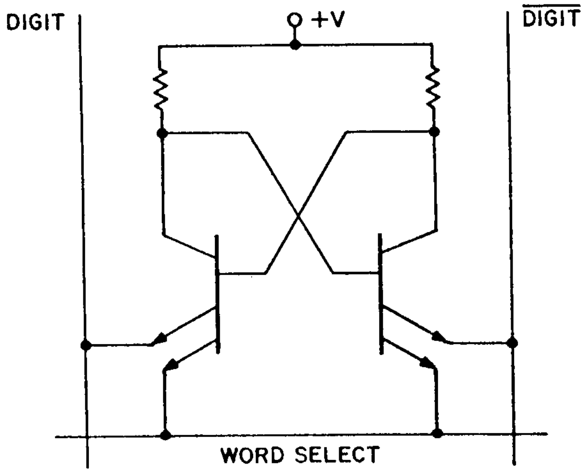
As with logic circuits, the ECL memories are inherently faster than TTL because of the non-saturating operation. All Bipolar memories are static memories as dynamic memories are not practical due to the relatively low impedences associated with Bipolar transistors.

ii. Metal oxide semiconductor (MOS) field-effect memories may be p or n channel devices operating in the depletion or enhancement mode. As in logic, most MOS memories are still p-channel devices because n-channel manufacturing difficulties have only recently been overcome. Static MOS memory cells are composed of flip-flops as with bipolar memory. The Dynamic MOS memory cell utilizes the high impedences of field-effect devices to store data by charging a capacitor. However some leakage does occur so periodic refresh is necessary. The dynamic memory has a distinct advantage in that it may be fabricated with only a single transistor, thus permitting very high packing densities.

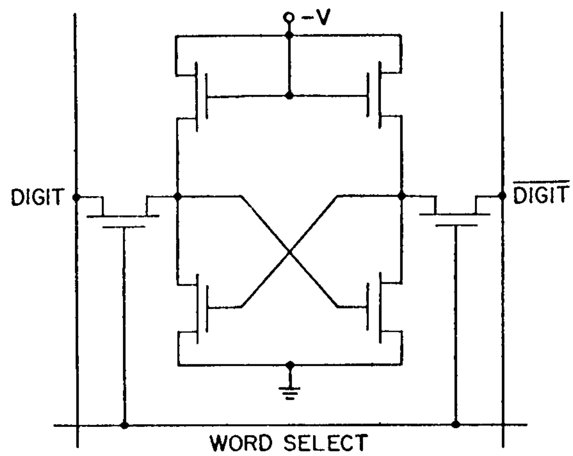
Dynamic memory cells consume very little power when not being read or written but they do require periodic refresh to recharge the capacitor. Static memory dissipates more power than does dynamic memory but is easier to use as no refresh cycling is necessary. Both dynamic and static MOS memories are available but dynamic are more common.

iii. Semiconductor Memory Comparisons. The various major families of semiconductor memory circuits have been listed in the following chart with a graded relative comparison under several performance parameter categories. The grading is the same as for the logic comparison, with 1 being the best and 6 being the worst. As with logic circuits, there may currently be evidence of superior performance of one family over another, in a particular category, in contradiction to the table below. The grading was determined from readily available, commercial products, and not the latest laboratory developments.

Fig.10. STATIC SEMICONDUCTOR MEMORY CELLS

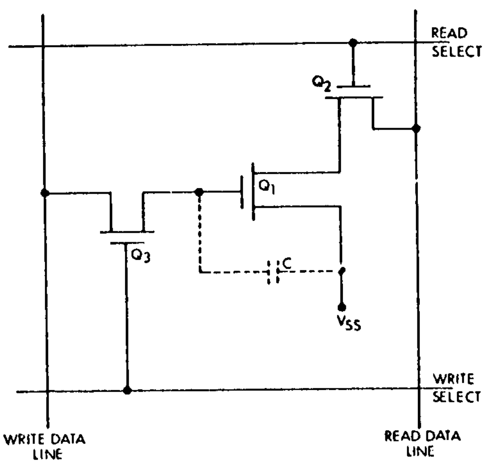


(a) Typical Bipolar cell

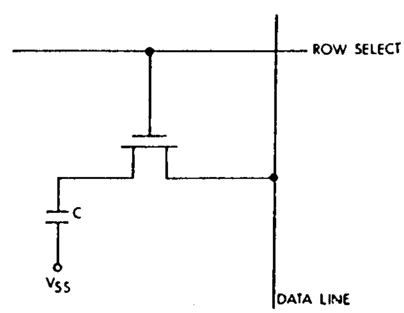


(b) Typical MOS cell

Fig. 11. DYNAMIC SEMICONDUCTOR MEMORY CELLS



(a) Typical 3 transistor MOS cell



(b) Typical 1 transistor MOS cell

PARAMETER	ECL	BIPOLAR SCHOTTKY TTL	TTL	N-CHANNEL	MOS P-CHANNEL	CMOS
ACCESS TIME	1	2	3	4	5	6
POWER CONSUMPTION	6	5	4	2	3	1
PACKING DENSITY	4	4	4	1	2	3
COST/BIT	6	5	4	1	2	3

SEMICONDUCTOR MEMORY COMPARISON

Semiconductor memories are still in a relatively early stage of development, especially in the cases of n-channel and complementary MOS. Although costs of materials are increasing, at sometimes alarming rates, the continual drive of semiconductor manufacturers, to reduce inter-cell spacings and cell size, is steadily eroding the total material costs and increasing yields, to produce a present overall trend to decreasing device costs.

4.2.5.4 Ferrite Core Memory

Circular ferrite cores are manufactured of ferrite material which exhibits magnetic properties. The ferrite materials are, typically,powdered compounds of manganese, zinc, copper or nickel. A current drive through the coil, wound on the ferrite core, will cause the core to magnetically polarize in a direction related to the current direction. The cores are assembled in a X-Y matrix of cores, similar to the matrix in a semiconductor memory. Individual cores are accessed by selecting specific X and Y lines. Cores have an advantage over most semiconductor memories in that the memory is non-volatile, i.e., data are not lost if the power supply is turned off. However, it is necessary to re-write the data after it has been read as data bits stored in core are destroyed during the read cycle.

4.2.6 Readers

The majority of present-day interactive data terminals have keyboard data entry mainly because of the relatively low cost of keyboards. Keyboards have some drawbacks in that some operator training is required (for a full alphanumeric keyboard) before the operator becomes proficient. Even with training however, the maximum input data rate is still severely limited. Faster data input rates can be achieved if some reader/scanner can be employed to read the data. There are three distinct types of reader, presently available, that could be employed for data input, namely optical, magnetic, and mark. A rapidly increasing number of applications of both optical and magnetic scanners are being employed in the interactive terminal field. This is particularly evident in point-of-transaction terminals such as credit verifiers and electronic cash registers for reading product codes, credit cards, etc. The mark resistance scanners are employed in optical mark readers.

4.2.6.1 Optical Scanners

Although various means of converting images into electronic signals have existed for some years, most early electronic methods of optical scanning employed vacuum tube technology, principally for television cameras. Semiconductor devices may be employed in image sensing (with varying degrees of success) because, when light is incident upon these devices, electron-hole pairs are created, the number of which is proportional to the intensity of the image. However, only recently have solid-state image scanning technological developments, in the photodiode and, most recently, the CCD fields, shown promise of replacing vacuum tube technology. Television-style camera tubes are generally too bulky and too expensive to be employed as a reader input for interactive data terminals. Some examples of facsimile equipment still employ photo-multiplier tubes to obtain an electronic picture of an image, but the potentially low cost and small size of the semiconductor image sensors will soon displace vacuum tube technology. Presently, semiconductor imaging arrays are expensive but once initial manufacturing difficulties are overcome, simplicity of silicon fabrication, high reliability, high packing density, low power and low noise advantages of these devices will push them into a position of market dominance.

i. Charge Coupled (CCD) Image Scanners

Charge-coupled or charge transport technology was first reported in 1970 but now all the large semiconductor firms are devoting some attention to this technology. Despite the fact that CCD is a relatively new device concept, it is based on well-developed semiconductor technology and it has an advantage in that the technology has promising applications in three major areas:

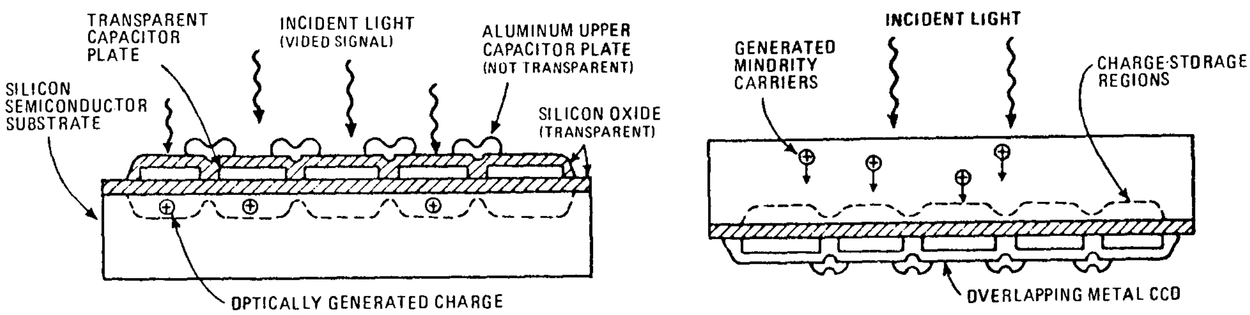
- Image sensing devices
- Shift register memories
- Analog delay lines

Besides this versatility, CCD technology is extremely simple, being basically a dynamic analog shift register fabricated from a closely spaced array of MOS capacitors. A minority charge packet is stored in the inversion region, under a depletion-biased electrode. This charge packet is moved from one region to the next region, in shift register fashion, by manipulating the electrode potentials. The charge representation of the image is clocked into a read amplifier, in serial format, to produce a scanned signal output.

Although the fabrication of charge-coupled devices employs techniques common to the manufacture of integrated circuits it cannot be represented by a conventional equivalent circuit such as is possible with IC logic devices. CCD's are functional devices as a whole and so cannot be separated into individual elements as with logic devices.

ii. MOS Photodiode Arrays

Superficially the MOS photodiode array operates in a manner similar to CCD image sensors, with electronic image representation being scanned in shift-register fashion. Fabrication techniques are also similar, but the performance differs because of the method of reading the signals. The MOS transistors are fabricated on the same monolithic structure as the photodiode array. The MOS transistors are employed as switches and the photodiodes conduct current proportional to the incident light of the image. The MOS transistors are sequentially scanned so that the signal representation of the image is multiplexed onto a common line. MOS photodiode arrays convert incident light signals more efficiently than CCD arrays because generally CCD's must employ back illumination because the structures have opaque metalization electrodes on the front. MOS photodiodes may be front illuminated and therefore the light losses are less. See Fig.12 for physical comparisons.



(a) Typical MOS photodiode array (b) Typical CCD array

Fig. 12

MOS photodiode arrays suffer from transistor switching noise when the array is sequentially scanned but CCD image sensors suffer from greater thermal noise. In general, though MOS scanners are noisier than CCD devices. CCD scanners are a simpler structure than the MOS photodiode device and therefore the individual cell size is smaller for CCD. For this reason CCD images appear to be the most likely candidate for high-resolution TV quality pictures. However, for lower resolution applications, such as in data terminals, MOS photodiode arrays have sufficient capabilities.

iii. Laser Scanners

Lasers have been available for approximately ten years but only recently have costs decreased to a point where they are being applied in data readers, credit verifiers and facsimile equipment. The present costs for volume quantities of helium-neon gas lasers is \$100 - \$150 and the advantages of employing a high-energy monochromatic light source for reading conventional printed labels renders the laser system cost competitive with other light source/scanner systems that require expensive reflective labels. The monochromatic high intensity laser source permits relatively easy detection of variations in the reflected light, by a phototransistor of photo-diode, as it passes over a character or image imprinted on a page or label. Laser light sources can be fabricated from semiconductor materials but these are, at present, not cost-competitive with gas lasers.

4.2.6.2 Magnetic Scanners

Magnetic scanners are also widely employed in reading cards and labels. Although optical character readers have the advantage that the page or label is also readable by humans, a considerably greater amount of internal hardware and software is required for computer readability. Optical code readers are similar to magnetic code readers in that there is no advantage of one scheme over the other as far as human readability is concerned. At present there are no real sub-assembly cost advantages between optical and magnetic code readers; the usage of one particular technology appears to be determined only on the user's particular bias. The very recent decisions by various merchant associations to settle on optical coding will push this technology to the predominant position.

Magnetic code readers can be divided into two main types, employing technology also employed in some keyboard switches.

i. Hall-effect Scanners

The magnetic code recorded on the card or badge produces a small local magnetic field. This field, when scanned by a semiconductor material (which possesses Hall-effect properties), induces an output voltage in the semiconductor. The magnetically recorded data are encoded in binary code to correspond to the price, or stock number or authorization code attached to a particular product or card.

ii. Magnetoresistive Scanners

With this type of scanner the detector is a material in which the resistance varies in proportion to the magnetic field strength. This variable resistance must be translated into a voltage signal by an amplifier. This type of scanner does not appear to be readily available on a commercial basis mainly due to a poor cost-effective position relative to Hall-effect devices.

4.2.6.3 Mark Scanners

These types of scanners are used for mark sense cards and, although the card is optically readable, the conventional method of reading is by sensing the low resistance pencil carbon mark. Of the data terminals surveyed, the only example employing a resistance-type mark scanner utilized a unique thick-film circuit with an array of pads to provide the mark contacts.

4.2.7 Badge/Card Update

Data terminals that are applications oriented, such as point-of-transaction terminals often employ some type of card or badge input. for fast and efficient user or customer identification. For some applications, particularly in the case of credit cards, it may be advantageous to write new information on the card so that, for example, a current authorized credit limit is always available.

For cards that have a magnetic tape or stripe for storing data, write heads, such as those employed in magnetic tape and floppy disc memories are used. A magnetic film similar to conventional magnetic tape is permanently bonded to the card. Since it is necessary to have relative motion between the magnetic tape and the write head, any updated data to be written on the card, are recorded as the card is ejected at a fixed speed, under motor control. As with conventional magnetic tape, the card magnetic stripe data may be erased and rewritten several thousand times without any significant degradation in quality.

It is not technically feasible to update optical bar codes on cards or badges because of difficulties in data erasure. There are presently available some terminals which are capable of conventional alphanumeric printout on the same cards that have been used for data input. The cards are generally of an IBM punched card style and the printers are of the impact printwheel style. Non-impact style printers could be employed but are not presently available because of costs and manufacturing difficulties in producing special (thermally sensitive etc.) cards.

4.2.8 Data Transmission

All interactive data terminals under examination in this study are considered to be physically remote from the central processing unit. The distances between the terminal and the CPU may range from a few feet to thousands of miles. But in any event, some means of transmitting and receiving the signal via a transmission medium must be employed.

4.2.8.1 Line Drivers/Receivers

For relatively short distances up to about a thousand feet it is possible to use simple and inexpensive integrated circuit line drivers and receivers to obtain acceptable data error rates. These line drivers generally operate in differential mode over a twisted pair of dedicated lines between the data terminal and the CPU. The data is transmitted in binary form with current drive in one direction for a "1" bit and current drive in the opposite direction for a "0" bit. Differential drive is employed in equipment wherever the line lengths exceed a few feet. For very short distances a single-ended mode of line driving may be used where the current is driven on one line only with the ground connection forming the return path. However, differential drive is the preferred mode as it avoids the noise problems associated with long ground loops. Integrated circuit line transmitters and receivers may cost from $5 to $25 depending upon the features provided and so the contribution to the overall terminal cost is generally negligible.

Although the line driver approach to data transmission is acceptable for short distance, dedicated line system configurations, it does not satisfy the needs when long distance multiple port access is required. The most readily available medium for this type of data transmission is the common carrier telephone system. However, at present, a problem arises here in that the data terminal and CPU operate on digital signals whereas the telephone communications network was developed primarily as an analog communications medium.

4.2.8.2 Digital

Digital data networks have only recently become available and, although rapid expansion of this service is expected through 1985, a completely digital, switched, data network is not expected to approach the level of the present analog network by that time. Certainly, even the present digital networks, such as Dataroute and Infodat, offer considerable transmission cost savings, at some data rates, over comparable analog service and it would be expected that further savings might be realized as the digital service matures and new developments become available. Also, the interface between the data terminal and the transmission medium becomes simpler, and therefore less expensive, because no digital to analog and analog to digital conversion is necessary. Essentially, integrated circuit drivers, similar in function to the line transmitters and receivers already described, may be employed.

4.2.8.3 Modem

As previously stated, the most extensive transmission medium presently available is the telephone system. In order to utilize the wide serving area of the telephone network, modems have been available for several years, to interface between the network and the wide range of terminals and computers. The word modem is an acronym for modulator - demodulator. In this context modulation is the digital to analog conversion process; demodulation is the analog to digital conversion process. The function of a modem is to convert digital input data to an analog signal suitable for transmission over the switched telephone network, and vice versa.

The digital data to be transmitted may modulate the analog carrier signal by one of several techniques:

amplitude modulation
frequency modulation
phase modulation

i. Amplitude modulation

In amplitude modulation, the amplitude of the transmitted analog carrier signal is varied in accordance with the modulating signal representing the information to be transmitted. New frequencies, appearing above and below the carrier frequency, are called upper and lower sidebands, and occupy a total bandwidth of twice the modulation rate. This type of transmission is called double-sideband AM.

However since both sidebands convey the same information and are therefore, mutually redundant, it is not necessary to transmit them both to convey the information. Two systems, single-sideband AM and vestigial-sideband AM, take advantage of this characteristic. In the former, only one sideband is transmitted with or without the carrier, and the required transmission bandwidth is only half that required by double-sideband AM. Single-sideband AM gives the best bandwidth economy, but not without penalty. Fairly complex modulation/demodulating circuitry is required, and for this reason the technique is used for high speed data transmission (4800-9600 baud) over a band-limited channel.

In vestigial-sideband AM, both the wanted sideband and a portion of unwanted sideband and carrier are transmitted. This eliminates the need for special encoders and permits use of conventional filters. The bandwidth is approximately 1.3 times that required for single-sideband AM systems, and the technique is typically used in modems operating at up to 7200 bps over voice-grade telephone lines.

In summary:

- AM is satisfactory if the channel amplitude characteristic is stable and there is little noise and interference.

- Single-sideband AM is attractive because it requires the narrowest bandwidth and has good noise tolerance. However, the carrier recovery problem necessitates a complex receiver. In combination with four-level coding and automatic line equalization, this technique is used in 9600-bps modems.

- Vestigial sideband AM requires a 30 percent wider transmission channel than single-sideband AM. Again, a complex receiver is required. The technique is used widely in modems operating at up to 7200 bps over voice-grade channels.

ii. Frequency modulation

Frequency modulation is defined as varying the frequency of the carrier in proportion to the instantaneous value of the modulating signal. When transmitting binary data, the frequency of the transmitted signal is shifted between two discrete values, one representing binary one and the other binary zero. This is called frequency shift keying (FSK).

Theoretically, the bandwidth required for transmission of a frequency modulated wave is infinite. By proper choice of modulation parameters, a bandwidth of approximately the same order as for a double-sideband AM system can be obtained. This occurs when the transmission rate in bits per second numerically equals the frequency shift between the two binary levels.

Implementation of FSK modulation requires moderately complex circuitry however, with the recent developments in semiconductor integrated circuit phase locked loops, the costs have decreased considerably. The FSK technique is characterized by good noise immunity and tolerance to amplitude variations. Binary FSK is the most widely used technique for transmitting data, at rates up to 1200 baud, over voice grade telephone lines.

iii. Phase modulation

This may be defined as varying the phase of the transmitted carrier signal in proportion to the instantaneous value of the modulating signal. Since in digital data transmission only discrete phase shifts are needed, phase shift keying (PSK) is extensively used. Presently, two-phase, four-phase and eight-phase systems are in use.

Four- and eight-phase systems are popular because the required bandwidth may be reduced by factors of 2 and 3 respectively when compared with double-sideband AM systems. Binary data transmission systems using PSK are synchronous and require that the transmitter and receiver timing be synchronized to permit the use of coherent detection techniques.

PSK provides the best tolerance to noise, but when detected differentially is limited to synchronous operation. Differential four-phase modulation requires the same bandwidth as binary single-sideband transmission, and is used for synchronous operation at 2400 bps. Differential eight-phase modulation is used for synchronous operation at 4800 bps.

Modems are hardwired into the telephone network whereas acoustic couplers are "connected" via the handset. The interconnection between modem/acoustic coupler and the data terminal is a hardwired connection. The signal levels for binary data transmission between the modem/coupler and the data terminal are dictated by an industry standard EIA RS232 specification. Some data terminals are manufactured with modems built into the equipment but, at present, the majority of terminals have an RS232 or European equivalent standard CCITT V24 interface to connect to an external modem.

4.2.8.4 Teletype[R] Current Loop

Some terminals have been designed for "plug compatibility" with the long-standing Teletype[R]. Teletypewriters operate on a standard signal drive of 20 milliamperes in a current loop. The transmit and receive circuitry to simulate the teletypewriter is quite simple and inexpensive. The Teletype[R] current loop transmission rate is ordinarily 10 characters/second and so is only employed where relatively long transmission times may be tolerated.

4.2.8.5 Touch Tone Transmission

The Touch Tone tranmission is a multi-tone method of data transmission. There are generally eight distinct Touch Tone frequencies associated with the 12 digit telephone "dial" with a two of eight coding providing differentiation between inputs. Although coding and decoding these frequencies would ordinarily be more expensive than the two frequency binary FSK technique employed in acoustic couplers, the Touch-Tone method is quite inexpensive because of their high volume useage in conventional telephones. As the older dial telephone is phased out in favour of the Touch Tone telephone, the volume of coders and decoders consumed by the telephone industry will definitely affect the price paid for such units used in data transmission applications. Touch Tone data transmission is, at present, only employed in low cost data entry/dial-in inquiry type of interactive data terminals.

R. registered T.M.

4.3 TERMINAL POPULATION ESTIMATES

One of the objectives of the study was to obtain reasonable estimates of interactive data terminal populations in Canada, the U.S., and foreign countries. Considerable effort was made to obtain population figures as part of our questionnaire response and to reconcile these figures with as many possible relevant figures from other sources. It should be emphasized that accuracy cannot be guaranteed without a major research study for a number of reasons:

a) The supply of terminals comes from a wide diversity of manufacturers and representatives and this universe is continually changing.

b) There is a reluctance on the part of large dominant manufacturers to release information as to products shipped.

c) Geographically, terminals may be widely spread and are frequently under the control of several departments in the user company.

d) The same terminal types may be used for purposes other than interactive data processing so that the presence of the terminal does not necessarily represent a population unit.

e) Manufacturers frequently have OEM contracts to other suppliers or systems houses, and therefore the end use is not necessarily known to the originator of the equipment.

Regardless, however, we have developed what appears to be supportable figures, the details of which are shown in Appendix E. In summary our figures show that at the end of 1973 there is an installed base of approximately 31,000 interactive terminals in Canada. The same figure for the U.S.A. is approximately 500,000, and for Europe the figure is approximately 100,000.

The present total growth rate in the U.S. is given at approximately 25% per year and the same figure for Canada and Europe are 75% and 50% respectively.

The relative occurrence of similar terminal types is roughly comparable for each market. On the average, it would indicate that presently keyboard/printer and keyboard/display terminals are approximately equal in Canada and together represent 75% of the installed population but that present growth rate favours keyboard/display, limited interaction enquiry, point of sale and digital facsimile.

Sources: A. D. Little
Eurodata
Frost & Sullivan
Organization for Economic Cooperation & Development, Paris
Bell Telephone Company of Canada
Trans Canada Telephone System
Computer/Communication Task Force, Canada
Datamation Magazine
Urwick, Currie Questionnaire

5. CONCLUSIONS AND RECOMMENDATIONS

As stated originally the ultimate objective of these related studies is to assist the Canadian Government in evolving a strategy for the development of a viable data terminal industry. With this in mind we conclude our report by summarizing the relevant observations made and by making tentative recommendations as may seem appropriate in the context of this objective.

5.1 The Canadian market for data terminals is substantial and growing but because of the apparent significance of LSI in most products and the scale required to justify its use, we see the Canadian market alone as being restrictive to product development.

Recommendation - Any strategy for the development of a Canadian data terminal product would have to assume international marketing or be highly subsidized.

5.2 The Canadian market is well serviced by data terminal products of the latest technologies and therefore is assumed to be as sophisticated as any.

Recommendation - Any identified requirements of the Canadian market should be thought of as a prototype for a product which can be marketed internationally.

5.3 The typical cost involved in the fabrication of a terminal from components is of the order of 10% of the total direct manufacturing costs. Therefore the Canadian content at the manufacturing level would be low unless significant components as well can be manufactured.

Recommendation - Any strategy to encourage Canadian manufacture of data terminals should consider more than just assembly of components in order to make any significant contribution to the economy.

5.4 The conventional and most popular devices, keyboard/display and keyboard/printer, are well represented by suppliers and by all indications is a very competitive field. Suppliers in newer, more specialized, fields are much more limited.

Recommendation - Although the entry cost may be higher we recommend the investigation of some of the newer markets such as digital facsimile or graphic input as representing better opportunity for a unique Canadian contribution and in this regard we suggest in-depth market studies.

5.5 If there is to be a viable data terminal industry, there will be a continuing need for good general market data and as experienced in the efforts to get population figures, data is sparse and difficult to obtain at the present moment.

Recommendation - Thought should be given to ways in which market data may be readily obtained (e.g. liaison with the computer census taken by the Canadian Information Processing Society), so that major markets and growth trends can be readily identified. In addition, we recommend that products and suppliers be categorized and catalogued on an on-going basis and that trends be monitored.

5.6 The development of relevant technology for data terminals in the past has been greatly influenced by other volume markets and it would appear that this will continue. Examples are LED and LCD displays, as well as the present trends in hard copy printers.

Recommendation - Technology trends and developments in non data terminal markets should be continuously examined for development opportunities.

5.7 From allindications Liquid Crystal has the greatest potential for displays of the future, although the technology and production methods are not fully proven.

Recommendation - The Canadian Government could examine this area more fully to determine if it would be advantageous to support this technology development in Canada.

While these general recommendations may be helpful, we believe that considerable information has been gathered during this study which can only be usefully interpreted or applied in a specific context or problem analysis. It is, therefore, a final point that details of data collected or of personal interviews conducted beyond that which can be readily published in our report may be of value when evaluating a specific strategy. We would recommend the consideration of further discussions and elaborations as may prove useful.

6. REFERENCES

6.1 TERMINALS

1. "Alphanumeric Display Terminal Survey"
   Datamation v. 19, n. 11, Nov. 1973 p. 71.

2. "Data Communications Terminals - A Survey"
   Telecommunications v. 7, n. 11, Nov. 1973 p. 23.

3. "Fast Interactive Hardcopy Terminals"
   Datamation v. 19, n. 10, Oct. 1973 p. 77.

4. "The Facsimile Market"
   Telecommunications v. 7, n. 7, July 1973 p. 13.

5. "The Computer Data Terminals Market" (2 Vols.)
   Frost & Sullivan Inc., 1971.

6. "Remote Data Terminals and Audio Response 1973-1982"
   Frost & Sullivan Inc., 1973.

7. "Computer Data Entry Systems" (2 Vols.)
   Frost & Sullivan Inc., 1973.

8. "European Computer & Communications Markets 1973-1985"
   Quantum Science Corp., 1973.

9. "Data Communications Market Segmentation Study" (2 Vols.)
   Casson-Oman Management Consultants 1973.

10. "Outlook for Computer Peripheral Equipment"
    A.D. Little Inc., 1972.

11. "Auerbach Computer Technology Reports - Data Communications"
    Auerbach Corp.

6.2 SUB-ASSEMBLIES

6.2.1 Displays

1. "Penetration Colour Tubes are Enhancing Information Displays"
   Electronics v. 46, n. 2, Jan. 18/73 p. 155.

2. "The New Displays Complement the Old"
   Electronics v. 46, n. 8, April 12/73 p. 91.

3. "Current and Future Graphic Displays for Military Systems"
   Computer Design v. 12, n. 2, Feb. 1973 p. 65.

4. "Visual Displays for Computers"
   Computer Design v. 10, n. 10, Oct. 1971 p. 55.

5. "The Right Numeric Readout: A Critical Choice for Designers"
   Electronics v. 44, n. 11, May 24, 1971 p. 65.

6.2.2 Printers

1. "Printer Selection Factors"
Computer Design v. 11, n. 12, Dec. 1972 p. 45.

2. "Non Impact Printers"
Datamation v. 19, n. 5, May 1973 p. 71.

3. "The Technology Gap Starts to Close for Computer Peripherals"
Electronics v. 45, n. 16, July 13, 1972 p. 59.

6.2.3 Keyboards

1. "Keyswitch and Keyboard Selection Factors for Computer Peripherals"
Computer Design v. 12, n. 3, Mar. 1973 p. 67.

2. "Keyboards: Chasing the Captives"
Electronic News Oct. 22, 1973.

3. "A Primer on Keyboards"
Electronic Engineering Times Dec. 3, 1973.

6.2.4 Memory

1. "Semiconductor Memories are Taking Over Data-Storage Applications"
Electronics v. 46, n. 16, Aug. 2, 1973 p. 75

2. "Semiconductor RAMS Land Computer Mainframe Jobs"
Electronics v. 45, n. 18, Aug. 28, 1972 p. 63.

3. "Selection and Application of Semiconductor Memories"
Computer Design v. 13, n. 1, Jan. 1974 p. 65.

4. "Floppy Discs"
Quantum Science Corp. v. 73, n. 376, 1973.

5. "The Technology Gap Starts to Close for Computer Peripherals"
Electronics v. 45, n. 16, July 31, 1972 p. 59.

6. "Crystal-Balling the Low Cost Data Recording Industry"
Telecommunications v. 6, n. 9, Sept. 1972.

6.2.5 Scanners

1. "The Tradeoffs in Monolithic Image Sensors: MOS vs CCD"
Electronics v. 46, n. 11, May 24, 1973 p. 106.

2. "Charge-coupling Improves its Image, Challenging Video Camera Tubes"
Electronics v. 46, n. 2, Jan. 18, 1973 p. 162.

6.2.6 Data Transmission

1. "Modems - Another Look"
Telecommunications v. 7, n. 6, June 1973.

6.3 GENERAL

1. "The Great Takeover"
Electronics v. 46, n. 22, Oct 25, 1973.

APPENDIX A

COMPOSITION OF STUDY TEAM

This study was carried out by the following staff members and technical consultants of the consultant firm of Urwick, Currie & Partners Ltd.*:

W.M. Kerrigan	Partner-in-Charge
Technical Consultants	
R.T. Marshall	Ruscom Logics Limited
I.G. Kaye	Ivor Kaye Associates

The study was monitored by the following members from the Communications Research Centre:

R.G. Fujaros	Project Officer
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APPENDIX B

QUESTIONNAIRE SUMMARY AND RESPONSE

1. QUESTIONNAIRE USED

While for reasons of bulk the full questionnaires are not included in this report, a summary of the data content is given as follows:

1.1 SUPPLIERS OF TERMINAL PRODUCTS:

- Individual products listed by terminal classification
- Features/operating characteristics
- Prices
- No. installed
- Manufacturer & technology of major sub-assemblies
- Fabrication techniques (where manufactured)

1.2 SUPPLIERS OF TERMINAL SUB-ASSEMBLIES

- Individual products by classification
- Prices (current, quantity effect and historical trends)
- Performance/features
- Technologies involved - Past/Present/Future
- Primary market - end use - other markets
- R & D effort
- Manufacturing technology

2. QUESTIONNAIRE RESPONSE

Firms polled are divided into 2 groups, Canadian and US/Foreign and, as was emphasized, the greatest effort was made in obtaining data on products made or represented in Canada. With a few minor exceptions, U.S. or foreign firms with products represented in Canada, are therefore included in the first group and it can be assumed that the second represents only those firms which do not currently have entry into the Canadian market.

On this basis the response to the survey can be summarized as follows:

Canadian and Canadian represented firm:	- 146 contacted		
Not in field	55		
Unable to contact	9		
Net universe	82		
Answered Questionnaire	46	56%	
Sent brochures only	8	66%	(cum)
Promises outstanding	21	91%	"
Requested 2nd. Questionnaire	7	100%	"
Accounted for		100%	"

U.S. and Foreign firms	- 157 firms contacted		
Not in field	12		
No address or returned	10		
Net universe	134		
Answered Questionnaire	30	22%	
Brochures only	12	31%	(cum)
Promises Outstanding	4	35%	"
Accounted for		35%	"

APPENDIX C

TABLE OF PRODUCTS BY TERMINAL TYPE

TERMINAL TYPE: KEYBOARD/DISPLAY

MANUFACTURER	MODEL	CAN. REP.	NO. INSTAL. IN CAN.	PRICE RANGE	DISPLAY	DATA TRANS.	TECHNOLOGIES	FEATURES
Ann Arbour Terminals Inc. (U.S.A.)	Design III	x	N.A.	N.A.	CRT	- RS232 - TTY loop	MOS memory	- up to 3200 char. display
Applied Digital Data Systems Inc. (U.S.A.)	Consul 580 Consul 840 Consul 880	x	150	$1,750 and up	CRT	- RS232	MOS char. gen. and memory	- 1920 & 2048 char. display - Optional TTY loop or Modem
Beehive Terminals Inc. (U.S.A.)	Super Bee Mini Bee	x	100 +	$1,800 - 4,200	CRT	RS232	Reed switch keyboard MOS encoder MOS char. Gen. TTL/MOS logic	- 2000 char. display
Bunker Ramo (U.S.A.)	2206/17 2204/15	x	50 N.A.	$1,700 and up	CRT	RS232	MOS/LSI logic	- 960 char. display
Business Computers Ltd. (U.K.)	A/N 16	x	15	$3,500	CRT		Reed switch keyboard MOS encoder	
Car-Mel Electronics Ltd. (U.S.A.)	D-301 D-302	x	0	$1,000 - 2,000	CRT	RS232	Mechanical contact keyboard MOS encoder	- 512 char. display
Computek Inc. (U.S.A.)	200	x	Few	$ 5,000 - 12,000	CRT	RS232	MOS memory	Touch sensitive screen option - 2000 char. display
	300		N.A.	$ 4,620 - 5,770				- Graphics capability on 256 x 256 grid - 1000 char. display
	400		N.A.	$ 9,500				- Graphics capability on 1024 x 800 grid - Local display gen.
Computer Optics Inc. (U.S.A.)	CO:77		N.A.	$ 4,200 - 4,600	CRT	N.A.	N.A.	- 1920 char. display
Conrac Corp. (U.S.A.)	401 480		N.A.	$ 3,200 - 3,600 $ 1,100 - 1,700	CRT	RS232 TTY loop	Mix of Hall-effect and Reed switch keyboards MOS encoders	- 2000 char. display 960 char. display
Control Data Canada (Sub. of U.S. firm)	713	x	2,000 +	$ 2,600	CRT	RS232	Reed switch keyboard MOS encoder Bipolar logic MOS memory	- 640 or 1280 char. display
	Plasma Display		0	N.A.	Plasma Panel			Graphic capability 129 x 128 grid

TERMINAL TYPE: KEYBOARD/DISPLAY

MANUFACTURER	MODEL	CAN. REP.	NO. INSTAL. IN CAN.	PRICE RANGE	DISPLAY	DATA TRANS.	TECHNOLOGIES	FEATURES
Data Disc Inc. (U.S.A.)		x	N.A.	$ 4,800 and up	CRT	RS232	Hall-effect keyboard MOS encoder	Colour display
Datamedia Corp. (U.S.A.)	1500 2000 2100A 2500	x	N.A.	$ 1,700 - 1,900 $ 2,150 - 2,300 $ 2,500 - 2,600 $ 2,500	CRT	RS232	Reed switch keyboard Bipolar encoder	480-1920 char. display 960&1920 char. display 1440 & 1920 " " 1920 " "
Datapoint Corp.	3300 2200	x	40 250	$ 3,850 - $ 7,500 - 16,000	CRT	RS232	TTL/MSI logic MOS memory	- 1800 char. display - 960 & 1920 char. display - Modem option 9600 baud - Hard copy option
Delta Data Systems Inc. (U.S.A.)	5200	x	200	$ 4,700	CRT	RS232	Reed switch keyboard Bipolar encoder	2160 char. display
Digi-Log Systems Inc. (U.S.A.)	33 3300	x	N.A.	$ 1,500 - 1,700 $ 2,500	CRT	-Acoustic coupler RS232 or Modem	TTL/MOS logic MOS Microprocessor	1280 char. display 1960 char. display
Ferranti Ltd. (U.K.)	WDM 1001 WDM 2001	x	0 0	$5,000	CRT	RS232 equiv.	Various types of keyboards and encoders employed MOS ROM char gen MOS SR refresh Bipolar ROM char gen	1056 char display (10 x 7 dot matrix) 600-4300 Baud 2080 char display (8 x 7 dot matrix) 600-2400
Four-Phase Systems Inc. (U.S.A.)	IV/70	x	100 - 200	Rental $45/month	CRT	RS232	Reed switch keyboard MOS encoder	288 to 1930 char. display
GTE Information Systems Inc. (U.S.A.)	IS7800	x	N.A.	$ 6,500 and up	CRT	RS232	N.A.	240 to 1920 char. display
Hazeltine Corp. (U.S.A.)	1000 2000	x	5 - 10 60 - 70	$ 2,000 $ 3,600	CRT	RS232	N.A.	960 char. display 2000 char. display
Hitachi Co. Ltd. (Japan)	H-9411		0	N.A.	CRT	N.A.	Hall-effect keyboard MOS encoder	
Imlac Corp. (U.S.A.)	PDS-4	x	0	N.A.	CRT	RS232	N.A.	Graphic display 2048 x 2048 grid 16 level grey scale
Infoton Inc. (U.S.A.)	Vistar Vista	x	N.A.	$ 2,100 $ 1,800	CRT	RS232 & TTY Loop	N.A.	1920 char. display 1600 char. display Light pen option

TERMINAL TYPE: KEYBOARD/DISPLAY

MANUFACTURER	MODEL	CAN. REP.	NO. INSTAL. IN CAN.	PRICE RANGE	DISPLAY	DATA TRANS.	TECHNOLOGIES	FEATURES
International Computer Ltd. (U.K.)	7181	x	0	$ 6,250	CRT	N.A.	Mix of Hall-effect & Reed switch keyboards Bipolar encoder MOS char. gen.	2000 char. display
Lear Siegler Inc. (U.S.A.)	7700	x	N.A.	$ 3,800	CRT	RS232 or TTY Loop	N.A.	2000 char. display
Lektromedia (Can.)	LEK 100 LEK 110 LEK 120	x	~ 50 ~50 ~50	$ 2,000 - 5,000 No longer available $ 7,000 - 10,000	CRT	RS232	Reed switch keyboard MOS encoder TTL/DTL logic MOS memory - Slide projection - Acoustic wave touch sensitive CRT screen	1280, 1920 char. display 100 audio message capability
Logical Associates Ltd. (Can.)	Light-writer	x	New	$ 2,500	Plasma panel	Acoustic coupler	Conductive elastomer keyboard TTL logic	256 char. display
Megadata Computer & Communications Inc. (U.S.A.)	SIR - 1000	x	15	$ 4,000	CRT	RS232	MOS memory MOS microprocessor Reed switch keyboard	Graphic capability 256 char. display 7 colour video output option
Princeton Electronic Products Inc. (U.S.A.)	801	x	N.A.	$ 9,300 - 13,600	CRT	RS232	Silicon target storage tube	Graphics capability 1024 x 1024 grid 32 level grey scale
Raytheon Data Systems (U.S.A.)	PTS 100	x	N.A.	$ 5,500 - 7,800	CRT	RS232		1920 char. display
Research Inc. (U.S.A.)	3301 3311	x	N.A.	$ 1,100 $ 2,000	CRT	RS232	Hall-effect keyboard MOS encoder TTL & some discrete circuits	960 char. display 1920 char. "
Sanders Data Systems Inc. (U.S.A.)	8170		N.A.	N.A.	CRT	RS232	N.A.	480 to 190 char. display
Scientific Measurement Systems Inc. (U.S.A.)	SMS-1440	x	120	$ 2,500 and up	CRT	RS232	TTL logic MOS memory	1440 char. display
I. P. Sharp Assoc. (Can) Ltd.	IPSA - 100	x	N.A.	N.A.	CRT	Acoustic coupler	N.A.	Connects to users TV set 1024 char. display
Siemens A.G. (Germany)	8150		0	N.A.	CRT	RS232 equiv.	MOS memory	1008 char. display

TERMINAL TYPE: KEYBOARD/DISPLAY

MANUFACTURER	MODEL	CAN. REP.	NO. INSTAL. IN CAN.	PRICE RANGE	DISPLAY	DATA TRANS.	TECHNOLOGIES	FEATURES
Sycor Inc. (U.S.A.)	340 255	x	30 - 50 0	$ 7,300 - 10,300 $ 4,700 - 5,300	CRT	RS232	N.A.	1920 char. display
TEC Inc. (U.S.A.)	400	x	20	$ 1,700 - 4,800	CRT	RS232	N.A.	1920 char. display
Tektronix (U.S.A.)	4012 4013	x	100	$ 4,200 - 5,800	Storage CRT	RS232	TTL/MOS logic MOS memory	Graphic capability 1020 x 780 grid 2590 char. display
Teletype Corp. (U.S.A.)	40	x	N.A.	$ 2,500 - 6,000	CRT	RS232	N.A.	1920 char. display
Vector General Inc. (U.S.A.)	Series 3		0	$25,000 and up	CRT	RS232	N.A.	Graphic capability 4096 x 4096 grid 32 level grey scale
Westinghouse Can. Ltd. (Sub. of U.S. firm)	1600	x	200	$ 2,500	CRT	RS232	Reed switch & disc contact keyboard Bipolar encoder MOS char. gen. Bipolar logic	1600 char. display
Wiltek Inc. (U.S.A.)	500		N.A.	$ 6,500 and up	CRT	RS232	N.A.	2000 char. display
Digital Equipment Corp. (U.S.A.)	VT05 VT06	x	) 25)		CRT	RS232 & TTY loop	Reed switch keyboard MOS memory	1440 char. display 1800 char. display

TERMINAL TYPE: KEYBOARD/PRINTER (INCLUDING PRINTER-PLOTTER)

MANUFACTURER	MODEL	CAN. REP.	NO. INSTAL. IN CAN.	PRICE RANGE	PRINTER	DATA TRANS.	TECHNOLOGIES	FEATURES
Ahearn & Soper Ltd. (Can.)	Multi-writer ASL/1	x	15	$ 4,600	Impact	RS232	N.A.	10-30 char/sec.
Centronics Data Computer Corp. (U.S.A.)	308	x	New	$ 3,900	Impact dot-matrix	Modem option	N.A.	120 char/sec. plotting capability
Computer Devices Inc. (U.S.A.)	1030	x	N.A.	$ 3,800 - 4,500	Thermal dot-matrix	Acoustic coupler	N.A.	10-30 char/sec. plotting capability
Computer Transceiver Systems Inc. (U.S.A.)	EX 310	x	N.A.	$ 4,000 - 6,000	Thermal dot-matrix	RS232	Reed switch keyboard MOS encoder	10-30 char/sec. plotting capability
Di-An Controls Inc. (U.S.A.)	9030	x	N.A.	$ 4,000 - 6,000	Dot matrix impact	RS232	Magnetic core switch keyboard MOS encoder	10-30 char/sec. plotting capability
General Electric Co. (U.S.A.)	Termi-net 300 1200	x	 N.A. N.A.	$ 5,950 - 6,500	Impact chain-type hammer	RS232	MOS/bipolar logic MOS memory	 10-30 char/sec. 10-120 char/sec.
Hitachi Co. Ltd. (Japan)	H-9515		0	$10,000 - 11,000	N.A.	N.A.	N.A.	N.A.
Memorex Corp. (U.S.A.)	1240	x	33	$ 4,500 - 9,300	Impact printwheel	Acoustic coupler or Modem	N.A.	10-120 char/sec.
Olympia Werke AG (Ger.)	SW150	x	2	N.A.	Impact typewriter	N.A.	N.A.	20 char/sec.
Siemens AG (Ger.)	T100		0	$ 2,000 - 4,000	Impact printwheel	TTY loop	Electromechanical	10 char/sec. Teletype equiv.
Teletype Corp. (U.S.A.)	33 35 38	x	250 10 15	$ 1,000 - 2,000 $ 2,000 - 6,000 $ 2,000 - 2,500	Impact printwheel	TTY loop TTY loop Modem option or RS232	Electromechanical	10 char/sec. 10 char/sec. 10 char/sec.
Texas Instruments Inc. (U.S.A.)	Silent 715	x	N.A.	$ 3,000 - 3,500	Thermal dot-matrix	RS232	Bipolar/MOS logic	30 char/sec. plotting capability

TERMINAL TYPE: KEYBOARD/PRINTER - PLOTTER

MANUFACTURER	MODEL	CAN. REP.	NO. INSTAL. IN CAN.	PRICE RANGE	PRINTER	DATA TRANS.	TECHNOLOGIES	FEATURES
Typagraph Corp. (U.S.A.)	DP-30		N.A.	$ 4,500 - 8,700	Impact printwheel	Modem	Reed switch keyboard MOS encoder	10-30 char/sec.
Anderson-Jacobson Inc. (U.S.A.)	AJ630	x	N.A.	$ 3,200	Thermal dot matrix	RS232	N.A.	10-30 char/sec. plotting capability
Data Interface Inc. (U.S.A.)	DI-240 DI-120	x	0	$ 5,500 - 5,700 $ 3,500	Magneto static dot matrix "	RS232 RS232	Reed switch keyboard MOS encoder	Up to 240 char/sec. plotting capability Up to 120 char/sec.
Harris Communications Systems (U.S.A.)	Code	x	Few	$ 4,300 +	Impact printwheel	Acoustic coupler or RS232	Mechanical and Hall effect keyboards Bipolar encoder	15 char/sec.
Honeywell Infor. Systems U.S.A. - manufactured in Canada	BTT330	x	75	$ 7,000	Impact printwheel 2 separate printers	Modem 1200 band	Hall-effect keyboard and MOS encoder Photodiode optical scanner MOS logic	20 char/sec. print Polling Banking terminal
Digital Equipment Corp. (U.S.A.)	LA30	x	N.A.	$2,800 - 3,200	Impact dot matrix	RS232 TTY loop	N.A.	10-30 char./sec plotting capacity
Portacom (U.S.A.)	PC8110	x	50	$ 2,100	Impact printwheel	Acoustic Coupler	Reed switch keyboard. TTL encoder	Portable terminal
Olivetti (Italy)	Te308S Tc349	x x	150 400	$ 2,400	impact impact	Acoustic coupler Modem 1200 baud	N.A.	15 char./sec 15 char./sec Banking terminal

TERMINAL TYPE: DOCUMENT READER/PRINTER

MANUFACTURER	MODEL	CAN. REP.	NO. INSTAL. IN CAN.	PRICE RANGE	SCANNER	DATA TRANS.	TECHNOLOGIES	FEATURES
Ferranti-Packard Ltd. (U.K.)	FP6921	x	0	$ 8,100	Optical - photodiode	RS232	Reed switch keyboard 8 digit vacuum florescent display Impact printwheel	Numeric and limited Non-numeric Keyboard input
Hitachi Co. Ltd. (Japan)	H-9243		0	$ 12,000- 13,000	Optical photodiode	N.A.	N.A.	
Litton Industries Ltd. (U.S.A.)	M/64	x	29	$ 11,000	Optical - phototransistor	N.A.	Optional impact drum or dot-matrix printer	Optical mark reader
Optical Recognition Systems Inc. (U.S.A.)	OCR-71		N.A.	$195,000- 325,000		N.A.	CRT display impact printwheel	Display for on-line operator corrections
T-Scan Ltd. (Can.)	T-Scan	x	50	$ 9,000- 10,000	Thick film resistance scanner and optical photodiode scanner	RS232	Impact printwheel TTL/DTL logic and discrete semicond circuits MOS memory	Optical mark reader

TERMINAL TYPE: POINT OF SALE

MANUFACTURER	MODEL	CAN. REP.	NO. INSTAL. IN CAN.	PRICE RANGE	DATA ENTRY	DATA TRANS.	TECHNOLOGIES	FEATURES
National Semiconductor Corp. (U.S.A.)	T2000 T3000		few	$2,600 - 5,200	Reed switch keyboard	Line driver	Mix of bipolar and MOS circuitry Gas discharge of display Impact hammer/drum printing	- Stand alone capability with battery backup on T3000
General Instrument Corp. Unitote Div. (U.S.A.)	302	x	0	$3,500 - 4,500	Reed switch keyboard	N.A.	MOS circuitry Impact dot matrix printer	- Stand alone capability - Card reader option - Optical or magnetic wand reader option

TERMINAL TYPE: LIMITED INTERACTIVE ENQUIRY

MANUFACTURER	MODEL	CAN. REP.	NO. INSTAL. IN CAN.	PRICE RANGE	DATA ENTRY	DATA TRANS.	TECHNOLOGIES	FEATURES
Addressogram - Multigraph Corp. (U.S.A.)	AMCAT-1	x	New	$ 1,700	- Mech. contract keyboard - Mag. stripe reader - Embossed character reader	Leased-line Multi-drop Pollfd FSK 300 band	MOS/LSI circuits Impact print-wheel	128 character buffer memory
Data Source Corp. (U.S.A.)	1100		N.A.	N.A.	- Thumbwheel data input - Optical and magnetic card reader	Leased-line Multi-drop FSK 300 band	N.A.	Standard keyboard and card imprint options available
Interface Technology Inc. (U.S.A.)	720		0	$70-$85	Conductive elastomer keyboard	Touch-tone signals	Discrete components	No response
	725		0	$125 - $135	"	"	"	4 status lights (computer activated)
	735		0	$480 - $580	"	"	Discrete and bipolar I.C. 8 digit led display	
Interface Systems Inc. (U.S.A.)	T-16	x	5	$270	N.A.	Touch tone signals	N.A.	Computer connected voice response system available
Iomec Inc. Digitronics Div. (U.S.A.)	Porta-verter 40		N.A.	$3,700		Modem 1200 band	Mag. tape cartridge impact printer	
Mega Products Corp. (U.S.A.)	10-9		New				10 digit LED display	48 character memory buffer
MSI Data Corp. (U.S.A.)	2100	x	300+	-$2,000	Dry contact keyboard MOS encoder	Acoustic coupler FSK	12 digit LED display mostly MOS/LSI logic, some TTL	Full numeric limited alpha input
	2000		Negligible	-$2,000	Reed switch keyboard	"	Mostly TTL logic	Full alpha numeric input
	1100		New	$1,200- 1,400	Dry contact keyboard MOS encoder	"	10 digit LED display Mostly MOS/LSI logic	Buffer memory Numeric + limited alpha input
Northern Electric Co. Ltd. (Can.)	Logic 256	x	New	N.A.	Dry contact keyboard		16 digit LED display (option) Mostly MOS/LSI logic	Voice response Auto dialer option Buffer memory Status lights
Digital Equipment Corp. (U.S.A.)	RT01	x	N.A.	$750 - $1,100	Limited alphanumeric keyboard	RS232	4,8,12 digit gas discharge display dry contact keyboard	110 - 4800 baud transmission rate
	RT02		New	$1,450 - $1,800	full alphanumeric keyboard	TTY loop	32 character dot matrix plasma	110 - 1200 baud transmission rate

TERMINAL TYPE: GRAPHIC ENTRY

MANUFACTURER	MODEL	CAN. REP.	NO. INSTAL. IN CAN.	PRICE RANGE	DISPLAY	DATA TRANS.	TECHNOLOGIES	FEATURES
Computek Inc. (U.S.A.)	200	x	Few	$ 5,000 - 12,000	CRT	RS232	MOS memory	Touch sensitive screen option
Control Data Corp. (U.S.A.)	240	x	0	N.A.	CRT	RS232	N.A.	Light pen input or touch sensitive CRT screen Graphic capability 1024 x 1024 grid
Infoton Inc. (U.S.A.)	Vista	x	N.A.	$ 1,800 - 3,500	CRT	RS232 & TTY loop	N.A.	1600 char. display Light pen option
Lektromedia (Can.)	LEK 120	x	~50	$ 7,000 - 10,000	CRT	RS232	Acoustic wave Touch sensitive CRT screen Reed switch keyboard MOS encoder TTL/DTL logic MOS memory	Audio message capability Slide projection Touch sensitive screen
Vector General Inc. (U.S.A.)	Series 3		0	$25,000 and up	CRT	RS232	N.A.	- Graphics capability 4096 x 4096 grid - 32 level grey scale - Light pen input

TERMINAL TYPE: DIGITAL FACSIMILE

MANUFACTURER	MODEL	CAN. REP.	NO. INSTAL. IN CAN.	PRICE RANGE	READER/SCANNER	DATA TRANS.	TECHNOLOGIES	FEATURES
DACOM INC. (U.S.A.)	412	x	0	$16,800	Photodiode	Digital via telephone lines	- Electrostatic dot matrix printer - LSI/MOS circuitry	- 30-60 sec page transmit time - full speed transmission via switched non-conditioned voice grade lines - digital data compression

APPENDIX D

INTERACTIVE DATA TERMINALS

SUBASSEMBLY COST STRUCTURES
(not including labour, marketing or overhead costs)

based on "average" terminals

1. KEYBOARD/DISPLAY

- Keyboard package incl. pc board and encoders	20%
- CRT display incl. power supply	12 - 15%
- Logic control memory package incl. pc boards supply	55 - 60%
- Packaging	5%
- Other	3 - 5%

Note: The percentage of logic costs would increase to as much as 60 - 65% for intelligent terminals

2. KEYBOARD/PRINTER

- Keyboard package	7 - 8%
- Printer mechanism	55 - 60%
- Logic control package	20 - 25%
- Packaging	10%
- Other	3 - 5%

3. LIMITED INTERACTION ENQUIRY TERMINAL

Low cost terminal ($60 - $100 range)

- Keyboard package	25 - 30%
- Logic control	30%
- Data transmission	30 - 35%
- Packaging	5%
- Other	3 - 5%

APPENDIX E

TERMINAL POPULATION CHARTS

(FIGURES ARE INSTALLED BASE INDEX 1973)

CANADA

	QUESTIONNAIRE RESPONSE	BEST ESTIMATE	% OF TOTAL
a. KEYBOARD/DISPLAY	3,650	11,000	35%
b. KEYBOARD/PRINTER	400	12,000	39%
c. KEYBOARD/PRINTER -PLOTTER	-	100	<1%
d. DOC.READER/PRINTER	80	125	<1%
e. POINT OF SALE	-	1,500	4%
f. LIMITED INTERACTIVE	305	3,500	11%
g. GRAPHIC ENTRY	50	100	<1%
h. ALL FACSIMILE	2,800	3,000	10%
		31,325	

OTHER

	U.S.A.	% OF TOTAL	EUROPE	% OF TOTAL
a. KEYBOARD/DISPLAY	135,000	27	46,000	48
b. KEYBOARD/PRINTER	230,000	46	38,000	40
c. KEYBOARD/PRINTER-PLOTTER	N.A.		N.A.	
d. DOC. READER/PRINTER	1,500	<1	150	<1
e. POINT OF SALE	25,000	5	2,000	2
f. LIMITED INTERACTIVE	4,000	8	10,000	10
g. GRAPHIC ENTRY	N.A.		N.A.	
h. ALL FACSIMILE	70,000	14	N.A.	
	501,000		96,150	

APPENDIX F

GLOSSARY OF COMMON ABBREVIATIONS

1. DATA TRANSMISSION

AM	Amplitude Modulation
FM	Frequency Modulation
FSK	Frequency Shift Keying
PM	Phase Modulation

2. DISPLAYS

CRT	Cathode Ray Tube
LED	Light Emitting Diode
LCD	Liquid Crystal Device
EL	Electroluminescent
VFT	Vacuum Fluorescent Tube
FD	Filament Display

3. MISCELLANEOUS

BCD	Binary Coded Decimal
OCR	Optical Character Recognition
OMR	Optical Mark Reader
PC BOARD	Printed Circuit Board
TTY	Teletypewriter

4. SEMICONDUCTORS

CCD	Charge Coupled Device
CMOS	Complementary-Symmetry MOS
DTL	Diode Transistor Logic
ECL	Emitter Coupled Logic
IC	Integrated Circuit
LSI	Large Scale Integration
MOS	Metal Oxide Semiconductor
MNOS	Metal Nitride Oxide Semiconductor
MSI	Medium Scale Integration
NMOS	N Channel MOS
PLA	Programmed Logic Array

PMOS	P Channel MOS
PROM	Programmable Read Only Memory
RAM	Random Access Memory
ROM	Read Only Memory
SOS	Silicon on Sapphire
TTL	Transistor-Transistor Logic

CRC DOCUMENT CONTROL DATA

1. ORIGINATOR: Department of Communications/Communications Research Centre

2. DOCUMENT NO: CRC Report No. 1276-1

3. DOCUMENT DATE: April 1975

4. DOCUMENT TITLE: Data Terminal Technology – Present and Future
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5. AUTHOR(s): by Staff of Urwick, Currie & Partners Ltd.
Edited by R.G. Fujaros

6. KEYWORDS: (1) Data Terminal
(2) Technology
(3) State-of-the-Art

7. SUBJECT CATEGORY (FIELD & GROUP: COSATI)

09		Electronics and Electrical Engineering
09	05	Subsystems

8. **ABSTRACT:** Data Terminal products currently available within Canada and those not yet available which have potential for significant future impact on the Canadian terminal market are surveyed. The products are classified according to major terminal types for each of which the approximate number installed in Canada and the price range are presented. The products are examined with respect to their physical and functional implementation, and the cost and extent of use of the various underlying technologies for the different terminal types are presented.*

* *Study conducted from November, 1973 to March, 1974.*

SOMMAIRE: On étudie le matériel de terminaux de transmission de données qui est actuellement disponible au Canada et celui qui ne l'est pas encore mais qui est susceptible d'avoir une influence importante dans l'avenir sur le marché canadien des terminaux. Le matériel est classifié selon les principaux types de terminaux, pour lesquels le nombre approximatif d'appareils installés au Canada et la gamme des prix sont indiqués. Le matériel est examiné en fonction de sa mise en oeuvre physique et fonctionnelle, et on indique le coût et la portée de l'utilisation des diverses technologies de base des différents types de terminaux.*

* *Étude effectuée de novembre 1973 à mars 1974.*

9. CITATION:

DATE DUE
DATE DE RETOUR

LOWE-MARTIN No. 1137

Government of Canada Gouvernement du Canada