C R T TERMINALS

VENTURE DEVELOPMENT CORPORATION

ALPHANUMERIC AND GRAPHIC

CRT TERMINALS

1975 - 1980

VENTURE DEVELOPMENT CORPORATION

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EXECUTIVE SUMMARY

- The CRT terminal industry is approximately fifteen years old, and represents a merger of two systems which are even older; teletype terminals and television sets. In 1965 IBM placed its stamp of approval on the CRT display when it announced the IBM 2260 terminal.

- Today the CRT industry is in a phase of rapid growth and, as of the beginning of 1975, there was an installed base of 418,000 CRT terminals worth $1.45 billion. In terms of units, 98.5% of this installed base is accounted for by alphanumeric terminals, and the remainder by graphic terminals. In terms of dollars, graphic terminals account for 7.4% of the installed base.

- IBM dominates the alphanumeric CRT industry. They have greater than a 15% share of the IBM 2260/ compatible market, and over 75% share of the IBM 3270/ compatible market. Other major factors in the market are Teletype Corp., Bunker Ramo, Sanders Associates, Univac, Hazeltine, ADDS, Incoterm, Sycor and DEC. Approximately 110 companies manufacture CRT terminals.

— The graphic CRT industry can be divided into high, medium and low priced segments. Tektronix dominates the low priced segment; DEC, Data General, Hughes, and Imlac are important factors in the medium priced market; and Sanders Associates, IBM, and Vector General are leaders in high priced graphic CRT's.

— The installed base, in units, divided by user segment is as follows:

	% of Units
Manufacturing	27%
Financial	17%
Government	15%
Scientific	10%
Transportation	12%
Education	7%
Retail	5%
Medical	3%
Miscellaneous	4%
TOTAL	100%

— Based on indices developed by VDC for forecasting CRT price trends, we believe that the average price of an alphanumeric CRT terminal will decline from $3400 in 1974 to $2500 in 1980, and the average price of a graphic CRT terminal will decline from $20,400 to $16,900 over the same period. Declining prices will be an important factor affecting

penetration of certain market segments, and in influencing the growth of the replacement market for IBM 2260, IBM 3270, and teleprinter terminals.

— The policies of AT&T concerning price, quality, and availability of data communication channels will have a direct bearing on the growth of CRT markets. Such policies are likely to be conducive to growth of remote terminal markets, with CRT teleprinter replacements and the Teletype Model 40 being the major beneficiaries.

— The nature and timing of the next generation of IBM CRT terminals, to replace the IBM 3270, will be the next major milestone for the CRT terminal industry. We believe that the IBM "4280", is likely to be introduced in mid-1978, and will be microprocessor based.

— CRT terminal shipments were $402.7 million in 1974, and are projected to grow at a 5.6% per year rate to $557.4 million in 1980. Unit shipments will grow twice as fast, from 119,000 units in 1974 to 221,000 units in 1980.

— Alphanumeric CRT terminals will grow at a 5.4% per year rate from $382 million in 1974 to $523 million in 1980. Unit shipments of alphanumeric terminals will grow at a 10.9% per year rate from 118,000 units in 1974, to 219,000 units by 1980.

— Graphic CRT terminals will grow at an 8.8% per year rate from $20.7 million in 1974 to $34.4 million in 1980. Unit shipments of graphic CRT's will grow from 1020 units in 1974 to 2170 units in 1980.

— In terms of units, alphanumeric CRT terminals can be segmented by product type as follows:

	1974 Market Share	1980 Market Share
IBM 2260 & Comp.	6%	0%
IBM 3270 & Comp.	44%	32%
Other Mainframe Mfgs.	9%	10%
Teleprinter Replacements	30%	38%
Teletype Model 40	3%	13%
Independent Systems	8%	7%
TOTAL	100%	100%

— In terms of units, graphic CRT terminal shipments can be segmented by product category as follows:

	1974 Market Share	1980 Market Share
Low Priced	51%	54%
Medium Priced	36%	37%
High Priced	13%	9%
TOTAL	100%	100%

— In terms of CRT screen size the installed base as of of 1975 was divided as shown below:

	% of Units
Small screen: 5" diagonal	5%
Medium screen: 9" diagonal	29%
Large screen: 12"-19" diag.	63%
Extra large screen: Over 15" diagonal	3%
TOTAL	100%

— In terms of character dot matrix the installed base as of 1975 was divided as follows:

	% of Units
5 x 7 dot matrix	45%
7 x 9 dot matrix	49%
Miscellaneous sizes	6%
TOTAL	100%

— In terms of size of the character set the installed base can be segmented as follows:

	% of Units
64 character	64%
96 character	23%
128 character	12%
Miscellaneous	1%
TOTAL	100%

— In terms of the number of characters per display the installed base can be segmented as follows:

	% of Units
240 characters	4%
480 characters	23%
960 characters	18%
1920 characters	54%
Miscellaneous	1%
TOTAL	100%

— In terms of the number of characters per row the installed base can be segmented as follows:

	% of Units
32 - 40 characters	27%
64 characters	7%
80 characters	65%
Miscellaneous	1%
TOTAL	100%

— In terms of the number of rows per display the installed base can be segmented as follows:

	% of Units
6 - 8 rows	4%
12 rows	37%
16 - 20 rows	5%
24 rows	53%
Miscellaneous	1%
TOTAL	100%

— At the beginning of 1975, 9% of CRT terminal installations were microprocessor based, while 24% of 1974 shipments were microprocessor based. By 1980, 60% of shipments will be microprocessor based. In 1980 the installed base of CRT terminals will be distributed as follows:

	% of Units
Microprocessor based	46%
Minicomputer based	1%
Non-microprocessor based	53%
TOTAL	100%

— We believe that of all the alternatives to CRT displays, only gas panel technology stands a chance of increasing its share of the alphanumeric terminal market. CRT displays will remain the dominant technology throughout 1980.

— In 1980 we believe that the installed base of CRT terminals will be segmented as follows:

	% of Units
Government	14%
Manufacturing	26%
Retail	8%
Financial	15%
Transportation	6%
Medical	5%
Scientific	12%
Education	10%
Miscellaneous	4%
TOTAL	100%

- In 1980, 58% of the installed base of CRT terminals will be used in remote applications and 42% in local applications. At the same time 53% will be stand alone terminals and 47% will be used in clustered applications.

- We believe that the business opportunities in the CRT terminal industry are centered around microprocessor based terminals which will provide some protection to both users and manufacturers from technical obsolescence. Survival in this industry will depend on a company's ability to react to technical change and provide customer service.

INTRODUCTION

The purpose of this report is to provide terminal industry management with a tool to evaluate changing CRT terminal markets and new technologies during the next five years.

The organization of this report reflects what we believe to be the four predominant areas of interest in the CRT terminal industry:

- Industry structure
- Display technologies
- Market growth estimates from 1975 to 1980
- Competitive market strategies and business opportunities.

The first section of the report describies the present industry structure from several vantage points. The CRT terminal market can be viewed as a subset of the much larger data terminal industry, or as an industry segment by itself with numerous categories, such as graphic or alphanumeric terminals. The approach taken will be to give a static view of the CRT terminal industry in 1975, which will serve as an accurate base from which to make reasonable estimates of the future market.

The second section of the report deals with the technology used in the terminal industry, with particular emphasis on the hardware used and the potential for alternate display technologies. Examples of the topics covered in this section include:

- CRT display features
- Communications equipment
- Display peripherals
- Graphics displays
- Color CRT monitors
- Plasma panels

This section is intended to give an individual with a non-technical background an overview of terminal technologies, to improve the coordination between marketing and engineering functions, and to provide direction to future research and product development efforts.

The third section of this report provides estimates of the market for CRT terminals from 1975 to 1980. Our marketing forecasts are based on projected shipments of minicomputers, general purpose computers, the growth in time-sharing, of point-of-sale devices and of replacements for teleprinter terminals over the next five years. Both foreign and domestic CRT terminal markets will be

projected, and the major forces causing the trends and growth rates in the terminal market will be identified. This section should be invaluable to marketing and manufacturing functions for short and intermediate term planning.

The fourth and final section of the report is an analysis of the competitive market strategies which will enable companies to survive and profit in the CRT terminal market over the next decade. The analysis will include the competitive strategies and probable responses of the major terminal manufacturers in terms of price changes, technical obsolescence, reduced profits, interface compatability, software support, maintenance or antitrust suits. This section will provide each terminal manufacturer with an analysis of the strategic alternatives necessary to maintain or increase market share over the next five years.

For the company considering entry into the CRT terminal industry, this section will point out the critical variables to be considered, such as pricing, terminal compatability, software support, maintenance and capital requirements.

The report in total is an industry guide which can be used by corporate executives to provide direction for marketing, engineering and production functions. The comparison of an individual corporate policy with aggregate industry practices will allow terminal manufacturers to evaluate their unique position within the market and to choose an optimal competitive strategy to meet their corporate goals.

HISTORY OF THE CRT TERMINAL INDUSTRY

Over the past 15 years the CRT terminal industry has progressed from the infancy stage of initial product development and acceptance, to the present growth stage in the life cycle of the industry.

The infancy stage can be characterized by vacuum tube technology, high prices, special purpose applications and a general lack of flexibility toward interface or communications standards. The first CRT displays were developed as fast and quiet input/output devices for general purpose computers, and the first major commercial applications were for airline reservation systems and stock market quotation systems.

The CRT terminal represents a merger of two older industries: teletype terminals and the television set. This combination of technologies seemed to be a logical extension and improvement over the noisy, slow-speed teletype, and a novel application of the CRT monitor, which had been a focal point of engineering design efforts.

The original CRT terminals provided a fast and quiet information exchange medium, but the major drawback was a lack of "hard copy" or printed output. The initial lack of printed output capabilities, together with high price tags, caused an initial lack of industry acceptance and the CRT terminal remained somewhat of a novelty during the early 1960's.

A major turning point in the development of the CRT display industry was the announcement of the IBM 2260 terminal in 1965. With this move the computer industry leader placed its stamp of approval on the CRT terminal as a practical computer input/output device.

Improvements in the performance of CRT terminals during the latter part of the 1960's roughly paralleled the developments of digital circuitry in the electronics industry; speed, complexity, size and price being the areas of major improvements. However, the CRT monitor as a display medium has undergone only nominal changes over the last 15 years.

The CRT monitor is relatively old and inefficient when compared to the newer display technologies. It is the result of almost a century of development efforts, and has the advantage of a low cost and stable design.

The decade of the 1960's was the infancy stage of the CRT terminal industry, and in it product development and acceptance were accomplished. This stage included the transistion from vacuum tubes to integrated circuits, and served as a shakedown period for unwritten interface and communications standards to develop.

The CRT terminal industry is presently in a growth stage with shipments projected to accelerate during the next five years. This growth will be a result of the improved cost effectiveness of the CRT terminal as a business tool. This favorable trend can be directly traced to developments in the integrated circuit industry toward faster, larger capacity and less expensive storage devices which are utilized in CRT terminals for character storage or generation, and for program or data storage in intelligent terminals.

A new type of integrated circuit, developed in the early 1970's, which is having a profound effect on the CRT terminal market is the microprocessor. The microprocessor has increased the performance and flexibility of CRT terminals, and has influenced the trend toward moving the source of control and intelligence

from a central computer to a remote site. The trend over the last ten years has been from entering data at a central location to positioning a data terminal as close as possible to the source of the data.

In the early 1970's the data terminal industry could be divided into two segments:

- Teleprinters
- CRT terminals

The teleprinter market is dominated by AT&T's Teletype models 33/35, and the CRT terminal market by the IBM 3270. Prior to 1973 these two industry giants had taken almost opposite competitive strategies. AT&T had concentrated on the low cost and high volume segment, while IBM was content to compete in the higher performance and more expensive segment of the terminal market.

The increasing popularity of the teleprinter replacements led to a declining market share for AT&T, and their competitive response was to introduce the Teletype model 40. The model 40 is almost guaranteed success due to its large captive market. Its introduction raises the possibility of direct competition between the two industry leaders for the rapidly expanding market.

From 1965 to 1975 installations of CRT terminals have increased by a factor of 25, and during the next decade terminal installations will more than double. It is in a setting of rapid growth and a changing technology that this study will analyze the competitive forces within the market and point to the most probable direction for the CRT terminal industry in the next five years.

INDUSTRY STRUCTURE

The structure of the CRT terminal industry can be analyzed only after we have developed a common notion of what a terminal is and where CRT terminals fit with respect to the overall data terminal market.

DEFINITION OF A TERMINAL

Our definition of a "terminal" is any computer input/output device, or a human/machine interface. This interpretation fits in with an oversimplified notion of a computer consisting of the following four basic systems:

- Central processor
- Memory
- Communications facilities
- Input/output terminals

Examples of input/output terminals are:

- Teletype units
- Interactive CRT displays
- Electronic cash registers
- Batch I/O stations consisting of a card reader and line printer.

The computer which is interconnected to one of the above terminals may vary from a large general purpose processor, to a minicomputer, and even to a microprocessor.

INTERACTIVE TERMINALS

This report will focus primarily on interactive terminals which have the potential for an inquiry/response, or conversational type of operation. Terminals oriented toward batch I/O operations, such as card readers, line printers, paper tape devices, disks and tape drives, are not considered interactive terminals, and as such are beyond the scope of this report.

The interactive terminal market at the beginning of 1975 had a market size of 1.28 million units, with a value of $2.85 billion. This market is divided into three segments:

- Teleprinters
- CRT terminals
- Point-of-sale, intelligent and special purpose terminals

There is considerable overlap between these three market segments. This conflict has been resolved by counting every interactive terminal as a CRT terminal if it includes a CRT display.

Teleprinter Terminals

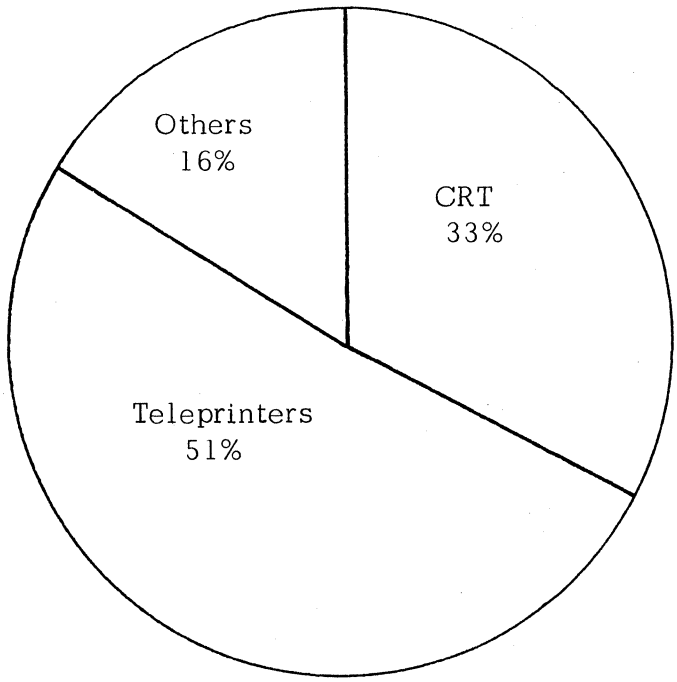
Teleprinters presently account for 51% of interactive terminal installations in terms of units, but only 30% of installations in terms of dollars. This fact is consistent with the marketing strategy of AT&T, which is aimed at low cost/high volume applications. Although the number of teleprinter installations continues to increase in absolute numbers, their market share has been declining since 1972. This is due to the increasing use of CRT terminals as teleprinter replacements. See Figures 1 and 2.

Figure 1

INSTALLED BASE OF INTERACTIVE TERMINALS

1975

(% of Units)



INSTALLED BASE OF INTERACTIVE TERMINALS

1975

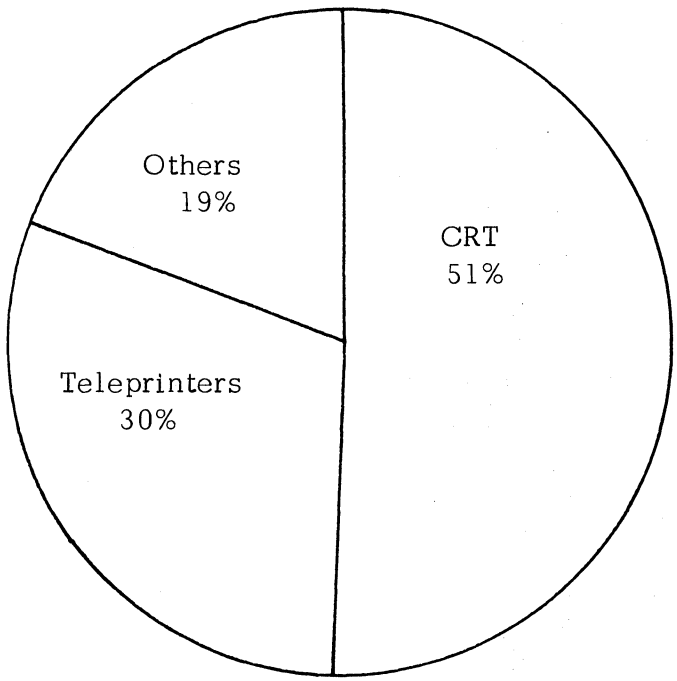
	Number of Terminals
Teleprinter	688,000
CRT	418,000
Others (POS, Intelligent, etc.)	205,000
TOTAL	1,280,000

Figure 2

INSTALLED BASE OF INTERACTIVE TERMINALS

1975

(% of Dollars)



INSTALLED BASE OF INTERACTIVE TERMINALS

1975

	Billions of Dollars
Teleprinter	$ .85
CRT	1.45
Others (POS, Intelligent, etc.)	.55
TOTAL	$2.85

CRT Terminals

Figures 1 and 2, also show that the CRT terminal segment in 1975 consisted of 418,000 installed units with a market value of $1.45 billion. During the last 5 years the market for CRT terminals has grown at more than a 25% annual rate, which was faster than the growth of the entire interactive terminal market. This implies that the market share for CRT terminals has been increasing over time, due to the successful IBM 3270 terminal and the growing teleprinter replacement market.

POS/Intelligent/Special Purpose Terminals

The third category of interactive terminals includes POS (point-of-sale), intelligent, and special purpose terminals. This segment represents about 16% of the units and 19% of the value of the installed base of interactive terminals by the beginning of 1975. Although this segment is small with respect to teleprinters and CRT terminals, it represents the highest growth area of all terminal segments during the past two years.

CRT TERMINAL CLASSIFICATIONS

The installed base of 418,000 CRT terminals at the beginning of 1975 can be subdivided into three categories:

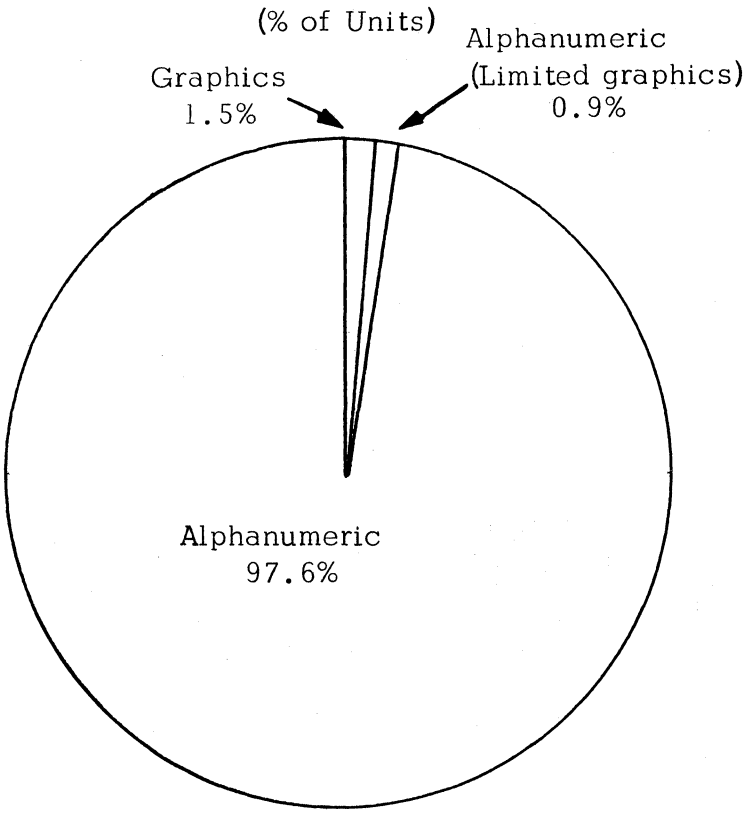
- Graphics
- Alphanumeric with limited graphics
- Alphanumeric terminals

Alphanumeric terminals have a 97.6% share of the CRT terminal market, and dominate because of their low cost and general purpose applicability. Graphics terminals have a 1.5% market share and are more expensive, both in terms of hardware and software. They offer the user more flexibility than alphanumeric terminals. "One picture is worth a thousand words," is an appropriate saying when comparing graphic and alphanumeric displays. A limited graphics capability can be added to an alphanumeric terminal by expanding the character set. A relatively inexpensive option that gives the terminal much more versatility for display formats. Alphanumeric terminals with limited graphics comprise a 0.9% market share. See Figures 3 and 4.

Figure 3

INSTALLED BASE OF GRAPHIC/ALPHANUMERIC CRT TERMINALS

1975



INSTALLED BASE OF GRAPHIC/ALPHANUMERIC CRT TERMINALS

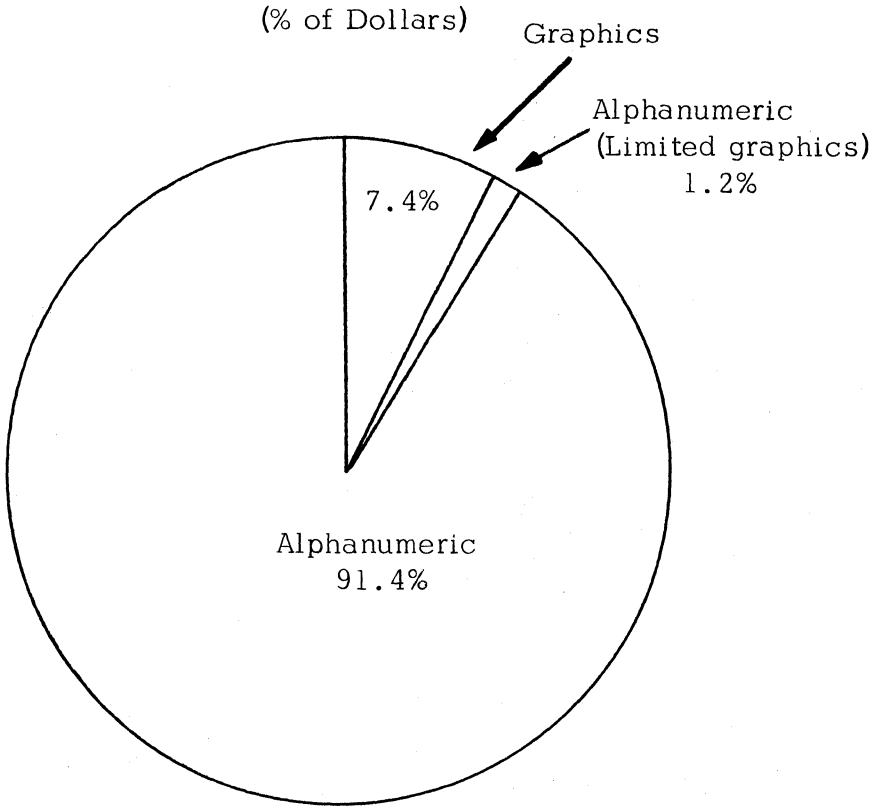
1975

	Number of Terminals
Alphanumeric	408,000
Alphanumeric (limited graphics)	3,900
Graphics	6,100
TOTAL	418,000

Figure 4

INSTALLED BASE OF GRAPHIC/ALPHANUMERIC CRT TERMINALS

1975



INSTALLED BASE OF GRAPHIC/ALPHANUMERIC CRT TERMINALS

1975

	Billions of Dollars
Alphanumeric	$ 1.32
Alphanumeric (limited graphics)	.02
Graphics	.11
TOTAL	$ 1.45

The graphic/alphanumeric terminal segments are so distinct that the industry structure of each will be considered separately.

INSTALLED BASE OF ALPHANUMERIC CRT TERMINALS

In the beginning of 1975 the alphanumeric CRT terminal market consisted of 412,000 installed units, worth $1.34 billion, which can be distributed among six categories as follows:

- IBM 2260 and compatibles
- IBM 3270 and compatibles
- Other mainframe manufacturers
- Teleprinter replacements
- Teletype 40 and compatibles
- Independent systems

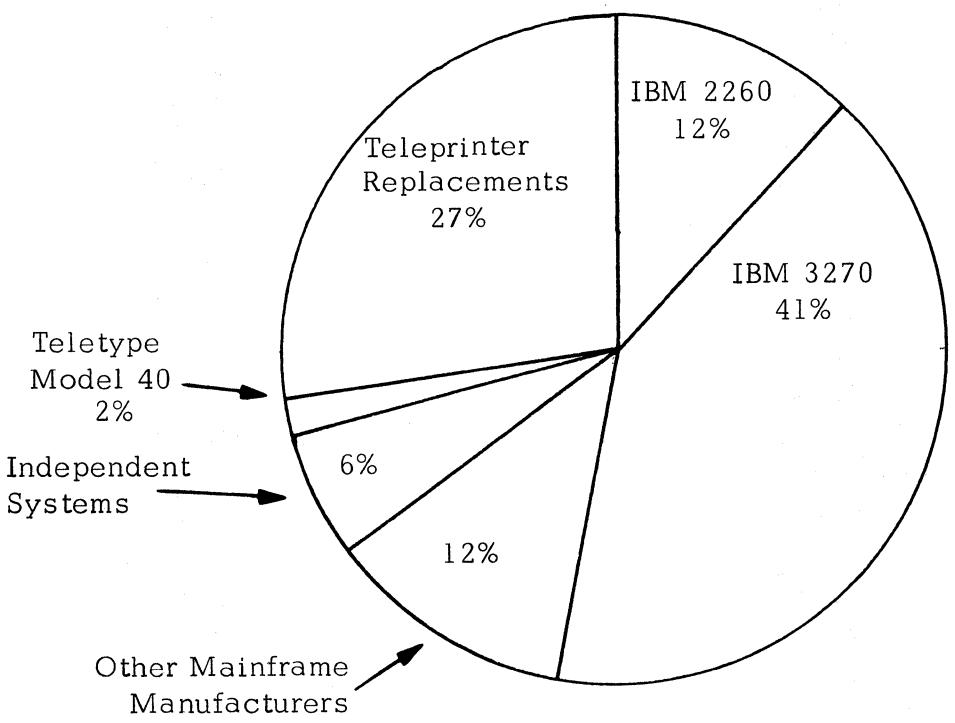
The first three categories of alphanumeric CRT terminals have grown in proportion with computer sales, and represent market segment developed by IBM and the seven other computer mainframe manufacturers. The next two categories of alphanumeric terminals represent market segments which were developed by and are dominated by AT&T. The final category includes independent terminal systems which are not direct replacements for IBM or AT&T equipment. See Figures 5 and 6.

Figure 5

INSTALLED BASE OF ALPHANUMERIC CRT TERMINALS

1975

(% of Units)



INSTALLED BASE OF ALPHANUMERIC CRT TERMINALS

1975

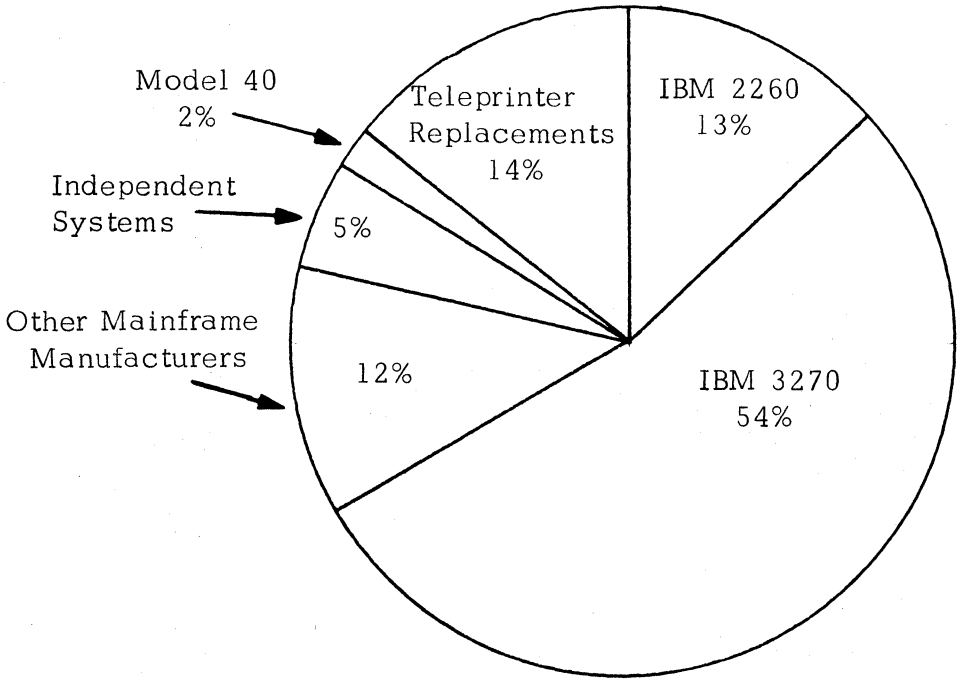
	Number of Terminals
IBM 2260 and compatibles	49,500
IBM 3270 and compatibles	169,000
Other mainframe manufacturers	49,500
Teleprinter replacements	111,000
Teletype 40 and compatibles	8,000
Independent systems	25,000
TOTAL	412,000

Figure 6

INSTALLED BASE OF ALPHANUMERIC CRT TERMINALS

1975

(% of Dollars)



INSTALLED BASE OF ALPHANUMERIC CRT TERMINALS

1975

	Billions of Dollars
IBM 2260 and compatibles	$ .17
IBM 3270 and compatibles	.72
Other mainframe manufacturers	.16
Teleprinter replacements	.19
Teletype 40 and compatibles	.03
Independent systems	.07
TOTAL	$ 1.34

IBM 2260 and Compatibles

The IBM 2260 CRT terminal is a technically obsolete peripheral which will gradually become extinct over the next decade. The IBM 2260, and compatible terminals from independent manufacturers, amounted to 49,500 installed units in 1975, with a value of $170 million. Although the market for the 2260 has continued to decline, its existence has been prolonged by the large software/hardware investments made in 2260 terminals, and an established replacement market. Because the IBM 3270 CRT terminal is not a fully compatible replacement for the 2260, an IBM 360 computer user must be willing to incur additional software costs in order to install the less expensive 3270 equipment. The 2260 terminal market is kept alive by a group of aggressive independent terminal manufacturers who sell 2260 replacements to terminal users who have made substantial hardware purchases and feel "locked-in" to the product line. The independents market terminals which emulate an IBM 2260, and offer performance and prices which are comparable with an IBM 3270 terminal.

IBM 3270 and Compatibles

The IBM 3270 terminal was introduced in 1971 as a replacement and technical improvement over the 2260 terminal line, and in less than five years has become the best selling alphanumeric CRT terminal. The IBM 3270, and compatible terminals from several independent manufacturers, amounted to 169,000 installed units worth $720 million by the beginning of 1975, which represents 41% of the units and 54% of the value of the installed base of alphanumeric CRT terminals. These market shares are consistent with the IBM marketing strategy of concentrating on the higher priced and more profitable peripheral segments. A substantial replacement market for leased IBM 3270 terminals is developing as a result of more sophisticated end users buying from aggressive independent manufacturers. Following the trend in the computer peripheral industry, end users of terminals are making more informed purchases based on equipment price/performance rather than blindly taking the system package offered by the mainframe manufacturer.

An IBM 3270 terminal is typically leased as part of a much larger system 370 package, and the price of this terminal is nominal

with respect to the total system cost. The independent terminal manufacturers compete in the 3270 replacement market by offering a product with improved performance features at a lower price than the IBM terminal.

Other Mainframe Manufacturers

The computer mainframe manufacturers, other than IBM, offer terminals which are a mixture of in-house and OEM terminal lines. These terminals amounted to 49,500 units worth $160 million, which represented 12% of the units and 12% of the dollars of the installed base of alphanumeric CRT terminals at the start of 1975. Of the eight major computer manufacturers six make their own terminals, while two purchase them from OEM terminal suppliers.

Teleprinter Replacements

The teleprinter market is dominated by the Teletype Corporation, which is a subsidiary of AT&T. Teletype models 33, 35, and 38 have over a 75% market share of the present teleprinter market, but CRT replacements of teleprinters are gaining in popularity.

The market for CRT replacements has developed because CRT terminals offer higher transmission speeds, lower noise levels and comparable prices. The major drawback in replacing a teleprinter with a CRT terminal is the lack of a hard copy output, although an auxiliary printer may be added. CRT teleprinter replacements amounted to 111,000 units worth $190 million in 1975, which represented 27% of the units and 14% of the value of the installed base of alphanumeric CRT terminals.

Teletype Model 40

The Teletype model 40 is a new CRT terminal segment, which represented only 2% of the installed base of CRT terminals in 1975. The Teletype Model 40 is given a separate category because we project that it will become a major market segment in the next five years.

Independent Systems

Independent CRT terminal systems amounted to 25,000 units with a value of $70 million, which represented 6% of the installed base in 1975. This category includes some special

purpose CRT terminals with limited markets, and large terminal manufacturers who have the reputation and service organizations to support their own terminal lines.

1974 SHIPMENTS OF ALPHANUMERIC CRT TERMINALS

Figures 5 and 6 were intended to give a static view of the alphanumeric CRT terminal market in 1975. In order to gain insight into the past trends in each market segment the 1974 sales in each of the six categories will be examined. See Figures 7 and 8.

IBM 2260 and Compatibles

Sales of IBM 2260 terminals continued at a level of 7,000 units worth $23 million, which represented only 6% of all alphanumeric CRT terminal sales in 1974. This anemic sales level is further evidence of the decline which has taken place in this market.

IBM 3270 and Compatibles

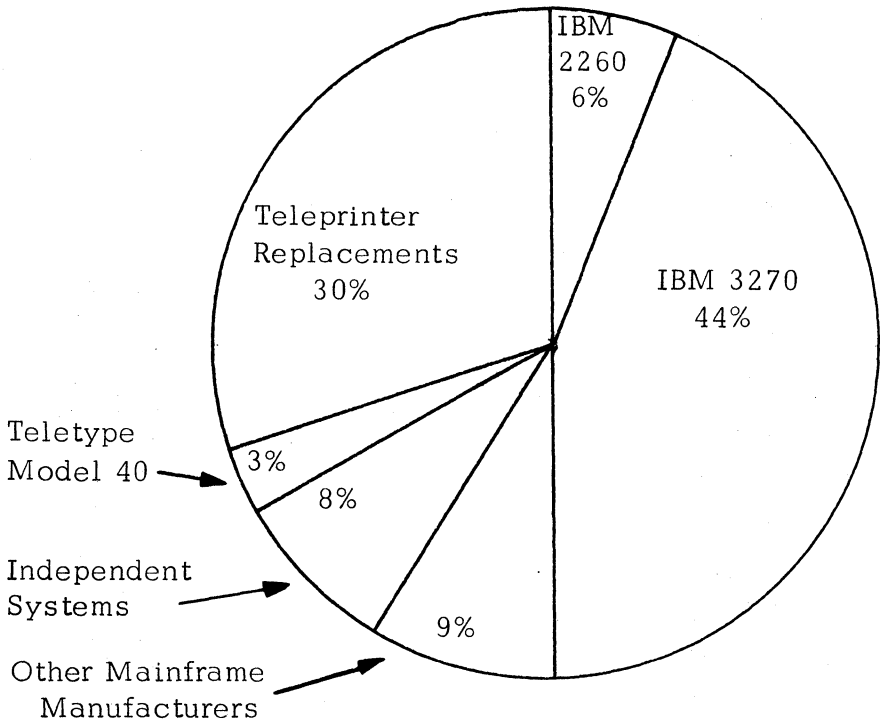
In contrast, IBM 3270 terminal sales were booming at 52,000 units worth $222 million in 1974. These sales represented 44%

Figure 7

ALPHANUMERIC CRT TERMINAL SALES

1974

(% of Units)



ALPHANUMERIC CRT TERMINAL SALES

1974

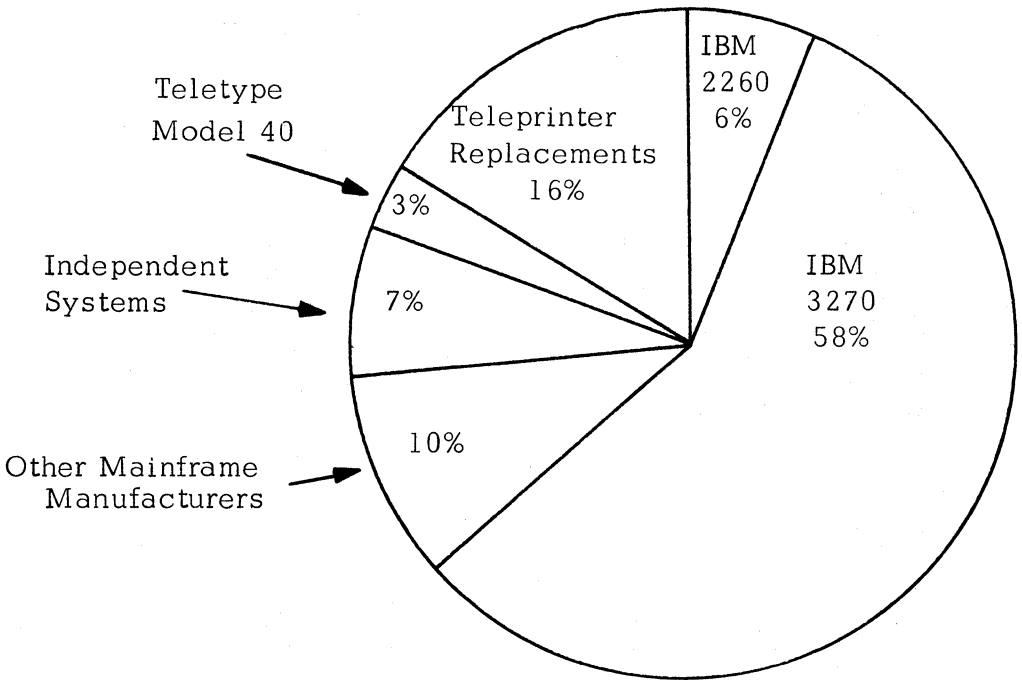
	Number of Terminals
IBM 2260 and compatibles	7,000
IBM 3270 and compatibles	52,000
Other mainframe manufacturers	11,000
Teleprinter replacements	35,000
Teletype model 40	3,000
Independent Systems	10,000
TOTAL	118,000

Figure 8

ALPHANUMERIC CRT TERMINAL SALES

1974

(% of Dollars)



ALPHANUMERIC CRT TERMINAL SALES

1974

	Millions of Dollars
IBM 2260 and compatibles	$ 23
IBM 3270 and compatibles	222
Other mainframe manufacturers	38
Teleprinter replacements	61
Teletype model 40	11
Independent Systems	27
TOTAL	$382

of the units sold and 58% of the value of all alphanumeric CRT terminal shipments. This implies that the IBM 3270 market share is increasing over time. Increased IBM 3270 sales levels can be traced to mainframe shipments and replacement of technically obsolete IBM 2260 terminals.

Other Mainframe Manufacturers

Other mainframe manufacturers roughly maintained their market shares by selling 11,000 units at $38 million, which was 10% of the total 1974 sales of alphanumeric CRT terminals.

Teleprinter Replacements

The teleprinter replacement market in 1974 amounted to 35,000 units at a value of $61 million. The expanding teleprinter replacement market is a result of declining prices and a wider acceptance of terminals without a printer output.

Teletype Model 40

The Teletype model 40 market is the fastest growing segment of the alphanumeric CRT terminal industry, because the terminal has a captive market in the AT&T communications network. Sales in 1974 were 3000 units, worth $11 million, which was 3% of the total industry sales.

Independent Systems

Shipments of independent terminal systems were 10,000 units, with a value of $27 million in 1974. Although this segment is small, its growth is dynamic due to the increasing sophistication of peripheral end users in purchasing terminals based on price/performance criteria.

Figures 7 and 8 show that in terms of volume the largest segments of the alphanumeric CRT terminal industry are the IBM 3270 and teleprinter replacement categories. A comparison of Figure 5 with Figure 7 will show that the fastest growing segments in terms of 1974 sales relative to the installed base, are the Teletype 40 and independent systems categories.

MARKET SHARE DISTRIBUTIONS OF ALPHANUMERIC CRT TERMINALS

In order to gain further insight into the composition of each of the six categories of alphanumeric CRT terminals, the market share distributions of each category will be examined.

IBM 2260 and Compatibles

The market leader in the IBM 2260 segment is still IBM, although the industry giant does not actively support this product and would prefer to switch its customer base to IBM 3270 terminals. The current lawsuits between IBM and Sanders over interface standards is an example of the IBM competitive strategy to "encourage" its customers to update their equipment. In response to the highly profitable IBM 2260 terminal line, eight independent terminal manufacturers developed a replacement market in the six year period between the IBM 2260 and IBM 3270 terminal introductions. These eight manufacturers are Bunker Ramo, Courier, Delta-Data, Four-Phase, GTE, Incoterm, Sanders, and Trivex. Each one has at least a 3% share of the IBM 2260 market, and together they control over 70% of the replacement market. See Figure 9.

Figure 9

MARKET SHARE DISTRIBUTION OF IBM 2260 AND COMPATIBLES

Over 15% Market Share

Bunker Ramo
IBM
Sanders

10% - 15% Market Share

GTE

5% - 10% Market Share

Courier
Incoterm
Trivex

3% - 5% Market Share

Four-Phase
Delta Data

1% - 3% Market Share

Datapoint
ITT
Quotron
Westinghouse

IBM 3270 and Compatibles

The IBM 3270 terminal was IBM's competitive response to their declining profitability in the 2260 market, and the need to update an obsolete terminal line. IBM has succeeded in developing a new segment in the CRT terminal market, which in four years has become the largest and most profitable terminal line. IBM has over 75% of the IBM 3270 market, with eight independent terminal manufacturers making a replacement market, and each having from 1% to 5% market shares. IBM compatible replacements are continuing to grow as a percentage of the IBM 3270 market due to their lower prices and increased flexibility of having programmable intelligence features. See Figure 10.

Figure 10

MARKET SHARE DISTRIBUTION OF IBM 3270 AND COMPATIBLES

Over 75% Market Share

IBM

3% - 5% Market Share

Four-Phase
Incoterm
Sycor

1% - 3% Market Share

Conrac
Courier
Datapoint
GTE
Terminal Communications

Other Mainframe Manufacturers

The market share distribution for other mainframe manufacturers shows a competitive market, with only one company having over a 20% market share, and all seven having at least a 5% market share. Honeywell and NCR purchase their terminals on an OEM basis from Datapoint and ADDS respectively. Digital Equipment has the fastest growing segment among mainframe manufacturers with an inexpensive terminal and a large minicomputer customer base. See Figure 11.

Figure 11

MARKET SHARE DISTRIBUTION OF OTHER MAINFRAME MANUFACTURERS

Over 20% Market Share

Univac

15% - 20% Market Share

Burroughs
Honeywell

10% - 15% Market Share

Control Data
Digital Equipment

5% - 10% Market Share

NCR
Singer

Teleprinter Replacements

The teleprinter replacement market is the most dynamic CRT terminal segment. Manufacturers compete on the basis of price, product quality and corporate reputation. Only one firm has over a 10% market share, while over twenty firms have a 1% or better market share, and more than fifty firms offer teleprinter replacements. See Figure 12.

Teletype Model 40

There are two prime producers of the Teletype model 40 type terminal, Teletype Corp., and ICC. Teletype Corp., commands over 90% of this small but expanding market, while ICC offers a terminal which has the potential of being a lucrative replacement for Teletype's unit.

Figure 12

MARKET SHARE DISTRIBUTION OF TELEPRINTER REPLACEMENTS

Over 10% Market Share

Hazeltine

5% - 10% Market Share

Ann Arbor
ADDS
Datapoint
Infoton
TEC

3% - 5% Market Share

Beehive
Delta Data
DEC
Lear Siegler
Tektronix

1% - 3% Market Share

Conrac
Datamedia
Data 100
Digi-log
Hewlett-Packard
ITT
Pertec
Research Inc.
Wang
Teletype Corp.

Independent Systems

Independent terminal manufacturers represent another competitive market where the criteria for success includes a special purpose terminal line, or alternately, an established reputation with a strong balance sheet position. More than 20 firms compete in this terminal segment, with seven firms having over a 5% market share and numerous companies operating in the low volume end of this segment. See Figure 13.

Figure 13

MARKET SHARE DISTRIBUTION OF INDEPENDENT SYSTEMS

10% - 20% Market Share

ADDS
Hazeltine
Incoterm
Sycor

5% - 10% Market Share

Beehive
Sanders
TEC

1% - 5% Market Share

Datapoint
Hendrix
Kustom
Megadata
Microtech
Ontel
Sharp
Zentec

Figures 9 through 13, were intended to identify the dominant firms in each CRT terminal category, and to give an indication of the competitive nature in each segment. The degree of competition can be measured by the concentration of market share in the leading firms, the number of companies with relatively small market shares, and the total number of firms in each terminal segment.

SEGMENTATION OF INSTALLED BASE OF ALPHANUMERIC CRT TERMINALS BY SYSTEM TYPE

Alphanumeric CRT terminals are analyzed as follows in order to better understand the composition of the overall market:

- Stand alone/clustered terminals
- Clustered terminal sizes
- Local/remote terminals
- Minicomputer/microprocessor based terminals

Stand Alone/Clustered Terminals

A terminal is considered to be stand alone if each CRT display has a dedicated control unit. A clustered terminal is one which has a central controller which can support multiple independent

displays. By 1975 stand alone terminals accounted for 198,000 units, or 48% of the installed base, while the remaining 214,000 units, or 52% of the installed base, were clustered terminals. These figures are somewhat misleading because over 90% of the CRT teleprinter replacements are stand alone units. If we exclude the 112,000 units of CRT teleprinter replacements from consideration then the remaining 300,000 units of the installed base represent 68% clustered terminals and 32% stand alone terminals. See Figures 14 and 15.

Clustered Terminal Sizes

Of the 214,000 clustered terminals in the installed base as of the start of 1975 the average cluster size was 6.8 terminals. Eighty-five per cent were made up of 2 to 8 terminal clusters, while the most frequently used cluster had 5 to 8 terminals. Cluster sizes have been increasing due to two factors:

- Declining terminal prices
- Distributed processing

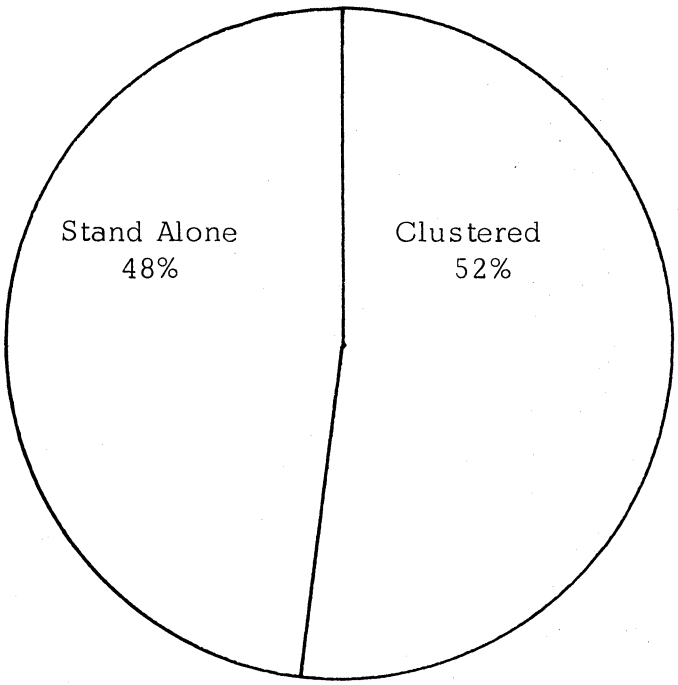
See Figure 16.

Figure 14

INSTALLED BASE OF STAND ALONE/CLUSTERED TERMINALS

1975

(% of Units)



INSTALLED BASE OF STAND ALONE/CLUSTERED TERMINALS

1975

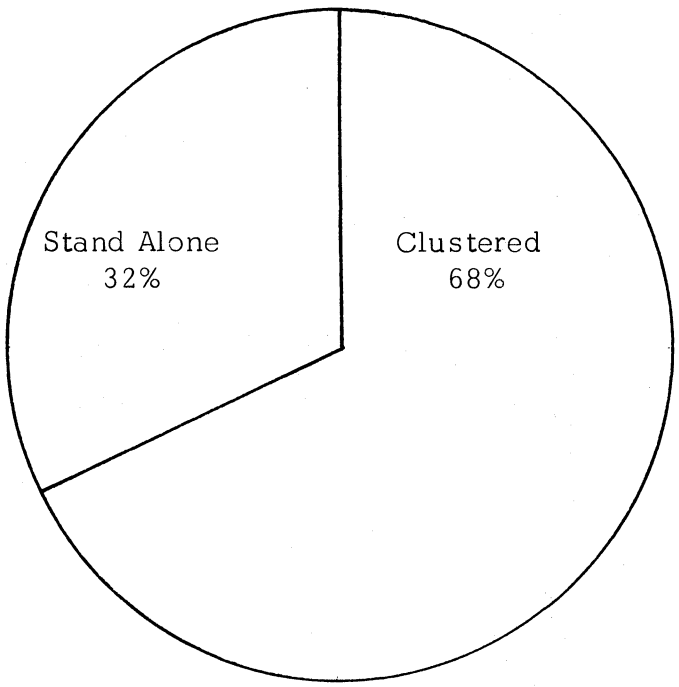
	Number of Terminals
Stand Alone	198,000
Clustered	214,000
TOTAL	412,000

Figure 15

INSTALLED BASE OF STAND ALONE/CLUSTERED TERMINALS

WITHOUT TELEPRINTER REPLACEMENTS

(% of Units - 1975)



INSTALLED BASE OF STAND ALONE/CLUSTERED TERMINALS

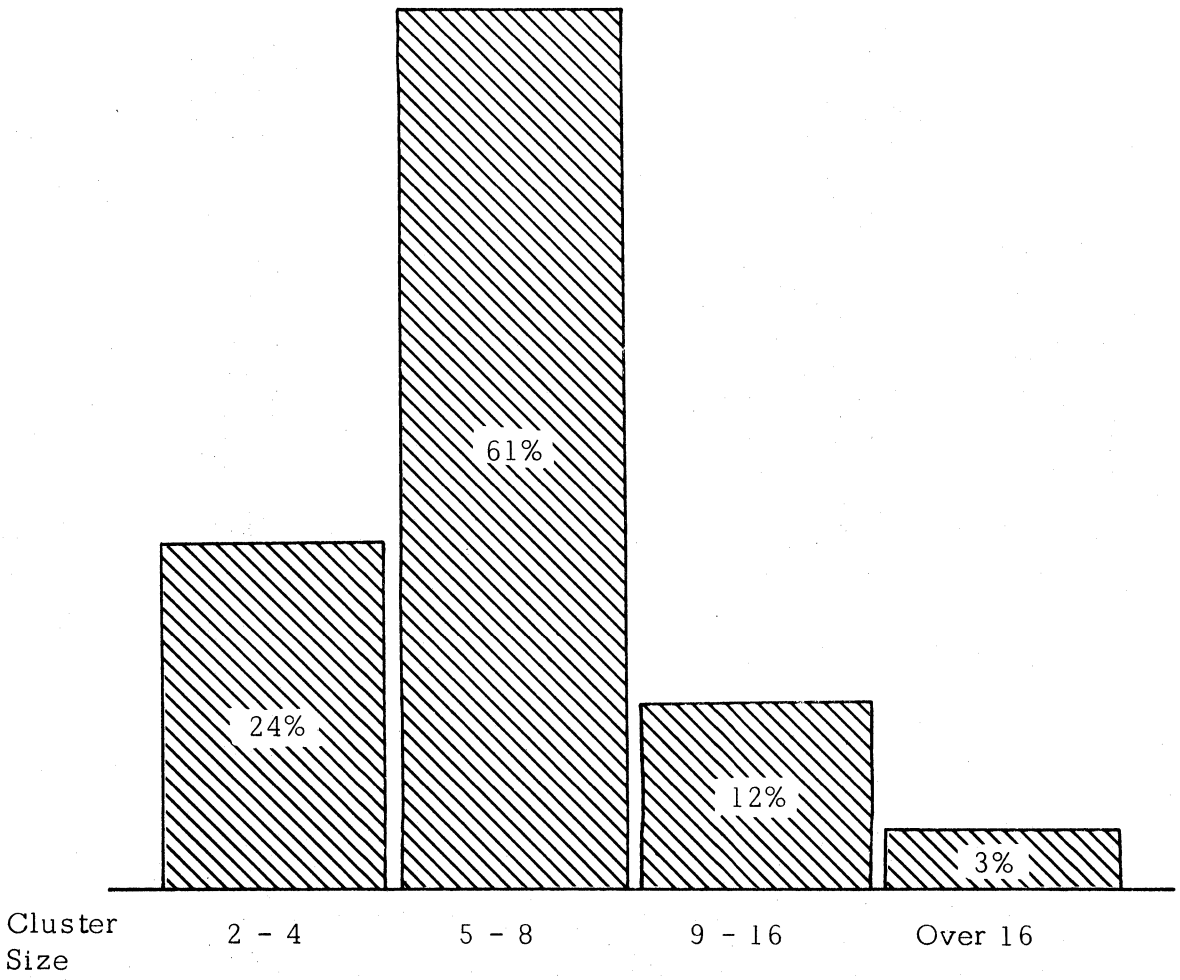
WITHOUT TELEPRINTER REPLACEMENTS

	Number of Terminals - 1975
Stand Alone	96,000
Clustered	204,000
TOTAL	300,000

Figure 16

CLUSTERED TERMINAL SIZES

(% of Units)



Local/Remote Terminals

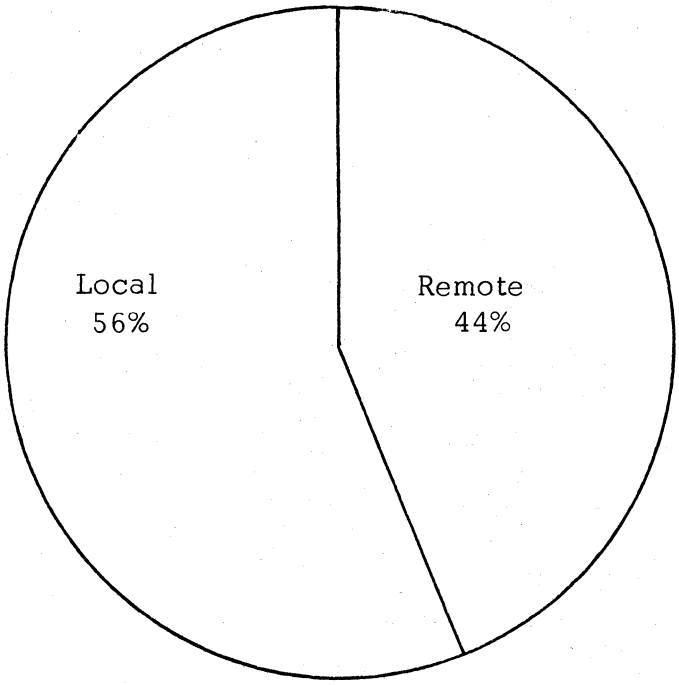
The trend toward distributed processing can be confirmed by analyzing the distribution of alphanumeric CRT terminals between local and remote applications. Local terminals imply a direct connection to a central computer which may be facilitated by a control unit or a communication processor, with distances limited to several hundred feet. In contrast, a remote terminal is connected to a central computer via a communications link, such as the telephone network, and the distance can be several thousand miles. Local terminals represented 230,000 units or 56% of the total installed base as of 1975, while remote terminals made up the remaining 182,000 units or 44% of the total installed base. In terms of 1974 shipments of alphanumeric CRT terminals, 54,000, or 46%, were intended for local applications, while the remaining 64,000 units, or 56%, were remote installations. A comparison of the installed based with 1974 shipments of local/remote terminals implies an increasing percentage of remote terminals and confirms the trend toward distributed processing. See Figures 17 and 18.

Figure 17

LOCAL/REMOTE TERMINAL INSTALLATIONS

1975

(% of Units)



LOCAL/REMOTE TERMINAL INSTALLATIONS

1975

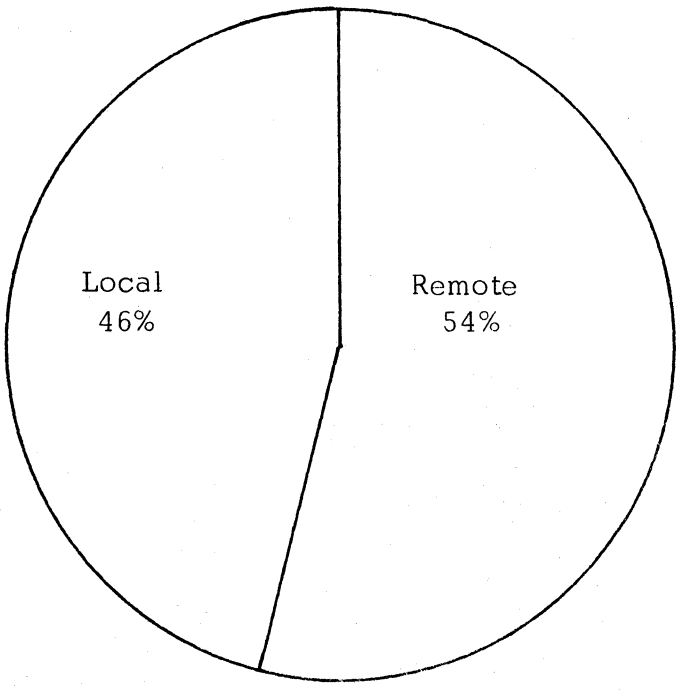
	Number of Terminals
Local	230,000
Remote	182,000
TOTAL	412,000

Figure 18

LOCAL/REMOTE TERMINAL SHIPMENTS

1974

(% of Units)



LOCAL/REMOTE TERMINAL SHIPMENTS

1974

	Number of Terminals
Local	54,000
Remote	64,000
TOTAL	118,000

The communications policies of AT&T have also been a prime factor in the increasing use of remote terminals. By providing communications lines with improved quality/consistency, and modems which will support higher transmission rates, AT&T has decreased the effective cost of transmitting a bit of data. The reduced cost of data transmission has helped to make the remote terminal a more cost effective device.

Minicomputer/Microprocessor Based Terminals

The microprocessor is rapidly becoming an important factor in the CRT terminal market as more firms update their hardware to provide the additional features and flexibility which a microprocessor affords.

The increasing use of microprocessor based CRT terminals can be seen by comparing the installed base of terminals with microprocessors as of 1975, and microprocessor based shipments in 1974. Microprocessor based CRT terminals represented 37,000 units or 9% of the installed base as of year 1975, while they amounted to 29,000 units or 24% of the 1974 shipments, which points to their increasing popularity.

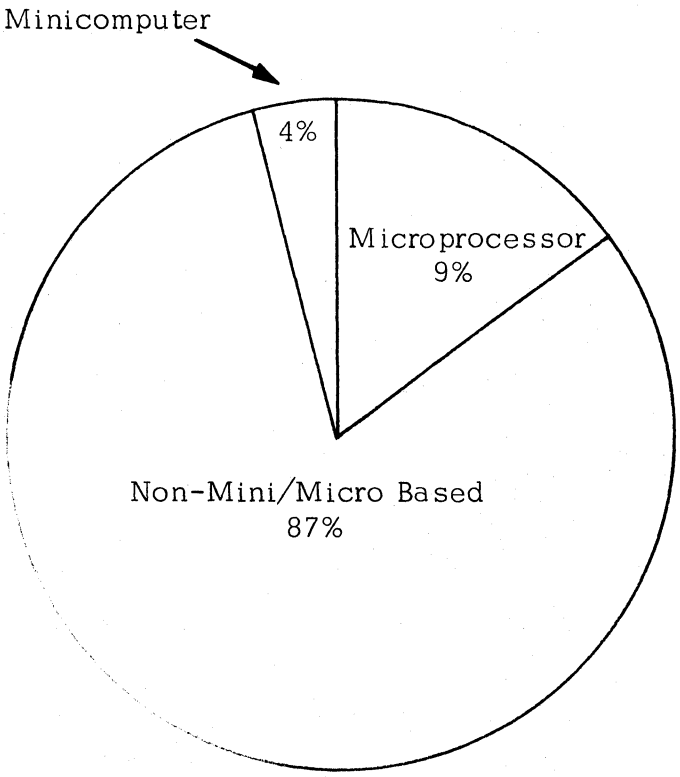
Minicomputer based CRT terminals have a dedicated mini which performs a central control function, and is not to be confused with a CRT terminal which is an I/O device for a minicomputer. The trend is away from mini based CRT terminals because the lower cost microprocessor is an acceptable alternative.

CRT terminals with programmable intelligence features are taking an increasing market share which, together with an increase in remote terminal installations, points the way toward collecting data closer to its source and relieving the burden on the central computer. See Figures 19 and 20.

Figure 19

MINICOMPUTER/MICROPROCESSOR BASED CRT TERMINAL INSTALLATIONS

(% of Units - 1975)



MINICOMPUTER/MICROPROCESSOR BASED CRT TERMINAL INSTALLATIONS

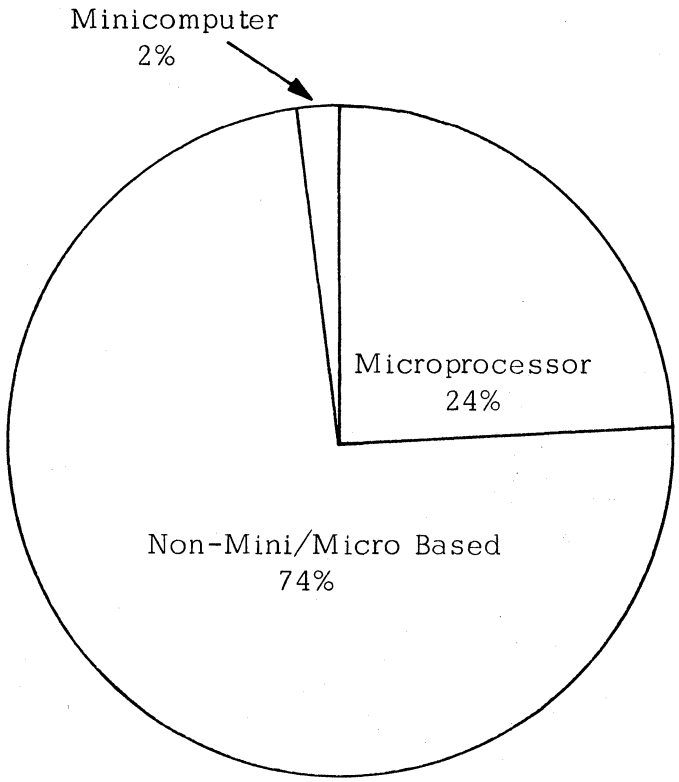
1975

	Number of Terminals
Minicomputer	16,000
Microprocessor	37,000
Non-Mini/Micro Based	359,000
TOTAL	412,000

Figure 20

MINICOMPUTER/MICROPROCESSOR BASED CRT TERMINAL SHIPMENTS

(% of Units - 1974)



MINICOMPUTER/MICROPROCESSOR BASED CRT TERMINAL SHIPMENTS

1974

	Number of Terminals
Minicomputer	2,000
Microprocessor	29,000
Non-Mini/Micro Based	87,000
TOTAL	118,000

GRAPHIC CRT TERMINALS

The market for graphic CRT terminals is much smaller than the alphanumeric segment and amounts to 6100 units, or 1.5% of the installed CRT terminal base, worth $110 million, which represents 7.4% of the total value of the installed base by year end 1974. Graphic terminals are more expensive than alphanumeric terminals, which accounts for their representing 1.5% of the units and a disproportionate 7.4% of the dollar value.

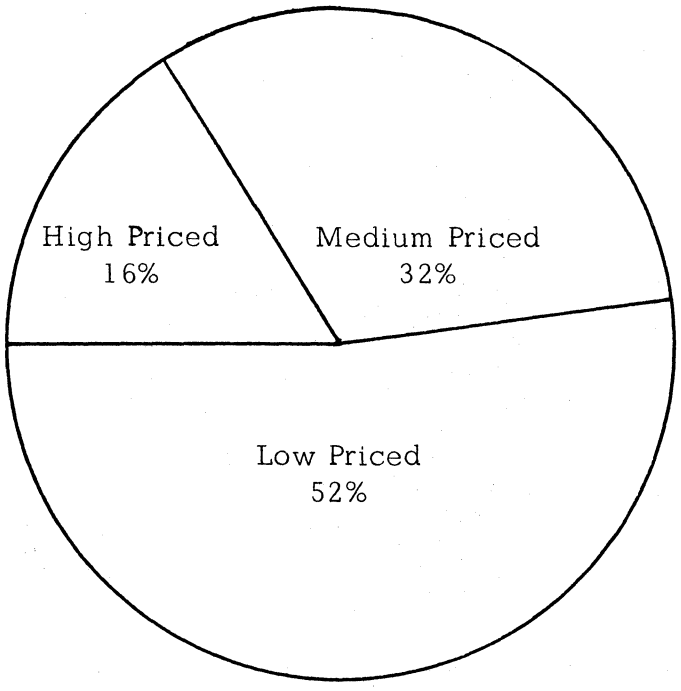
A comparison of graphic and alphanumeric terminals shows that graphics offer the user more flexibility with a corresponding increase in complexity and price. An alphanumeric terminal offers general purpose applicability at a lower price. Graphic terminals involve higher software/hardware costs and require more user sophistication to realize the full potential of the terminal. See Figures 21 and 22.

Figure 21

INSTALLED BASE OF GRAPHIC DISPLAY TERMINALS

1975

(% of Units)



INSTALLED BASE OF GRAPHIC DISPLAY TERMINALS

1975

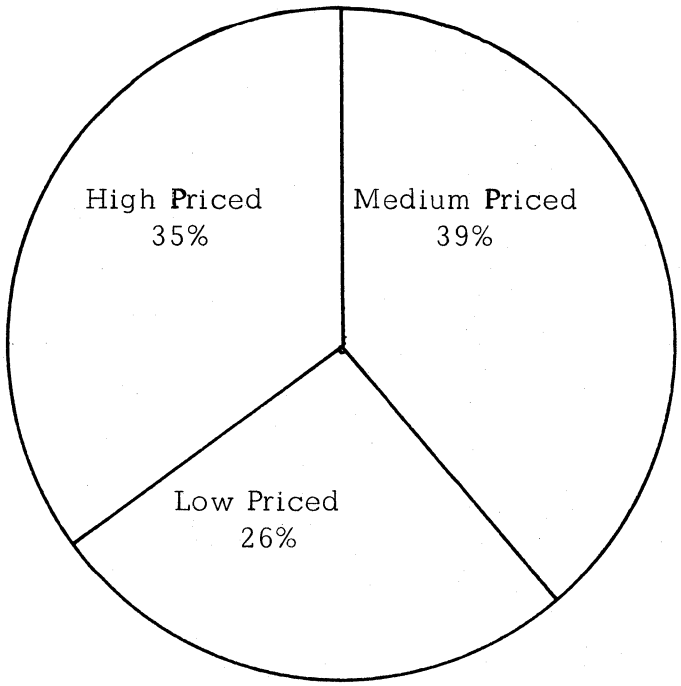
	Number of Terminals
High priced	950
Medium priced	1950
Low priced	3200
TOTAL	6270

Figure 22

INSTALLED BASE OF GRAPHIC DISPLAY TERMINALS

1975

(% of Dollars)



INSTALLED BASE OF GRAPHIC DISPLAY TERMINALS

1975

	Millions of Dollars
High priced	$ 39
Medium priced	$ 43
Low priced	$ 28
TOTAL	$110

PRICE/PERFORMANCE GRAPHIC CRT TERMINAL SEGMENTS

The market for graphic CRT terminals in 1974, as shown in Figures 23 and 24, has been divided into the following three segments, based on the price/performance of the terminal hardware:

- High priced - over $30K
- Medium priced - $10K - $30K
- Low priced - under $10K

The price of a graphic terminal is approximately proportional to performance, with the high priced segment generally leaning toward a hardware implementation of graphic functions, while the low priced segment tends to rely on software.

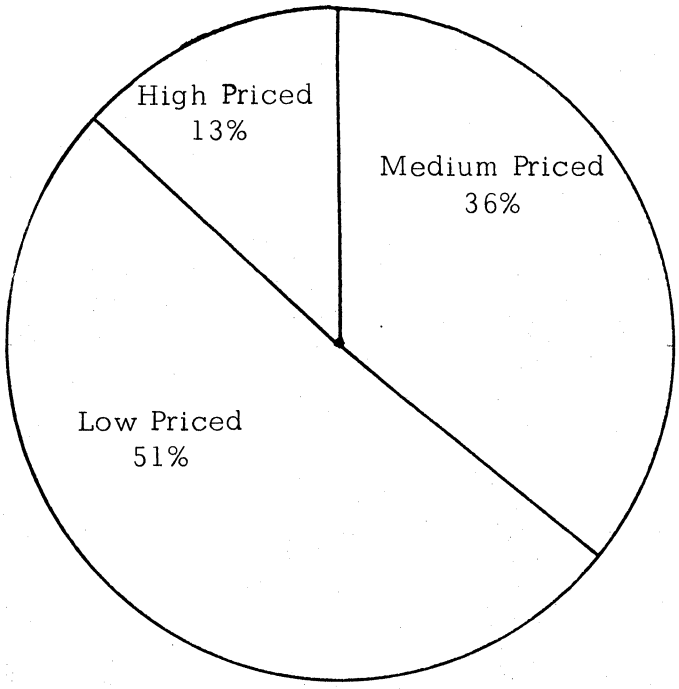
For example, a circle can be generated with software by connecting a large number of short straight line segments, or alternately in hardware by specifying the parameters of position/radius and allowing a hardware module to generate the appropriate drive signals.

Figure 23

GRAPHIC CRT SALES

1974

(% of Units)



GRAPHIC CRT SALES

1974

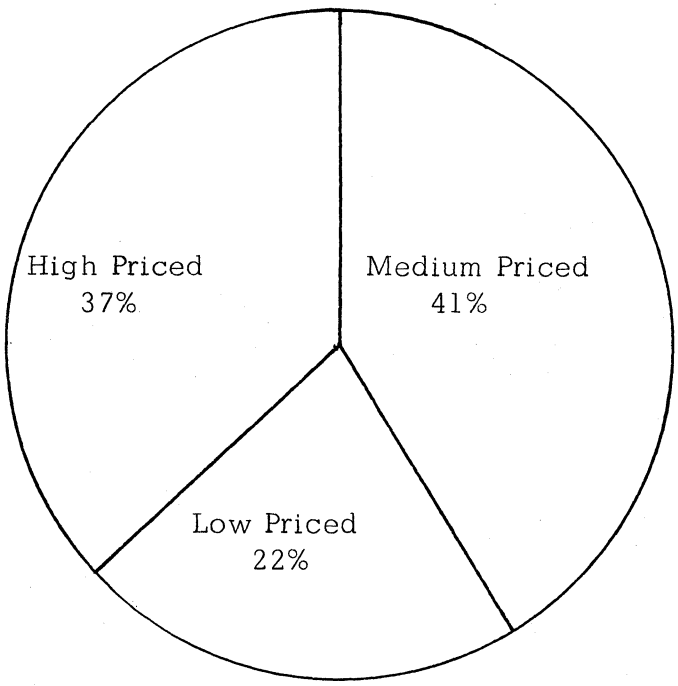
	Number of Terminals
High priced	130
Medium priced	370
Low priced	520
TOTAL	1020

Figure 24

GRAPHIC CRT SALES

1974

(% of Dollars)



GRAPHIC CRT SALES

1974

	Millions of Dollars
High priced	$ 7.7
Medium priced	$ 8.4
Low priced	$ 4.6
TOTAL	$20.7

Low Priced Segment

The low priced segment of the graphic CRT terminal market is the largest segment in terms of units, and the smallest in terms of dollar value. Low priced graphic terminals amounted to 3200 units with a value of $28 million by the beginning of 1975, which represents 52% of the units and 26% of the dollar value of the installed base of graphic CRT terminals. See Figures 21 and 22.

Sales of low priced graphic CRT terminals in 1974 were 520 units at a value of $4.6 million, which implies a stable market share. See Figures 23 and 24.

The low priced segment is dominated by Tektronix, which has over 80% of the market, while Computek and Princeton are the two main competitors. See Figure 25.

This segment utilizes storage tube displays and customers tend to be first time graphic terminal users. As the price of graphic terminal hardware continues to decline, a number of alphanumeric terminal users may switch to low priced graphic terminals to take advantage of the added performance and versatility.

Figure 25

GRAPHIC CRT TERMINAL MARKET SHARE DISTRIBUTIONS

LOW PRICED SEGMENTS

Over 80% Market Share

Tektronix

10% - 15% Market Share

Computek

1% - 5% Market Share

Princeton

Medium Priced Segment

The medium priced segment of graphic CRT terminals amounted to 1950 units worth $43 million by the beginning of 1975, which represented 32% of the units and 39% of the dollar value of the installed base. See Figures 21 and 22.

Shipments in this segment were 370 units valued at $8.4 million in 1974, which amounted to 36% of the unit and 41% of the dollar total of graphic CRT terminals. See Figures 23 and 24.

A comparison of the installed base and 1974 shipments of medium priced graphic CRT terminals implies that this segment is gaining market share at the expense of the high priced segment.

The medium priced segment has nine manufacturers holding significant market share. The top six firms control over 85% of the market, and no one firm has more than a 25% market share. Digital Equipment and Imlac are the leaders in this market segment. Data Disc, Hughes, and Ramtek offer strong competition with innovative hardware and responsive software support. See Figure 26.

Figure 26

GRAPHIC CRT TERMINAL MARKET SHARE DISTRIBUTIONS

MEDIUM PRICED SEGMENTS

Over 20% Market Share

Digital Equipment
Imlac

10% - 20% Market Share

Data Disc
Hughes
Idiom
Ramtek

1% - 5% Market Share

CPS
Digicom
Princeton

High Priced Segment

The high priced segment of graphic CRT terminals consisted of 950 units valued at $39 million by the beginning of 1975, which is 16% of the unit and 35% of the dollar value of the installed base. See Figures 21 and 22.

Shipments in 1974 were 130 units worth $7.7 million which was 13% of the volume and 37% of the dollar value of all 1974 graphic CRT terminal shipments. See Figures 23 and 24.

A comparison of the installed base with 1974 shipments shows that the share of the market accounted for by the high priced segment is declining. A potential replacement market for the high priced graphic terminals exists since lower and medium priced graphic terminal manufacturers can offer software compatibility and updated technology.

The high priced graphic terminal segment is controlled by four firms which dominate over 80% of the market. However, sales of the IBM 2250 graphics terminal have dwindled and IBM is no longer a prime force in the high priced segment. Their market share continues to decline. Sanders and Vector General are the dominant forces in the high priced segment. Adage, Evans and Sutherland, and Lundy offer strong competition. See Figure 27.

Figure 27

GRAPHIC CRT TERMINAL MARKET SHARE DISTRIBUTIONS

HIGH PRICED SEGMENTS

Over 30% Market Share

Sanders

20% - 30% Market Share

IBM
Vector General

5% - 10% Market Share

CDC

1% - 5% Market Share

Adage
Evans and Sutherland
Lundy

COST COMPONENTS OF GRAPHIC CRT TERMINALS

The high prices of some graphic terminals is misleading because the purchase price may include a dedicated minicomputer which provides timing and control for the terminal.

Although we have divided the graphic CRT terminal market into three segments based on price, the initial hardware cost is only one of three cost components in the overall cost of operating a graphic terminal. The three cost components include:

- Initial hardware cost
- Initial software development cost
- Recurring CPU cost

We have already segmented the graphic terminal market according to initial hardware costs in terms of low, medium and high priced terminals. The initial software development costs vary depending on the complexity of the intended application and the degree to which the graphics are implemented in hardware vs. software. To pursue the previous example further, a hardware implementation of a circle would require only one or two instructions, while a software approach is likely to involve a lengthy subroutine.

The recurring CPU costs of a graphics terminal involves the inability of a computer to perform other work when it services a graphics terminal; or the necessity of choosing a higher performing, more expensive computer containing additional memory to handle both the graphics terminal and other work. In some cases the initial hardware costs may be only 10% of the total operating expenses. Graphic terminal users must be sophisticated enough to evaluate the overall system cost rather than just the initial hardware price. The level of software support offered by a graphics terminal manufacturer is a key factor in a firm's marketing policy.

Graphic terminals offer greater performance and versatility when compared with alphanumeric terminals, and should be considered by users as cost effective business tools only if the additional expenses can be evaluated and justified. Unfortunately, many potential graphic terminal users are fightened away by higher hardware costs and vague estimates of software expenses before they can make a price/performance evaluation.

CRT TERMINAL USERS

The CRT terminal industry can also be segmented into eight basic user categories as follows:

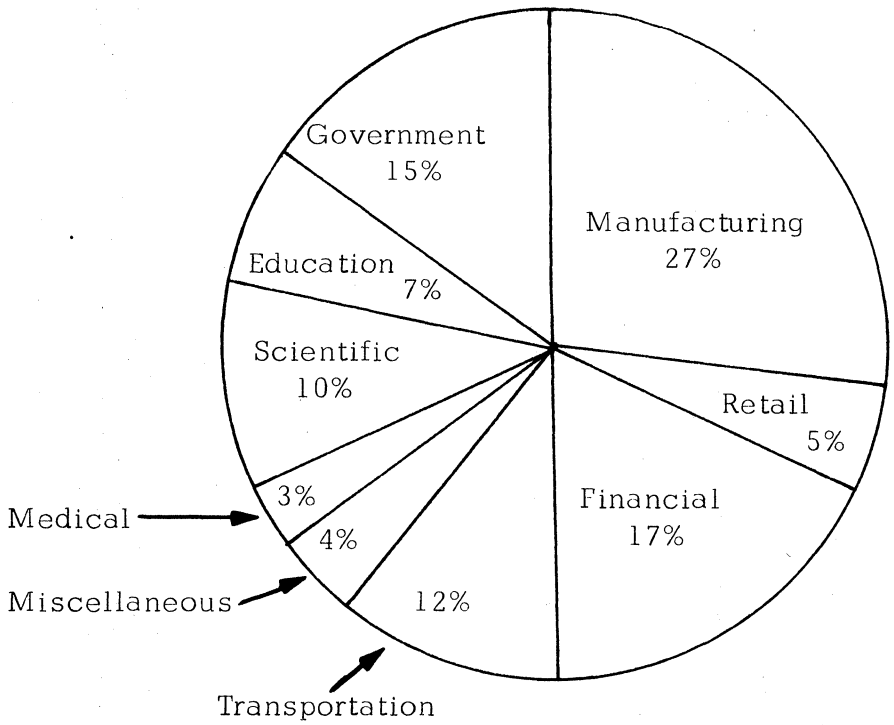
- Manufacturing
- Retailing
- Financial
- Government
- Scientific
- Educational
- Transportation
- Medical

The manufacturing segment accounted for 27% of the 1975 installed base of 418,000 CRT terminals. Financial, government and scientific applications continue to be significant user segments, each with at least 10% of the market. The transportation segment amounted to 12% of the market, but will not grow as fast as the other user segments over the next five years. The three remaining user classes, education, medical and retail, are presently small and have a cumulative market share of 15%. These three segments have the greatest potential for growth in the next five years. See Figure 28.

Figure 28

CRT TERMINAL USER DISTRIBUTION

(% of 1975 Installed Base In Units)



CRT TERMINAL USER DISTRIBUTION

(1975 Installed Base)

	Number of Terminals
Manufacturing	113,000
Retail	21,000
Financial	71,000
Transportation	50,000
Miscellaneous	17,000
Medical	12,000
Scientific	42,000
Education	29,000
Government	63,000
TOTAL	418,000

Average Number of Terminals Per User

Further insights into the nature of CRT terminal markets can be gained by analyzing the number of terminals purchased by each user. See Figure 29.

By the end of 1974 the average CRT terminal user had installed slightly over 21 terminals. This average figure of 21 terminals per user is somewhat misleading because the distribution is roughly divided into the following two classes:

- Low volume users (1 to 14 terminals)
- Moderate to high volume users (over 14 terminals)

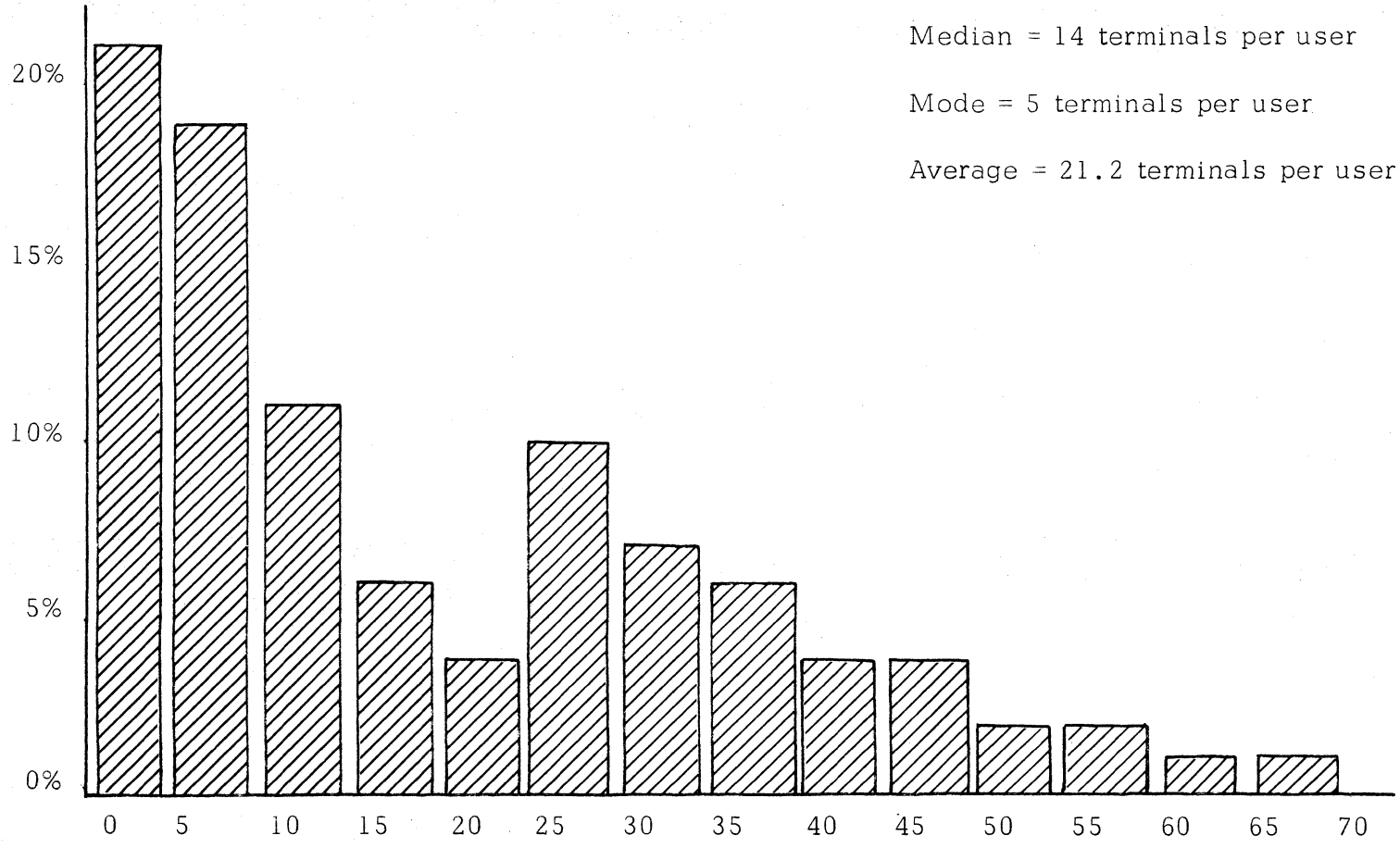
The distinction between low and moderate volume users is not an arbitrary choise, fourteen terminals is the median of the user distribution. Half of all terminal installations have a size from 1 to 14 units, with the mode (most probable value) at 5 terminals.

The low volume segment can be characterized by three types of terminal users:

- The small user with a time-sharing or small computer application who needs 1 to 8 terminals.
- The systems house that purchases a small quantity of terminals on an OEM basis for resale as a complete computer system.

Figure 29

NUMBER OF CRT TERMINAL INSTALLATIONS PER USER



1974

— The potential high volume user who purchases from 2 to 8 terminals for evaluation purposes.

The moderate to high volume terminal users are large corporations or educational institutions that, after an initial evaluation period, place large volume orders at quantity discounts.

The average size of terminal installations is presently in a declining trend, which can be attributed to both time-sharing applications and first-time mini/small computer applications that are low volume CRT terminal users.

This section of the study on the structure of the CRT terminal industry was intended to provide a "snapshot" view of the size and nature of the market at the beginning of 1975. This section analyzed CRT terminals from the dual perspective of both suppliers and users in order to provide a cornerstone from which we will forecast industry directions from 1975 to 1980.

CRT TERMINAL TECHNOLOGY

CRT terminal technology has been in a constant state of flux due to the rapid advancement in the state-of-the-art of integrated circuits. The life cycle of a CRT terminal design has been short; a typical length has been three to six years. For example, the IBM 2260 was introduced in 1966 and is now technically obsolete. Six years later, in 1972, the IBM 3270 was unveiled and quickly became the "industry standard." Now a growing number of firms are introducing microprocessor based terminals which out perform the IBM 3270 and will eventually lead to a new generation of CRT terminals.

In this setting of continuing technical change we will describe CRT technology, as it exists today, and how we envision it in the future. This section will describe only the most common technologies in order to gain some insight into the unwritten, but very real, "industry standards". Alphanumeric CRT terminal technology will be described first, then we will provide an overview of graphic CRT terminal technology.

ALPHANUMERIC CRT TERMINAL TECHNOLOGY

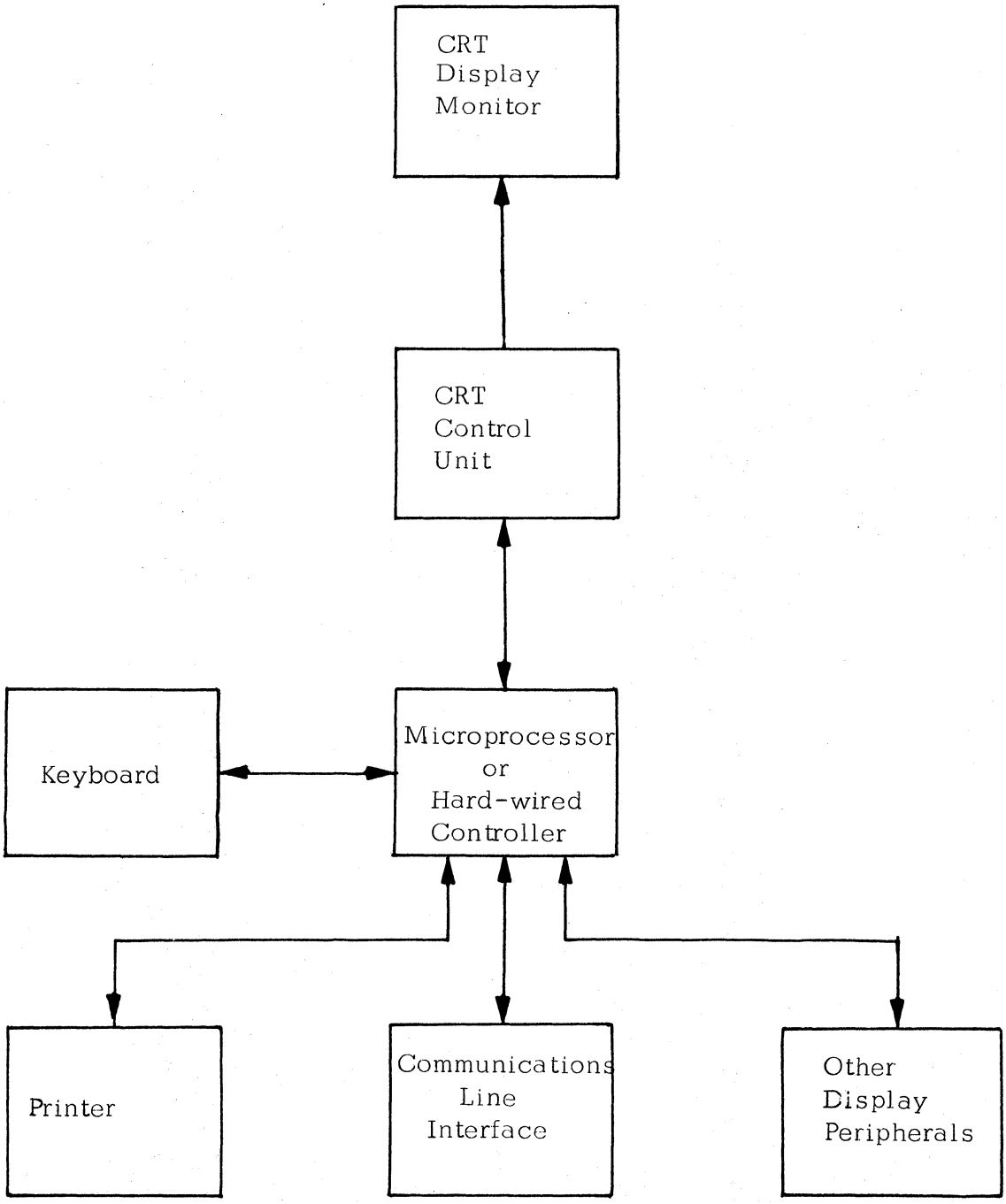
The technology of alphanumeric CRT terminals is best described by means of a block diagram (see Figure 30) which is composed of the following subsystems:

- CRT display monitor
- CRT control unit
- Keyboard
- Microprocessor or handwired controller
- Communications line interface
- Printer
- Other display peripherals

These eight subsystems are listed in order of commonality, ranging from the CRT display as the most basic component to "other display peripherals" as optional extras. It is possible to start with a CRT display monitor and add subsystems to form a more complex yet integral CRT terminal.

Figure 30

ALPHANUMERIC CRT TERMINAL BLOCK DIAGRAM



CRT Display Monitor

The CRT display monitor is the result of a 19th century invention which has benefited from decades of design efforts and is exemplified by the modern television set. The display used in alphanumeric CRT terminals can be thought of as a high quality television monitor with the tuning circuits deleted. The average price for a CRT display monitor is $150. At the extremes one can buy a black and white monitor for under $50, or a high quality color monitor for over $1000.

A basic understanding of the operation, the characteristics and the limitations of CRT displays is necessary to make informed product line decisions. The following topics shall be discussed to impart such information:

- Operation of a raster scan CRT display
- Phosphors
- Flicker
- Brightness
- Video linearity

Operation of a CRT Monitor

The operation of the common raster scan CRT display consists of a horizontal array of lines (typically 525 lines) which cover the screen from top to bottom. A beam of electrons strikes the screen which is coated with a phosphor and results in a small bright spot. The spot is deflected from left to right along each horizontal scan line and then quickly retraced to the next lower scan line, where the deflection is repeated until the entire screen has been covered from top to bottom. This scan of the entire screen is continually repeated at a typical rate of 60 times per second. The spot can be turned on or off at any point in time, which implies that the screen can be effectively divided into a large matrix of dots, each of which can be independently controlled. By illuminating selected dots on the screen, characters can be formed and information displayed.

Phosphors

The phosphor on the screen of a CRT terminal can be characterized by its color and persistence level. Persistence is a measure of the amount of time before the light on the screen decays to an imperceptible level. The most common phosphor used, called P4,

is characterized by white light and a relatively short persistence level. Due to the short persistence, any information to be displayed on the screen must be updated or "refreshed" at a rate of 50 to 60 times per second in order that the image appears stable to the human eye. If the refresh rate is not high enough the display will appear to blink or "flicker". Such a condition is a source of operator fatigue. Green phosphors have a longer persistance level than white phosphors and are used in applications where the refresh rate is low or flicker must be reduced. Some users object to green characters because of inadequate brightness.

Flicker

Flicker is a common problem in CRT displays and can be alleviated by adding a filter in front of the screen, by using a longer persistence phosphor, or by increasing the refresh rate. The light transmission properties/density of CRT filters are chosen to solve the flicker problem. A very dense filter cuts down on the total light output and must be compensted for by increasing the brightness. This can result in poor character quality. A longer persistence phosphor reduces flicker at the expense of brightness and character clarity. Increasing the

refresh rate to solve the flicker problem is not a viable option because it can cause a distortion commonly called "belly-dancing", which is a snake-like undulation of the information displayed on the screen. "Belly-dancing" is a sympton of a poor design and can be corrected by matching the refresh rate with the ac line frequency (60 Hz in the U.S., 50 Hz in Europe), or by shielding ac power transformers mounted close to the CRT display.

Brightness

The spot size and brightness level quoted by CRT manufacturers are subject to "specsmanship". Typically, a 10 mil spot size at a minimum brightness level of 30 foot lanberts is specified. Excessive brightness can cause "blooming", which is characterized by an increased spot size and reduced character quality. Over extended periods of time, excessive brightness can result in permanent damage to the phosphor, or "burnt phosphor." In general, both users and manufacturers of CRT terminals evaluate brightness on a subjective basis, with the extremes of low/high brightness bothering everyone.

Video Linearity

Video linearity is a measure of consistent size and shape of characters over the entire screen. "Pincushioning" is a common distortion caused by the curvature of the screen, and causes poorer quality characters in the four corners. Focusing of the spot over the entire screen is another area of concern. Good central focus can result in poor focus in the corners of the screen, and vice versa. A design compromise is required to obtain best overall spot focus over the entire screen. Horizontal and vertical linearity problems refer to inconsistent character height, width and shape, from various screen positions, from left to right and from top to bottom. Video linearity can be obtained by purchasing high quality/expensive, CRT monitors. The user must make a character quality/cost tradeoff.

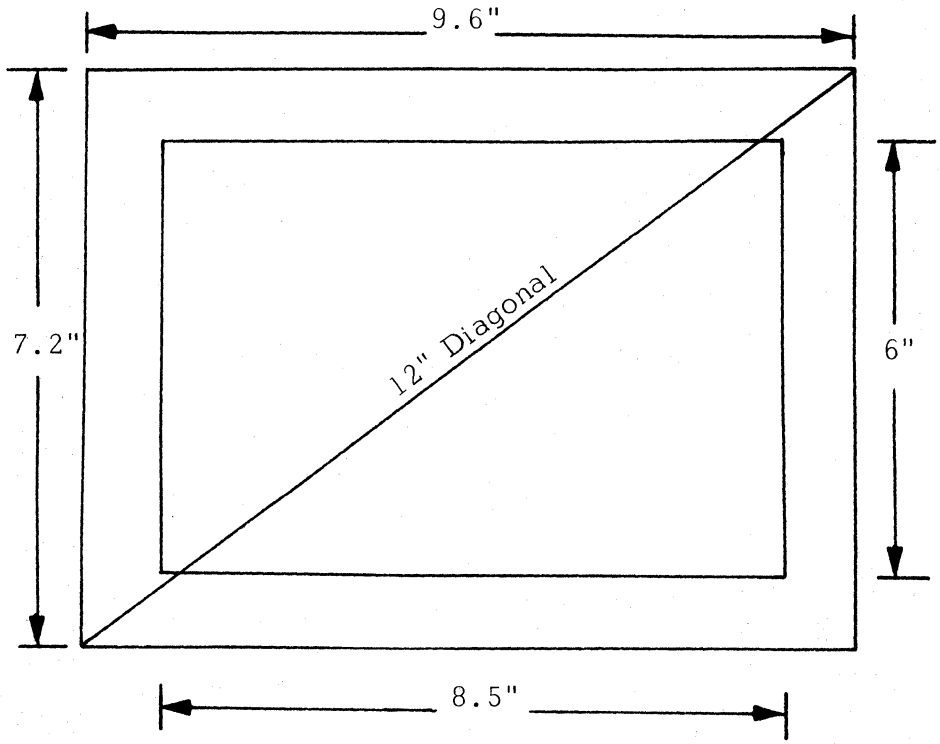
Screen Sizes

The size of CRT screens varies from 3 to 18 inches, measured along the diagonal. The 12 inch size is the most popular. The majority of CRT displays have an aspect ratio of 3 to 4, which implies that the screen is approximately 3 units high, 4 units wide and 5 units along the diagonal. The dimensions of a typical

12 inch CRT display are shown in Figure 31. The actual viewing dimensions are 75% - 85% of the height and 80% - 90% of the width.

Figure 31

TYPICAL DIMENSIONS FOR A 12" CRT DISPLAY



Overall dimensions: 7.2" x 9.6"

Viewing area: 6" x 8.5"

Market Share by Screen Size

We have divided the installed base of 412,000 CRT terminals, as of the beginning of 1975, into the following four categories:

- Small screen; 5" or smaller diagonal
- Medium screen; 9" diagonal
- Large screen; 12"-14" diagonal
- Extra large screen; 15" or larger diagonal

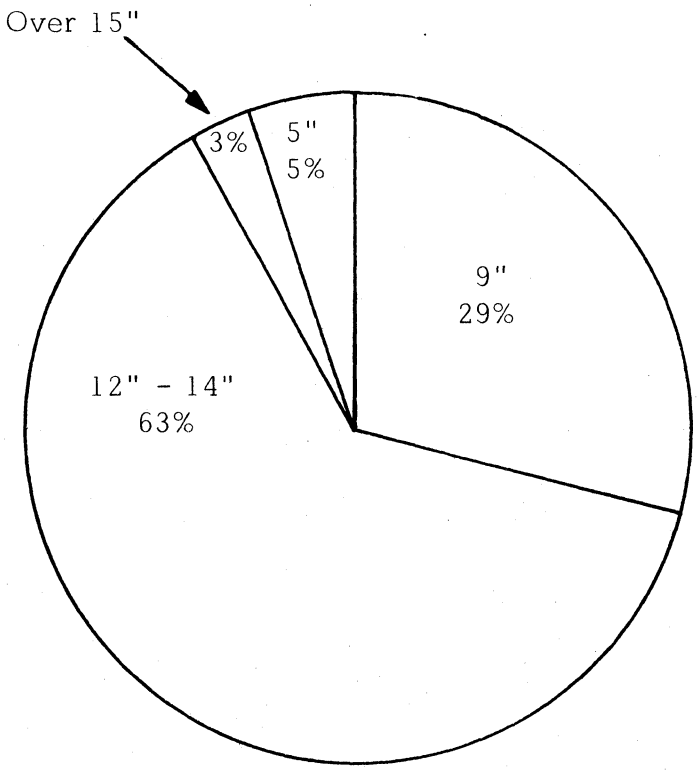
As shown in Figure 32, the 5" screen represents a 5% share of the installed base and is generally used for displays which contain approximately 500 characters. The 5" screen is gaining in popularity at the expense of medium sized screens. The 9" screens, used to display 1000 characters, accounts for 29% of the installed base, at present, but will lose market share in the future due to increasing sales of small/large screen terminals. The 12" - 14" screen represents the most popular size, with a 63% share of the installed base, and is generally used to display about 2000 characters. It is the industry standard. The extra-large screen accounts for only a 3% share of the installed base and is used in applications where the viewing distances is greater than 8 feet. We project continued dominance by the large screen and substantial growth in small screen shipments.

Figure 32

SHARE OF INSTALLED BASE BY CRT DISPLAY SCREEN SIZE

1975

(% of Units)



CRT DISPLAY SCREEN SIZE

1975

	Number of Terminals
Small screen: 5" diagonal	21,000
Medium screen: 9" diagonal	119,000
Large screen: 12" - 14" diagonal	260,000
Extra large screen: over 15" diagonal	12,000
TOTAL: Installed Base	412,000

Character Sizes

The physical size of each character displayed on the screen varies as a function of the screen size, number of characters and the normal viewing distance. The most common character size is 0.18" high by 0.08" wide, which represents an aspect ratio of approximately 2:1.

CRT Monitor Standards

In the United States the standard for television monitors is 525 horizontal scan lines at a 60 cycle refresh rate. This standard is used in about 60% of domestic CRT terminal installations. There exists an EIA standard for the timing and electrical characteristics of the signals required to drive a standard TV monitor, but the standard is only used in 15% of domestic installations.

CRT technology does not vary much from manufacturer to manufacturer. All use similar techniques to obtain quality characters at reasonable prices. The most commonly used CRT displays cost about $150, and operates with 525 lines, at a 60 cycle refresh rate, with a white P4 phosphor, on a large 12" - 14" screen.

CRT Control Unit

The second major CRT terminal subsystem is the CRT control unit which determines the following:

- Character dot matrix
- Character generator
- Size of the character set
- Number of characters per display
- Number of characters per row
- Number of rows per display
- Refersh memory
- Cursor representation and control
- Special video options

Character Dot Matrix

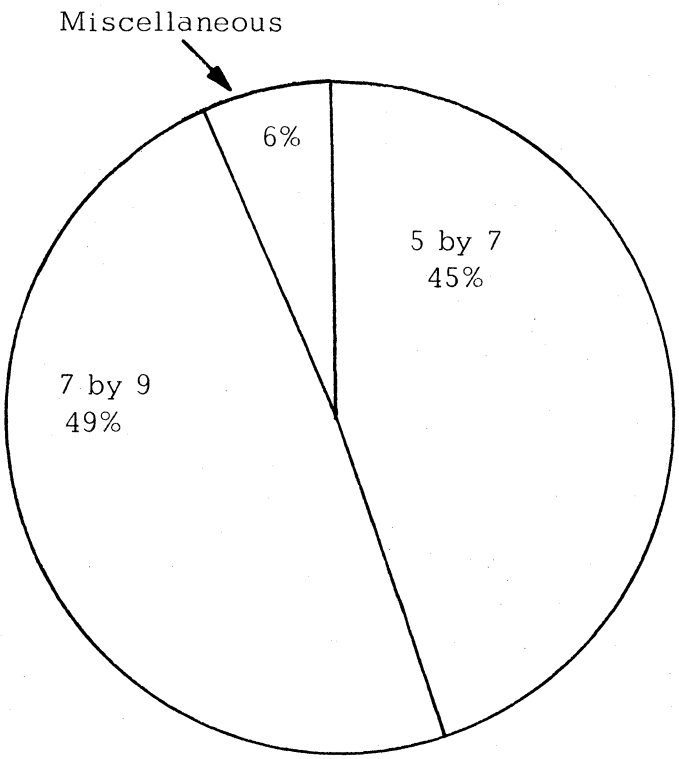
The character dot matrix refers to the format of dots used to compose each character and directly determines the readability of the display. The 5 by 7 character font is common and consists of a unique matrix of 5 horizontal dots by 7 vertical dots to form each character. The 5 by 7 matrix is used in 45% of the installed CRT terminals as of the beginning of 1975. The 7 by 9 matrix is slightly more popular and accounts for 49% of the installed base. See Figure 33.

Figure 33

SHARE OF INSTALLED BASE BY CHARACTER DOT MATRIX

1975

(% of Units)



CHARACTER DOT MATRIX

1975

	Number of Terminals
5 by 7 dot matrix	185,000
7 by 9 dot matrix	202,000
Miscellaneous sizes	25,000
TOTAL: Installed Base	412,000

The IBM 3270 terminal uses a 7 by 9 dot matrix which helps explain its large market share. Nonstandard character fonts make up 6% of the market and are cost effective only for large production runs. Inter-character spacing should be at least 1 to 2 dots, and inter-row spacing 3 or more dots to insure readability at a viewing distance of 1 to 4 feet. The trend in the future is toward the 7 by 9 matrix because of character quality. But the 7 by 9 matrix forces the terminal manufacturer to use a higher priced/higher quality CRT monitor.

Character Generator

The character generator contains the entire dot matrix for each of 64 to 128 characters, and is implemented by a ROM (read only memory). Character generators are available with options such as; foreign language fonts, dot matrix size, and character set size. Prices range from $10 to $80.

Size of Character Set

The size of the character set refers to the number of unique displayable characters, and is typically 64, 96, or 128 characters. The 64 character set is the most popular, with a 64% share of

CRT terminals installed as of the beginning of 1975. The 64 character set is composed of the upper-case alphabet, numerals, and punctuation. The 96 character set has a 23% market share and usually adds the lower-case alphabet to the basic 64 character set. The 128 character set has a 12% market share and adds special symbols beyond the 96 character set. The various characters in a set are generally identified by the standard ASCII code or the EBCDIC code used by IBM. The trend is toward the 128 character set because users prefer the flexibility of having lower-case letters and special symbols at only a nominally higher price. See Figure 34.

Number of Characters Per Display

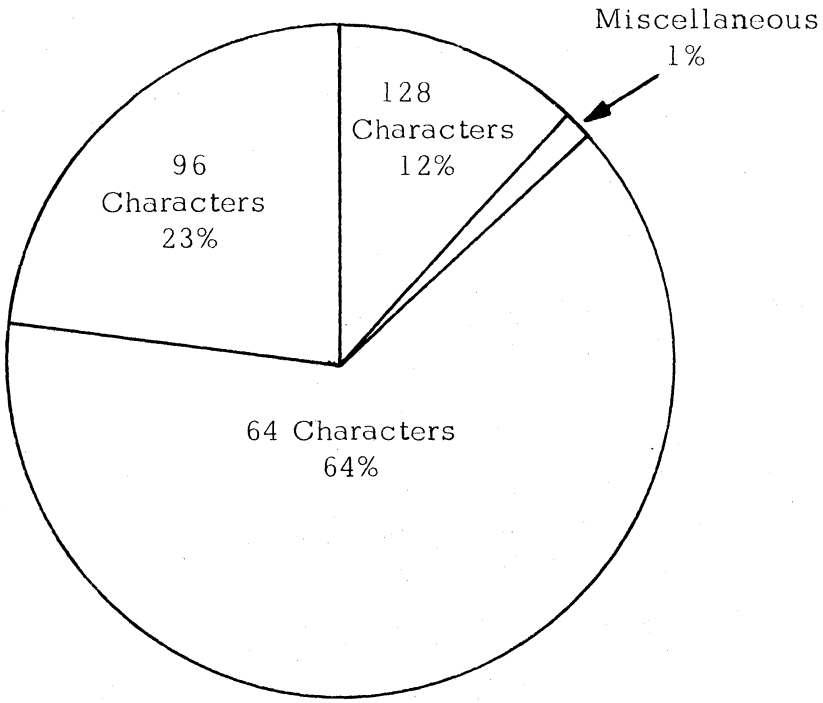
The total number of character locations on a display varies from 16 to 4000, while the most common sizes are 480, 960 and 1920 characters. Displays with 1920 characters are the most popular size, and represent 54% of the CRT terminals installed at the start of 1975. Intermediate sized displays, containing 960 characters have an 18% market share, while small sized displays of 480 characters account for 23% of the market. In the future,

Figure 34

SHARE OF INSTALLED BASE BY SIZE OF CHARACTER SET

1975

(% of Units)



SIZE OF CHARACTER SET

1975

	Number of Terminals
64 characters	264,000
96 characters	95,000
128 characters	49,000
Miscellaneous	4,000
TOTAL: Installed Base	412,000

large 1920 character displays will continue to dominate, with the small 480 character displays eroding the market share of the intermediate 960 character displays. See Figure 35.

Number of Characters Per Row

The number of characters per row on a CRT display varies from 16 to 96, with the most common values being 40 to 80 characters per row. The 80 character row is the most widely used type with a 65% share of the installed base, followed by the 40 character row with a 27% share. The 40/50 character row was developed as a result of the 80 column punched card, but is not as efficient in terms of memory requirements as 32/64 character row. See Figure 36.

Number of Rows Per Display

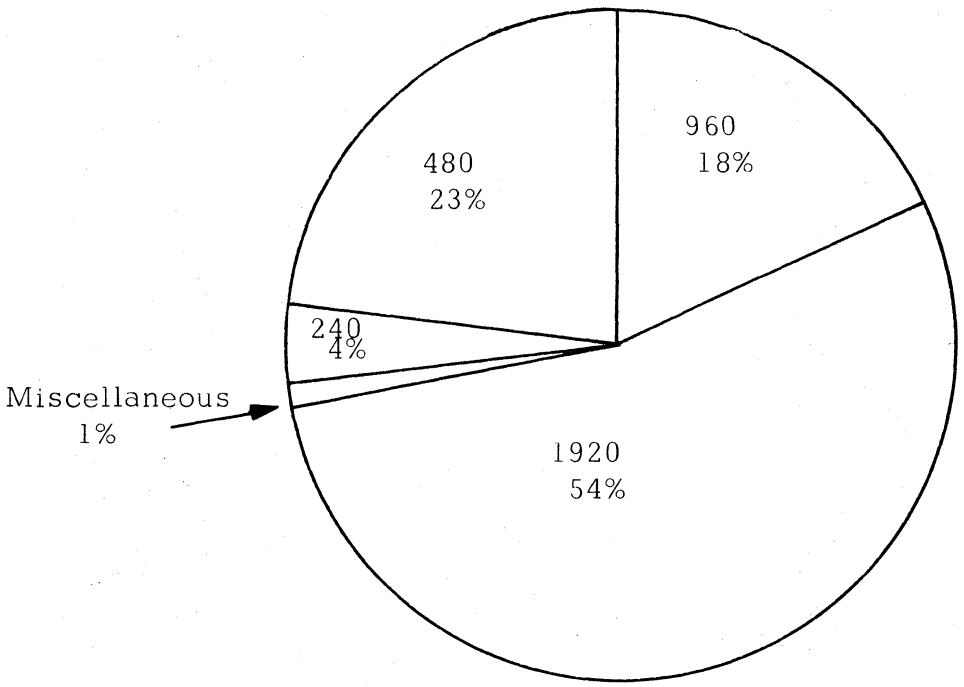
The number of rows of characters per display varies from 6 to 50, with 12 and 24 being the most common sizes. Displays with 24 rows have a 53% share of the installed base, while 37% of the market is made up of 12 row displays. See Figure 37.

Figure 35

SHARE OF INSTALLED BASE BY NUMBER OF CHARACTERS PER DISPLAY

1975

(% of Units)



NUMBER OF CHARACTERS PER DISPLAY

1975

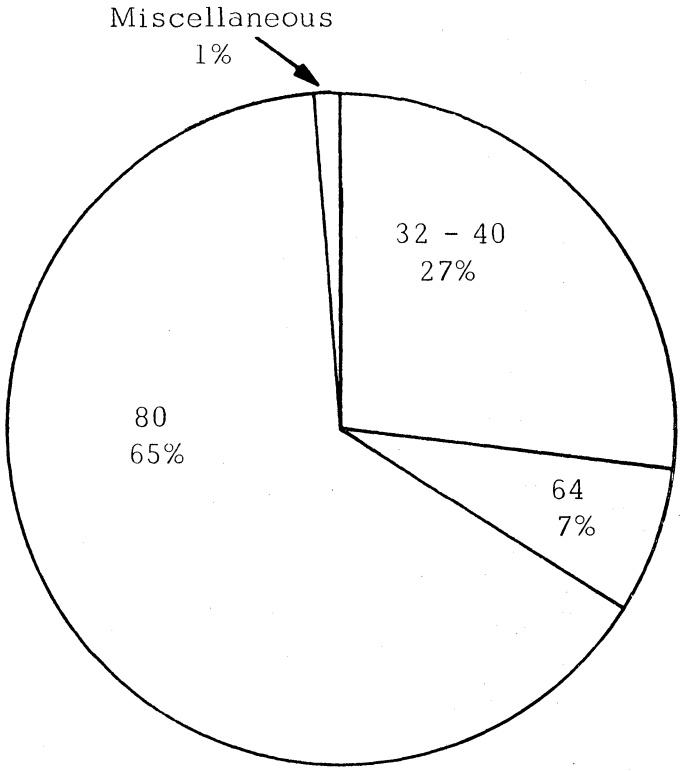
	Number of Terminals
240 characters	16,500
480 characters	95,000
960 characters	74,000
1920 characters	222,500
Miscellaneous	4,000
TOTAL: Installed Base	412,000

Figure 36

SHARE OF INSTALLED BASE BY NUMBER OF CHARACTERS PER ROW

1975

(% of Units)



NUMBER OF CHARACTERS PER ROW

1975

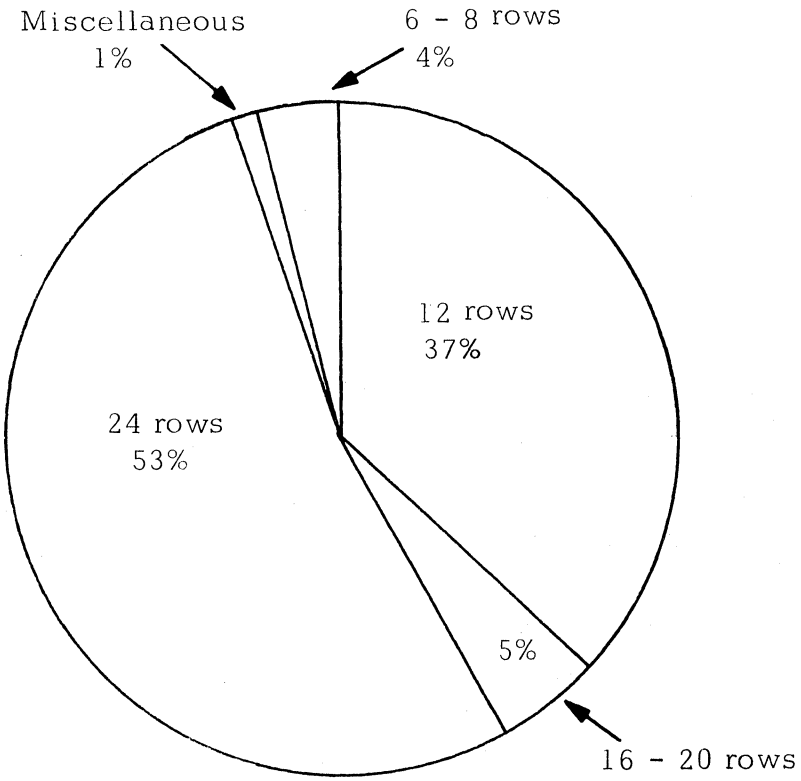
	Number of Terminals
32 - 40 characters	111,000
64 characters	29,000
80 characters	268,000
Miscellaneous	4,000
TOTAL: Installed Base	412,000

Figure 37

SHARE OF INSTALLED BASE BY NUMBER OF ROWS PER DISPLAY

1975

(% of Units)



NUMBER OF ROWS PER DISPLAY

1975

	Number of Terminals
6 - 8 rows	16,500
12 rows	133,500
16 - 20 rows	21,000
24 rows	218,000
Miscellaneous	4,000
TOTAL: Installed Base	412,000

By combining the results of Figures 35, 36, and 37, we can see that the large 1920 character display in a 24 row by 80 character format is the de facto industry standard. The small 480 character display in a 12 row by 40 character format is the next most popular.

Refresh Memory

A refresh memory is an integral part of each CRT control unit, and is typically implemented by a shift register or RAM (random access memory). The refresh memory is used to store each individual character in the form of a 6 to 8 bit character code. The refresh memory must be large (3K to 16K bits) and have a fast access time (.4 to 1.2 ms) in order to retrieve each character displayed on the screen at a rate of 60 times per second. The refresh memory acts as a buffer between the high speed CRT display and a lower speed microprocessor or communication line.

Cursor Representation and Control

A cursor is used to identify the position on the display where the next character is to be entered. The cursor is generally nondestructive, and does not erase the information currently

displayed on the screen. Several distinct symbols are used to denote the cursor, but the most common implementation is an "underline", positioned between rows of characters. The cursor is sometimes designed to blink at a 1 Hz to 6 Hz rate in order to attract the operator's attention. Controls for the cursor may be implemented in hardware or software, and include the following functions:

- Home: top left position on the screen
- Left: one character to the left
- Right: one character to the right
- Up: one row up
- Down: one row down
- Return: left position on the next lower row

Newer systems are likely to rely on software implementation of cursor controls, because they permit more flexibility in meeting customer requirements. The cursor can be positioned anywhere on the screen by specifying row and column values, or by a cursor control instruction.

Special Video Options

A number of special video options such as blinking, inverted characters, or half-intensity characters, may be included to alert the terminal operator. These functions can also aid in formatting the data on the screen. Characters which are blinked at a rate of 1 Hz to 8 Hz tend to "stand out", but low frequency flashing has been found to be a source of operator fatigue. Normally characters are displayed in white or green light on a neutral background. The inverted video option results in presenting only the outline of the characters. Half-intensity characters can be displayed by reducing the brightness level at a particular character position. This feature has a visual effect similar to boldface type.

CRT Control Unit Standards

The CRT control unit is an integral part of every CRT terminal, and provides timing and control signals for the CRT display. Surprisingly, an industry standard for CRT timing and control does not exist. Each terminal manufacturer has developed a proprietary design to determine characteristics such as screen format, cursor controls and video options.

The typical CRT control unit costs from $100 to $400, and consists of IC's operating in the 5 MHz to 20 MHz range. We believe that a potentially lucrative market exists for a company to develop a standard, "off-the-shelf", CRT control unit useful to all terminal manufacturers. This standard control unit would consist of a few LSI circuits which could be programmed by the terminal manufacturers to implement their specific product requirements.

Keyboards

The third major subsystem of a CRT terminal is the keyboard; a common device for data entry. There are three major types of keyboards:

- Typewriter keyboards
- Numeric keyboards
- Special function keyboards

Typewriter Keyboards

The typewriter keyboard is by far the most popular type, since operators are familiar with the format. Over 80% of all CRT terminals have a typewriter keyboard. The output codes have been standardized and employ either ASCII or EBCDIC character codes.

Numeric Keyboards

The numeric keyboard utilizes the format of a 10 key adding machine. The numeric keyboard is suited for such numerical entry applications as banking and point-of-sale terminals. The numeric keyboard, in many cases, replaces the typewriter keyboard, but is also used as a supplement to it.

Special Function Keyboards

A special function keyboard is used to save operator time in performing complex but repetitive functions. Examples of special function keys are:

- Screen erase: erase entire screen
- Row erase: erase entire row
- Character repeat: key in multiples of one character.
- Data transmit: send data to remote device
- Page advance: update screen with next "page" of data
- Page roll: move data up/down by one row, at a continuous rate
- Print: send data to printer

Terminal manufacturers can customize a keyboard by adding special keycaps to suit a particular user application. Limitations to today's keyboards are two fold:

- Problems detecting multiple depressions of the same key.
- Responding to high speed typists.

The cost of a typical keyboard varies from $50 to $200, depending on the mechanical quality and the type of electronic decoding included.

Microprocessor / Hard-Wired Controller

The fourth CRT terminal subsystem is the "controller", which is the heart of every computer terminal. The level of intelligence, or sophistication, of a controller varies depending on the intended function of the terminal and the technology available when the equipment was originally designed. The controller coordinates the sequence and flow of data within the terminal. The basic functions performed by a controller include:

- Recognize a keyboard depression and decode the character.
- Send data to the printer when it is idle.
- Send/receive data via the communication line.

- Process data (arithmetic, logic, or data transfer)
- Retrieve/store data from/into memory
- I/O interface control

Controller Technology

Terminal controller technology during the past decade has paralleled the advancements made in the integrated circuits industry. The development of the RAM, ROM, and the microprocessor have had the most significant impact. In the 1960's, terminal controllers were "hard-wired", or custom designed, for specific applications (i.e., stock quote or airline reservation systems). A new application would require redesign of the controller and months of engineering/production efforts. Obviously, the main drawback of hard-wired controllers is the lack of flexibility. Prior to the introduction of the microprocessor, several terminal manufacturers designed custom "micro-computers" which used RAM as a temporary storage device, and ROM to store instructions and canned messages. A new user application was met by reprogramming the micro-computer. This made the terminal a much more flexible device. As technology progressed, the microprocessor replaced the custom designed

micro-computers. The implication of this changing technology on terminal manufacturers was that hardware design became static and software was used to satisfy specific applications.

Intelligence Level

The level of intelligence of a CRT terminal is extremely difficult to quantify, and many manufacturers are guilty of "specsmanship". The classification of a terminal as "smart" or "dumb" has little significance, because all terminals have some level of intelligence. We believe that a measure of the level of intelligence can be gained by evaluating units for the following sophisticated functions:

- Programmable by user or manufacturer
- Processing capabilities (arithmetic/logical)
- Formatted data entry with protected fields and editing
- Cursor controls
- Special function keys (page rolling, line delete, page erase, etc.)
- Interrupts via keyboard/communication line
- Preprocessing of communication data/block transmission
- Auxiliary I/O control (printer, cassette, disk)

The I.Q. of a terminal must be considered in light of a price/performance tradeoff, and the flexibility to change terminal configurations. The low price and superior performance of some recently introduced microprocessor based terminals is offset in the minds of some users by the service record and industry acceptance of older terminal lines.

Future Role of Microprocessors

Clearly, there is a trend toward an increasing usage of microprocessors in CRT terminals. Prices of microprocessors are expected to decline, and design engineers will become increasingly familiar with these devices.

At the beginning of 1975, 9% of CRT terminal installations were microprocessor based, while 24% of the 1974 shipments were microprocessor based. These figures point to a growing market share for microprocessor based terminals, and we believe that this market share will exceed 60% of total shipments by 1980. However, there is a great deal of "user inertia".

A more useful predictor of the future of microprocessor based terminals is their usage in new terminal designs. In 1975 over 50%

of the new terminal lines on the design table were microprocessor based, and we expect the share to exceed 80% by 1980. We believe that there will be increasing utilization of microprocessors in CRT terminals as a result of cost reductions, performance advantages, and flexibility to meet diverse user applications. The transition to microprocessor based terminals will be directly determined by price decreases and product development in the integrated circuit industry.

Communications Line Interface

The fifth subsystem of a CRT terminal is the communications line interface; commonly referred to as the telecommunications interface. There is a decided trend toward an increasing utilization of remote data transmission. We believe that terminal manufacturers/users will focus a great deal of their resources on advancing the state-of-the art of data communication technology.

Data Communication Hardware

CRT data communication hardware consists of a communication controller unit, a modem and an acoustic coupler. The combined costs for these components averages $250, and can vary from $100 to $400. The cost of data communication hardware represents a small percentage of the total cost of a CRT terminal.

- Communications controller - The communications controller provides the timing and control between the terminal and the communications line. A typical terminal can process data at rates which are from 1 to 5 orders of magnitude faster than communication line speeds. The communication controller acts as a data buffer, which interrupts the terminal when a character is ready to be received or transmitted. The design of communication controllers has been advanced by the development of an integrated circuit called the URT (Universal Receiver/Transmitter). The URT is an LSI circuit which performs the required overhead tasks of buffering and preprocessing of data to be received/transmitted. The URT is a prime example of advances in IC technology resulting in CRT's

which can be sold at lower cost, are smaller, consume less power, have improved reliability, and take less engineering time to design. The communication controller provides serialized digital data which is then converted to analog form for the communication line by a device called a modem.

— Modems - The word "modem" comes from the term "modulator-demodulator", and refers to an interface device which converts digital information from a terminal into the analog signals required for transmission over a communication line. A modem may be thought of as a two-way digital to analog converter where two or four digital levels are represented by either amplitude, frequency or phase techniques.
Bell Telephone is the market leader among modem manufacturers, but their market share has been reduced from the near 100% they enjoyed almost a decade ago. Agressive, independent modem manufacturers now control over 30% of this high growth market, mainly due to antitrust legislation and price competition. A Bell supplied protective device, called a DAA (Data Access

Arrangement) is presently required to interface non-Bell equipment to the telephone system. We believe that continuing pressure will result in eliminating the requirement for the DAA.

The price of modems depends primarily on their transmission speed and diagnostic testing capabilities. Transmission speeds vary from 110 to over 9600 baud (corresponds to bits per second), with about 90% of all modems having a transmission speed of 4800 baud or lower. Diagnostic testing capability refers to self-test and special data patterns which are used to isolate errors to either the communication line, the modem, or the terminal. The industry standards for modems are set by the Bell system, which acts as a stabilizing force in this rapidly developing market.

— Acoustic couplers - An acoustic coupler interfaces the modem to the telephone network. Acoustic couplers and modems have allowed manufacturers to develop portable terminals, since such terminals have the ability to link any two points within reach of a telephone headset.

— EIA RS 232 Interface Standard - RS 232 is an industry standard for asynchronous data communications which defines a 25 pin connector interface and the signals required to interface a terminal with a modem. The RS 232 standard does not provide timing specifications, and almost half of the pins in the connector are not standardized. As a result, pin connections may vary from one CRT terminal manufacturer to another.

Data Transmission Techniques

A host of formats, codes and conventions have been developed for representing data on a communication line. The concepts of synchronous/asynchronous transmission, ASCII/EBCDIC character codes and block/character message formats will be discussed in order to provide insight into design tradeoffs and industry standards.

— Simplex/half duplex/full duplex - Simplex and half/full duplex refers to the direction of data flow over a communication line. Simplex refers to one-way communication of data where the terminal is used merely as a "slave", to display messages.

Half duplex refers to two-way data transmission, but in only one direction at a given time. Full duplex involves simultaneous two-way data communications. Full duplex transmission is slightly more efficient than half duplex, but has the disadvantage of requiring more complicated timing and multiple communication lines. Half duplex transmission is the unwritten industry standard due to the lower cost and less complicated hardware/software requirements.

— Asynchronous data transmission - Asynchronous data transmission is commonly used for low speed communication on an individual character basis. Asynchronous data is formatted as single characters in blocks of 10 or 11 serial bits. Each character begins with a single start bit, followed by 8 bits of data (may include a parity bit) and 1 or 2 stop bits. The receiving hardware strips away the start and stop bits to identify the relevant data. The start/stop bits are identified by sampling the data on the communication line at a multiple of the transmission rate and then looking for a particular bit pattern.

Asynchronous transmission is typically at speeds of 110 to 600 baud (roughly 10 to 60 characters per second) and data may be transmitted in spurts, on an irregular basis. Asynchronous data transmission is the industry standard for Teletype replacement terminals, and for over 60% of non-IBM compatible terminals. It is an efficient means of character transmission.

— Synchronous data transmission - Synchronous data transmission is commonly used for high speed communication of large blocks of characters. With synchronous transmission, data is formatted as a continuous stream of 8 bit characters, timed by a system clock. The clock is also transmitted over the communication line. The beginning of a large block of characters is preceeded by a sync character which serves as a reference point. The sync character consists of a unique 8 bit code and the receiving hardware searches for this code.

Synchronous transmission allows operation at rates of 1200 to 9600 baud (150 to 1200 characters per second) and data must be transmitted at regular intervals while

in operation. Synchronous transmission is the industry standard for IBM compatible terminals, and is more efficient for high speed transmission of larger blocks of data.

— Character transmission codes - The two most common character codes used for data transmission are ASCII and EBCDIC. These codes each define a unique 8 bit code to represent up to 256 different characters. Use of ASCII predominates, but EBCDIC must be used to interface with IBM equipment. The distinction between the codes is not of great significance, and terminal manufacturers can offer both via software changes.

Transmission Line Characteristics

Transmission lines can be characterized by speed, cost, and quality. Transmission lines can be divided by speed into three "bands" as follows:

— Narrow band, 0 - 300 baud

— Voice band, 300 - 9600 baud

— Wide band, over 9600 baud

Sources of transmission lines include:

- The public telephone system
- Dedicated leased lines
- Microwave carriers

The choice of one of these modes depends on usage rates, speed requirements, and distance. In general, the public telephone system is used for speeds limited to 4800 baud, low or irregular usage rates, and communication with a large number of points. Dedicated leased lines are typically used for high volume communications between a limited number of points. The public telephone system carries over 80% of the data communication volume, and the most popular transmission rates are 110, 300, 1200, 2400, and 4800 baud.

Digital Transmission Lines

The vast majority of data communications occur over lines which were not designed for digital data transmission and require complex interface hardware. To meet the future growth in digital data transmission, AT&T has introduced the DDS (Dataphone Digital Service) to a limited number of large cities. The DDS is specially designed for digital information transfer at speeds up to 56,000

baud, for lower line losses and for reduced hardware interfaces. The policies which AT&T implements over the next five years will greatly determine the technology used for data transmission in the future.

Line Control Procedures

The information which is transmitted over a communication line is comprised of both data and control characters. Line control procedures are used to increase transmission efficiency by establishing rules of "etiquette" between the transmitter and receiver. The control characters are used to send messages between the data transmitter/receiver based on the line control procedures. The three main line control procedures are ASCII, SDLC, and BSC. BSC (Binary Synchronous Control) and SDLC (Synchronous Data Link Control) were both developed by IBM and are now the industry standards for synchronous transmission. SDLC was introduced in late 1974 as a replacement for BSC, and manufacturers who offer IBM compatible terminals must have the flexibility to implement the required software changes. For asynchronous transmission the ASCII line control procedures are the industry standard. Line control procedures are generally

implemented in software, but the choice of a particular line control procedure depends on the hardware and transmission technique used.

Error Detection/Correction

The two most common methods for error detection are parity checking and CRC (Cyclical Redundancy Checking). Parity checking is the most widely used and may be done for individual characters or large blocks of data. The parity bit at the transmitter is adjusted to yield either an even or odd number of "logical 1" data bits, which is verified by the receiving hardware. Parity checks are generally used for transmission on a character by character basis, where parity has a much higher probability of detecting an error. CRC is a more sophisticated error detection technique which is used for synchronous transmission of large blocks of data. CRC produces a unique 16 bit check code based on the large block of transmitted data which is compared with a similar code generated as the data is received. CRC has a much higher probability of detecting errors in large blocks of data than does parity checking. Error correction in CRT terminals is usually implemented by a retransmission of the original data, if an error is detected.

More sophisticated techniques for error correction exist, but their additional cost is not justified for most CRT terminal applications.

Multi-Terminal Configurations

Pollable, addressable, multidrop, and multipoint configurations refer to multi-terminal applications using one or more communication lines. Pollable refers to a central data source which interrogates many terminals in sequence. Addressable denotes a unique code which preceeds the data mesage and notifies a particular terminal to send/receive data. Multidrop configurations have many modems on one line, while multipoint configurations involve many communication lines which are interfaced to a single central computer. The choice of a multi-terminal configuration depends on several factors:

- The location of the central computer relative to the terminal.
- The similarity of data to be transmitted to a group of terminals.

An automatic answering capability is important in multi-terminal configurations because it allows the central computer to communicate with remote sites on an irregular basis without operator intervention.

Printers

The sixth CRT subsystem is the printer. The printer is a critical issue for many CRT terminal users, since the controversy concerning the requirement for "hard copy" is still unresolved. Recent improvements in the cost/performance of printers have alleviated the problem by making it economical to purchase a terminal with both a CRT and a printer. Thirty-two percent of the current installed base of CRT terminals includes a printer, and over 70% have the I/O port necessary to interface with a printer. The average price for a printer is about $500, although prices range from $150 to over $1000. Printers can be divided into two categories:

- Impact
- Non-impact

Impact Printers

Impact printers are the most widely used type and can be characterized by low cost, low speed, multi-copy capability, and moderate noise levels. Impact printers can be subdivided into full-character and dot matrix printers.

Full-character printers are slow (about 30 characters per second) because of the mechanical limitation of selecting a particular position on a wheel, but offer good legibility. Matrix printers offer much higher speeds (about 100 characters per second) and have the flexibility of changing character fonts, but produce slightly less legible characters. Reliability is a key consideration for impact printers, and we believe that over the next five years impact printers will decline in price, and have improved speed/reliability characteristics.

Non-Impact Printers

Non-impact printers are characterized by higher speed, higher cost, higher reliability, lower noise level, and the lack of a multi-copy capability. Some non-impact printers have the drawback of requiring special paper or special ink. These inconveniences are compensated for by their improved reliability, as a result of having fewer moving parts. The lack of a multi-copy capability and higher costs are the main reasons why non-impact printers are not widely accepted by CRT terminal manufacturers.

Other Terminal Peripherals

There are a number of peripheral devices which may be attached to a CRT terminal to perform the functions of data input/output and temporary data storage. A list of the most common devices are shown below:

- Cassette tape recorder
- Floppy disk
- Paper tape reader/punch
- Audible alarm
- Operator input/warning indicators
- Embossed card reader

The two most important CRT peripheral devices are the cassette recorder and the floppy disk, which are used for temporary data storage. (Refer to Venture Development Corporation's reports THE DATA RECORDING INDUSTRY II 1975 - 1980, and FLOPPY DISK MARKETS 1975 - 1980, for more information on these devices). Numerous other "bells and whistles" can be added to a CRT terminal and are limited only by increased size/cost of the terminal I/O hardware, and the flexibility of the terminal manufacturer to respond to software changes.

GRAPHIC CRT TERMINAL TECHNOLOGY

Graphic CRT terminal technology is extremely complex. Indicative of the hardware complexity is the fact that graphic terminals cost six times as much as alphanumeric terminals. However, graphic terminals utilize the same microprocessor control and communication line interface technology as alphanumeric CRT's. The main differences in technology are the cathode ray tube display unit and the hardware/software tradeoffs required to implement graphic functions.

Graphic CRT Display Operation

Our goal in describing the operation of a graphic CRT display is to provide an overview of the most common technology used. A typical graphic CRT display is composed of a matrix of points, commonly 1024 high and 1024 wide for a total of 1,048,576 points. Each point on the screen is addressable by a unique X and Y coordinate, and can be connected to any other point on the screen by a straight line called a vector. Each vector to be displayed on the screen can be generated on an absolute basis by specifying the two end points, or on a relative basis by specifying an X and Y deflection from the present point on the screen. The hardware to

control a graphic CRT display consists of an arithmetic unit to calculate vector slopes/lengths, and a digital to analog converter to generate X and Y deflection signals which move the spot on the screen. A graphic figure is formed on the screen by connecting a large number of vectors of varying slopes/lengths. The information for the vectors is stored as a series of software instructions. The information displayed on the screen can be altered by changing the software instructions which define the vectors.

The three main types of graphic CRT displays are:

- Storage tube
- Random scan
- Raster scan

Storage Tube Displays

The storage tube is the most widely used and least expensive type of graphic display. The storage tube gets its name from the ability to store a graphic image on the screen without requiring a periodic refresh. The entire screen is initially erased and then a computer program is sequenced to generate a graphic image which can be maintained for extended periods of time. The speed with which

vectors are generated is not very important because no refresh is required. Storage tube displays are best suited for stable or slowly changing information, but are limited if rapidly changing information must be displayed. The main advantages of storage tubes are:

- Low cost
- No flicker
- Inherent data storage

The main limitations of storage tubes are:

- Moderate resolution
- One level brightness
- Uneven intensity, due to a tendency to burn phosphors
- Poor response to rapidly changing graphic data

Random Scan Displays

The random scan display is similar in operation to the storage tube, except that the display must be continually refreshed at a 30 to 60 cycle rate. The refresh rate of a random scan display is directly determined by the number of vectors to be drawn and the writing speed of the display. Therefore, the writing

speed for vectors is an important specification for a random scan graphic display. Flicker can be reduced by increasing the writing speed, shortening the program length or changing the screen to a longer persistence phosphor. The main advantages of a random scan display are:

- Good resolution
- Variable intensity video
- Good response to dynamically changing graphic data

The main drawbacks are:

- Flicker
- High writing speed
- High cost
- Limited program length

Raster Scan Display

The operation of the raster scan has already been described for alphanumeric CRT displays. Raster scan graphic displays usually have more than the standard 525 scan lines and, therefore, operate at much higher (video) rates. Additional hardware is required to convert vectors with random slopes/lengths into the right timing required for a raster scan display.

The main advantages of raster scan displays are:

- Moderate cost
- Special video options
- Good response to rapidly changing graphic data

The main limitations are:

- Additional hardware is required to convert to raster scan
- Slight flicker/resolution problems are encountered for narrow vectors which are parallel to the raster

Hardware/Software Tradeoffs

The total cost of operating a graphic CRT terminal is comprised of the following three components:

- Hardware costs
- Software costs
- Computer memory requirements and CPU burden

The hardware cost of a graphic terminal are well known and published by the manufacturers. The software costs are illusive and can sometimes be ten times as large as the hardware cost, depending on the application.

For example, a circle can be implemented in hardware and software by a single instruction specifying the radius and center position of the circle. The same circle can be implemented in software by connecting a large number of short vectors with varying slopes and positions.

With wages continuing to rise and integrated circuit prices declining, the hardware implementation of graphic functions is the least expensive approach in the long run. The computer memory requirements and CPU burden add significant cost if a graphic terminal worth $20,000 uses a major part of the resources of a $50,000 minicomputer. A valid hardware/software tradeoff, and an analysis of the overall cost of a graphic terminal, can only be made if the terminal manufacturer/user evaluates all three cost components.

ALTERNATE DISPLAY TECHNOLOGIES

The CRT display may reflect an old and inefficient technology when compared with recent display developments; but with several decades of development behind it we believe it will remain dominant for years to come. The numerous inefficiences of the CRT display include:

- High power consumption
- Excessive heat generation
- High voltage requirements
- Rare-earth Phosphors
- Video distortion due to screen curvature
- The bulky cabinet required to house the glass CRT

Yet, in spite of these shortcomings, the CRT continues to be a dominant factor in visual information displays.

The demise of the CRT has been predicted by numerous experts in the past, yet only 2% of the terminal shipments in 1974 used an alternate display technology to replace a CRT. Reasons for the continued dominance of the CRT are:

- Low cost
- Engineers are experienced in the design of CRT interfaces

— Users are reluctant to discard a proven design and venture out to the leading edge of technology

Significant barriers-to-entry exist for manufacturers to develop alternate display technolgies because of the high cost/uncertainties of their research and development efforts, together with the price declines of CRT's. In spite of these conditions, more than ten firms are actively marketing, or developing, alternate display technologies. Our purpose in describing alternate display technologies is to cover only the factors which will have a significant impact on the CRT terminal industry in the next five years.

LIGHT EMITTING DIODES

The technology required to develop large arrays of LED's (light emitting diodes) is available as evidenced by the 8 to 12 digit displays found in most pocket calculators. There are, at present, two technical constraints which prevent the LED from becoming a CRT replacement:

— LED's do not have adequate intensity to be viewed in high ambient light.

— LED's are usually multiplexed in order to reduce the number of connectors.

The necessity to continually refresh a large array of characters will not produce sufficient intensity while avoiding the flicker problem. Therefore, the intensity limitations of LED's will prevent them from replacing the CRT.

LIQUID CRYSTALS

Liquid crystals still suffer from development problems which have not been completely resolved. Electrical connections for a large array of characters are generally unreliable and result in a complex interface. Manufacturers of liquid crystals still have tolerance problems in putting a large number of distinct elements on a small screen. Liquid crystals have excellent intensity in strong ambient light, but may require backlighting for viewing in a dark area. We believe that the present technical limitations will prevent liquid crystals from competing with CRT displays during the next five years. They have the potential to become an important factor from 1980 - 1985.

GAS PANEL DISPLAYS

The gas panel display has been the most successful CRT replacement. The gas panel display has been able to overcome the intensity and connector problems which plague LED's and liquid crystals. Two gas panel manufacturers, Owens-Illinois and Burroughs, offer proven products which are presently used in terminal lines. There are three terminal manufacturers, IBM, Burroughs and Magnavox, who have included gas panel displays in their products. This technical commitment by such leading industrial firms has guaranteed the gas panel display an entry and acceptance into the data terminal industry.

IBM 3760/3790 Terminal

In mid-1975 IBM introduced a key-to-disk data entry system which included a gas panel display. The display is small and can display 236 characters, formatted into six rows. This introduction was a significant event since the industry leader placed its stamp of approval on the gas panel display. This move by IBM has signalled to the data terminal industry that the gas panel display may become the de-facto industry standard in the next generation of IBM terminals.

Burroughs Self-Scan Panel Display

The Burroughs display is available in various sizes, up to 256 characters, formatted into eight rows. It is also offered with timing, character generation and memory circuits included at a price of $700, in quantity. The display panel and drive electronics sell for slightly over $300, in quantity, which is about twice the price of a 9" CRT monitor. The Burroughs display panel is also used in the model TD700 alphanumeric display terminal.

Owens-Illinois Digivue Plasma Panel

The Digivue panel is available in two sizes with a display capacity of over 2000 characters. It is expensive, but its current price of $2300 is expected to decline as sales volume increases. The Digivue has the added feature of not requiring a refresh memory, because every element on the display screen has an inherent memory. This feature relaxes the timing constraints on the display and allows the screen to be updated at a slower rate than a corresponding CRT display. The most significant application of the Digivue panel is in the Magnavox terminal, which is expensive but offers the advantage of

rear-screen microfiche projection. This feature is ideally suited for educational applications. We believe that if prices continue to decline the Burroughs and Owens-Illinois displays will offer a superior replacement to the CRT display over the next five years.

COLOR CRT DISPLAYS

The vast majority of CRT displays are limited to either white or green video. ADDS and Ramtek are the only two manufacturers that offer color CRT terminals. Improvements in color monitor technology have led to smaller spot sizes and lower prices, which makes color terminals attractive for process control applications. We believe that color displays will increase in popularity over the next five years, but will represent less than 3% of the installed base of CRT terminals by 1980.

TRADEOFFS OF CRT/ALTERNATE DISPLAY TECHNOLOGIES

The main advantages of the CRT display when compared with alternate display technologies are listed below:

- Lower cost
- A proven technology with a stable design
- Engineers have accumulated experience in designing interfaces for CRT displays
- Random scan option for graphic displays
- Wide user acceptance

The most often mentioned advantages of alternate display technologies over CRT displays are listed below:

- Less bulky
- Less power consumption/no high voltage requirements
- Relaxed timing constraints
- Flat panel/no video distortions
- Consistent character size, quality and intensity
- Interface tends to be more digital than analog
- IBM stamp of approval

We believe, that during the planning period of this study the advantages of alternate display technologies will be more than offset by the lower cost and wide acceptance of CRT displays.

FUTURE OF ALTERNATE DISPLAY TECHNOLOGIES

The future of alternate display technologies as a replacement for the CRT display depends on their cost and the IBM competitive strategy. The costs of alternate display technologies are presently two to ten times higher than the costs of CRT displays. Over the next five years we expect CRT display prices to rise slightly due to wage increases, while prices of alternate display technologies will decline at an annual rate of 15% to 20%. IBM has already introduced a terminal line with a gas panel display and will be able to judge market acceptance. If the next generation of IBM terminals includes a gas panel display, then the CRT display will gradually be phased out over the next ten years.

Based on the assumption of declining prices for alternate display technologies and a continued commitment by IBM to gas panel displays, we predict that alternate display technologies will increase from 2% of the installed base of CRT terminals in 1974

to 20% by 1980. Shipments of terminals in 1980 with alternate display technologies will increase to 35% of total CRT terminal sales by volume.

CRT TERMINAL MARKETS

MARKET FACTORS

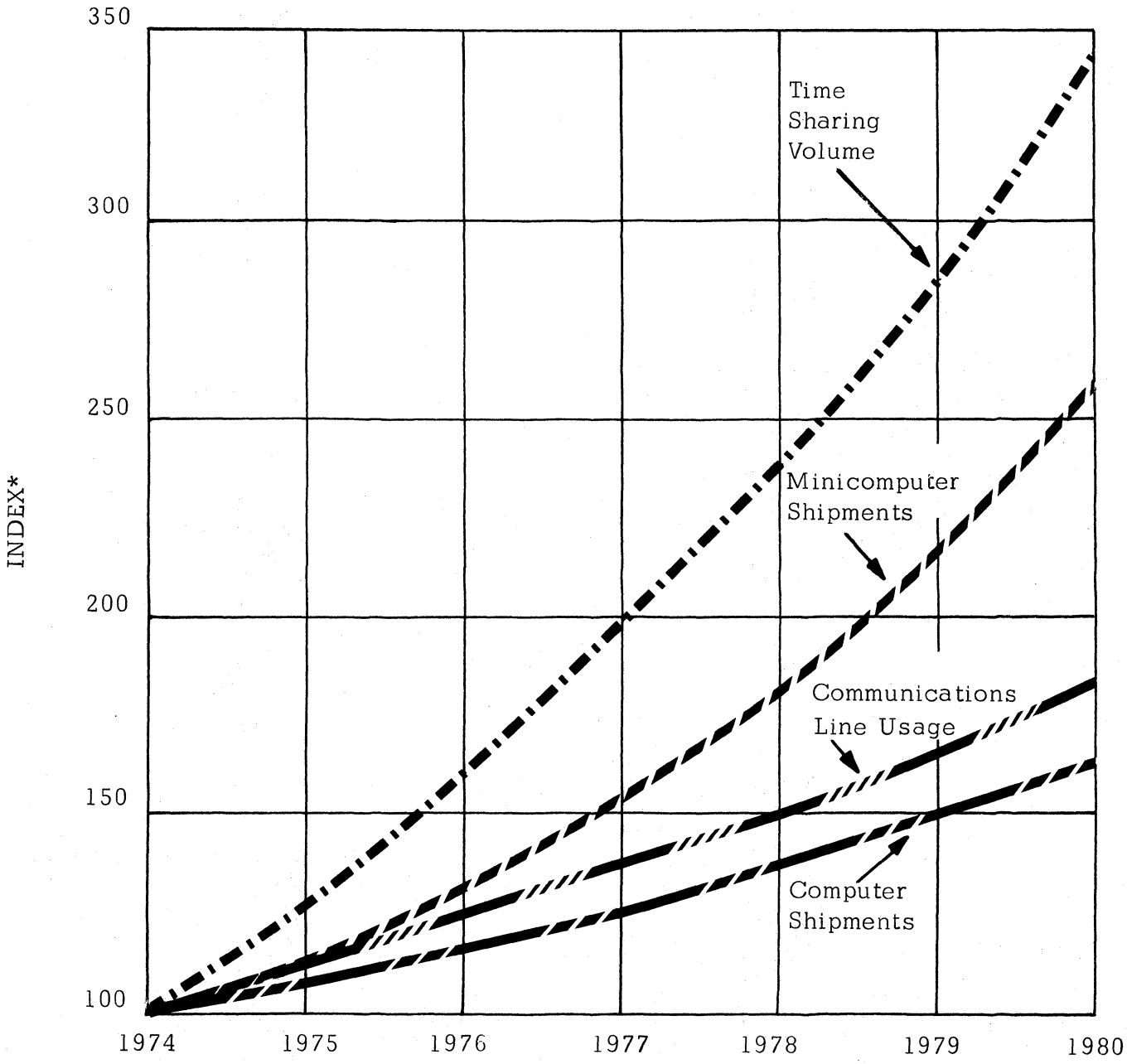
The market for CRT terminals in the periods from 1975 to 1980 will be influenced by the following factors:

- Computer shipments.
- Minicomputer shipments.
- Time-sharing volume.
- Data communications line usage.
- CRT terminal price trends.
- AT&T's policies concerning the price, quality and availability of data communications lines.
- Uncertainty concerning the timing and nature of the next generation of IBM CRT terminals to replace the 3270.

Each of the above factors affects the market for CRT terminals to varying degrees, and the first four factors have been quantified by Venture Development to be used as indices in arriving at CRT terminal forecasts. See Figure 38.

Figure 38

INDEXED FACTORS AFFECTING CRT TERMINAL SALES



*Base year: 1974 = 0

Computer Shipments

Computer shipments are a dominant factor influencing the CRT terminal market, and are forecast to increase at an 8.5% annual rate from 1975 to 1980. Over 40% of the CRT terminals shipped can be traced to a system including a computer mainframe.

Minicomputer Shipments

Minicomputer shipments are forecast to grow at a 17.1% annual rate over the next five years, and during this period CRT terminals will continue to be a popular minicomputer I/O device. On the order of 20% of CRT terminal shipments can be directly attributed to minicomputer sales, and with the high rate of growth in minicomputer shipments over the next five years this will be a major growth area for CRT terminals.

Data Communications Line Volume

Data communications line volume refers to the use of public/private lines for remote data transmission, and is projected to grow at a 10.7% annual rate from 1975 - 1980. The quantity and usage rates of communications lines are leading indications

of CRT terminal sales because 44% of the installed base of CRT terminals are used in remote applications. The CRT teleprinter replacement market is the predominant segment of the remote terminal markets. This implies that the communications line growth rate is an especially strong predictor of CRT teleprinter replacement and teletype model 40 shipments.

Time-Sharing Volume

The growth in time-sharing volume is forecast to be at a 22.8% annual rate over the next five years. Time-sharing applications of CRT terminals account for less than 12% of annual shipments. With the impressive growth predicted for time-sharing, we believe that this segment will develop into a substantial source of CRT terminal shipments.

Of the four indicators discussed, computer and minicomputer shipments strongly influence the markets for the IBM 2260, IBM 3270, and other mainframe manufacturer's terminals. Communications line usage and time-sharing volume are better indicators for the CRT teleprinter replacement and Teletype model 40 markets.

CRT Terminal Price Trends

Trends in the price of CRT terminals will be another important indication of the strength and size of the market. We believe that the price of a CRT terminal depends primarily on the following two factors:

- Wage levels
- Integrated circuit prices

Wage levels are expected to increase at an average rate of 7.4% per year, with a turbulent period from 1974 - 1976, followed by a more stable period of 5%-6% wage increase from 1976 to 1980.

In contrast, integrated circuits and electronic equipment in which they are included, are expect to continue to decline in price over the next five years at a 20.6% annual rate.

Therefore, the price of a CRT terminal is made up of two compoents which are moving in opposite directions, tending to offset each other. However, the price decline of integrated circuits is the more dominant factor. We forecast that the net effect will be an average price decline of 4.5% per year for alphanumeric terminals, and 3.1% per year for graphic CRT terminals from 1975 - 1980.

Price for alphanumeric CRT terminals are declining at a faster rate than the prices for graphic CRT terminals because the alphanumeric market has a higher volume, more competition and a greater opportunity to take advantage of economies of scale. See Figure 39.

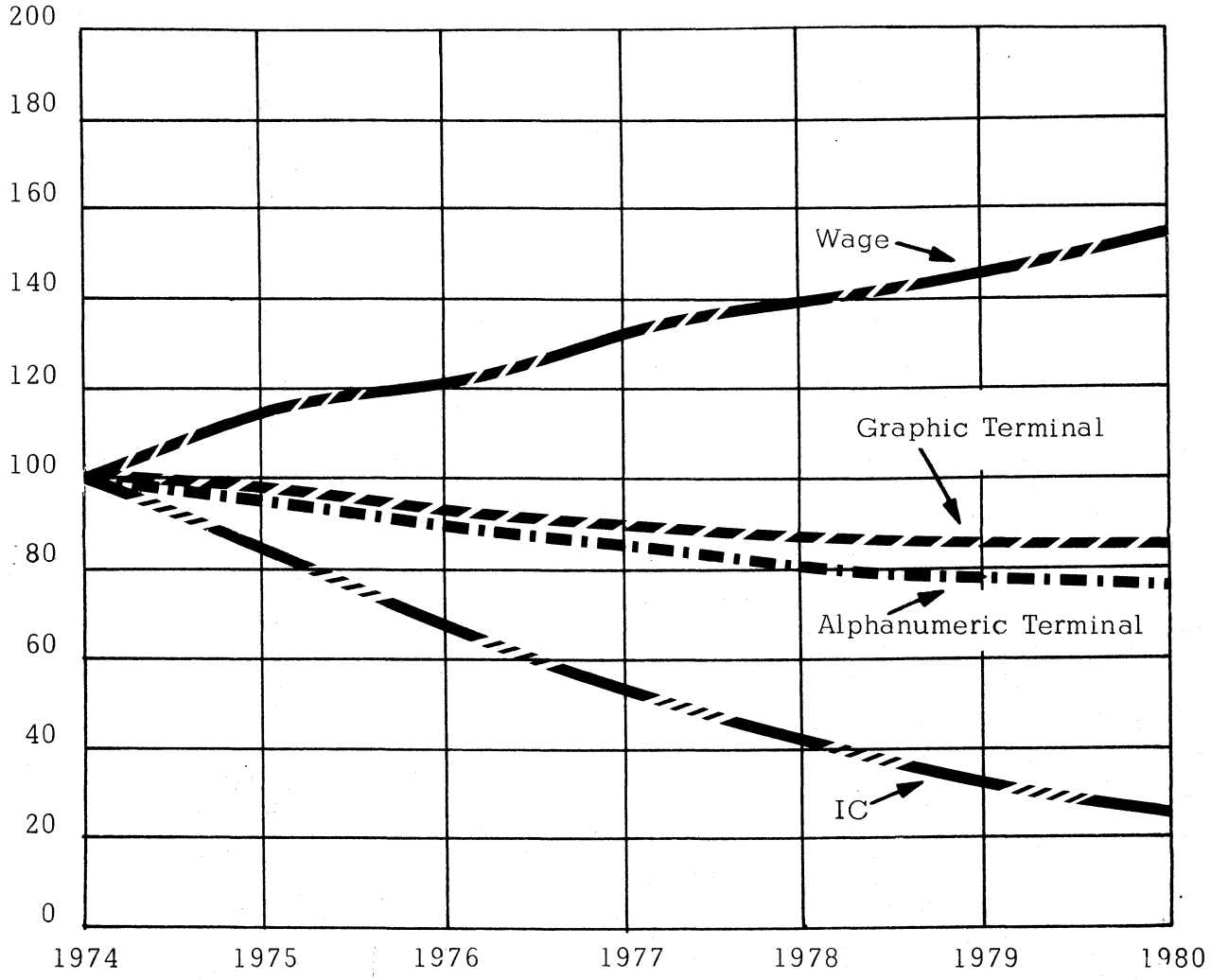
Based on the terminal price indices forecast in Figure , the average price of an alphanumeric CRT terminal will decline from $3400 in 1974 to $2580 in 1980, and the average price of a graphic CRT terminal will decline from $20,400 in 1974 to $16,900 in 1980. See Figures 40 and 41.

The trend toward declining CRT terminal prices is an important factor affecting market penetration because low prices will encourage systems designers to include CRT terminals in more and more applications.

Declining CRT terminal prices will also influence the growth of the replacement market for the IBM 2260, IBM3270, and teleprinter terminals. As prices continue to decline many terminal users will choose to update their old equipment with low cost modern terminals. Declining graphic CRT terminal prices will open the low and medium priced segments to many first time users

Figure 39

CRT TERMINAL PRICE INDEX

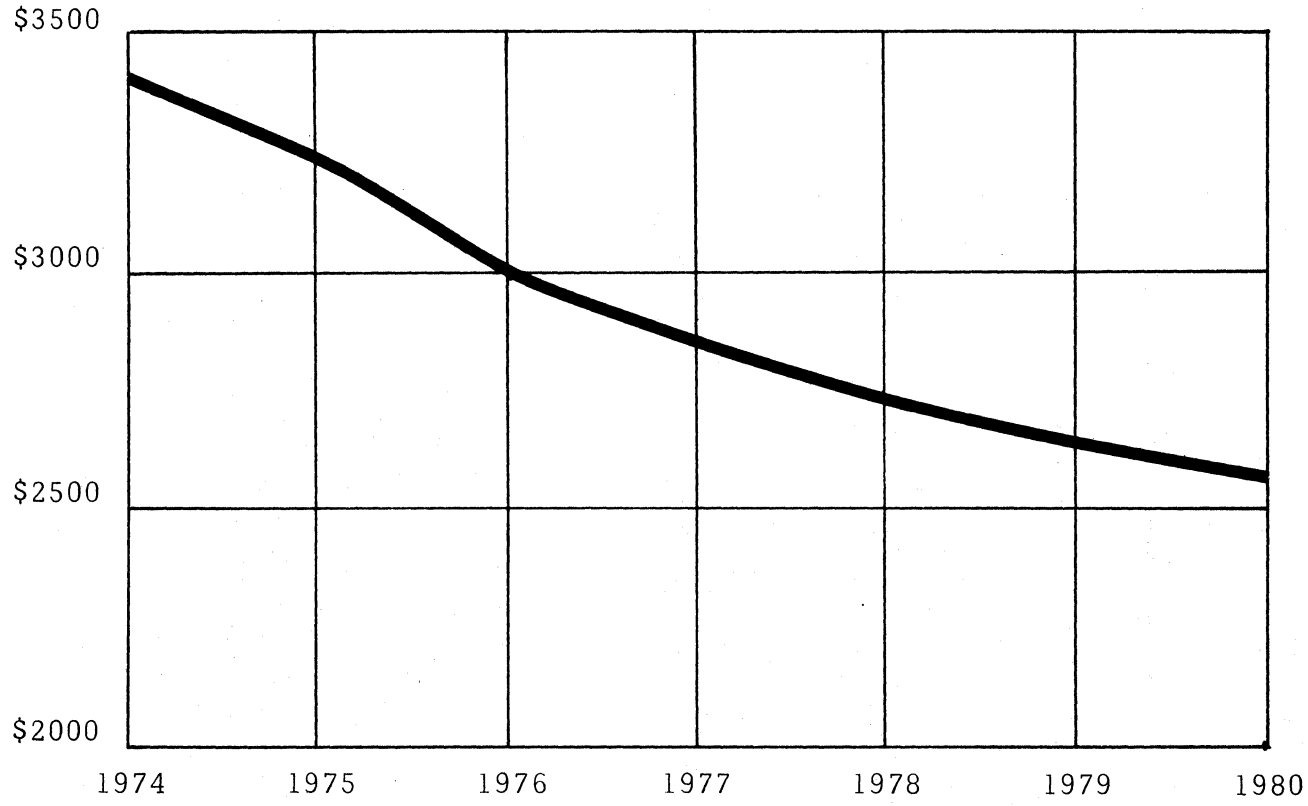


CRT TERMINAL PRICE INDEX

	1974	1975	1976	1977	1978	1979	1980
Wage Price Index	100	112	121	131	138	147	154
IC Price Index	100	84	66	52	41	33	25
Alphanumeric Terminal Price Index	100	95	88	84	80	78	76
Graphic Terminal Price Index	100	97	91	88	85	84	83

Figure 40

AVERAGE ALPHANUMERIC CRT TERMINAL PRICES

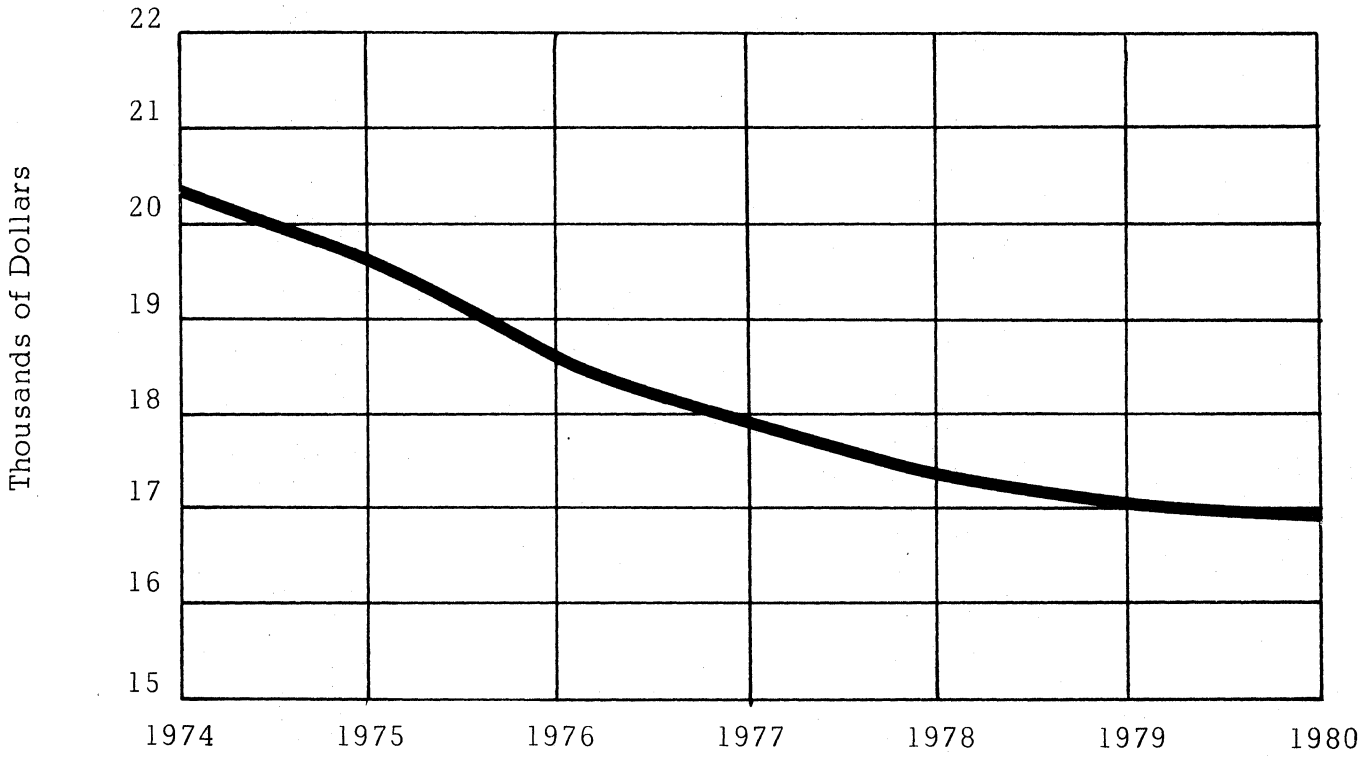


AVERAGE ALPHANUMERIC CRT TERMINAL PRICES

	1974	1975	1976	1977	1978	1979	1980
Average Alphanumeric Terminal Price	$3400	$3230	$2990	$2850	$2720	$2650	$2580

Figure 41

AVERAGE GRAPHIC CRT TERMINAL PRICES



AVERAGE GRAPHIC CRT TERMINAL PRICES

(Thousands of Dollars)

	1974	1975	1976	1977	1978	1979	1980
Average Graphic Terminal Price	$20.4	$19.7	$18.6	$17.9	$17.3	$17.1	$16.9

who previously could not justify the purchase on a cost effective basis. Naturally, the policies of the two industry leaders, AT&T and IBM, will be major factors in determining the growth and direction for the CRT terminal industry from 1975 to 1980.

AT&T Data Communication Policies

The policies of AT&T concerning the price, quality and availability of data communications lines, have a direct bearing on the remote terminal market. The quality and availability of communications lines will continue to improve over the next five years as evidenced by developments in DDS (Dataphone Digital Service), an AT&T digital transmission system. At present, DDS is being introduced between major U.S. cities, making more communications lines available with higher transmission speeds, lower error rates, and simpler line interfaces. Prices for data transmission services will have to increase over the next five years to cover the heavy capital expenditures anticipated by AT&T. In general, the AT&T policies will be conducive to growth in the remote terminal market with CRT teleprinter replacements and the Teletype model 40 being the major beneficiaries.

Future IBM Terminal Lines

The nature and timing of the next generation of IBM CRT terminals to replace the IBM 3270 will be a significant milestone for the CRT terminal industry. We expect a new terminal line (which VDC, and possibly IBM, will call the "4280") to be introduced around mid-1978; but the timing is sensitive to the vitality and growth of the IBM 3270 market. The new IBM terminal line is expected to be microprocessor based and oriented toward distributed processing. In fact, the market for CRT terminals could temporarily be dampened as users and terminal manufacturers wait to see the impace of the new "industry standard".

It has been IBM's product policy to introduce a new CRT peripheral when sales of the previous generation begin to level off. As a result, IBM, with the introduction of the IBM 3270, was able to maintain the growth that the IBM 2260 had generated. Similarly, the IBM "4280" will be announced when IBM 3270 sales begin to lag. When such an announcement is made (be it 1978 or 1980) outstanding orders are likely to be switched from the 3270 to the "4280". VDC coped with the uncertainty in the timing of a "4280" product introduction, and its impact on the market, by including shipments of any new IBM CRT terminals in our projections for the IBM 3270.

CRT TERMINAL SHIPMENTS

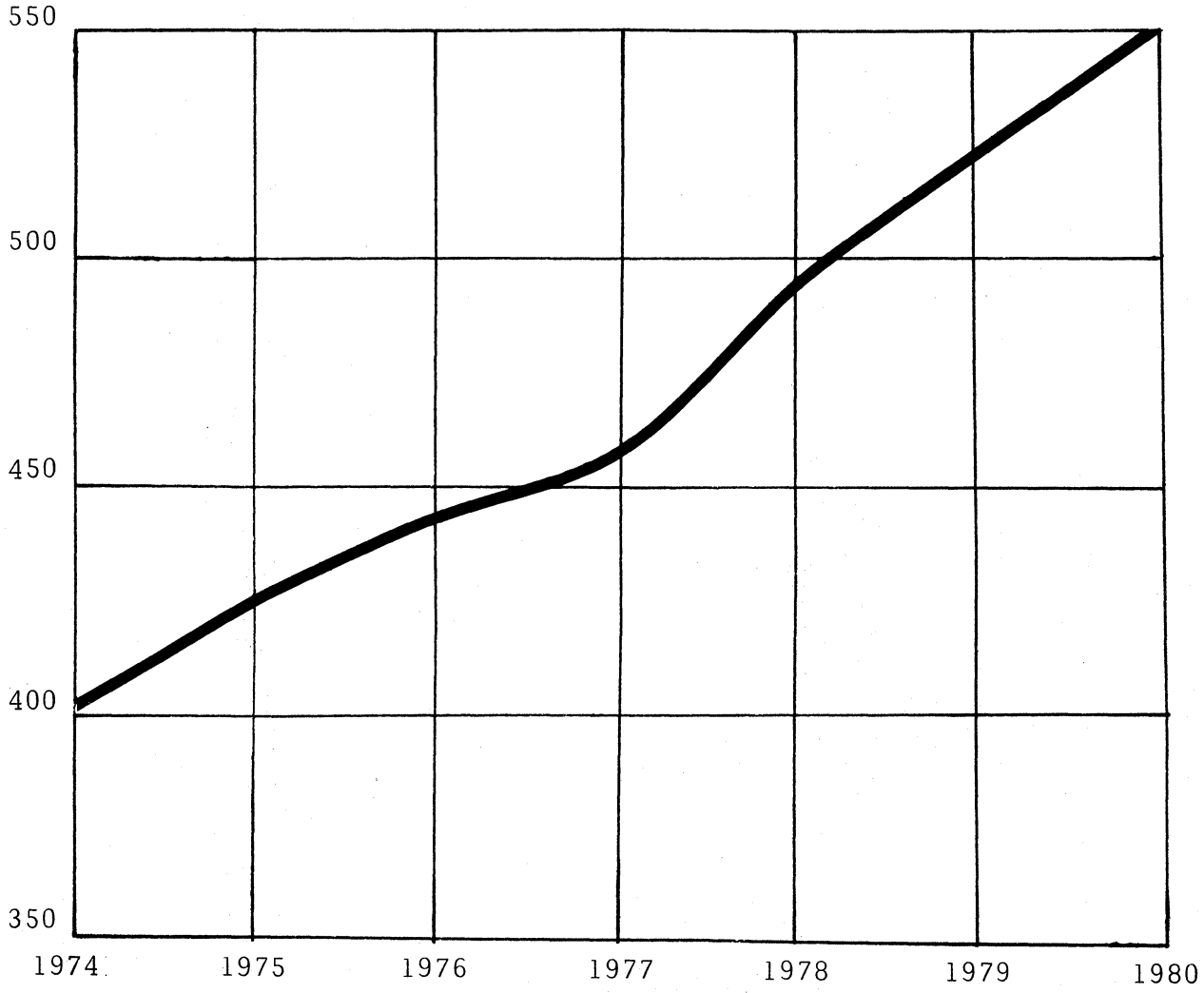
CRT terminal dollar shipments were $402.7 million in 1974, and are projected to grow at a 5.6% per year rate to $557.4 million in 1980. Due to projected price declines unit shipments will grow twice as fast as dollar shipments. Unit shipments of CRT terminals will grow at a 10.9% rate from 119,000 units in 1974 to 221,000 units in 1980.

Shipments of alphanumeric CRT terminals will grow at a 5.4% per year rate from $382 million in 1974 to $523 million in 1980. Graphic CRT terminals will grow at a 8.8% per year rate from $20.7 million in 1974 to $34.4 million in 1980. In terms of dollars, alphanumeric CRT terminals accounted for 95% of all CRT shipments in 1974 and will continue to dominate CRT shipments throughout 1980. Figures 42, 43, and 44, provide dollar shipments of total CRT terminal shipments, alphanumeric CRT terminal shipments, and graphic CRT terminal shipments.

Figure 42

TOTAL CRT TERMINAL SHIPMENTS

(Millions of Dollars)



TOTAL CRT TERMINAL SHIPMENTS

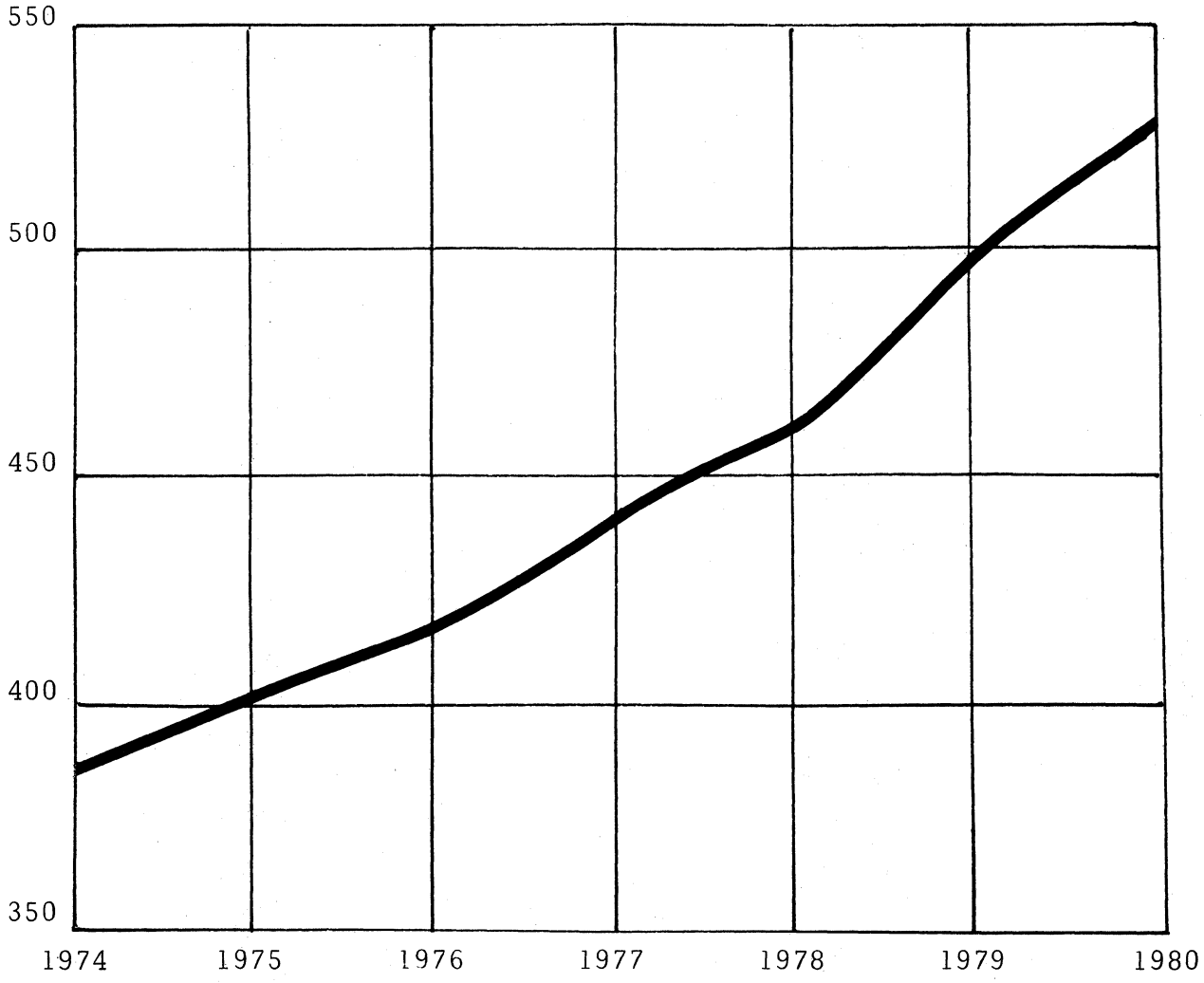
(Millions of Dollars)

	1974	1975	1976	1977	1978	1979	1980
Forecast	$402.7	$424.5	$441.8	$456.6	$493.4	$527.3	$557.4

Figure 43

ALPHANUMERIC CRT TERMINAL SHIPMENTS

(Millions of Dollars)



ALPHANUMERIC CRT TERMINAL SHIPMENTS

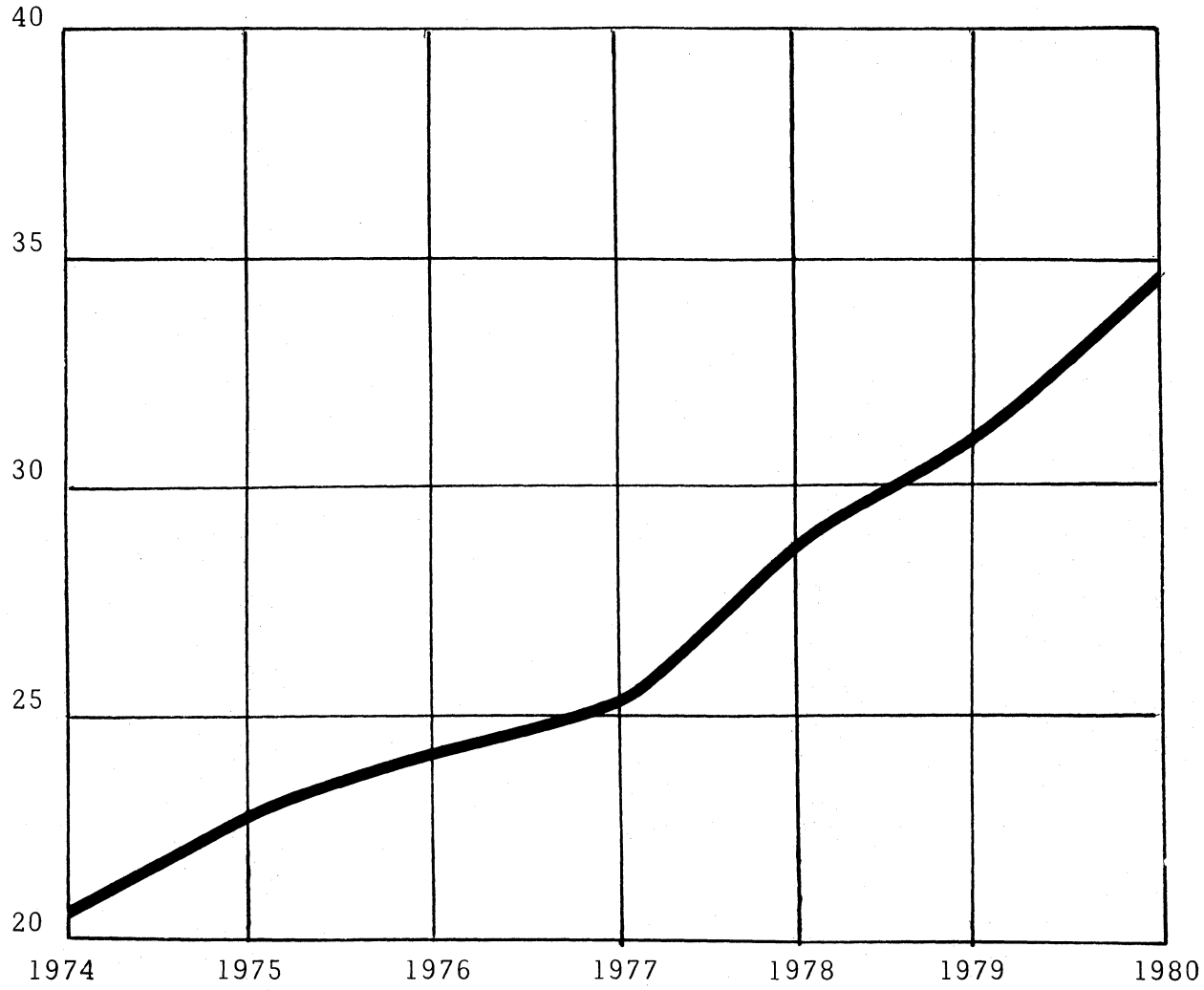
(Millions of Dollars)

	1974	1975	1976	1977	1978	1979	1980
Forecast	$382	$402	$418	$440	$465	$496	$523

Figure 44

GRAPHIC CRT TERMINAL SHIPMENTS

(Millions of Dollars)



GRAPHIC CRT TERMINAL SHIPMENTS

(Millions of Dollars)

	1974	1975	1976	1977	1978	1979	1980
Forecast	$20.7	$22.5	$23.8	$25.6	$28.4	$31.3	$34.4

ALPHANUMERIC CRT TERMINAL SHIPMENTS

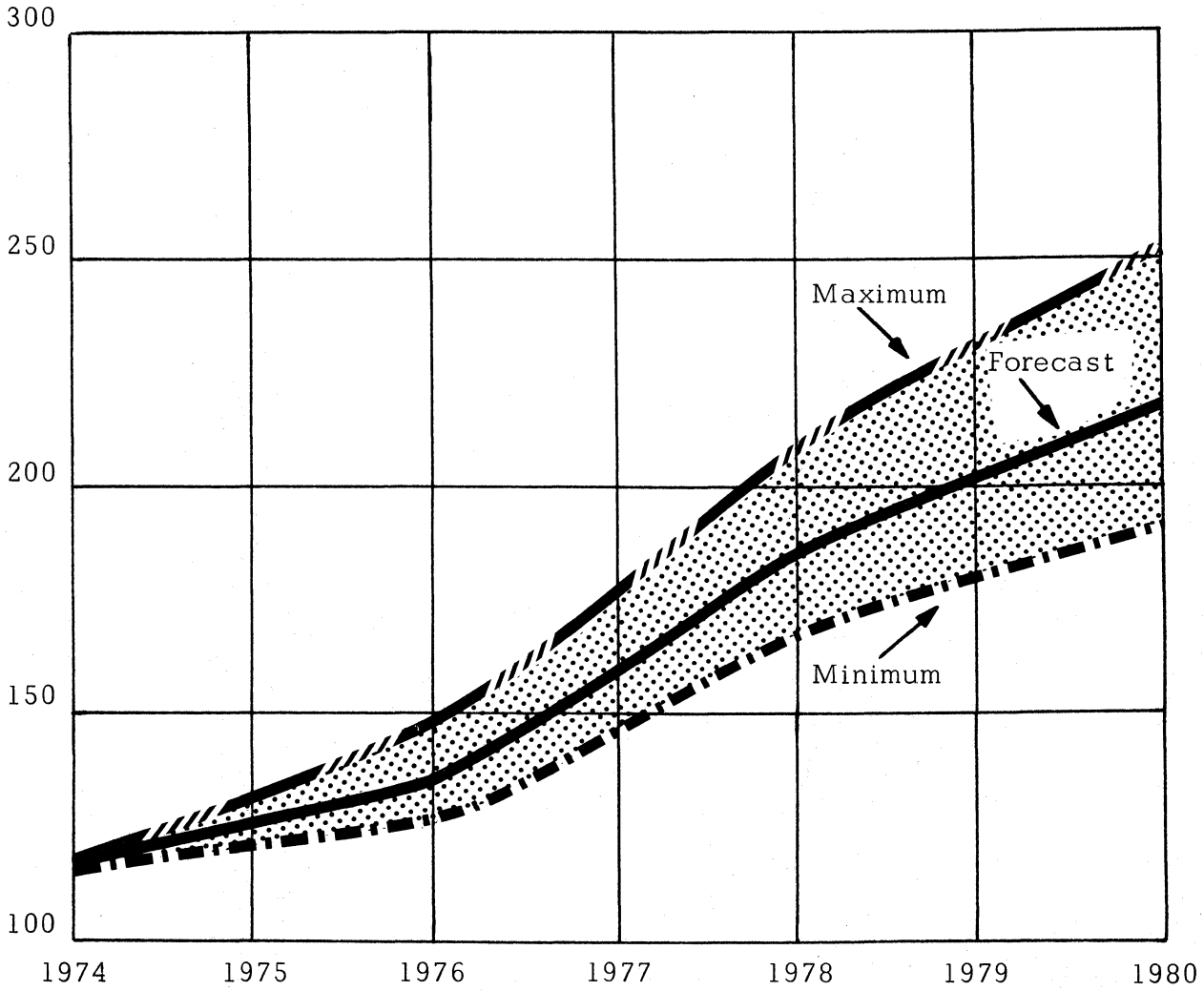
Based on our analysis of the seven factors influencing the CRT terminal market, we predict that alphanumeric CRT terminal shipments will grow at a 10.9% annual rate from 1974 to 1980. Shipments are forecast to increase from 118,000 units in 1974 to 219,000 units by 1980. The uncertainty in alphanumeric CRT terminal shipments is based primarily on the relative price levels of CRT teleprinter replacements and the impact of a new IBM terminal line.

Shipments of alphanumeric CRT terminals have been broken down into the six segments which were previously identified. It should be noted that while unit shipments are forecast to grow at a 10.9% rate, revenues are predicted to grow at only a 5.4% annual rate from $382 million in 1974 to $523 million by 1980. The difference between unit and dollar growth rates reflects a decline in the average terminal price. See Figures 45, 46, 47, and 48.

Figure 45

TOTAL ALPHANUMERIC CRT TERMINAL SHIPMENTS

(Thousands of Units)



TOTAL ALPHANUMERIC CRT TERMINAL SHIPMENTS

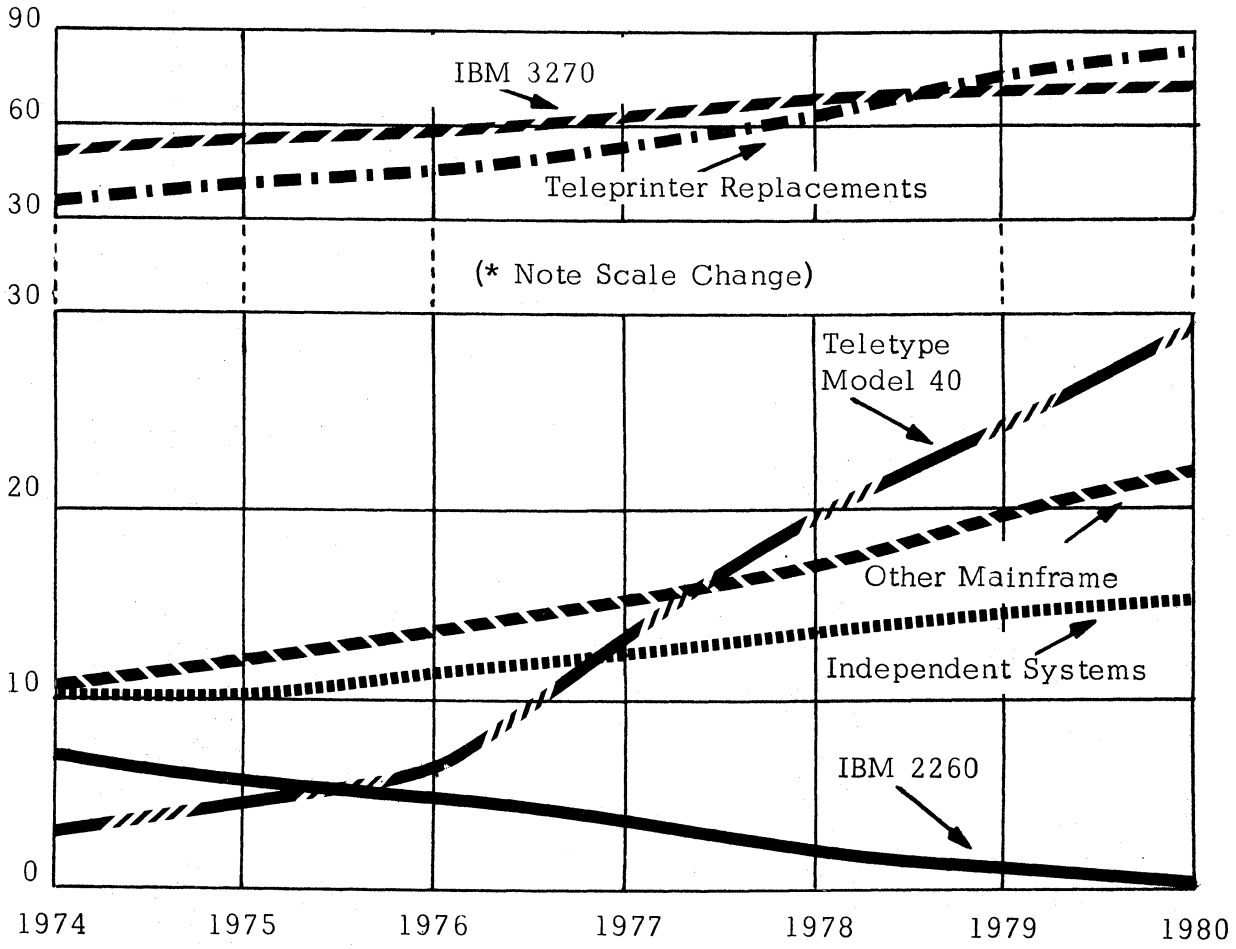
(Thousands of Units)

	1974	1975	1976	1977	1978	1979	1980
Maximum	118	132	147	178	210	233	254
Forecast	118	125	135	158	184	202	219
Minimum	118	121	125	147	168	180	192

Figure 46

ALPHANUMERIC CRT TERMINAL SHIPMENTS*

(* Note Scale Change)



ALPHANUMERIC CRT TERMINAL SHIPMENTS

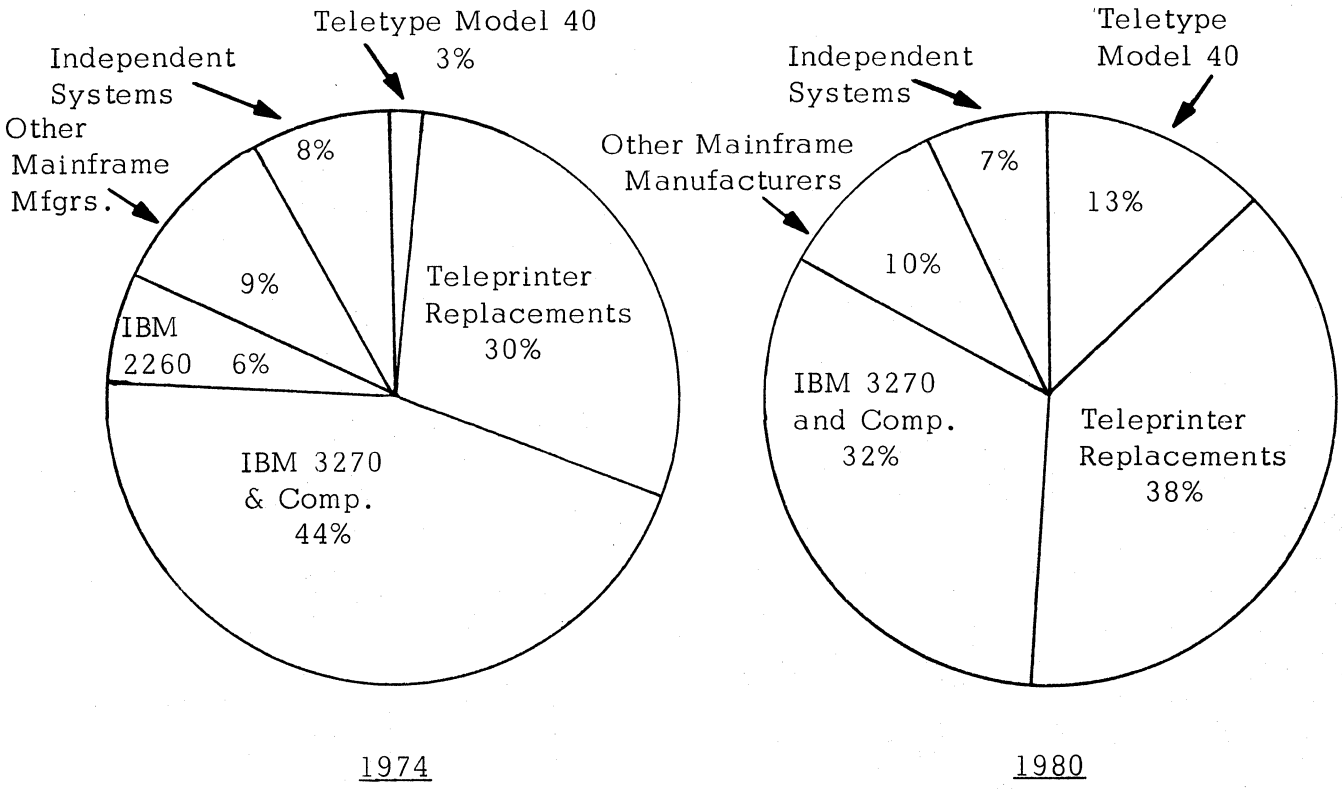
(Thousands of Units)

	1974	1975	1976	1977	1978	1979	1980
IBM 2260 & Comp.	7	6	4	3	2	1	-
IBM 3270 & Comp.	52	54	58	63	68	70	70
Other Mainframe Mfg.	11	12	13	15	17	19	22
Teleprinter Replacements	35	39	43	52	65	74	83
Teletype Model 40	3	4	6	13	19	24	29
Independent Systems	10	10	11	12	13	14	15
TOTAL	118	125	135	158	184	202	219

Figure 47

ALPHANUMERIC CRT TERMINAL SHIPMENTS

(% of Units)



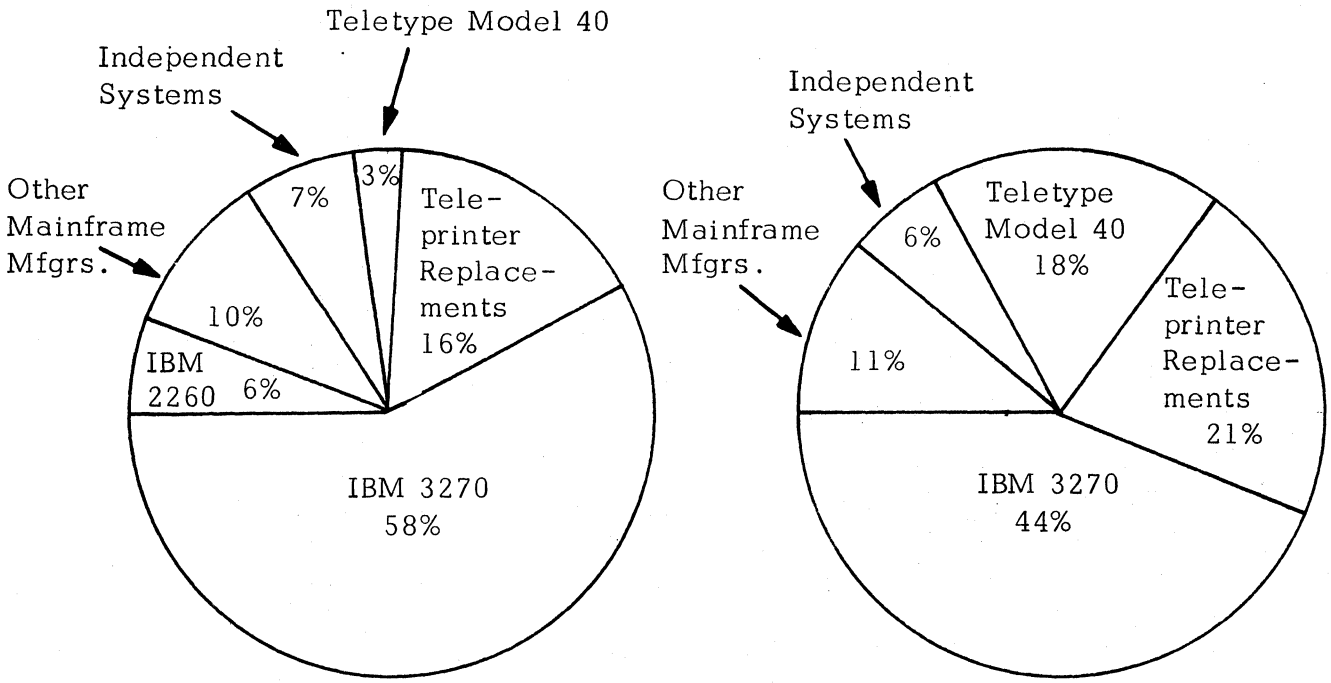
ALPHANUMERIC CRT TERMINAL SHIPMENTS

	1974 Number of Terminals	1980 Number of Terminals
IBM 2260 and Comp.	7,000	-
IBM 3270 and Comp.	52,000	70,000
Other Mainframe Mfg.	11,000	22,000
Teleprinter Replacements	35,000	83,000
Teletype Model 40	3,000	29,000
Independent Systems	10,000	15,000
TOTAL	118,000	219,000

Figure 48

ALPHANUMERIC CRT TERMINAL SHIPMENTS

(% of Dollars)



ALPHANUMERIC CRT TERMINAL SHIPMENTS

(Millions of Dollars)

	1974	1980
IBM 2260 and Comp.	$ 23	$ -
IBM 3270 and Comp.	222	230
Other Mainframe Mfg.	38	58
Teleprinter Replacements	61	110
Teletype Model 40	11	94
Independent Systems	27	31
TOTAL	$382	$523

IBM 2260 and Compatibles

The market for the IBM 2260 and compatible terminals is forecast to decline from its present shipment level of 7000 units, worth $23 million in 1974, to an insignificant level by 1980. All of the technically obsolete IBM 2260 equipment will be replaced by newer IBM 3270 terminals or by microprocessor based units.

IBM 3270 and Compatibles

The market for the IBM 3270 and compatible terminals will continue to grow over the next five years, but at a slower rate than the total CRT terminal market. Sales of IBM 3270 terminals depend on the following three factors:

- Computer shipments
- IBM 2260 replacements
- New IBM CRT terminal line

IBM 3270 shipments are tied to computer shipments, which are forecast to grow at only an 8.5% rate. IBM 3270 sales as replacements for IBM 2260 terminals will continue to decline as this market becomes extinct. Any new IBM CRT terminal line is expected to have a dampening effect on IBM 3270 sales in the 1978 period as loyal IBM users delay their purchases in anticipation of the new generation of terminals. Our forecast for the IBM 3270 market is moderate growth of 8% from 1975 to 1978, followed by flat or declining sales after 1978.

Other Mainframe Manufacturers

Terminal shipments by other mainframe manufacturers will grow at a 12.2% annual rate from 11,000 units in 1974 to 22,000 units by 1980. This growth rate is higher than the 8.5% growth for computer shipments and reflects a gain in market share for non-IBM computers.

Independent Systems

Shipments of independent terminal systems will grow at a 7% annual rate from 10,000 units in 1974 to 15,000 units by 1980. This slow growth rate is due to user uncertainty in making a commitment to an independent terminal line which is not second sourced.

Teletype Model 40

The market for Teletype model 40 terminals is the fastest growing segment in the CRT terminal industry. We forecast a 46% annual growth rate with shipments increasing from 3,000 units in 1974 to 29,000 units by 1980. This rapid growth is a function of the large captive market in the AT&T communications system and the impressive technical features of the model 40.

Teleprinter Replacements

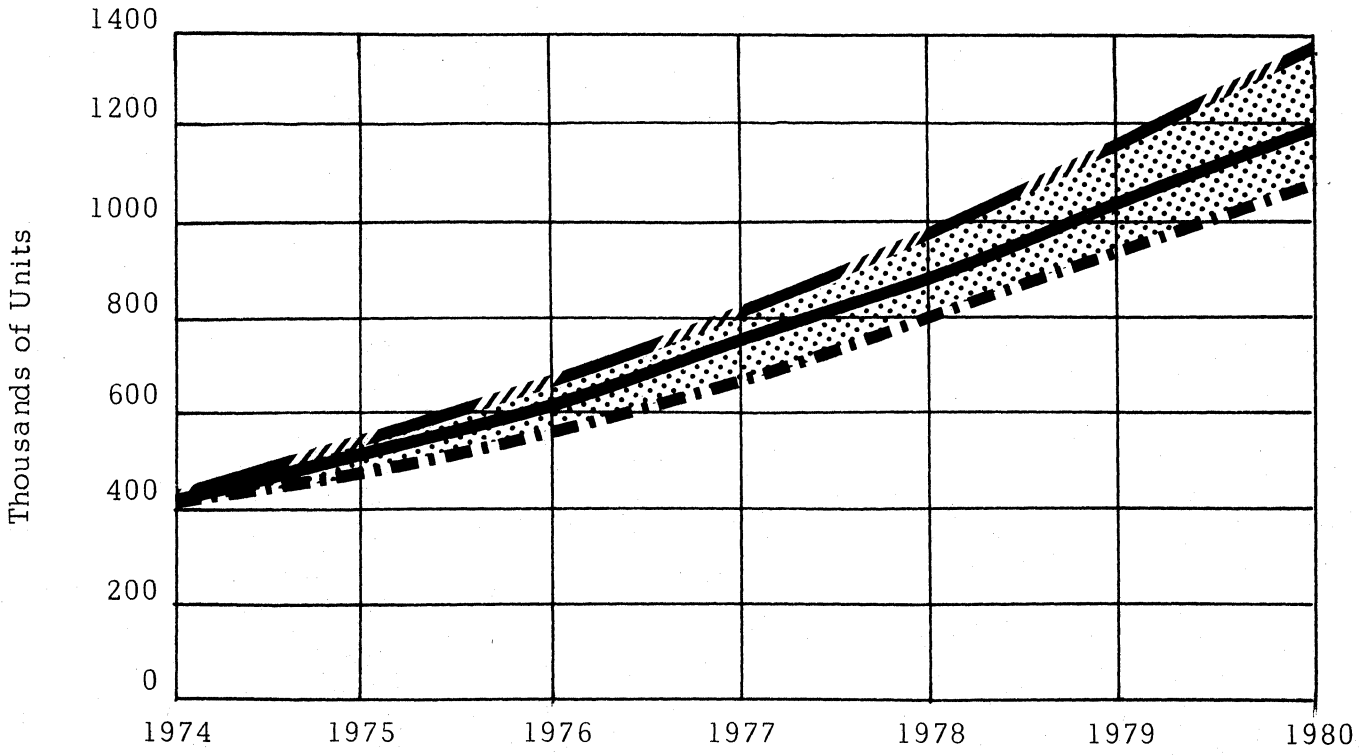
The market for CRT teleprinter replacements is predicted to be the largest CRT terminal segment and will account for 38% of 1980 unit sales. Shipments will grow at a 15.5% annual rate from 35,000 units in 1974 to 83,000 units by 1980.

Price is a crucial factor in the CRT teleprinter replacement market with the $1000 barrier being recently crossed by several manufacturers. The inherent lack of "hard copy", or printed output, in a CRT terminal is a controversial area, and the growth in this terminal segment depends on a marketing strategy aimed at users who want fast quiet operation with a minimal printed output requirement.

The total installed base of alphanumeric CRT terminals will increase at a 19.3% annual rate from 412,000 units in 1974 to 1,190,000 units by 1980. The net change in the installed base from year to year is always less than the shipment levels because 10% - 20% of all sales are replacements of existing outdated terminal equipment. See Figure 49.

Figure 49

INSTALLED BASE OF ALPHANUMERIC CRT TERMINALS



INSTALLED BASE OF ALPHANUMERIC CRT TERMINALS

(Thousands of Units)

	1974	1975	1976	1977	1978	1979	1980
Installed Base	412	515	620	740	870	1020	1190

WORLD MARKETS FOR ALPHANUMERIC CRT TERMINALS

Our research into world markets for alphanumeric CRT terminals shows that foreign shipments will increase in market share from 32% in 1974 to 39% by 1980. See Figure 50.

Japan

The Japanese market for U.S. manufactured CRT terminals will increase in market share from 6% of total shipments in 1974 to 10% by 1978, and then decline to 8% by 1980. Japanese CRT terminal manufacturers are expected to expand their technology and production facilities. From the point of view of a U.S. terminal manufacturer, the Japanese market will exhibit attractive short term growth for terminals. Programmable microprocessor based terminals with a Katakana character font option will be in demand.

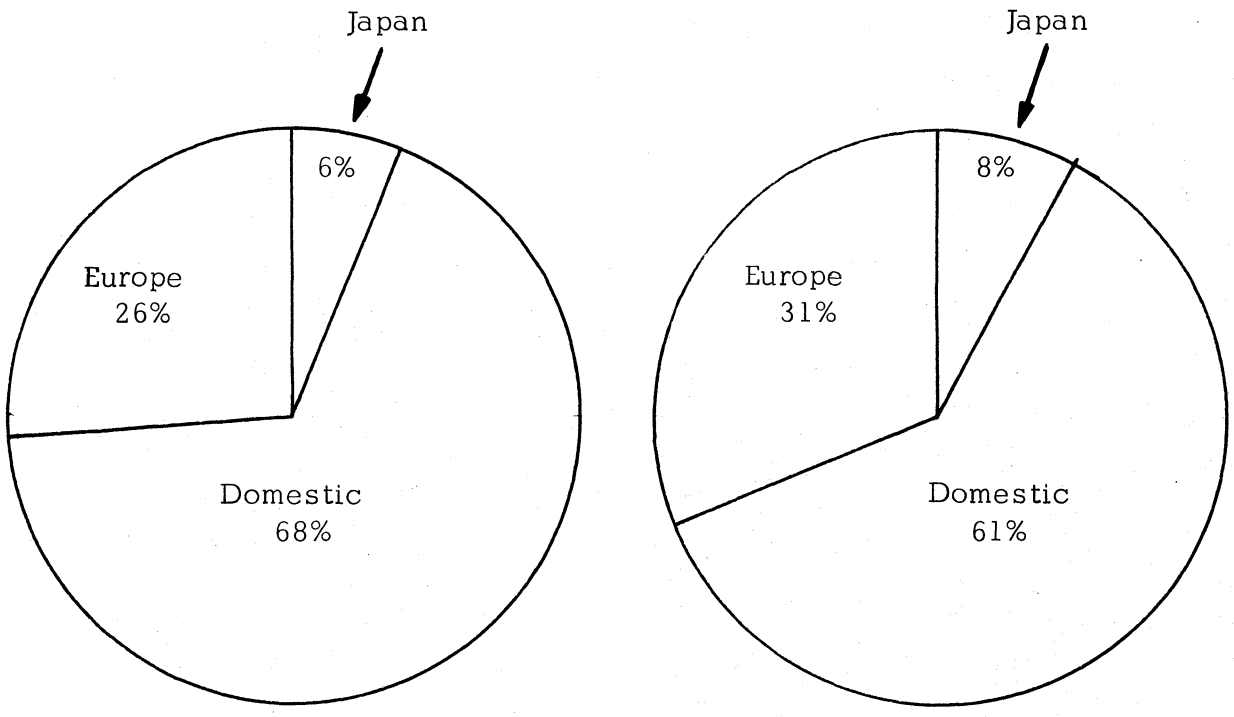
Europe

The European market for alphanumeric CRT terminals will grow at a 14% annual rate from 31,000 units or 26% of total shipments in 1974 to 68,000 or 31% by 1980. France, Germany and the

Figure 50

WORLD ALPHANUMERIC CRT TERMINAL SHIPMENTS

(% of Units)



WORLD ALPHANUMERIC CRT TERMINAL SHIPMENTS

	1974 Number of Terminals	1980 Number of Terminals
Domestic	80,000	134,000
Europe	31,000	68,000
Japan	7,000	17,000
TOTAL	118,000	219,000

United Kingdom dominate the European market and comprised 70% of European shipments in 1974 and will account for 74% by 1980. U.S. terminal manufacturers will find attractive opportunities in the European market with France and Germany offering the greatest potential. See Figure 51.

GRAPHIC CRT TERMINAL SHIPMENTS

The market for graphic CRT terminals is forecast to more than double in terms of shipments during the period from 1974 to 1980. The graphic CRT terminal market is sensitive to price and the low/medium priced segment will grow in response to price reductions as many first time users justify the purchase.

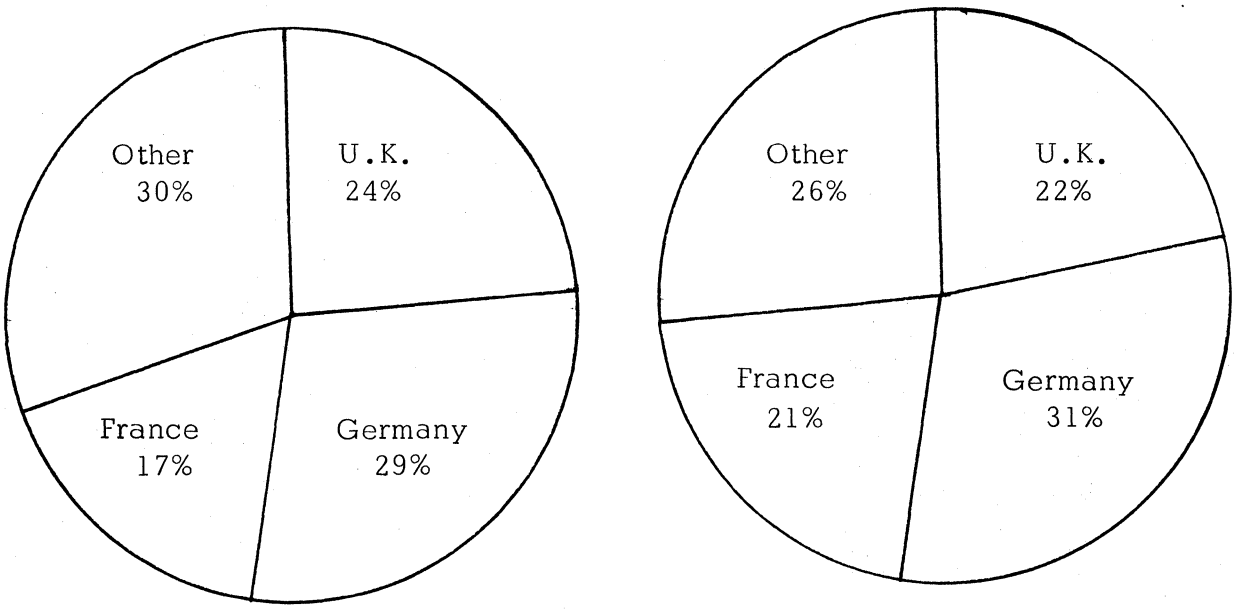
We predict that shipments of graphic CRT terminals will grow at a 13.4% annual rate from 1020 units in 1974 to 2170 units by 1980. See Figure 52.

The uncertainty expressed in our forecast of shipments is a function of the size/timing of price reductions and the potential for a new generation of IBM graphic terminals to replace the obsolete IBM 2260 line. Our optimistic forecast of a shipment level of 2700 units by 1980 represents an annual growth rate of 17.6% and is based on the introduction of a new IBM graphic

Figure 51

EUROPEAN ALPHANUMERIC CRT TERMINAL SHIPMENTS

(% of Units)

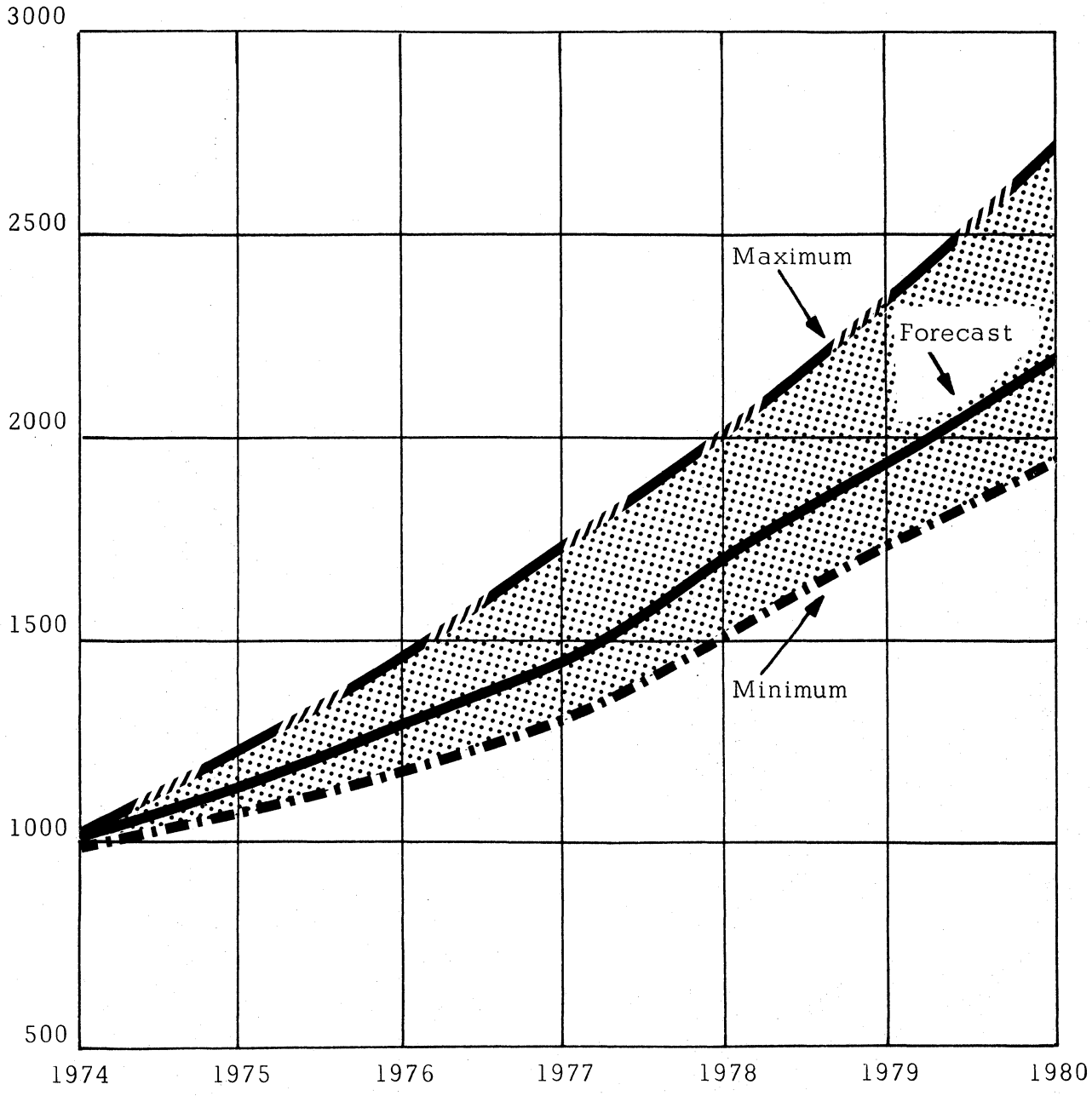


1974 1980

EUROPEAN ALPHANUMERIC CRT TERMINAL SHIPMENTS

	1974 Number of Terminals	1980 Number of Terminals
United Kingdom	7,400	15,000
Germany	9,000	21,000
France	5,300	14,300
Other European Countries	9,300	17,700
TOTAL	31,000	68,000

GRAPHIC CRT TERMINAL SHIPMENTS



GRAPHIC CRT TERMINAL SHIPMENTS

(Units)

	1974	1975	1976	1977	1978	1979	1980
Maximum	1020	1240	1450	1730	2000	2350	2700
Forecast	1020	1140	1280	1430	1650	1910	2170
Minimum	1020	1080	1190	1300	1510	1740	1960

terminal line by 1976/1977 with a purchase price on the order of $20,000.

Our forecasts of graphic CRT terminal shipments from 1974 to 1980 have been divided into high, medium, and low priced segments based on price/performance considerations. See Figures 53, 54, and 55.

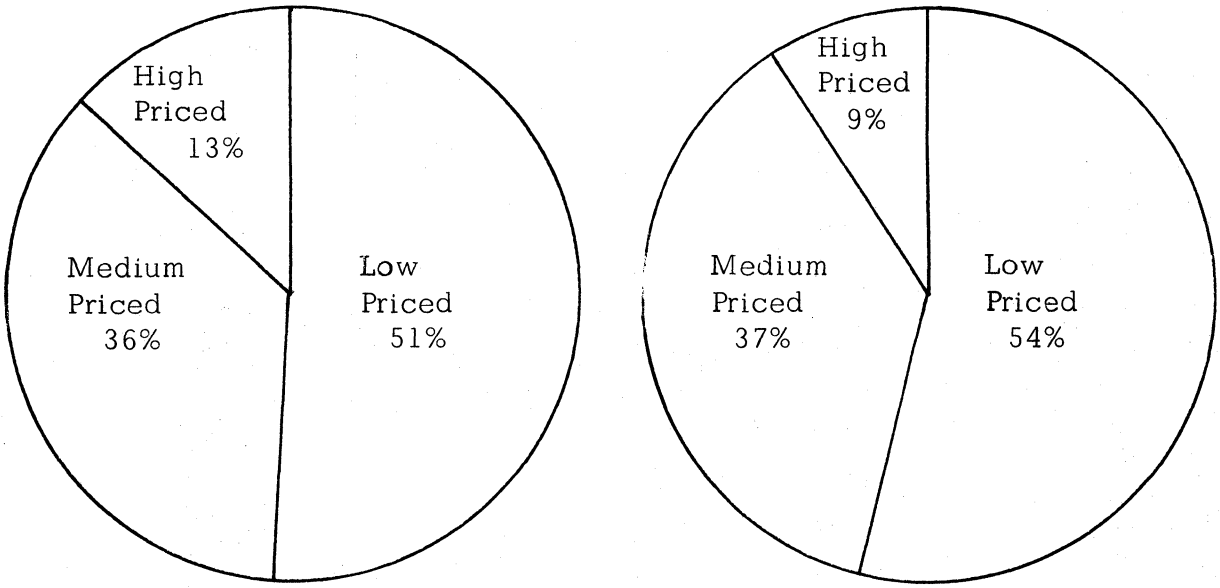
Low Priced Segment

Shipments in the low priced segment will grow at a 14.6% annual rate from a level of 520 units valued at $4.6 million in 1974 to 1180 units worth $9.3 million by 1980. This segment has been dominated by Tektronix with a terminal line priced from $4,000 to $10,000. We expect Tektronix to continue their market leadership in the low priced segment but with renewed competition from medium priced graphic terminal manufacturers who offer equipment in the $7,000 to $10,000 price range. The low priced graphic terminal segment will increase its share of the total graphic terminal market, both in terms of units and dollars, over the next five years. The market share accounted for by low priced models will increase from 51% of unit shipments in 1974 to 54% by 1980. Low priced shipments in dollars will

Figure 53

GRAPHIC CRT TERMINAL SHIPMENTS

(% of Units)



1974 1980

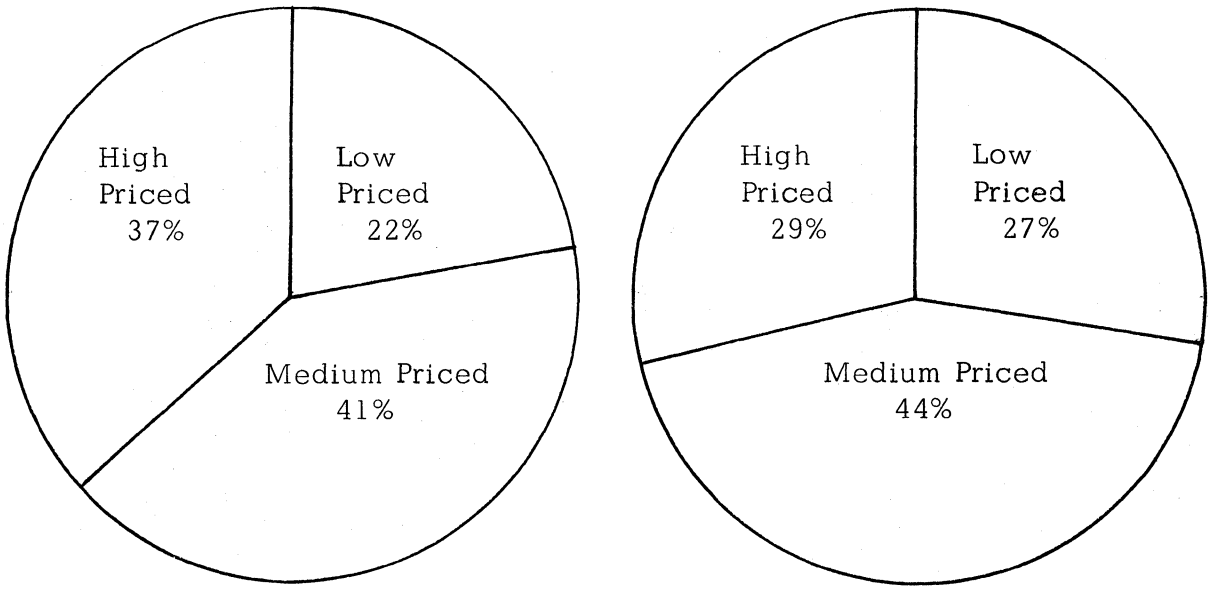
GRAPHIC CRT TERMINAL SHIPMENTS

	1974 Number of Terminals	1980 Number of Terminals
High priced	130	200
Medium priced	370	790
Low priced	520	1,180
TOTAL	1,020	2,170

Figure 54

GRAPHIC CRT TERMINAL SHIPMENTS

(% of Dollars)



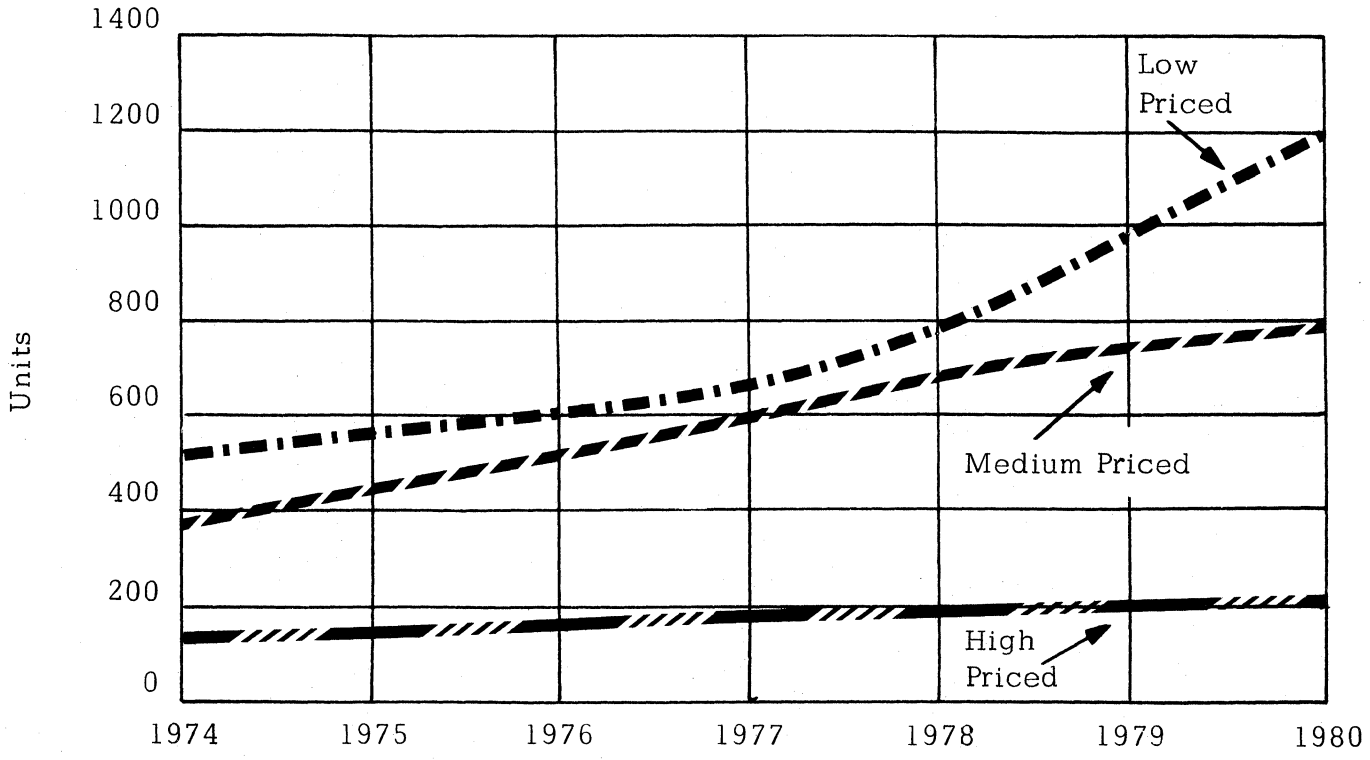
GRAPHIC CRT TERMINAL SHIPMENTS

(Millions of Dollars)

	1974	1980
High priced	$ 7.6	$10.0
Medium priced	8.5	15.1
Low priced	4.6	9.3
TOTAL	$20.7	$34.4

Figure 55

GRAPHIC CRT TERMINAL SHIPMENTS



GRAPHIC CRT TERMINAL SHIPMENTS

	1974	1975	1976	1977	1978	1979	1980
High priced	130	140	160	180	190	200	200
Medium priced	370	440	520	600	680	740	790
Low priced	520	560	600	650	780	980	1,180
TOTAL	1,020	1,140	1,280	1,430	1,650	1,920	2,170

increase from a 22% market share in 1974 to 27% by 1980. Growth in the low priced segment over the next five years depends heavily on the trend in terminal prices, the level of competition in the segment, and the competitive reaction by Tektronix.

Medium Priced Segment

Shipments of medium priced graphic CRT terminals are predicted to grow at a 13.5% annual rate from a level of 370 units worth $8.5 million in 1974 to 790 units valued at $15.2 million by 1980. The medium priced segment will grow at an impressive 16.4% rate from 1974 to 1978, but the growth will slow to an 8% rate from 1978 to 1980 as the products marketed by some manufacturers cross over into the low priced segment. In spite of the transition of some terminal manufacturers from medium to low priced markets, the medium priced graphic CRT terminal segment will increase its share of the total graphic terminal market both in terms of units and dollars over the next five years. The market share accounted for by medium priced graphic terminals will increase from 36% of unit shipments in 1974 to 37% by 1980 and medium priced shipments by dollars will increase from a 41% market share in 1974 to 44% by 1980.

The substantial growth in the medium priced graphic CRT terminal segment will result from an erosion of the high priced segment. The potential for a new IBM graphic terminal line in the medium priced segment would act as a stimulus for the entire graphic terminal industry and introduce graphics to a large number of first time users.

High Priced Segment

The high priced segment of graphic CRT terminals will lose market share to the low/medium priced segments. We predict that shipments of high priced graphic terminals will increase at a modest 7.4% annual rate from 130 units valued at $7.6 million in 1974 to 200 units worth $9.9 million by 1980. Although shipments continue to increase, the high priced segment is growing at a slower rate than the entire graphic terminal industry. As a result the high priced segment will lose market share both in terms of units and dollars over the next five years. The market share for high priced shipments by units will decline from 13% in 1974 to 9% by 1980. High priced shipments by dollars will decrease from a 37% market share in 1974 to 29% by 1980.

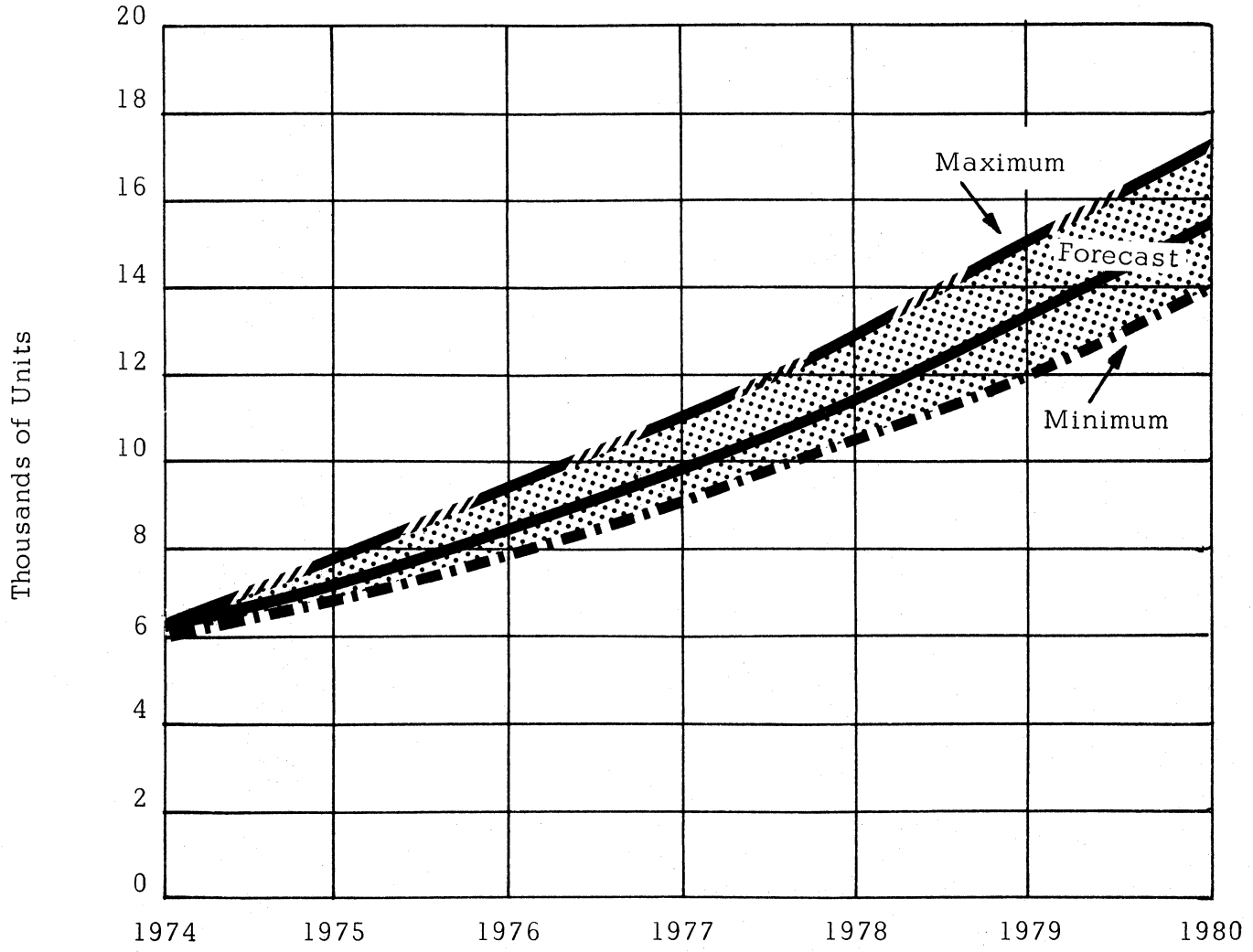
This relative decline in the high priced segments is caused by two factors:

- A number of firms will leave the high priced segment to compete in the more profitable low/medium priced segments.
- The purchase price is too high for many potential first time users to justify.

The installed base of graphic CRT terminals will grow at a 16.7% annual rate from 6100 units in 1974 to 15,400 units by 1980. The uncertainty expressed is a function of the future trend in graphic terminal prices and the potential for a new IBM graphic terminal line. See Figure 56.

Figure 56

INSTALLED BASE OF GRAPHIC CRT TERMINALS



INSTALLED BASE OF GRAPHIC CRT TERMINALS

	1974	1975	1976	1977	1978	1979	1980
Installed base of graphic terminals	6,100	7,200	8,400	9,800	11,400	13,300	15,400

WORLD MARKETS FOR GRAPHIC CRT TERMINALS

The world markets for graphic CRT terminals will continue to be strong with foreign markets growing at over a 20% annual rate. The high growth rate in foreign graphic terminal markets is caused by a general lack of technology and production facilities abroad.

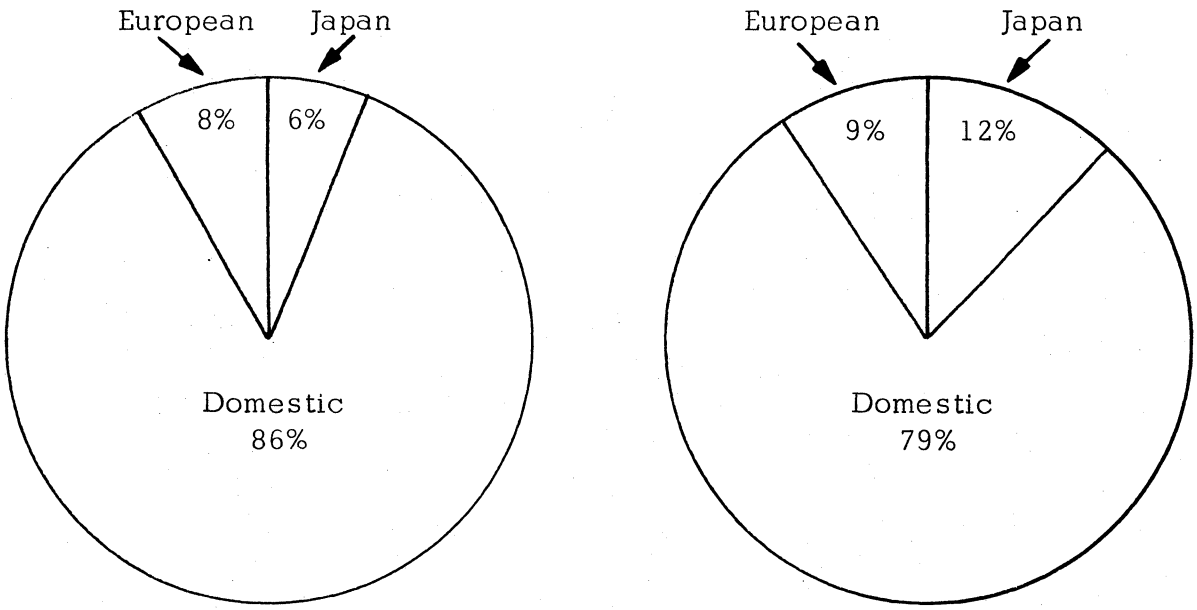
The European market for graphic terminals will increase roughly in proportion to the entire graphic terminal market. European market share by units will increase from 8% in 1974 to 9% by 1980.

The Japanese market for graphic CRT terminals will exhibit an explosive 27.3% annual growth rate as graphics gain in popularity in process control and interactive design applications. Japanese market share by units will increase from 6% in 1974 to 12% by 1980. Graphic terminal sales to Japanese customers of low/medium priced models will predominate. The Japanese market for U.S. produced graphic terminals will begin to subside by 1982 as Japanese terminal manufacturers switch their design/production efforts from alphanumeric to graphic terminals. See Figure 57.

Figure 57

DOMESTIC/FOREIGN GRAPHIC CRT TERMINAL SHIPMENTS

(% of Units)



1974 1980

DOMESTIC/FOREIGN GRAPHIC CRT TERMINAL SHIPMENTS

	1974 Number of Terminals	1980 Number of Terminals
Domestic	880	1710
European	80	200
Japan	60	260
TOTAL	1020	2170

In general, worldwide graphic CRT terminal markets will increase over the next five years and can be characterized by declining prices, increasing competition and moderate new business opportunities in the growing low/medium priced segments. The major growth in shipments and revenue will occur in the low/medium priced segments and the potential new IBM graphic terminal line will signal the strength and vitality of the graphic CRT terminal markets in the future.

TERMINAL APPLICATIONS AND USAGE

The applications for CRT terminals over the next five years will be analyzed by industry segment and by terminal classification. We have divided the users of CRT terminals into eight industry segments as follows:

- Manufacturing
- Financial
- Government
- Transportation
- Scientific
- Education
- Retailing
- Medical

We have grouped CRT terminal classifications as follows:

- Minicomputer/microprocessor based
- Local/remote
- Stand alone/clustered

In order to analyze the changing usage patterns of CRT terminals over the next five years, we will compare the installed base of CRT terminals in 1974 with our market forecasts for 1980.

APPLICATIONS BY INDUSTRY SEGMENT

Of the eight industry segments which we have identified, all will grow in terms of absolute units and the installed base will almost triple over the next five years. However, in terms of market share, education, retailing, and medical will exhibit the fastest growth, while the transportation segment will suffer the sharpest decline. See Figure 58.

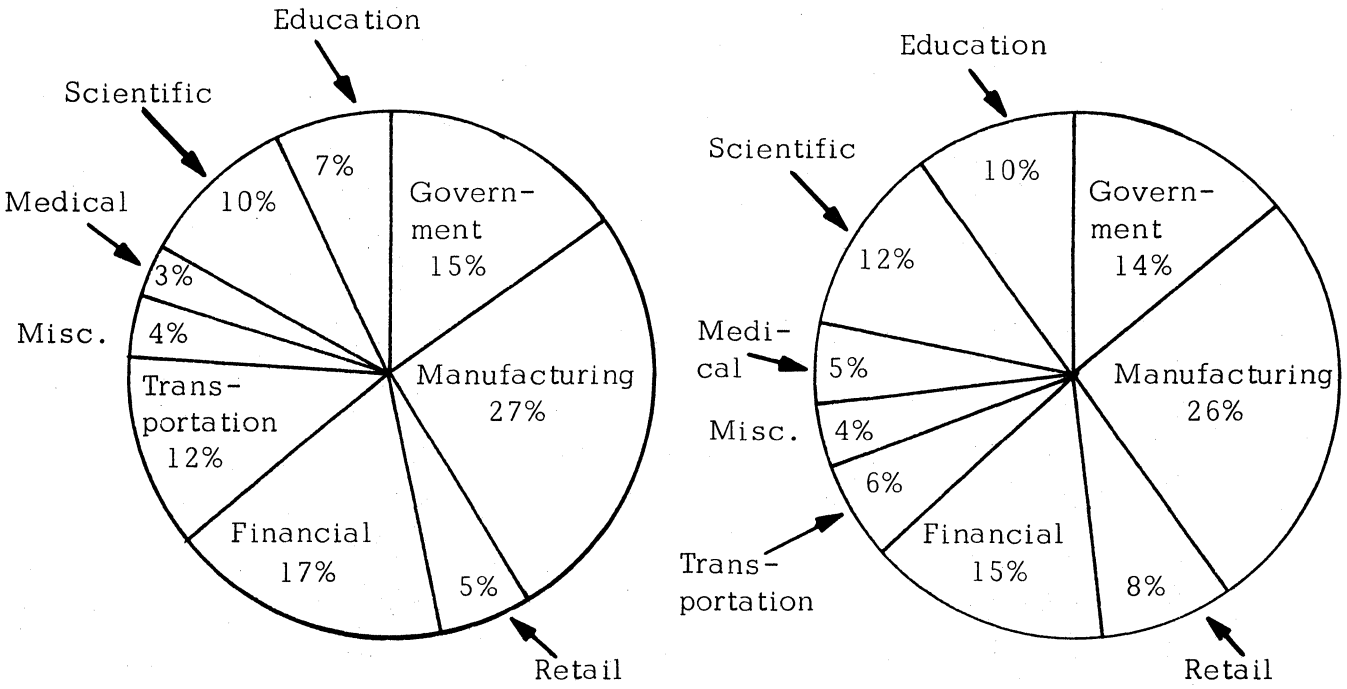
High Growth Industry Segments

The fastest growing industry segments will be educational retailing and medical applications. The average annual growth rate of installed units in these three segments is 28% per year. This substantial growth rate is caused by an increasing user acceptance of computer equipment in these industries. Combined with declining prices this makes purchase easier to justify based on a cost/benefit analysis. Another reason for growth in these industry segments is that they are now the focus of increasing marketing efforts, as more traditional sources of terminal sales have started to dry up. After 1980 these three high growth segments will approach saturation and market growth will decline to the industry average of about 12% increase in installed units per year.

Figure 58

CRT TERMINAL USER DISTRIBUTION

(% of Units)



1974 1980

CRT TERMINAL USER DISTRIBUTION

	1974 Number of Terminals	1980 Number of Terminals
Government	63,000	170,000
Manufacturing	113,000	316,000
Retail	21,000	97,000
Financial	71,000	182,000
Transportation	50,000	73,000
Miscellaneous	17,000	49,000
Medical	12,000	61,000
Scientific	42,000	146,000
Education	29,000	122,000
TOTAL	418,000	1,216,000

Stable Industry Segments

The manufacturing, financial, scientific, and government segments will offer relative stability over the next five years. Scientific applications will show modest gains which reflect the increasing usage of CRT terminals for computer aided design and process flow applications. Government applications are likely to experience small declines and, naturally, will be a function of government expenditures for computer systems. Financial applications will also decline. Manufacturing applications will maintain an almost constant market share over the next five years.

Declining Industry Segments

The market share for transportation applications will decline from 12% in 1974 to 6% by 1980. The below average performance of terminal installations in the transportation industry will be caused by the high degree of saturation in this market and a slowing of the growth of this industry segment.

TERMINAL USAGE CLASSIFICATIONS

The composition of the three terminal user classifications will change in the next five years based on improved microprocessor technology, the trend toward distributed processing, and the declining prices of CRT teleprinter replacement terminals.

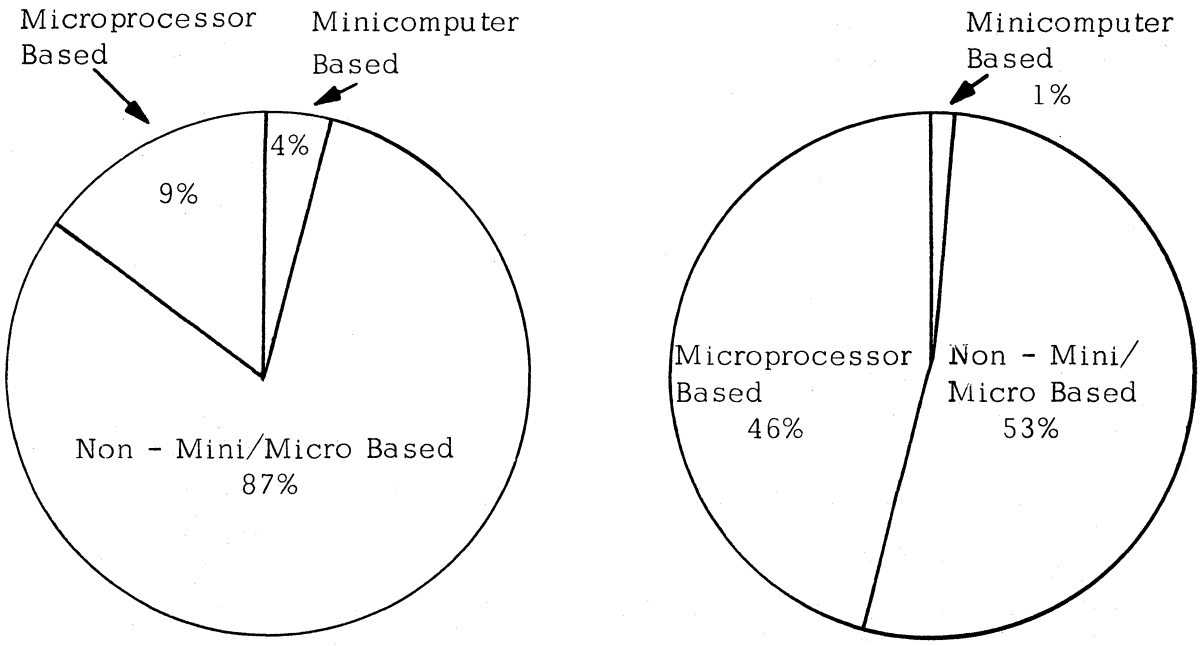
Microprocessor Based Terminals

The microprocessor gives a CRT terminal increased flexibility by allowing the terminal manufacturer to be more responsive to customer needs and to the product innovations of competitors. As such it is a partial hedge against technical obsolescence for both the terminal manufacturer and user. We believe that over 80% of the new terminal lines being designed over the next five years will include microprocessors, and that over 60% of 1980 shipments will be microprocessor based. In terms of the installed base of CRT terminals, microprocessor based units accounted for a 9% market share in 1974 which we predict will rise to 46% by 1980. This dramatic increase in microprocessor based terminals is due primarily to cost savings and improved performance. See Figure 59.

Figure 59

MINICOMPUTER/MICROPROCESSOR BASED CRT TERMINALS

(% of Units)



MINICOMPUTER/MICROPROCESSOR BASED CRT TERMINALS

	1974 Number of Terminals	1980 Number of Terminals
Microprocessor based	38,000	560,000
Minicomputer based	17,000	12,000
Non-mini/micro based	363,000	644,000
TOTAL	418,000	1,216,000

Local/Remote Terminals

The trend toward distributed processing is caused by improvements in communication line hardware and the desire to collect data as close to the source as possible. Improved speed/quality of data transmission lines and the wide availability of time sharing services will be responsible for the growth predicted for remote terminal installations over the next five years. In 1974, 44% of the installed base of CRT terminals were remote units, by 1980 this market share will increase to 58%. See Figure 60.

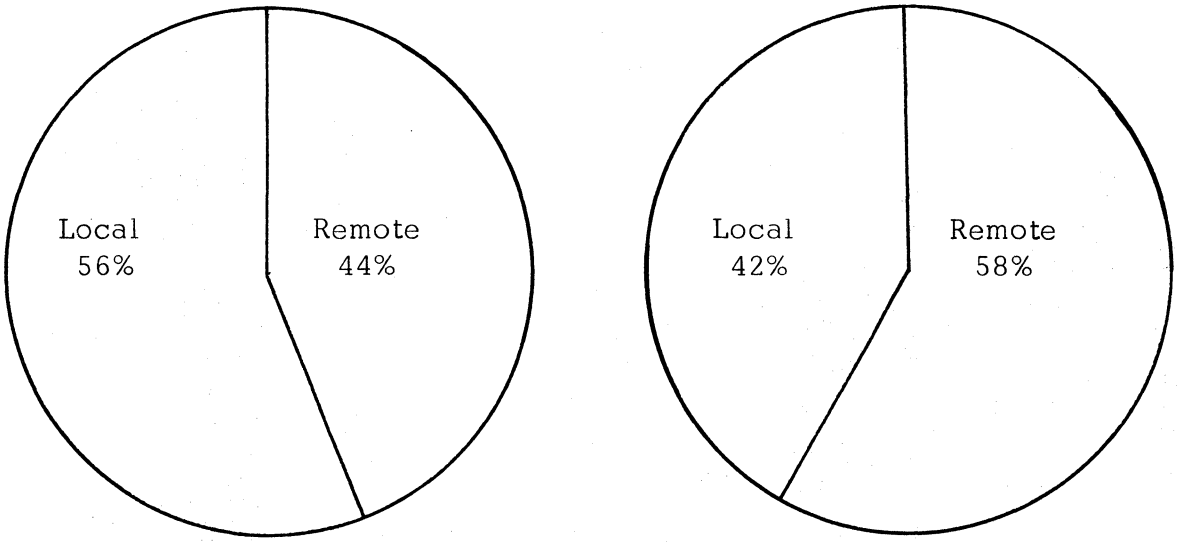
Stand Alone/Clustered Terminals

In 1974, 44% of the installed base of CRT terminals were stand alone units and we predict that the market share will grow to 53% by 1980. The above average growth we have forecast for stand alone terminals over the next five years is a result of strong sales growth in the CRT teleprinter replacement market. Teleprinter replacement terminals are stand alone units. The growth in the time sharing industry is another factor influencing the trend toward stand alone terminals. See Figure 61.

Figure 60

LOCAL/REMOTE CRT TERMINALS

(% of Units)



1974 1980

LOCAL/REMOTE CRT TERMINALS

	1974 Number of Terminals	1980 Number of Terminals
Local	234,000	511,000
Remote	184,000	705,000
TOTAL	418,000	1,216,000

Figure 61

STAND ALONE/CLUSTERED CRT TERMINALS

(% of Units)

1974 1980

STAND ALONE/CLUSTERED CRT TERMINALS

	1974 Number of Terminals	1980 Number of Terminals
Stand alone	201,000	644,000
Clustered	217,000	572,000
TOTAL	418,000	1,216,000

FUTURE TRENDS IN TERMINAL USAGE

In summary, the largest growth rates in CRT terminal installations over the next five years will occur in the educational, retail, and medical industries. The future trend among users is toward microprocessor based, remote and stand alone terminal installations.

USER DECISION CRITERIA

This section serves a dual purpose; first it serves as a checklist for potential terminal users and second it serves as a marketing guide for terminal manufacturers. The decision criteria used to purchase a CRT terminal can be divided into the following two categories:

- Cost/performance evaluation of terminal hardware
- Analysis of the terminal manufacturer

Our experience has been that many terminal users do not make a balanced analysis, but rather purchase a terminal based primarily on the reputation of the manufacturer, or alternately, on the low price or superior performance of the hardware.

COST/PERFORMANCE EVALUATION OF HARDWARE

The checklist which follows is intended to highlight the hardware features which need to be analyzed by potential terminal users:

- Conformity to industry standards developed by IBM and AT&T.
- Microprocessor based as a hedge against technical obsolescene.

- Position of the terminal hardware in the product life cycle - from the leading edge of technology to obsolete equipment.
- Screen size and format of characters.
- Display character sizes, quality, and brightness.
- Special video options.
- Communication line capabilities.
- Printer speed, legibility and dependability.
- Cursor controls.
- Keyboard organization and special functions.
- Hardware flexibility to meet user needs.
- Amount of operator training required.
- Noise and heat levels.
- Power consumption
- Hardware reliability in terms of mean time between failure and mean time to repair.
- Compatibility with existing software.
- Option for purchase, lease or rental in view of obsolescence date and timing of the next generation of terminals.
- Expected obsolescense date.

- Resale or salvage value of terminal.
- Applicability of a standard hardware configuration to user needs.
- Cost of the terminal hardware relative to the industry leader.

An important point of reference for a terminal user is to establish the hardware configuration which is required for a particular application. The "fit" of the hardware to the users' needs is of critical consideration, since manufacturers tend to develop standard hardware for all applications. In order to compare the prices of competing terminals the estimated costs for maintenance, software modification, and terminal hardware must be included.

ANALYSIS OF THE TERMINAL MANUFACTURER

A CRT terminal user should carefully analyze the manufacturer based on the following checklist, which highlights the strengths and weaknesses of each firm:

- Present market share of terminal installations.
- Annual terminal sales in dollars and units.
- Number of years as a terminal manufacturer.
- Size and location of maintenance.

- Quality and responsiveness of maintenance.
- Level of software support.
- Flexibility in modifying hardware configurations to meet user needs.
- Financial size and strength of overall firm.
- Current profitability and rate of change of profits.
- Terminal sales as a percentage of total sales.
- Financing available for terminal leases or rentals.
- Reputation for competence in particular industries or applications.
- Technical sophistication of salesmen.
- Speed in adapting terminal hardware to technical improvements.
- Reputation of terminal manufacturer among users.
- Recommendations from current terminal users.

The overall strength of a terminal manufacturer is an important consideration to a terminal user, because the relationship with the manufacturer continues long after the initial hardware evaluation and purchase. Warning signals which a potential terminal user should be wary of include:

- Thinly capitalized firms.
- Small service networks.

— Manufacturers who price their terminals at very low prices to obtain sales.

The CRT terminal industry is an extremely competitive market, with over 100 firms operating in a rapidly changing technical environment. In this setting the terminal user has been able to exert some leverage over the manufacturers in terms of price and delivery.

COMPETITIVE STRATEGIES

The competitive strategies which a CRT terminal manufacturer employs will depend on variables such as:

- The demand for terminals.
- The company's financial position.
- The company's size/position in the terminal market.

We have divided the competitive strategies of CRT terminal industry participants into five categories:

- IBM
- AT&T
- Other mainframe manufacturers
- Manufacturers of replacements for IBM/AT&T terminals
- Independent systems manufacturers

IBM COMPETITIVE STRATEGY

The competitive strategy of IBM is based on their goals of dominating the terminal market and increasing future profits. However, IBM's goals are constrained by price competition from

other terminal manufacturers, a rapidly changing technology resulting in equipment obsolescence, and by government threats of anti-trust legislation. On the other hand, the goals of IBM are advanced by their ability to establish industry standards which shape the future technology, their ability to sell terminals as part of a computer system, and their strong reputation among users.

Prices which are established by IBM tend to serve as a ceiling for comparable hardware configurations produced by competitors. IBM is able to maintain higher prices because of their reputation, user inertia, their extensive maintenance system, and a general unwillingness on the part of users to change their software or hardware interface in order to use non-IBM equipment.

The IBM competitive strategy in terms of a rapidly changing technology is to avoid the extreme leading edge of technology and to introduce a new generation of terminals as sales of the previous generation begin to level off. The life cycle of a CRT terminal is about six years, and it is probable that IBM will introduce new graphic and alphanumeric terminal lines sometime around 1978. This short life cycle enables IBM to keep shipments high as a percentage of the installed base, but has the disadvantage of making sales difficult as a new generation appears imminent.

The continual threat of anti-trust suits tends to moderate IBM's actions (relative to their actions in the 1960's), but the slow speed of the legal system is clearly a benefit to IBM. Change in the computer industry is swift, while litigation can take 1 to 5 years (or more) to resolve a dispute. In the span of 5 years the technology at issue may be obsolete, industry standards may have shifted and small terminal manufacturers may have their financial positions undermined. The competitive strategy of IBM towards anti-trust legislation is to avoid actions which could provoke lawsuits while, at the same time, committing substantial resources for legal defense, which makes future lawsuits by their competitors look unattractive. From the government's point of view, it receives complaints from smaller computer equipment manufacturers which the government feels obliged to consider. On the other hand, large-scale anti-trust actions could have serious implications on tax revenues and foreign exchange rates.

The competitive tools which IBM uses to further their goals are industry standards and terminal sales as part of a large computer system. Because IBM is a dominant force in the market, much of their hardware and software represents de-facto industry standards.

The ability to influence industry standards allows IBM to introduce technical changes today which anticipate their plans for 1980. For example, IBM's introduction of a new communication line procedure, called SDLC, will influence the course of telecommunications through 1980. Another competitive tool which IBM uses is to sell terminals as part of a larger computer system. This allows IBM to develop a large, stable, market from which to launch a new generation of terminals. In addition, it permits IBM to use its established marketing system which reduces the effective cost of selling a terminal. The reputation enjoyed by IBM tends to reinforce their market dominance in terms of profits and R&D capabilities.

In total, the business strategies used by IBM provide formidable barriers to direct competition. However, the IBM strategy is somewhat predictable and permits competition based on lower prices or higher performance. In light of potential anti-trust suits, IBM will have to moderate its policies in the future to engage in a more "polite" form of competition.

AT&T COMPETITIVE STRATEGIES

In the past AT&T has chosen not to compete directly with IBM. It competes in the low priced/high volume teleprinter market. The trend over the last five years has been toward an erosion of the market share and profitability of AT&T's subsidiary, Teletype Corp. This erosion has occurred because of increased competition from other teleprinter manufacturers, and also from CRT teleprinter replacements.

In 1973, Teletype Corp. introduced the model 40, their initial entry into the CRT terminal market. The model 40 is not directly competitive with the CRT teleprinter replacements because of its higher price and performance. Rather, the model 40 represents a technical update of communication line terminals, which are oriented toward higher speed block data communication.

The AT&T competitive strategy is to concentrate in the low to medium price communications terminal segment, and not to compete directly with IBM.

Because AT&T controls most of the communication lines in the U.S., they are able to influence future industry standards with their present terminal equipment. The Teletype model 40 is almost

assured of success because of the large in-house terminal needs of the AT&T system. Teletype Corp. already has an extensive marketing and maintenance system which can be adapted to handle CRT terminals. The introduction of the model 40 is a competitive move by AT&T to maintain its control over the communication lines and to maintain the market dominance of the Teletype Corp. subsidiary.

OTHER MAINFRAME MANUFACTURERS

The competitive strategy of the six or seven computer manufacturers other than IBM, that participate in the CRT terminal business, is to include their own terminals in the computer system package. Five of the seven firms manufacture their own terminal lines, while the other two purchase CRT terminals on an OEM basis. Three of the seven computer manufacturers offer terminals which are compatible with IBM, while the other four are specifically designed to interface with a particular computer line. The success of the CRT terminals marketed by these mainframe manufacturers is based primarily on the total demand for their computer equipment. The competitive strategy of these mainframe manufacturers in the future is to offer a technically competitive terminal line which will allow them to market a complete computer system.

REPLACEMENTS FOR IBM/AT&T TERMINALS

As industry leaders, IBM and AT&T provide stable short-term markets for CRT terminals and set standards concerning the maximum price and minimum performance levels acceptable. The largest replacement markets are for the IBM 2260, IBM 3270, and CRT teleprinter terminals, with a future replacement market likely to grow for the Teletype model 40.

The competitive strategy in the replacement market is to offer lower priced and/or higher performance terminals in order to overcome the inherent bias in favor of the terminals offered by the industry leaders. More than price/performance advantages are required to offset the lack of a strong reputation or extensive service network. The most valuable marketing tool for a terminal manufacturer in the replacement market is to offer responsive customer service. The replacement market is very competitive and manufacturers need to be flexible to the specific hardware and software needs of the user.

One competitive option for a manufacturer in the replacement market is to develop a reputation for expertise in a specialized industry or application. It is very important in the replacement

market to have the flexibility inherent in a microprocessor based terminal which can be reprogrammed to suit a particular user, or to include the latest featurers offered by the industry leaders. Therefore, the competitive strategy in the replacement market is to offer lower prices, higher performance, strong customer service and the flexibility which a microprocessor affords in meeting specific user needs and developments of the industry leaders.

INDEPENDENT SYSTEMS

The competitive strategy for independent terminal system manufacturers is similar to the replacement market strategy, except that the independent systems manufacturers do not face the structure of prices, performance and industry standards provided by the industry leaders. The overall competitive strategies of most independent terminal manufacturers is to develop a reputation in a specialized industry or application, to offer better service to small customers and to have a microprocessor based terminal which gives flexibility in a rapidly changing technical environment.

BUSINESS OPPORTUNITIES

The section on business opportunities is intended to serve the small to medium sized terminal manufacturers who are interested in finding growth markets over the next five years. We have analyzed the entire market in our search for terminal segments which have only moderate competition and high enough profit levels to justify the design of a new terminal line.

We believe that there are two growth segments in the CRT terminal industry which will enjoy high sales volume over the next five years:

- The IBM 3270 replacement market.
- The potential replacement market for the Teletype model 40.

The CRT teleprinter replacement market will be another high growth area over the next five years, but we do not believe that sufficient profit margins will exist to justify entry into this market. The CRT teleprinter replacement market has too many firms competing for this low price/high volume business, and we expect some consolidation in this market over the next five years.

IBM 3270 REPLACEMENT MARKET

The IBM 3270 market can be characterized by moderate competition, and by having the potential of being only a moderately attractive business opportunity. The IBM 3270 replacement market should be looked at as containing two time frames. The first period is from the present until the introduction of the next generation of IBM CRT terminals, and the second period covers the time after introduction to the eventual demise of the IBM 3270 market.

The first period, from now to about 1978, will have the stability of IBM leadership in terms of price, performance and industry standards. The second period, after 1978, will involve much more price competition as IBM 3270 market volume declines. In terms of a business opportunity, we believe that the first period is attractive, while the second period will represent a difficult market in which to make acceptable profits.

In order to compete in the IBM 3270 replacement market, a terminal manufacturer should design a microprocessor based terminal and develop some expertise in a specialized industry or application. Customer service, software support and hardware flexibility to user requests are the keys to success in this market. The terminal

manufacturer should realize that a long-range financial commitment cannot be made to the IBM 3270 market. Rather, the manufacturer must adopt a short-term perspective of 2 to 5 years, accept moderate profit levels, and be willing to abandon this marketplace as it begins to deteriorate. The flexibility of a microprocessor in an IBM 3270 replacement terminal will serve as a hedge against technical obsolescence and a declining IBM 3270 market.

TELETYPE MODEL 40 REPLACEMENT MARKET

We have forecast the Teletype model 40 to be a high growth segment of the CRT terminal industry over the next five years. With a very low level of competition, at the present time, and the market stability offered by AT&T, we believe that this market offers an excellent business opportunity for a limited number of manufacturers. To compete in this market, manufacturers should design a microprocessor based terminal which is flexible enough to maintain software compatibility with any future developments made by AT&T. The replacement market can be characterized by lower prices, strong customer service, and a willingness by new market entrants to offer better software support and flexible hardware configuration.

In conclusion, the business opportunities in the CRT terminal industry, in the future, are centered around microprocessor based terminals which provide some protection to both users and manufacturers from technical obsolescence. Survival in the fast growing competitive CRT terminal industry will depend on developing a strong reputation for customer service and the ability to adapt to a rapidly changing technical environment.