Semiconductor User Information Service
Company Profiles

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Company Profiles

INTRODUCTION

This section of Volume II contains specific information on individual semiconductor manufacturers. The company profiles that form the main part of the volume are filed alphabetically by company name behind the appropriate tabs.

COMPANY PROFILES

Each company profile in the main body of the volume discusses the following kinds of information:

- Overview--General description of the company; number of employees; highlights of the company for the year; major shareholders

- Operations--The divisions of the company; revenue by lines of business; semiconductor revenue as a percent of total revenue; international activities; the company's facilities and their locations

- Capital spending and research and development spending--Capital and R&D spending as a percent of revenue; recent developments; special focus of efforts

- Semiconductor activities--Main product areas, main product families; recent product introductions; cross licensing and second-source agreements

- Nonsemiconductor products summary--Brief description of the other divisions of the company; impact, if any, of the other divisions on the semiconductor division (e.g., in-house use of products)

Wherever possible, we include a financial synopsis for publicly held companies, as well as our estimates of the company's revenue from major categories of semiconductor sales.

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Altera Corporation

Altera Corporation
3525 Monroe Street
Santa Clara, California 95051
Telephone: (408) 984-2800

(Altera Corporation is a privately held company; therefore, balance sheet and income statement data are unavailable.)

Altera Corporation

THE COMPANY

Overview

Altera Corporation was founded in June 1983 to design, manufacture, and market user-configurable CMOS electrically programmable logic devices (EPLDs) and computer-aided development tools. It was founded by Robert Hartmann, Michael Magranet, and Paul Newhagen, all formerly with Source III, Inc., and by Dr. James Sansbury, formerly with Hewlett-Packard Company. Altera Corporation was the first company to introduce EPLDs and intends to design and produce a wide variety of user-configurable integrated circuits.

The Company develops EPLDs to provide an alternative to gate arrays for the replacement of TTL and CMOS SSI/MSI devices. EPLDs are distinguished from such devices by their ability to be programmed by the user at the user's facility. EPLDs offer benefits of reprogrammability, low power consumption, and significantly higher density over older bipolar PLDs.

Long-Term Outlook

Altera Corporation has thus far been a successful CMOS PLD supplier and is positioned as the number one CMOS supplier. As a result of its recent agreement with WaferScale Integration, Altera expects to develop more PLD products in order to sustain market leadership.

Altera and other PLD suppliers face several critical issues. One such issue is the rumblings of emerging Japanese suppliers. With their wide experience in EPROM technology and EEPROM technology and with superb business skills, the Japanese could pose a threat to today's North American PLD suppliers. Monolithic Memories (MMI) is aggressively struggling to maintain its market position. In December 1986, it brought suit against two CMOS suppliers--Altera Corporation and Lattice Semiconductor. MMI charged Altera with patent infringement. In April 1987, Altera and MMI settled the patent infringement suit and agreed to license each other under certain patents in the programmable logic arena.

Altera Corporation

Management and Employees

Altera currently employs 110 people. The Company's executives are listed in Table 1.

Table 1

Altera Corporation
COMPANY EXECUTIVES

Position	Name	Prior Company	Prior Position
President	Rodney Smith	Fairchild	GM/Linear Div.
VP Marketing	David A. Laws	AMD	VP Bus. Dev.
VP Finance	Paul Newhagen	Source III	Controller/CFO
VP Sales	John Duffy	Fairchild	VP Sales/Mktg.
VP Technology	James Sansbury	Hewlett-Packard	Producton Mgr.
VP/IC Engr.	Robert F. Hartmann	Source III	President
VP Software Engr.	Clive McCarthy	Fairchild	Mktg. Mgr./Linear Div.
VP Operations	Bipin Shah	Fairchild	Analog Prod. Line Mgr.

Source: Altera Corporation
October 1987

Altera Corporation

Financial Information

Altera Corporation has received four rounds of funding totaling $27.9 million, as shown in Table 2.

Table 2

Altera Corporation
SOURCES OF FUNDING AS OF JANUARY 1987
(Millions of Dollars)

Date	Round	Sources	Amount
June 1983	Round 1	Alpha Partners	$ 1.3
April 1984	Round 2	Allstate Investments; Cable and Howse; F. Eberstadt & Fleming; John F. Shea; Technology Venture Investors; Welsh, Carson, Anderson & Stowe Venture Growth Associates	6.0
	Lease	Bank of America	2.0
March 1985	Round 3	Original investors; Analog Devices Ent.; Citibank N.A.; Demuth, Folger, & Terhune Venture Capital; Institutional Venture Partners; Parker Drilling Company	9.9
	Lease	Bank of America	2.0
May 1986	Round 4	European Investors	5.0
	Lease	Bank of America	1.7
			$27.9

Source: Dataquest
October 1987

Altera Corporation

PRODUCTS AND MARKETS

Semiconductor Product Markets

Altera developed the first complementary metal oxide semiconductor (CMOS), ultraviolet erasable (UV-erasable), reprogrammable logic device. It also developed engineering development tools that are easy to use and understand. By combining CMOS and EPROM technology to implement logic, user programmability and low power consumption are achieved. With Altera EPLDs and advanced development tools based on IBM PCs, system designers can have the best of both worlds: a standard, off-the-shelf product and a custom LSI.

Table 3 shows the estimated revenue for Altera Corporation.

Table 3

Altera Corporation
ESTIMATED REVENUE
(Millions of Dollars)

	1984	1985	1986
Total CMOS	0.2	3.9	12.0
EPLD	0.2	3.9	12.0

Source: Dataquest
October 1987

Altera's approach is to target the semicustom IC market by offering a product that solves many of the existing problems associated with current application-specific integrated circuit (ASIC) techniques. The Company intends to eliminate a portion of the cost element associated with existing semicustom alternatives. Altera is taking advantage of its ability to improve CAD tools and is offering a device that eliminates considerable engineering interface, long development cycles, nonrecurring engineering costs, and dedicated inventory.

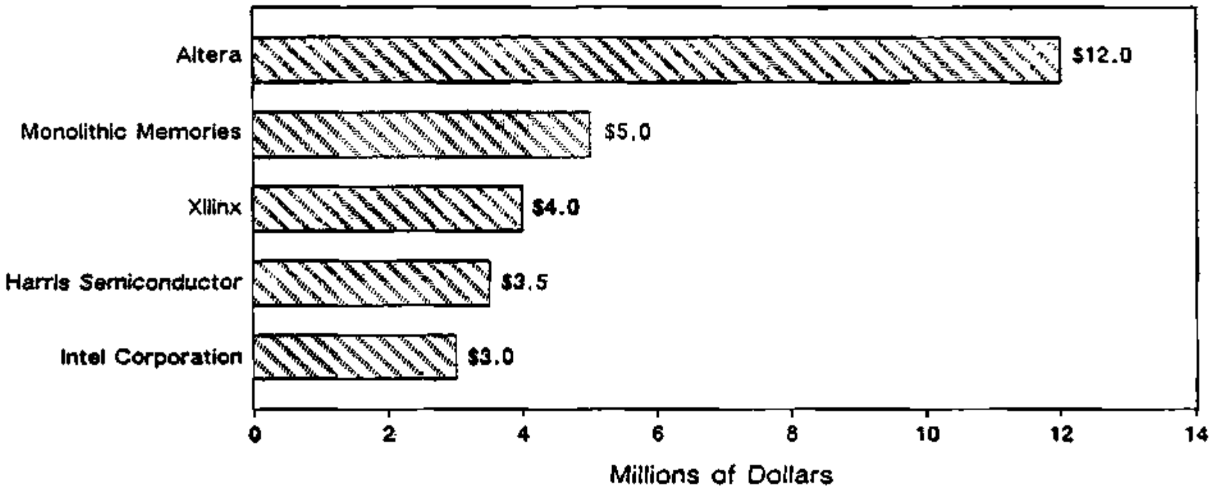
Competition

Figure 1 shows the top five 1986 competitors in the CMOS PLD market. Note that two of these suppliers are young start-up companies. In the future, market share per company could change dramatically.

Altera Corporation

Figure 1

ESTIMATED 1986 WORLDWIDE PROGRAMMABLE LOGIC DEVICE SHIPMENTS--CMOS



Source: Dataquest
October 1987

Application and End-Use Markets

EPLDs are purchased for five market segments: electronic data processing, communication, industrial, military, and consumer. The customers for these devices require low power consumption and quick turnaround time.

Semiconductor Products and Technologies

Technology and Manufacturing

Altera's facility now occupies 52,000 square feet of space. The additional 29,000 square feet added in 1986 is being used for marketing and sales, test, administration, and warehouse space.

Wafers are provided by Intel and other manufacturers. Volume assembly is done in the Far East, and prototype assembly is done locally to ensure quick turnaround.

Product List

As stated previously, Altera manufactures EPLDs and computer-aided development tools. Table 4 lists Altera's products.

Altera Corporation

Table 4

Altera Corporation
PRODUCT LIST

Erasable Programmable Logic Devices

EPLD Devices	Equivalent Gates
EP300	300 gates
EP600	600 gates
EP900	900 gates
EP1200	1,200 gates
EP1210	1,200 gates
EP1800	2,100 gates

Computer-Aided Design Tools

CAD Software	Application
PLDS2, PLCAD4	Development systems for programmable logic
A+PLUS	Software logic compiler for programmable logic
NetMap	Design capture
Logic Map II	Software program to verify and examine existing parts
LogicCaps	Schematic capture
PC-CAPS	Schematic capture
DASH 2	Schematic capture
DASH 3	Schematic capture
PLSME	State machine software
PLFSIM	Simulation
PLSLIB	TTL macrofunction library
PLVAX	Software logic compilation for VAX
Programming Hardware	Various hardware programming units Various package adapters

Source: Dataquest
October 1987

Altera Corporation

Agreements and Alliances

Altera has entered the following agreements and alliances:

- Intel

  - August 1984--Altera entered a five-year technology exchange agreement with Intel whereby Intel is providing its CHMOS EPROM wafer process technology and foundry services, while Altera is providing its EPLD design and test technology and software and hardware development support. Intel is an alternate source for the CHMOS EPLDs, and both companies cooperate on developing support tools for EPLD development systems.

  - June 1985--The agreement with Intel was extended to include additional products using Intel's CHMOS process and its evolutions.

- Personal CAD Systems

  - February 1985--Altera entered a marketing agreement that called for combining P-CAD's PC-CAPs (used for schematic capture) and PC-LOGs (a logic simulator) with Altera's A+PLUS and LogicMap software.

- Data I/O-FutureNet

  - May 1985--Altera entered an OEM marketing agreement with Data I/O's FutureNet for the DASH series of schematic capture packages.

- WaferScale Integration Inc.

  - January 1987--Altera entered a technology exchange agreement focused on the development of new, high-performance, user-configurable logic products. Altera will provide architecture, circuit design, and software support for the new family of products. WSI will contribute its strengths in high-speed CMOS process and EPROM development with high-volume manufacturing through Sharp in Japan.

Altera Corporation

- Cypress Semiconductor

    - June 1987--Cypress and Altera entered into a five-year technology development agreement for 5,000-equivalent-gate CMOS EPLDs. The new devices are designated MAX for Multiple Array Matrix. Altera will provide new architecture, circuit design, and software support. Cypress will provide its manufacturing capability in Austin, Texas; use of its 0.8-micron EPROM process; and full marketing support. No cash or equity was involved.

Analog Devices, Incorporated

Analog Devices, Incorporated
One Technology Way
Norwood, Massachusetts 02062
Telephone: (617) 329-4700
(Millions of Dollars)

Balance Sheet (October 29)	1983	1984	1985	1986	1987	1988
Total Current Assets	$ 128.3	$ 152.0	$ 152.0	$ 161.7	$ 176.5	$ 221.3
Cash	$ 24.2	$ 13.8	$ 11.3	$ 6.3	$ 5.8	$ 22.7
Receivables	$ 41.6	$ 60.5	$ 56.5	$ 65.6	$ 76.3	$ 87.9
Inventory	$ 56.6	$ 73.2	$ 77.1	$ 79.1	$ 83.8	$ 97.4
Net Property, Plant, & Eqp.	$ 69.4	$ 112.5	$ 160.8	$ 173.2	$ 186.2	$ 200.7
Depreciation	$ 42.9	$ 55.7	$ 75.0	$ 98.1	$ 129.5	$ 158.6
Other Assets	$ 24.8	$ 31.6	$ 35.0	$ 34.1	$ 34.7	$ 27.4
Total Assets	$ 222.5	$ 296.1	$ 347.7	$ 369.0	$ 397.3	$ 449.4
Current Liabilities	$ 38.4	$ 65.0	$ 59.2	$ 59.9	$ 57.7	$ 72.8
Long-Term Debt	0	0	0	$ 38.8	$ 42.2	$ 35.4
Total Liabilities	$ 33.1	$ 35.8	$ 50.7	$ 98.7	$ 99.9	$ 108.1
Total Shareholders' Equity	$ 151.1	$ 195.3	$ 237.8	$ 270.4	$ 297.5	$ 341.2
Conv. Preferred Stock	$ 16.00	$ 26.00	$ 28.00	$ 12.00	$ 19.00	$ 22.00
Common Stock	$ 3,152	$ 4,247	$ 5,393	$ 7,398	$ 7,560	$ 7,811
Retained Earnings	$57,961	$95,323	$125,071	$205,145	$167,156	$148,477

Income Statement (October 29)	1983	1984	1985	1986	1987	1988
Revenue	$ 214.0	$ 313.4	$ 322.4	$ 334.4	$ 370.4	$ 439.2
Cost of Sales	$ 99.0	$ 134.1	$ 150.4	$ 151.4	$ 171.7	$ 200.8
Gross Margin (%)	54	57	53	55	54	54
R&D Expense	$ 19.6	$ 28.5	$ 38.1	$ 45.3	$ 56.0	$ 60.5
SG&A Expense	$ 51.4	$ 76.1	$ 68.4	$ 75.3	$ 84.5	$ 94.3
Marketing Expense	$ 11.5	$ 17.9	$ 19.0	$ 22.1	$ 23.7	$ 28.2
Operating Income (Loss)	$ 32.6	$ 56.9	$ 46.6	$ 40.4	$ 34.5	$ 55.4
Interest, Net	$ 3.8	$ 3.3	$ 1.1	$ 3.8	$ 3.3	$ 1.1
Pretax Income	$ 27.1	$ 54.9	$ 39.1	$ 32.1	$ 25.6	$ 51.6
Effective Tax Rate (%)	32.0	31.9	24.0	27.0	27.0	26.0
Net Income	$ 18.4	$ 37.4	$ 29.7	$ 23.4	$ 18.7	$ 38.0
Average Shares Outstanding (Millions)	31.64	33.86	34.21	46.03	46.6	47.7
Capital Expenditure	$ 19.0	$ 58.2	$ 68.8	$ 36.7	$ 43.0	$ 49.2
Employees	3,661	4,759	4,789	4,959	5,219	5,347

Source: Analog Devices, Incorporated Annual Reports

Analog Devices, Incorporated

THE COMPANY

Background

Analog Devices, Incorporated, was founded in 1965 by president Ray Stata and current board member Matthew Lorber. Shares were publicly offered in 1969.

The Company is a leading manufacturer of precision linear integrated circuits and is the top-ranked worldwide supplier of data conversion devices. Analog Devices also manufactures a broad range of products that employ assembled product technology, including modules, subsystems, and systems. The Company's products are used primarily in computerized equipment and systems that involve processing information obtained from real-world sensors measuring such phenomena as temperature, pressure, and light intensity. The major applications markets for Analog Devices' products are instrumentation (engineering, scientific, and medical), defense/avionics, industrial automation, telecommunications, and computer equipment.

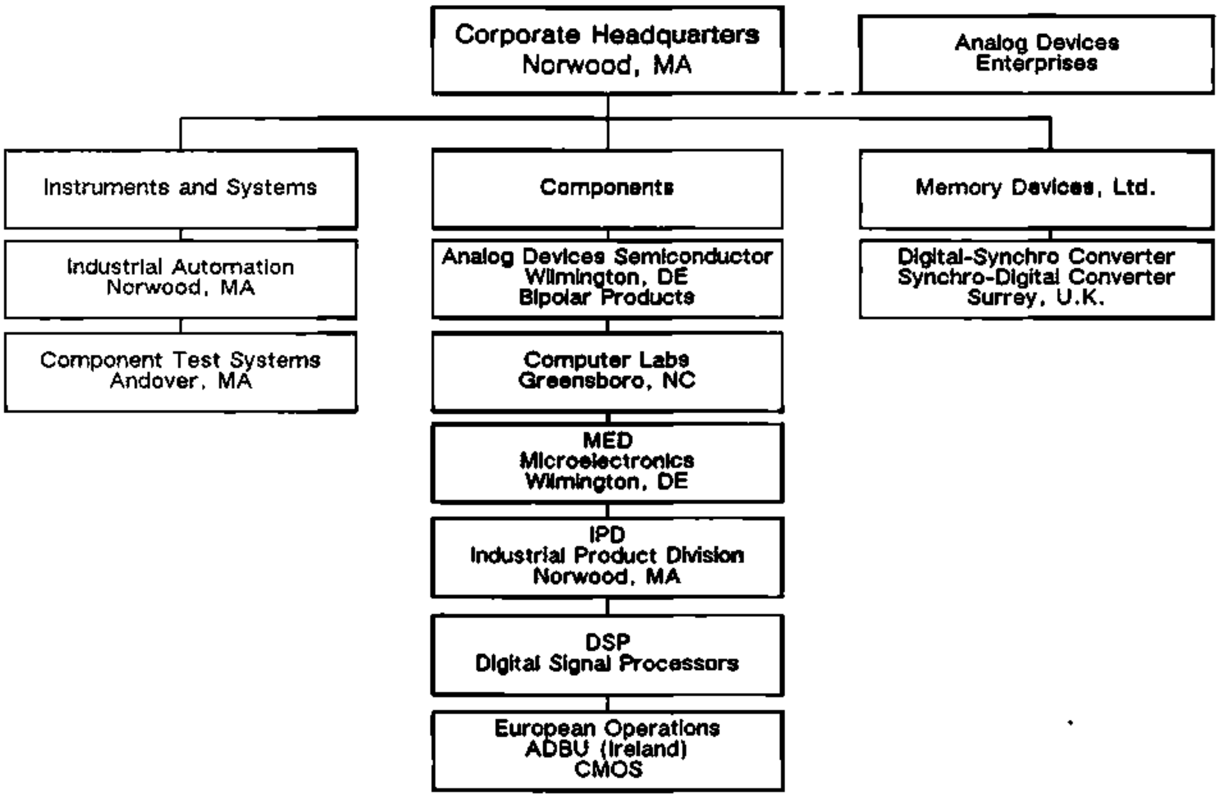
Modular operations amplifiers were among the Company's initial products. In 1969, Analog expanded its participation in the semiconductor market into monolithic integrated circuits and began offering switches manufactured using the newly developed CMOS process. Currently, Analog Devices is well positioned in the linear integrated circuits market, targeting high-performance, precision applications that typically make use of proprietary designs and technologies. Since the Company's formation, its product line has expanded to include complex converter and digital signal processing (DSP) chips as well as application-specific integrated circuits (ASICs). Nearly 90 percent of Analog's sales at present are in the areas of data conversion and signal conditioning.

Organization

Analog Devices has three product area divisions, as shown in Figure 1. They are the Instruments and Systems Division, the Components Division, and the Memory Devices Division. The revenue contribution of each of the Company's product groups is shown in Table 1. Analog Devices Enterprises operates as a separate division with the responsibility of managing the Company's technology and product acquisition efforts through investment in start-up companies.

Figure 1

**Analog Devices, Incorporated
Organization by Division**



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Source: Analog Devices, Incorporated

Analog Devices, Incorporated

Table 1

Analog Devices, Incorporated
Estimated Revenue by Product Category

	Fiscal Year Ending October 29				
	1984	1985	1986	1987	1988
Signal Conditioning	$100.3	$106.4	$100.3	$107.4	$127.4
Percentage of Revenue	32%	33%	30%	29%	29%
Data Conversion	$163.0	$167.6	$190.6	$222.2	$272.3
Percentage of Revenue	52%	52%	57%	60%	62%
Subsystems and Systems	$ 50.1	$ 48.4	$ 43.5	$ 40.7	$ 39.5
Percentage of Revenue	16%	15%	13%	11%	9%
Total	$313.4	$322.4	$334.4	$370.4	$439.2

Note: Columns may not add to totals shown because of rounding.

Source: Analog Devices, Incorporated
Annual Reports and Forms 10-K

The corporate officers of Analog Devices are as follows:

- Chairman of the Board and President—Ray Stata
- Executive Vice President—Jerald G. Fishman (All product divisions and associated shared resources report to this office.)
- Senior Vice President, Finance—Joseph M. Hinchey
- Vice President, Human Resources—Arnold F. Kanarick
- Vice President—Heinrich F. Krabbe
- Vice President and Treasurer—Joe McDonough
- Vice President, Sales and Marketing—Douglas H. Newman
- Senior Vice President—Melvin J. Sallen
- Vice President—A. Graham Sterling
- Senior Partner, Hale and Dorr, Boston, Massachusetts—Paul P. Brountas

- Vice President, Quality and Productivity Improvement—Art Schneiderman
- Vice President, Technology Development—Dennis Buss
- Vice President, Japanese Operations—Kozo Imai
- Vice President, European Operations—Tom Urwin

Acquisitions and Mergers

Analog Devices' strategy for entering new markets and acquiring new technologies has focused on acquisition of and investment in start-up companies. In 1968, the Company entered the analog-to-digital and digital-to-analog converter market through its purchase of Pastoriza Electronics. The acquisition in 1971 of Nova Devices enabled Analog Devices to establish integrated circuit manufacturing as a major part of its operations. Computer Labs was acquired in 1979, providing the opportunity for the Company to establish a strong position in the market for high-speed data acquisition components and assembled products. Additionally, the Company purchased Memory Devices Ltd. of Surrey, England, a producer of synchro-to-digital and digital-to-synchro converters, in 1980 and Digital Signal Processing Circuit, Inc., in 1983.

In 1980, Analog Devices Enterprises (ADE) was founded. ADE is an internal venture capital group that provides start-up funding to companies that have technologies aligned with Analog's strategic interests. Its first investment was Signal Processing Circuits, Inc., of Salt Lake City, Utah. This small start-up was engaged in the design of digital signal processing devices, which Analog had identified as one of its major strategic interests. As of June 1987, other ADE investments included a 58 percent holding in Numerix Corporation as well as holdings in Gigabit Logic and Bipolar Integrated Technology (BIT) Corporation.

Since the inception of ADE, the Company has invested in 12 companies. As of October 1988, the net carrying value of the seven venture capital investments in which Analog participates was approximately $23 million.

Financial Information

Analog Devices' sales increased 18.6 percent in 1988 to $439.2 million. Net income for the Company more than doubled from $18.7 million in 1987 to $38.0 million in 1988. Earnings per share increased from $0.40 in 1987 to $0.80 in 1988. Net income as a percentage of sales also rose significantly, increasing from 5.0 percent in 1987 to 8.6 percent in 1988 and reaching 9.7 percent of sales for the second half of fiscal 1988.

While the United States market remains Analog Devices' primary source of sales revenue at $181 million in 1988, significant sales growth has been experienced in all world markets. Sales to Japan increased 48 percent to $63 million. European sales grew to $96 million, also an increase of 48 percent. Sales to the Rest of World (ROW) market increased 66 percent to $20 million, as shown in Table 2.

Table 2

Analog Devices, Incorporated
Estimated 1988 Semiconductor Revenue by Geographic Region
(Millions of Dollars)

	United States	Japan	Europe	Rest of World	Total World
Total Semiconductor	$181	$63	$96	$20	$360
Integrated Circuits	$181	$63	$96	$20	$360
Linear	170	60	90	20	340
MOS Micro	11	3	6	0	20

Source: Dataquest
December 1989

Manufacturing Facilities

Analog Devices' manufacturing facilities are described in Table 3.

Table 3

Analog Devices, Incorporated
Manufacturing Facilities

City	Type	Clean Room Gross (Sq. Ft.)	Products	Technology
Greensboro	PAT	6,000	Linear ASIC	Bipolar
Wilmington	F	10,000	Linear logic operational amplifier A/D D/A	Bipolar BiCMOS
Wilmington	PAT	10,000	Memory logic ASIC	Bipolar MOS
Limerick, Ireland	DFAT	10,000	Linear D/A telecom	Bipolar

F = Fab
A = Assembly
D = Design Center
T = Test
P = Pilot Line

Source: Dataquest
December 1989

CAPITAL AND R&D SPENDING

The Company projects lower sales growth for 1989 and will constrain its total fixed expenses to be less than sales growth. However, a high priority will be placed on product, technology, and market development objectives through 1992.

Research and development (R&D) expense declined 9 percent from $50 million in 1987 to $45 million in 1988, as shown in Table 4. This decline signals a trend toward maintaining the Company's level of R&D at or slightly above the long-term model of 13 percent of sales. According to Analog, however, if sales growth slows as expected in 1989, R&D and marketing expenses will be allowed to grow faster than the long-term model.

Table 4

Analog Devices, Incorporated
Capital and R&D Spending as a Percentage
of Semiconductor Revenue by Calendar Year
(Millions of Dollars)

	1984	1985	1986	1987	1988
Semiconductor Revenue	$218.0	$226.0	$243.0	$292.0	$360.0
Semiconductor Capital Spending	$ 58.0	$ 62.0	$ 37.0	$ 50.0	$ 50.0
Percentage of Revenue	26.6%	27.4%	15.2%	17.1%	13.9%
Semiconductor R&D Spending	$ 21.9	$ 34.0	$ 40.8	$ 50.0	$ 50.0
Percentage of Revenue	10.0%	15.0%	16.8%	17.1%	12.5%
Combined Capital and R&D Spending	$ 79.9	$ 96.0	$ 77.8	$100.0	$ 95.0
Percentage of Revenue	36.7%	42.5%	32.0%	34.2%	26.4%
Percent Increase or Decrease	107.5%	20.2%	(19.0%)	6.9%	(26.8%)

Source: Dataquest
December 1989

In 1989, Analog plans to increase its capital spending to $68 million from $49 million in 1988. Investments will be directed toward enhancing existing wafer fabrication facilities, increasing test capability and capacity, and improving computer-aided design (CAD) capability.

SEMICONDUCTOR OPERATIONS

Technology

Analog Devices continued in 1988 the technological advances that will be necessary to sustain its leading position among the manufacturers of analog products. The Company completed development of an advanced bipolar/CMOS process that combines the density achieved by its digital CMOS process with the speed advances of bipolar analog devices. Called ABCMOS-1, the process will provide products that are six times faster than the Company's current-generation BiMOSII process and will achieve higher levels of digital integration. The further development of this technology will allow Analog Devices to advance its strong position in the data conversion applications market.

ABCMOS-2 is an enhancement of the ABCMOS-1 process that provides additional increases in speed and digital density and will be qualified in 1990. A radiation-hardened version of ABCMOS specifically designed to address military and space application requirements for advanced mixed-signal IC circuits will be qualified in 1989.

Analog Devices faces market share competition by manufacturers targeting its CMOS A/D and D/A converter market. In order to maintain its position, the Company qualified a 2-micron version of LC2MOS in 1988; this version presently features 4-micron geometrics. The initial products based on this technology will be introduced in 1989, and these products will offer upgraded performance at a reduced cost.

Also planned for 1989 are the introductions of other new products using a trench-isolated bipolar process, which Analog Devices calls STAT1. The development of this process was completed in 1988.

Product Lines

Analog Devices is continuing to shift product development emphasis from standard products to application-specific and user-specific devices. During 1989, Analog introduced 60 new products. Of this number, 46 were component products, 34 of which are based on proprietary designs. The Company predicts that by 1992, 70 percent of its sales revenue will come from data acquisition products and 17 percent from high-performance linear devices.

Table 5 provides an eight-year revenue history for Analog's semiconductor products. In 1987 and 1988, the Company had sales of $12 million and $20 million, respectively, for MOS microcomponents. These are digital devices produced specifically to work in conjunction with Analog's mainline linear products. With sales of $272.3 million in 1988, data conversion products represented 62 percent of the Company's sales, as shown in Figure 2.

Table 5

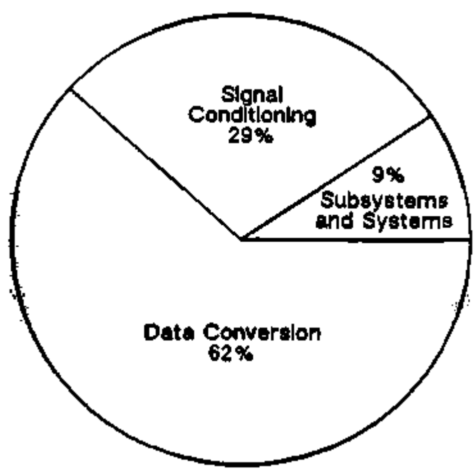
Analog Devices, Incorporated
Estimated Worldwide Semiconductor Revenue
(Millions of Dollars)

	1981	1982	1983	1984	1985	1986	1987	1988
Total Semiconductor	$89	$101	$145	$218	$226	$243	$292	$360
Integrated Circuits	$89	$101	$145	$218	$226	$243	$292	$360
Linear	89	101	145	218	226	243	280	340
MOS Micro	0	0	0	0	0	0	12	20

Source: Dataquest
December 1989

Figure 2

Analog Devices, Incorporated
1988 Revenue by Product Class



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Source: Analog Devices, Incorporated

Although sales to the U.S. market continue to represent the largest source of revenue for the Company, sales have been increasing in Japan, Europe, and the rest of the world. Linear products sales to Japan increased 116 percent in 1988, and linear sales in Europe increased 48 percent.

DSP

The worldwide DSP market grew 30.8 percent in 1988 to $586 million. Analog Devices' sales of $127.4 million represented 22 percent of the total market. The Company experienced an 18.6 percent growth rate in this product area over 1987's $107.4 million sold.

In the area of DSP products, Analog Devices has targeted automatic test equipment (ATE) as one of the largest applications of linear and mixed-signal technology. In order to maintain a leadership position, Analog has introduced a number of products specifically targeted at digital VLSI component testers. Included are monolithic ICs that combine four 12-bit D/A converters on a single chip, greatly reducing the board space required for the thousands of D/A converters used in each of these testers. The AD9500 digitally programmable time delay generator is used to generate critical timing signals and pin drivers, which regenerate very high speed pulses that are then applied to the digital device under test. Digital VLSI testers can test devices with as many as 256 to 512 pins, and these testers use very large quantities of the Company's components in each machine. Because board testers can have as many as 1,000 pins per tester, this represents a sizable growth opportunity for Analog Devices.

The 6B series of smart digitizing signal conditioners, intended for the industrial instrument market, is another product family designed for a specific application. Each module in this series provides a complete sensor-to-computer interface that greatly simplifies the acquisition of real-world signals in an industrial environment, particularly when significant distances exist between the sensors and the computerized equipment to which they are connected.

While seeking to advance its position in the application- and user-specific markets, the Company continues to enhance its line of standard products. The ADSP-2100A, a faster version of the ADSP2100 built on Analog's proprietary 1-micron digital CMOS process, was introduced in 1988. Considered to be the fastest and most versatile DSP microprocessor on the market, it is directed particularly toward military and aerospace applications.

Analog introduced two products directed at the high-speed data acquisition market. The AD7672 is a 3ns 12-bit ADC fabricated in an advanced mixed-technology, linear-compatible CMOS (LCCMOS). The AD7878 is a 12-bit 100-KHz ADC with interface for digital signal processing. It has an 8-word first-in/first-out (FIFO) memory, which allows up to 8 samples to be converted before the microprocessor is required to service the converter. In DSP, where servicing peripherals can have high software overhead, reducing the frequency of interrupt can be of significant benefit. The applications for these products include speech synthesis, spectrum analysis, high-speed modems, and digital servo control systems.

Data Conversion

The world market for data conversion products is $620 million. Analog Devices is the market leader in all segments of the market, with a 25 percent market share.

Analog is increasing its participation in the computer peripherals market. The AD890 and AD891 form an IC pair that accurately reads digital data from high-performance hard disk drives at rates in excess of 50 Mbps (megabytes per second). The AD892, now being sampled, is a lower-cost single-chip combination of the AD890 and AD891 that performs the same function for applications with lower data transfer rates. In 1988, the Company introduced the AD7669, a device specifically designed for positioning on the disk drive's read/write head. This product contains an 8-bit A/D converter, a track/hold amplifier, a voltage reference, and two 8-bit D/As, each with its own output amplifier.

For the high-resolution color computer display market, Analog Devices introduced the ADV471 and ADV478 in 1988. These are the first in a family of video D to A converters (DACs) aimed directly at meeting the needs of this growth market.

Up to now, Analog Devices has not participated materially in consumer products markets. The Company's initial entry into these markets is directed at high-end audio with proprietary products designed specifically for compact disc (CD) players, digital audio tape (DAT) players and recorders, synthesizers, digital audio amplifiers, and keyboards. The AD1856 is a 16-bit digital audio D/A converter designed to reconstruct the 1s and 0s stored on CDs into an analog music signal. This product was designed to be compatible with devices already used in high-volume production. The AD1856 was followed by the AD1860, an 18-bit D/A converter that provides a significant improvement in the quality of the reproduced sound. Additional products directed at the compact disk market, as well as an 18-bit A/D converter for the emerging digital tape market, are planned for introduction in 1989.

Product development in the areas of high-definition television (HDTV) and high-performance automotive devices—including ICs for engine controls, sensor-based warning systems, advanced antiskid braking systems, and smart accelerometer-driven shock absorbers—began in 1988.

Application- and User-Specific Products

In 1988, Analog Devices began the selective booking of orders for user-specific integrated circuits (USICs) using cells from the Company's standard cell library together with the Company's proprietary, mixed-signal CAD tools. The use of JANUS, as the CAD system is called, previously has been limited to a small group of engineers who had participated in its development. In early 1989, however, the Company will establish design centers in select target geographic areas in order to more aggressively pursue the market for high-performance mixed-signal USICs.

Semiconductor Alliances

In addition to seeking to increase its technology base through participation in start-up companies, Analog Devices has entered into agreements with established companies. These agreements are listed in Table 6.

Table 6

Analog Devices, Incorporated
Summary of Alliances

Other Company	Date	Agreement
Siliconix	July 1987	Siliconix expanded its data converter line with six chips second-sourced from Analog Devices.
	Aug. 1987	Analog Devices K.K. plans to begin linear IC production in Japan in 1992 and is looking for possible sites. The Company has a technical center in Kanagawa and has been assembling and testing imported ICs since 1981. After the new plant is built, design and R&D will be done at Kanagawa.
Brooktree	Jan. 1988	Brooktree signed Analog Devices as a second source of the Bt471 and Bt478 video DACs, which are designed for the PS/2 and VGA add-in boards.

Source: Dataquest
December 1989

Competitive Environment

Analog Devices was ranked number five among the U.S. suppliers of linear products. With growth in sales of linear products of 21.4 percent in 1988, as shown in Table 7, the Company's sales exceeded the rate of growth for the world analog market as a whole and for the U.S. analog market by 6.1 percent. U.S. companies with greater sales included National Semiconductor, Philips, Texas Instruments, and SGS-Thomson. Toshiba, ranked first in sales worldwide, had a 6 percent market share, while Analog claimed 3 percent.

Table 7

Analog Devices, Incorporated
Worldwide Semiconductor Market Share
(Millions of Dollars)

	1988 Rank	1987 Rank	1988 Revenue	Revenue Change (%) 1987-1988	Industry Change (%) 1987-1988
Total Semiconductor	27	25	$360	23.3%	32.9%
Integrated Circuits	25	21	$360	23.3%	37.6%
Linear	13	12	340	21.4%	16.1%
MOS Micro	31	33	20	66.0%	42.8%

Source: Dataquest
December 1989

The linear market is driven primarily by the needs of end-product manufacturers. Only in the high-performance segment does product innovation drive demand. Japanese companies control the high-volume market. Nearly 40 percent of linear sales worldwide in 1988 were monolithic analog devices designed for the consumer market. U.S. companies have an opportunity to increase participation in the high-volume segment of this significant market through leading-edge proprietary design and processes developed for telecommunications, consumer products in general, and CD audio.

Entry into the linear market is difficult. Design talent is critical to the success of a linear company. With such a small supply of linear designers (200 to 300 worldwide in 1988), relative to an estimated 2,000 to 3,000 digital IC designers, the entry of companies into the linear market will continue to be limited.

NONSEMICONDUCTOR PRODUCT SUMMARY

Sales of nonsemiconductor products, at $39.5 million, represented 9 percent of total sales revenue for Analog Devices in 1988. This marks the fourth year of declining sales in this area for the Company. Analog has chosen to emphasize growth in the DSP and data conversion areas of its product lines.

Analog Devices, Incorporated

The Company manufactures subsystems and systems products including digital instruments, measurement and control subsystems and systems, and component test systems. The assembly of these products generally includes the use of the Company's own data acquisition components along with components purchased from other manufacturers. Some of the products are board-level products, while others are contained within metal enclosures.

Analog's subsystems and systems either are intended for use with a microcomputer or computer, or they are supplied with a microcomputer. Typically, they are supplied with the computer software needed to run them also. Systems products include a family of microcomputer-based measurement and control systems designed for use in laboratory automation, process and machinery monitoring, control of processes and machines, and product testing.

The Company's subsystems and systems strategy focuses on the development of board-level products that can be marketed to original equipment manufacturers (OEMs), as opposed to box-level systems, which are typically sold to end users.

BUSINESS STRATEGIES

Analog Devices has been a broad-line analog supplier in high-performance products—ICs, subsystems, systems, and DSP. The Company's goal has been to move farther in the direction of enhancing its strong vertically integrated product line. The Company's stated objective for the next five years is to experience an average of 20 percent annual sales growth by continuing to follow this strategy. Although the data acquisition components market will remain Analog's most important market, many new applications are emerging in computer communications and consumer markets that will require the technologies and skills the Company has developed in serving the data acquisition market.

Analog will seek to gain market share and strength in the DSP arena by adding new products in an effort not only to increase DSP market share, but also to sustain market share in the area of data conversion. This market is becoming increasingly competitive for Analog Devices. Currently, customers may make DSP buys elsewhere, but they come to Analog for data conversion devices. By becoming a one-stop shop, the Company hopes to retain and enhance its data conversion share while gaining strength in DSP.

With the development of new products, Analog is entering the video DAC market. The Company is aggressively pursuing a position of leadership in this market.

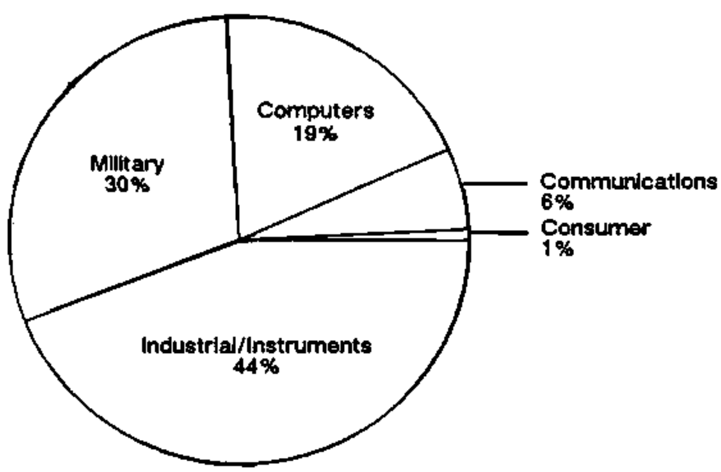
The digital audio market is an important one for Analog Devices with its data conversion family of products. The Company has not been a leader in this area. With new product introductions, however, Analog is focusing on gaining strength in this market.

Analog's sales have been strongest in the industrial and military market segments. With sales of $266.4 million in 1988, these segments represented 74 percent of the Company's total sales. The Company is making a strong effort to capture a growing share of the consumer market. Analog is aggressively directing its consumer product development focus toward the areas of automotive, audio CD players, and digital audio tapes, which present a significant growth opportunity.

The Company's goals for the year 1992 reflect the changing revenue contributions from its product areas. The military and industrial markets will decline in importance from 74 percent in 1988 to 61 percent in 1992. The Company expects computer product sales to increase to 25 percent and communications to 8 percent. Consumer products, which represent only 1 percent of sales currently, as graphically illustrated in Figure 3, will increase to 6 percent.

Figure 3

Analog Devices, Incorporated
Estimated Semiconductor Distribution
by Major End Market—1988



0005222-3

Source: Analog Devices, Incorporated

Applied Micro Circuits Corporation

Applied Micro Circuits Corporation
6195 Lusk Boulevard
San Diego, CA 92121
Telephone: (619) 450-9333
Fax: 619-450-9885

Applied Micro Circuits Corporation is a privately held company; therefore, balance sheet and income statement data are unavailable.

Applied Micro Circuits Corporation

THE COMPANY

Overview

Applied Micro Circuits Corporation (AMCC) specializes in the design and manufacture of high-speed ECL gate arrays and, most recently, a family of BICMOS gate arrays. The Company has targeted its products at OEMs that make industrial instruments, high-performance computers, electronic warfare systems, test equipment, graphics hardware, and telecommunications equipment.

Long-term Outlook

AMCC's strategic thrust is in high-performance end-use markets. With its ECL family of gate arrays and the recent addition of a CMOS family of gate arrays, the Company has concentrated on end-use markets that are out of the mainstream. In particular, the Company has focused on certain niches within the military and industrial segments, and we believe that 80 percent of AMCC's 1986 revenue came from products aimed at these segments. AMCC fabricates all products, regardless of the end-use application, to standard military screening procedures, thereby providing products that satisfy quality levels required for other segments. The end result is that the Company has aligned its product portfolio to be congruent with its customer base.

The ECL gate array market is dominated by a few large suppliers such as Fairchild, Fujitsu, and Motorola. While most of the large suppliers have concentrated on EDP market segments, they have also devoted resources to the military and industrial segments. The challenge for AMCC will be to position its products so as to erect barriers against these larger suppliers.

Management and Employees

Table 1 lists AMCC's corporate executives.

Table 1

Applied Micro Circuits Corporation
Corporate Executives

Position	Name
Chairman	Roger A. Smullen
President, CEO	Al Martinez
VP Finance/Administration	Joel O. Holliday
VP Marketing/Sales	A.C. D'Augustine
VP Operations	Don Shrock
VP Engineering	Ray Yuen

Source: Dataquest
October 1987

AMCC currently employs 230 people.

Financial Information

The Company has received three rounds of funding totaling $11 million, as shown in Table 2.

Table 2

Applied Micro Circuits Corporation
Sources of Funding as of January 1987
(Millions of Dollars)

Date	Round	Sources	Amount
April 1979	Round 1	Fred Adler & Co,; Ampersand Associates; International Industrial Investments Inc.; Kimball Organ; Timex	$ 5.0
March 1983	Round 2	Accel Capital; Asset Management Associates; Harrison Capital; International Industrial Investments (France); Kemper; Matrix Partners; Oak Investment Partners II; Prime Capital; Fleming Ltd.; Robertson, Colman & Stephens; US Ventures; Venture Growth Associates; Adler & Co.	6.8
Sept. 1987	Round 3	Accel Partners; Adler & Co.; Asset Management Co.; The Crossover Fund; Eberstadt Fleming; Robert Fleming; Matrix Partners; Oak Partners; Paine Webber Venture Capital; Sequoia Capital; U.S. Venture Partners	$12.0

Source: Dataquest
October 1987

Applied Micro Circuits Corporation

PRODUCTS AND MARKETS

Semiconductor Product Markets

AMCC derived 100 percent of its revenue from ECL bipolar gate array activities through June 1985. Last year, however, the Company expanded its product line with CMOS gate arrays, as shown in Table 3.

Table 3

Applied Micro Circuits Corporation
Estimated Revenue
(Millions of Dollars)

	1984	1985	1986
Total ASICs	18.0	21.0	19.0
Bipolar	18.0	21.0	18.0
CMOS	0	0	1.0

Source: Dataquest
October 1987

TECHNOLOGY AND MANUFACTURING

AMCC uses double-level-metal 2.0-, 3.0-, and 5.0-micron bipolar process technology; double-level-metal 1.5-micron CMOS process technology; and 1.5-micron BICMOS process technology.

All of AMCC's gate arrays are manufactured at its San Diego, California, facility. This facility occupies 48,000 square feet of space and includes 43,000 square feet for administration, marketing, development, and manufacturing. The remaining 5,000 square feet are devoted to a class 10 wafer fabrication clean room.

Product List

AMCC offers a broad range of products. Table 4 lists the Company's products.

Applied Micro Circuits Corporation

Table 4

Applied Micro Circuits Corporation
Product List

Family	Process	Line Width (micron)	Delay (ns)	Gates
		ECL Gate Arrays		
Q700	Bipolar	5.0	0.9	250 to 1,000
Q1500	Bipolar	5.0	0.9	1,500 to 1,700
Q3500	Bipolar	3.0	0.6	1,300 to 3,500
Q5000	Bipolar	N/A	N/A	1,300 to 5,000
		CMOS Gate Arrays		
Q6000	Si-Gate	1.8	1.3	1,394 to 6,206
Q9000	Si-Gate	1.5	1.0	2,200 to 3,500
		BICMOS Gate Arrays*		
Q12000	BICMOS	1.5	0.7	2,160 to 9,072
		Cell Libraries and Software Design Kits		
MicroMatrix	Bipolar	5.0	0.9	Custom Macros
MicroMatrix	Bipolar	5.0	0.9	3,200 gates, 18 MSI
MicroMatrix	Bipolar	3.0	0.6	220 gates, 4 MSI
		CMOS Cell Library		
MicroMatrix	Si-Gate	1.8	1.3	80 gates, 40 MSI
MicroMatrix	Si-Gate	1.8	1.3	80 gates, 40 MSI

*Preliminary data
N/A = Not Available

Source: Dataquest
October 1987

Applied Micro Circuits Corporation

Semiconductor Agreements

AMCC has entered into the following agreements and alliances:

- Signetics
  - April 1979—AMCC and Signetics agreed that Signetics would provide alternate sourcing of the Q700 Quick-Chip series. AMCC was licensed to market designs for Signetics' 8A-1200 gate array family.
  - September 1983—AMCC and Signetics signed an extension of the prior agreement covering a technology transfer of future families of gate arrays and junction-isolated and oxide-isolation processes.
- Sorep
  - January 1982—AMCC and Sorep agreed to participate in a joint venture to design, assemble, test, and market gate arrays in France.
- Thomson CSF
  - July 1982—AMCC signed an agreement with Thomson-CSF under which Thomson-CSF would provide alternate sourcing and develop AMCC's high-performance, bipolar Q700 Series of gate arrays. AMCC received $1 million over a period of five years.
- Daisy
  - February 1983—Daisy offered support for AMCC's Q700 Series gate array family on its Gatemaster gate array development system; AMCC provided the design software.
- Honeywell
  - August 1984—Honeywell signed an agreement to second-source AMCC's Q700 Series gate arrays and to be an alternate source for AMCC's bipolar gate arrays.
- Sanders
  - February 1985—Sanders agreed to develop prototype ECL gate arrays by customizing AMCC base wafers for in-house use only.
- Seiko-Epson/S-MOS
  - May 1985—S-MOS signed an agreement to second-source AMCC's Q600 Series of sub-2-micron CMOS logic arrays. Seiko-Epson licensed its SLA 6000 Series of high-performance gate arrays to AMCC.

C–D

Cypress Semiconductor Corporation

Cypress Semiconductor Corporation
3901 North First Street
San Jose, California 95134-1599
Telephone: (408) 943-2600
(Millions of Dollars)

Balance Sheet (December 29)

	1985	1986
Total Current Assets	$17.61	$ 97.62
Cash	$ 7.60	$ 76.44
Receivables	$ 6.24	$ 15.63
Inventory	$ 3.06	$ 4.38
Net Property, Plant, and Equipment Depreciation	$24.18	$ 51.28
Total Assets	$41.79	$150.85
Current Liabilities	$ 9.87	$ 21.50
Long-Term Debt	$ 8.30	$ 0.04
Total Liabilities	$24.19	$ 41.31
Total Shareholders' Equity	$17.60	$109.55
Conv. Preferred Stock	$34.58	0
Common Stock	$ 0.63	$113.90
Retained Earnings	0	0

Income Statement (December 29)

	1985	1986
Revenue	$17.37	$ 50.88
Cost of Sales	$10.00	$ 17.05
Gross Margin (%)	42.43	66.49
R&D Expense	$ 5.19	$ 10.44
SG&A Expense	$ 6.32	$ 10.25
Other Expense	0	0
Operating Income (Loss)	($ 4.13)	$ 13.15
Interest, Net	($ 1.18)	$ 1.59
Pretax Income	($ 5.31)	$ 14.73
Provision for Taxes	0	$ 7.47
Effective Tax Rate (%)	N/A	50.7
Net Extraordinary Items	($ 5.31)	$ 13.40
Average Shares Outstanding (Millions)	23.07	29.63
Capital Expenditures	$ 7.91	$ 32.31
Employees	N/A	505

N/A = Not Available

Source: Cypress Semiconductor Corp. Annual Report

Cypress Semiconductor Corporation

THE COMPANY

Overview

Cypress Semiconductor Corporation designs, manufactures, and markets high-performance, high-speed ICs using CMOS process technology. The Company was incorporated in California in December 1982 as INTJR, Inc. In March 1983, the Company adopted its present name; in February 1987, it was reincorporated in Delaware.

Cypress was founded by T.J. Rodgers, Fritz Beyerlein, Fred Jenne, Steve Kaplan, Michael Starnes, and Lowell Turriff. Dr. Rodgers, president and chief executive officer, managed the SRAM development team at Advanced Micro Devices (AMD) before forming Cypress. Most of the other key executives worked with Dr. Rodgers at AMD or at American Microsystems.

Cypress uses 1.2-micron or smaller CMOS technology to produce a broad line of standard products for numerous performance-driven niche markets. The Company focuses on products with minimal Japanese competition and differentiates its products with better speed, power, and value-added features.

Cypress offers fast static random access memories (SRAMs); erasable programmable read-only memories (EPROMs); and first-in, first-out (FIFO) memories; programmable logic devices (PLDs); a bit-slice family; and digital signal processing (DSP) devices.

In December 1986, Cypress formed a wholly owned subsidiary, Cypress Semiconductor Texas Inc. (CSTI) in Round Rock, Texas. (Cypress owns 100 percent of the outstanding CSTI common and preferred shares.)

Highlights

- December 1982—Incorporated as INTJR, Inc.
- March 1983—Renamed Cypress Semiconductor Corporation
- April 1983—Raised $19.8 million in first-round and lease financing
- July 1983—Set up a technology/product agreement with Monolithic Memories, Inc. (MMI)
- April 1984—Raised $11.7 million in second-round financing
- December 1984—Achieved sales of $3.2 million
- March 1985—Raised $10.5 million in third-round financing
- August 1985—Raised $10.5 million in fourth-round financing

- September 1985—Achieved profitability
- October 1985—Set up a license agreement with Matra-Harris
- December 1985—Achieved sales of $17.4 million
- June 1986—Raised $72.8 million in an initial public offering
- December 1986—Achieved sales of $50.9 million, a 193 percent growth rate
- December 1986—Formed a subsidiary in Texas
- February 1987—Reincorporated in Delaware
- March 1987—Raised $39.8 million through the sale of 3.5 million shares of common stock

Management and Employees

Board of Directors. Cypress' board of directors comprises prominent members of the venture capital community who have substantial experience in the semiconductor industry. Chairman L.J. Sevin was formerly founder and president of Mostek; Pierre Lamond was a founder of National Semiconductor Corporation and served as a vice president; and L. John Doerr was formerly a sales manager at Intel. Table 1 lists Cypress board members and their affiliation.

Table 1

Cypress Semiconductor Corporation
Board of Directors

Name	Position	Affiliation
L.J. Sevin	Chairman	Sevin Rosen Management Company
Pierre R. Lamond	Director	Sequoia Partners
L. John Doerr	Director	Kleiner, Perkins, Caufield & Byers
T.J. Rodgers	Director	Cypress Semiconductor Corporation

Source: Cypress Semiconductor Corp.

Cypress employed 505 people as of December 1986; 22 in administration, 45 in engineering and quality assurance, 145 in manufacturing, 53 in R&D, 186 in assembly and test, and 54 in marketing and sales. In 1987, Cypress added about 50 people to staff its Round Rock facility. Table 2 lists the officers of the Company.

Table 2

Cypress Semiconductor Corporation
Officers of the Company

Name	Position
T.J. Rodgers	President, chief executive officer, director
Clive E. Barton	President, Cypress Semiconductor Texas Inc.
Stanley J. Meresman	Vice president, finance and administration, chief financial officer, assistant secretary
Fritz Beyerlein	Vice president, manufacturing, assembly and test
Richard Gossen	Vice president, product development
Fred Jenne	Vice president, research and development
Steve Kaplan	Vice president, engineering
Mark Allen	Vice president, wafer fabrication
R. Michael Starnes	Vice president, process development
Lowell Turriff	Vice president, marketing and sales

Source: Cypress Semiconductor Corp.

Financial Information

Between 1983 and 1985, Cypress completed four rounds of venture capital and lease financing for a total of about $52.0 million. In June 1986, Cypress raised $72.8 million through an initial public offering and a follow-on offering of common stock.

In March 1987, Cypress offered 3.5 million shares of common stock, raising $39.8 million. The Company plans to use about $30.0 million during 1987 for capital expenditures. Of this amount, approximately $26.0 million will be used for wafer manufacturing and test and assembly equipment to expand production capacity at Cypress' San Jose and Texas facilities. Approximately $4.0 million will be used for R&D equipment and general administration at the Company's facilities in San Jose.

Cypress generated its first revenue in 1984 and has been profitable each quarter since the third quarter of 1985. The Company reported revenue of $17.37 million and a net loss of $5.31 million in 1985 and revenue of $50.88 million and a net income of $13.40 million in fiscal 1986.

Shareholders. As of December 28, 1986, there were 32.7 million outstanding shares of common stock held by approximately 1,000 shareholders. Table 3 lists Cypress' principal shareholders and the percentage of shares they hold after the offering in February 1987.

Table 3

Cypress Semiconductor Corporation
Principal Shareholders

Shareholders	Percentage of Shares
Kleiner, Perkins, Caufield & Byers	7.9%
Sevin Rosen Management Company	6.9%
T.J. Rodgers	1.9%
Monolithic Memories, Inc.	0.6%
Matra-Harris Semiconducteurs	0.2%
Prudential Venture Partners	0.2%
Thermco Systems, Inc.	0.2%
Eaton Corporation	*
KLA Instruments Corporation	*
All Officers and Directors as a Group	21.0%

*Less than 0.1%

Source: Cypress Semiconductor Corporation Prospectus

Facilities

Cypress fabricates 5-inch wafers in a subclass-10, 15,000-square-foot clean room at its San Jose, California, plant (Fab I). Almost all of the Company's products are assembled in a second clean room at its San Jose plant. A test area is organized as part of the assembly facility. In January 1987, Cypress occupied a 60,000-square-foot facility adjacent to its existing facility in San Jose.

During the second quarter of 1986, the Company leased a 65,000-square-foot wafer fabrication plant in Round Rock, Texas. This facility houses Fab II, which produces six-inch wafers in a class-1 clean room and is expected to reach its maximum capacity of 3,000 wafers a week before mid-1988.

PRODUCTS AND MARKETS

Semiconductor Product Markets

CMOS memory sales accounted for all of Cypress' 1984 and 1985 revenue, as shown in Table 4. In 1986, CMOS memory accounted for 90 percent of revenue, with CMOS logic making up the remainder.

Sales in the United States accounted for 88 percent of 1986 revenue, with the remainder attributed to European sales, as shown in Table 5.

Table 4

Cypress Semiconductor Corporation
Estimated Worldwide Semiconductor Revenue
(Millions of Dollars)

	1984	1985	1986
Total Semiconductor	$4	$18	$50
Total Integrated Circuit	$4	$18	$50
CMOS Total	$4	$18	$50
CMOS Memory	4	18	45
CMOS Logic	-	-	5

Source: Dataquest
November 1987

Table 5

Cypress Semiconductor Corporation
Estimated 1986 Worldwide Semiconductor Revenue by Region
(Millions of Dollars)

	United States	Europe	World
Total Semiconductor	$44	$6	$50
Total Integrated Circuit	$44	$6	$50
CMOS Total	$44	$6	$50
CMOS Memory	40	5	45
CMOS Logic	4	1	5

Source: Dataquest
November 1987

Marketing Strategy

Cypress is executing the following strategy:

- To offer high-performance products that command premium prices
- To utilize advanced technology (1.5-micron CMOS or smaller) as a technology barrier
- To target niche markets small enough to be unattractive to large companies (Most of the markets in which Cypress competes have a TAM of less than $40 million.)
- To proliferate multiple product lines
- To differentiate within product markets by using special packaging, access to military markets, and advanced designs for proprietary features

Major Competitors

The firm with the most comparable capability is Integrated Device Technology (IDT), which generated revenue of $77.8 million in its fiscal year ending March 29, 1987. However, IDT competes directly with Cypress only in high-density SRAMs, and in particular, those sold to military subcontractors.

Channels of Distribution

The Company uses four channels to sell its products: direct OEM sales through Cypress' sales force and manufacturing representatives firms, sales through distributors, and sales to Japan through the Tomen Electronics Corporation, a Japanese trading company.

Semiconductor Products and Technologies

Technology

The Company has been shipping products fabricated using 1.2-micron CMOS RAM technology since March 1984 and has made limited revenue shipments of an SRAM based on 0.8-micron CMOS RAM technology since April 1986. In addition, Cypress has shipped products using a 0.9-micron CMOS EPROM technology since November 1984.

Product Lines

SRAMs. Fast SRAMs constitute the largest single product line, accounting for an estimated 50 percent of current revenue. Cypress has limited its participation to access times of 55ns or less and initially focused on lower density components, an area where there is less competition. Cypress has earned a reputation as a good, reliable supplier of fast SRAMs in the lower-density levels (i.e., from 1K to 16K). The Company has been quite successful in "pushing" technology in order to lower the access times of lower-density SRAMs to the 15ns to 20ns range.

In 1986, Cypress ranked ninth among suppliers of fast 16K SRAMs. New SRAM products include a 25ns 64K SRAM introduced in the first quarter of 1987. The Company plans for even faster speeds in low-density devices and also for a more gradual move to the high densities (e.g., fast 256K SRAMs).

EPROMs. Cypress' EPROMs are replacement devices for bipolar PROMS. Cypress devices differ from their bipolar counterparts in that the data can be erased. The PROM market is highly fragmented, as different organizations, speeds, and circuit features are available at each density level. Cypress has focused on the highest-performance segment of the market and has incorporated many features, including registers and self-diagnostics, on the chip to differentiate its products further.

Cypress gained attention in 1985 with the introduction of high-speed CMOS EPROMs that offer access times of 55ns and below.

FIFO. FIFO memories are principally used in communications-buffering applications in which speed is generally a critical factor. Cypress has used its advanced CMOS process to attack the military and bit-slice architecture FIFO niche markets. Cypress' strength is in providing a full product line for the implementation of bit-slice systems.

PLDs. PLDs constitute Cypress' third major product family (an estimated 10 percent of revenue in 1986). The Company has been granted royalty-free rights to the patents on certain Monolithic Memories, Inc., programmable array logic (PAL) devices under an agreement reached in July 1983. (PAL is a registered trademark of Monolithic Memories, Inc.) In return, Cypress gave MMI a royalty-free license to use its 1.2-micron CMOS process technology.

Two companies that offer CMOS PLDs are Altera and Lattice Semiconductor. Altera manufactures its erasable programmable logic device (EPLD), using CMOS EPROM technology, but these devices are not directly compatible with PALs. Lattice Semiconductor also uses a CMOS EPROM technology to produce a generic logic array (GAL) family similar to Advanced Micro Devices' 22V10 logic circuits.

Bit-Slice Family. Cypress' bit-slice family contains CMOS versions of AMD's bipolar 2901 series, principally the 4-bit MPU, sequencer, and controller.

Digital Signal Processing. DSP products consist of 16x16 multipliers and multiplier-accumulators used as building blocks for applications such as imaging, pattern recognition, graphics, and radar.

Table 6 lists Cypress' products.

Table 6

Cypress Semiconductor Corporation
Products

Products	Speed	Introduced
SRAMs		
1K SRAM	15ns	First quarter 1984
64-Bit SRAM	15ns	Fourth quarter 1984
16K SRAM	35ns	Fourth quarter 1984
4K SRAM	25ns	Fourth quarter 1984
16K SRAM	25ns	First Quarter 1985
64-Bit SRAM	35ns	Fourth quarter 1985
4K SRAM	15ns	Second quarter 1986
64K SRAM	25ns	First quarter 1987
EPROMs		
16K Registered EPROM	35ns	Third Quarter 1984
4K EPROM	25ns	Second quarter 1985
8K EPROM	30ns	Second quarter 1985
16K EPROM	25ns	Third quarter 1985
64K Registered EPROM	40ns	Second Quarter 1986
64K EPROM	40ns	Fourth quarter 1986
128K EPROM	45ns	Second quarter 1986
FIFOs		
64x4/x5 FIFO	15 MHz	Fourth quarter 1984
64x4 FIFO	2 MHz	Fourth quarter 1984
64x4/x5 FIFO	25 MHz	Fourth quarter 1985
64x8/x9 FIFO	35 MHz	Second quarter 1987
PLDs		
PAL 16L8/R6/R4	25ns	Second quarter 1985
PAL 22V10	25ns	First quarter 1986
PAL 20G10	25ns	Second quarter 1986
DSP		
16x16 Multiplier	38ns	First quarter 1986
16x16 Multiplier-Accumulator	45ns	Second quarter 1986
16x16 Multiplier	45ns	Third quarter 1986
Microcomponents		
4-Bit-Slice MPU	23ns	First quarter 1985
4-Bit Sequencer	30ns	Fourth quarter 1985
16-Bit-Slice MPU	24ns	Second quarter 1986
12-Bit Controller	50ns	Third quarter 1986

Source: Cypress Semiconductor Corp.

Semiconductor Agreements

- Monolithic Memories, Inc. (MMI)—In July 1983, Cypress obtained a patent and royalty-free trademark license to use, manufacture, and sell certain PAL products developed by MMI. In exchange, MMI received a royalty-free license to use Cypress' 1.2-micron CMOS process. MMI provided fabrication facilities, equipment, and equipment-financing guarantees of up to $5 million. MMI purchased 375,000 shares of Cypress Series-A preferred stock for $250,000 and was granted a warrant to purchase up to 750,000 shares of Cypress' common stock for $1.33 per share (valued at $0.10 per share). MMI exercised this option in 1986.

- Matra-Harris Semiconducteurs (MHS)—In October 1985, Cypress granted MHS a $1 million license for manufacturing certain products in Europe, using Cypress' 1.2-micron CMOS RAM and 0.9-micron CMOS EPROM technologies. In addition, this license gives MHS worldwide marketing rights on the products that it designs. In 1986, MHS exercised an option to license the 0.8-micron CMOS technology for $3.0 million. MHS also became a preferred shareholder through the purchase of 333,000 shares of Cypress' Series-D stock for $2.5 million. In a second agreement, MHS licensed Cypress' dual-level metal technology for $500,000.

- Weitek Corporation—In October 1985, Cypress licensed its SRAM register file technology and a portion of its logic technology to Weitek in exchange for a patent license covering some of Weitek's logic products. No royalty or fees were incurred by either party.

- Sun Microsystems—In July 1987, Cypress and Sun agreed to jointly develop a reduced instruction set computer (RISC) MPU product line, based on the Sun scalable processor architecture (SPARC). This second-generation SPARC MPU chip will include an integer processor, a floating-point processor, a memory management unit (MMU), and cache memory.

E-F

Electronics Research and Service Organization (ERSO)

Electronics Research and Service Organization
195-4-S40, SEC. 4, Chung Hsing Road, Chu Tung, Hsin Chu
Telephone: 035-966100, Fax: 035-957826
(Millions of Dollars)

Balance Sheet (Combined with ITRI)

	1981	1982	1983	1984	1985	1986	1987
Revenue*	$ 7.7	$ 8.8	$11.8	$16.7	$17.2	$26.4	$28.4
Cost of Revenue	$ 5.2	$ 6.2	$ 8.8	$10.9	$12.7	$18.6	$20.0
R&D Expense	$ 0.4	$ 0.5	$ 0.8	$ 1.2	$ 1.3	$ 1.5	$ 1.6
SG&A Expense	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Pretax Income	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Total Employees (excluding G/A)	340	400	450	480	530	530	430
Exchange Rate (NT$/US$)	37.8	39.9	40.3	39.5	39.9	37.8	31.9

N/A = Not Available
*Revenue of IC sales to the merchant market only

Source: Electronics Research and Service Organization Annual Reports

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Electronics Research and Service Organization (ERSO)

BACKGROUND

The Electronics Research and Service Organization (ERSO) is the Electronics Division of Industrial Technology Research Institute (ITRI). Founded in 1974, ERSO promotes electronic technology in Taiwan. ERSO implements this mission in two ways: (1) develops advanced generic technologies and transfers them to industry; (2) provides needed technical services for the industry. ERSO concentrates its technology on semiconductors, computer/communication, industrial automation, reliability, and thin film devices, and has made significant achievements in these fields. In its first 10 years, ERSO developed ICs, computers, microwave tubes, precision parts, and quality assurance procedures. ERSO's IC demonstration plant has been both a research lab for technology development and a testing ground for manufacturing technology in Taiwan. As a result, ERSO, although an R&D organization, is also selling ICs to the merchant market. The success of ERSO's IC operation spurred creation of United Microelectronics Corporation (UMC), which received ERSO's technology. Because of ERSO's diverse activities, a financial report specifically addressed to merchant market IC sales has not been easy. The following report reflects the best estimates of ERSO's resources allocated to the merchant market IC sales and the income from it.

Capital spending (excluding VLSI lab) (Millions of U.S. Dollars):

	1983	1984	1985	1986	1987
Plant & Equipment	0.7	5.1	2.1	3.5	3.4
R&D	0.8	1.2	1.3	1.5	1.6

MAIN PRODUCTS AND TECHNOLOGIES

ERSO's main products are peripheral chips; microcontrollers; telecom, telephone, melody, audio, and television ICs; memories; A/D and D/A converters; gate arrays; standard cells; and full custom designs.

Its main technologies are:

- CMOS 1.5-micron, 2-micron, 3-micron, and 5-micron, Al-gate and Si-gate
- NMOS 3-micron, Si-gate
- Bipolar standard linear

Electronics Research and Service Organization (ERSO)

SALES (INCLUDING SALES TO GOVERNMENT) (Millions of U.S. Dollars)

	1981	1982	1983	1984	1985	1986	1987
Total Semiconductor	$9.0	$12.0	$25.0	$32.0	$26.0	$26.4	$28.4
Bipolar (linear)	0.2	0.2	0.5	2.0	2.1	3.4	3.7
MOS	8.8	11.8	24.5	30.0	23.9	23.0	24.7
CMOS	8.8	11.8	19.5	25.5	21.9	--	--
NMOS	--	--	5.0	5.0	2.0	--	--

Source: Dataquest
November 1988

FACILITIES

Facility Name	Clean Room Square Footage and Class
Pilot Plant	20,400 Square Feet, Class 100

INTERNATIONAL OPERATIONS

ITRI
2950 Scott Boulevard
Santa Clara, CA 95054-3312

Telephone: (408) 727-1280/81
Fax: (408) 727-1338

Fujitsu Limited

Fujitsu Limited
6-1, Marunouchi 1-chome
Chiyoda-ku, Tokyo 100, Japan
Telephone: 03-216-3211
Telex: J22833
(Billions of Yen except Per Share Data)

Balance Sheet (March 31)	1983	1984	1985	1986	1987
Total Current Assets	¥ 579	¥ 766	¥ 944	¥ 1,008	¥ 1,449
Cash	151	210	196	160	201
Receivables	221	279	369	418	463
Inventory	194	255	353	390	409
Other Current Assets	13	22	26	40	376
Net Property, Plant, and Equipment	¥ 248	¥ 328	¥ 497	¥ 554	¥ 546
Depreciation	¥ 257	¥ 325	¥ 425	¥ 538	¥ 650
Other Assets	¥ 176	¥ 183	¥ 280	¥ 310	¥ 3
Total Assets	¥ 1,003	¥ 1,277	¥ 1,721	¥ 1,872	¥ 1,998
Total Current Liabilities	¥ 431	¥ 527	¥ 711	¥ 710	¥ 796
Long-Term Debt	126	205	252	356	338
Other Liabilities	95	112	150	170	183
Total Liabilities	¥ 652	¥ 844	¥ 1,113	¥ 1,236	¥ 1,317
Total Shareholders' Equity	¥ 351	¥ 433	¥ 608	¥ 636	¥ 681
Convertible Preferred Stock					
Common Stock	52	64	100	102	117
Other Equity	121	135	196	206	232
Retained Earnings	178	234	312	328	332

Income Statement (March 31)	1983	1984	1985	1986	1987
Revenue	¥ 957	¥ 1,210	¥ 1,562	¥ 1,692	¥ 1,789
Domestic Sales	735	927	1,141	1,291	1,396
Overseas Sales	222	283	421	401	393
Cost of Sales	¥ 601	¥ 750	¥ 959	¥ 1,141	¥ 1,233
Gross Margin (%)	37	38	39	33	31
R&D Expense	¥ 86	¥ 103	¥ 133	¥ 157	¥ 166
SG&A Expense	¥ 173	¥ 223	¥ 276	¥ 310	¥ 328
Other Operating Expenses					
Total Operating Expenses	¥ 860	¥ 1,076	¥ 1,368	¥ 1,608	¥ 1,727
Operating Income (Loss)	¥ 97	¥ 134	¥ 194	¥ 84	¥ 62
Interest, Dividends, Net	13	17	15	33	14
Pretax Income	84	117	179	51	48
Provision for Taxes (Credit)	¥ 45	¥ 60	¥ 101	¥ 22	¥ 31
Effective Tax Rate	¥ 54	¥ 51	¥ 56	¥ 43	¥ 65
Extraordinary Items, Net	¥ 9	¥ 10	¥ 11	¥ 10	¥ 5
Net Income	¥ 48	¥ 67	¥ 89	¥ 39	¥ 22
Average Shares Outstanding (Millions)	1,069	1,084	1,211	1,370	1,516
Employees	52,593	62,071	74,187	84,277	89,293
Capital Expenditures	¥ 111	¥ 167	¥ 298	¥ 216	¥ 141
Exchange Rate (Yen per US$)	249	236	245	221	160

Source: Fujitsu Limited Annual Reports
Dataquest
December 1988

Fujitsu Limited

Fujitsu Limited
6–1, Marunouchi 1–chome
Chiyoda–ku, Tokyo 100, Japan
Telephone: 03–216–3211
Telex: J22833

(Millions of Dollars except Per Share Data)

Balance Sheet (March 31)	1983	1984	1985	1986	1987
Total Current Assets	$ 2,325	$ 3,246	$ 3,853	$ 4,561	$ 9,056
Cash	606	890	800	724	1,256
Receivables	888	1,182	1,506	1,891	2,894
Inventory	779	1,081	1,441	1,765	2,556
Other Current Assets	52	93	106	181	2,350
Net Property, Plant, and Equipment	$ 996	$ 1,390	$ 2,029	$ 2,507	$ 3,413
Depreciation	$ 1,032	$ 1,377	$ 1,735	$ 2,434	$ 4,063
Other Assets	$ 707	$ 775	$ 1,143	$ 1,403	$ 19
Total Assets	$ 4,028	$ 5,411	$ 7,024	$ 8,471	$12,488
Total Current Liabilities	$ 1,731	$ 2,233	$ 2,902	$ 3,213	$ 4,975
Long-Term Debt	506	869	1,029	1,611	2,113
Other Liabilities	382	475	612	769	1,144
Total Liabilities	$ 2,618	$ 3,576	$ 4,543	$ 5,593	$ 8,231
Total Shareholders' Equity	$ 1,410	$ 1,835	$ 2,482	$ 2,878	$ 4,256
Convertible Preferred Stock	0	0	0	0	0
Common Stock	209	271	408	462	731
Other Equity	486	572	800	932	1,450
Retained Earnings	715	992	1,273	1,484	2,075

Income Statement (March 31)	1983	1984	1985	1986	1987
Revenue	$ 3,843	$ 5,127	$ 6,376	$ 7,656	$11,181
Domestic Sales	2,952	3,928	4,657	5,842	8,725
Overseas Sales	892	1,199	1,718	1,814	2,456
Cost of Sales	$ 2,414	$ 3,178	$ 3,914	$ 5,163	$ 7,706
Gross Margin (%)	37	38	39	33	31
R&D Expense	$ 345	$ 436	$ 543	$ 710	$ 1,038
SG&A Expense	$ 695	$ 945	$ 1,127	$ 1,403	$ 2,050
Other Operating Expenses	0	0	0	0	0
Total Operating Expenses	$ 3,454	$ 4,559	$ 5,584	$ 7,276	$10,794
Operating Income (Loss)	$ 390	$ 568	$ 792	$ 380	$ 388
Interest, Dividends, Net	52	72	61	149	88
Pretax Income	337	496	731	231	300
Provision for Taxes (Credit)	$ 181	$ 254	$ 412	$ 100	$ 194
Effective Tax Rate	$ 54	$ 51	$ 56	$ 43	$ 65
Extraordinary Items, Net	$ 36	$ 42	$ 45	$ 45	$ 31
Net Income	$ 193	$ 284	$ 363	$ 176	$ 138
Average Shares Outstanding (Millions)	1,069	1,084	1,211	1,370	1,516
Employees	52,593	62,071	74,187	84,277	89,293
Capital Expenditures	$ 446	$ 708	$ 1,216	$ 977	$ 881
Exchange Rate (Yen per US$)	249	236	245	221	160

Source: Fujitsu Limited Annual Reports
Dataquest
December 1988

Fujitsu Limited

THE COMPANY

Overview

Fujitsu Limited was established in 1935 as a spin-off of the Communications Division of Fuji Electric Co., Ltd. Fujitsu manufactured telephone switching systems and related telephone equipment. The Company added a growing complement of carrier transmission and radio communications equipment to its product line to become a world leader in telecommunications. It is also involved in the manufacture and sale of computers and data processing systems, semiconductors and electronic components, and audio products. In 1954, Fujitsu pioneered the development of the first Japanese computer, the FACOM 100, a relay-type product.

Fujitsu is part of the Dai-Ichi Kangyo Bank (DKB) Group, the largest bank in Japan. Fujitsu's major financing comes from DKB and Mitsubishi Group financial institutions.

Fuji Electric is Fujitsu's largest shareholder (14.7 percent) and has a parent-like affiliation with Fujitsu and a strong influence on the Company, but it does not have majority control.

The Company employs 89,293 people worldwide, under the leadership of Chairman Taiyu Kobayashi, president Takuma Yamamoto, and executive vice presidents Bun-ichi Oguchi and Matami Yasufuku.

HIGHLIGHTS

The following are Fujitsu's fiscal 1987 highlights:

- Fujitsu reported consolidated revenue of ¥1,789 in fiscal 1987, an increase of 6 percent from fiscal 1986.
- The Company's semiconductor revenue in calendar 1987 was $1,801, an increase of 32 percent.
- The Company remained the largest worldwide supplier of bipolar ECL products in 1987 with revenue of $262 million.
- The Company remained the largest worldwide supplier of bipolar digital memory products with revenue of $178 million in 1987.

Fujitsu Limited

MAJOR SHAREHOLDERS

The major shareholders of Fujitsu and their percent of ownership are listed in Table 1. Foreign ownership of stock is 10.1 percent.

Table 1

Fujitsu Limited
Major Shareholders

Shareholders	Percent of Shares
Fuji Electric Co., Ltd.	14.7%
Asahi Mutual Life Insurance	7.1%
Dai-Ichi Kangyo Bank, Limited	4.9%
Mitsubishi Trust	2.5%
Industrial Bank of Japan, Limited	2.5%
Sumitomo Trust	1.7%
Nippon Life Insurance Company	1.7%
Mitsui Trust	1.5%
The Taiyo Kobe Bank, Limited	1.5%

Source: Japan Company Handbook

Fujitsu is listed on the Tokyo, Osaka, Nagoya, Frankfurt, London, Zurich, Geneva, and Basel exchanges.

Fujitsu's major financing comes from DKB and Mitsubishi Group financial institutions.

OPERATIONS

Fujitsu's consolidated sales in fiscal 1987 reached ¥1,789 billion, a 6 percent increase from fiscal 1986. Although the Company's sales have grown over the 1986 and 1987 period, profits dropped significantly. Operating income was ¥62 billion in 1987, compared with ¥84 billion in 1986 and ¥194 billion in 1985. Net income in fiscal 1987 was ¥22 billion, compared with ¥39 billion in 1986 and ¥89 billion in 1985. Fujitsu attributed the decline to the yen's sharp appreciation and sluggish semiconductor business.

Fujitsu's major lines of business are computers and data processing systems, communications systems, semiconductors and electronic components, and automotive audio equipment and electronics. Revenue by line of business is shown in Table 2.

Table 2

Fujitsu Limited
Revenue by Line of Business
(Billions of Yen)

	Fiscal Year Ending March 31				
	1983	1984	1985	1986	1987
Computers and Data Processing Systems	¥ 567	¥ 727	¥ 957	¥1,125	¥1,211
Communications Systems	170	186	211	254	270
Semiconductors and Electronic Components	152	218	307	226	222
Automotive Audio Equipment and Electronics	49	54	59	58	57
Other	19	25	28	30	29
Total Revenue	¥ 957	¥1,210	¥1,562	¥1,692	¥1,789
Exchange Rate (Yen per US$)	249	236	245	221	160

Source: Fujitsu Limited Annual Reports
Dataquest
December 1988

INTERNATIONAL ACTIVITIES

Fujitsu reported a decrease in overseas revenue, which, at ¥393 billion, was 2 percent below the preceding year's level. Fujitsu cited the yen's rapid appreciation, a sluggish international market, and intensified trade friction as reasons for the decrease.

Fujitsu's global business activities are represented by local manufacturing through active technology transfer. The Company is also increasing local procurement and encouraging local export.

Fujitsu Limited

Fujitsu has taken the following actions to improve its position as an international corporation:

- Began magnetic disk drive production in a Hillsborough, Oregon, facility
- Established Fujitsu America, Inc. (FAI) to market personal and business computers
- Established Fujitsu Canada, Inc. to market magnetic disk drives, printers, and other information processing products
- Established Fujitsu Imaging Systems of America, which purchased the Imaging Systems Division of Burroughs Corp.
- Established Fujitsu Component of America as a subsidiary of Fujitsu Microelectronics, Inc., which concentrates on integrated electronic components
- Opened an office in Shanghai to strengthen its sales and service to the People's Republic of China
  - In June 1987, Fujitsu also signed a tentative agreement to establish a joint venture with Fujian Province to develop software for digital switching systems.
- Signed a long-term contract for FETEX-150 digital switching systems with Singapore Telecom
- Established a technical assistance agreement with Hyundai Electronics Industries, Ltd., for medium- to small-capacity digital PBXs
  - Under the agreement, Fujitsu will supply major parts and components, which Hyundai will use to produce the same PBXs in Korea.

Semiconductor Facilities

Fujitsu has 19 semiconductor facilities throughout the world that cover all steps of semiconductor production. Fujitsu Microelectronics Inc. is planning to break ground on a new wafer fabrication facility in Portland, Oregon, which will be equipped to produce 6-inch and possibly larger diameter wafers. In April 1987, the magnetic disk drive plant in Hillsborough, Oregon, completed its first year of operation. The plant began assembling printed circuit boards for magnetic disk drives at the end of 1987.

Fujitsu Limited

In May 1988, Fujitsu announced plans to build a $24.8 million semiconductor factory in Malaysia. Construction began in June 1988 and will be completed by year's end. The factory will have 7,500 square meters of floor space and will house assembly and test activities for MOS memories, logic, and linear ICs. Products will be exported primarily to Japan and Asian newly industrialized countries.

Table 3 lists Fujitsu's semiconductor manufacturing locations in Japan and other parts of the world.

Table 3

Fujitsu Limited
Semiconductor Manufacturing Facilities

Factory	Floor Space (square meters)	Function/Products
Aizu Factory, Japan	57,308	Fab, Test--ICs, discretes
Fujitsu Miyagi Electronics, Japan	6,000	Assembly--MOS memory
Fujitsu Tohoku Electronics, Japan	6,000	Assembly--ICs
Fujitsu VLSI Design, Japan	17,000	Design
Iwate Factory, Japan	34,675	Fab, Test--MOS memory
Kyushu Fujitsu Electronics, Japan	8,400	Assembly
Kawasaki Factory, Japan	7,000	Fab, Test--ICs, discretes, optoelectronics
Mie Factory, Japan (Planned)	N/A	Fab--MOS memory
Aizu Factory #2, Japan	30,000	Fab
Miyazaki Factory, Japan	N/A	Assembly, Test
Wakamatsu Factory, Japan	30,000	MOS microdevices and logic
Yamanashi Electronics, Japan	16,000	Fab, Assembly, Test--MOS logic
Ikawa Factory, Japan	N/A	Assembly, Test
Mino-Kamo Factory, Japan (Planned)	N/A	N/A
Fujitsu Component Malaysia Sdn. Bhd.	N/A	N/A
Fujitsu Europe Limited	N/A	Fab, Assembly, Test--CMOS prototypes
Fujitsu Microelectronics Inc.	20,122	Assembly, Test--MOS memory
Fujitsu Microelectronics Ireland, Ltd.	11,150	Assembly, Test--MOS memory
Fujitsu Microelectronics Inc., Gresham Factory	14,000	Fab--MOS ICs

N/A = Not Available

Source: Dataquest
December 1988

CAPITAL AND RESEARCH AND DEVELOPMENT SPENDING

Although overall capital spending declined in fiscal 1987 by 18 percent, Fujitsu maintained a relatively high level of 17 percent of revenue, as shown in Table 4. Capital and R&D spending is also shown in dollars in Table 5.

Table 4

Fujitsu Limited
Capital Spending and R&D Spending as a Percent of Sales
(Millions of Yen)

	1983	1984	1985	1986	1987
Revenue	¥ 957	¥1,210	¥1,562	¥1,692	¥1,789
Capital Spending	¥ 111	¥ 167	¥ 298	¥ 216	¥ 141
Percent of Revenue	12%	14%	19%	13%	8%
R&D Spending	¥ 86	¥ 103	¥ 133	¥ 157	¥ 166
Percent of Revenue	9%	9%	9%	9%	9%
Combined Capital and R&D Spending	¥ 197	¥ 270	¥ 431	¥ 373	¥ 307
Percent of Revenue	21%	23%	28%	22%	17%
Exchange Rate (Yen per US$)	¥ 249	¥ 236	¥ 245	¥ 221	¥ 160

Source: Fujitsu Limited
Annual Reports
Dataquest
December 1988

Table 5

Fujitsu Limited
Capital Spending and R&D Spending in Dollars
(Millions of Dollars)

	1983	1984	1985	1986	1987
Revenue	$3,843	$5,127	$6,376	$7,656	$11,181
Capital Expenditures	$ 446	$ 708	$1,216	$ 977	$ 881
R&D Spending	$ 345	$ 436	$ 543	$ 710	$ 1,038

Source: Fujitsu Limited
Annual Reports
Dataquest
December 1988

Fujitsu Limited

The Company spent about $139 million in semiconductor capital investments in 1987, as shown in Table 6, an increase of 45 percent from 1986. Dataquest believes that the Company will increase calendar 1988 spending to $246 million.

Table 6

Fujitsu Limited
Semiconductor Capital Spending by Calendar Year
(Millions of Dollars)

	1983	1984	1985	1986	1987
Semiconductor Revenue	$673	$1,190	$1,019	$1,362	$1,801
Semiconductor Capital Spending	$226	$ 485	$ 303	$ 96	$ 139
Percent of Semiconductor Revenue	34%	41%	30%	7%	8%

Source: Dataquest
December 1988

Research and Development

In fiscal 1987, Fujitsu spent ¥166 billion, or 9 percent of sales, on research and development. In October 1986, the Company began the Fresh Fujitsu 1988 Campaign, which brought about advancements in digital telecommunications technology for ISDN. The effort also brought achievements in artificial intelligence technology, the core of fifth-generation computers, and microelectronics-related technology, including ultrahigh-speed, high-density devices and new functional devices.

The following are a few of Fujitsu's fiscal 1987 R&D highlights:

- In May 1987, a new North American R&D center was opened in Raleigh, North Carolina, to probe the latest network communications technology.
- In March 1987, Fujitsu initiated construction of an R&D center in Malaga, Spain, to foster computer and telecommunications technology and to support Spain's information industries.
- Fujitsu developed an on-board, cryogenic system for an infrared sensor that will be installed on the Earth Resources Satellite (ERS-1).

- Fujitsu developed a millimeter-wave, all-solid-state, high-power amplifier for use on the Engineering and Testing Satellite (ETS-VI).
- Fujitsu tested a prototype LSI for a cellular array processor (CAP) using a channelless-type CMOS master-slice.
- Manufacturing technology was established for distributed-feedback (DFB) lasers used in high-speed optical communications systems.
- Fujitsu developed a new low-cost, low-voltage transition liquid crystal for projection displays.
- Fujitsu developed a prototype 6-inch active matrix liquid crystal display.
- Fujitsu developed a hologram disk reproduction technology, which will be used in the optical systems for next-generation very small scanners.
- Fujitsu Laboratories in Atsugi, Japan, is studying resonant tunneling transistors as a means of extending circuit switching speeds beyond that of high electron mobility transistors (HEMT). The Company is examining both RHET (resonant hot electron transistor) and RBT (resonant bipolar transistor) structures for possible use in future high-speed digital hardware.

SEMICONDUCTOR PRODUCT MARKETS

Fujitsu showed increases in all product areas in which it participates. Dataquest estimates Fujitsu's 1987 semiconductor revenue, which is shown in Table 7, at $1,801 million, an increase of 32 percent over 1986. MOS devices account for about 56 percent of total semiconductor revenue, with MOS memory making up 63 percent of that amount.

Fujitsu Limited

Table 7

Fujitsu Limited
Worldwide Semiconductor Revenue
(Millions of Dollars)

	1983	1984	1985	1986	1987
Total Semiconductor	$673	$1,190	$1,019	$1,362	$1,801
Total Integrated Circuit	$606	$1,098	$ 940	$1,247	$1,660
Bipolar Digital (Technology)	$174	$ 305	$ 267	$ 397	$ 495
TTL	-	237	111	162	200
ECL	-	52	140	205	262
Other Bipolar Digital	-	16	16	30	33
Bipolar Digital (Function)	$174	$ 305	$ 267	$ 397	$ 495
Bipolar Digital Memory	90	136	95	145	178
Bipolar Digital Logic	84	169	172	252	317
MOS (Technology)	$406	$ 753	$ 631	$ 775	$1,014
NMOS	331	615	500	602	752
PMOS	7	7	4	-	-
CMOS	68	131	126	173	262
MOS (Function)	$406	$ 753	$ 631	$ 775	$1,014
MOS Memory	278	527	412	485	634
MOS Microdevices	85	121	106	120	146
MOS Logic	43	105	113	170	234
Linear	$ 26	$ 40	$ 42	$ 75	$ 151
Total Discrete	$ 32	$ 40	$ 37	$ 53	$ 70
Transistor	$ 32	$ 40	$ 37	$ 53	$ 70
Small Signal Transistor	-	30	27	-	-
Power Transistor	-	10	10	-	-
Total Optoelectronic	$ 35	$ 52	$ 43	$ 62	$ 71
Optical Couplers	-	28	20	-	-
Other Optoelectronics	-	24	23	-	-
Exchange Rate (Yen per US$)	235	237	238	167	144

Source: Dataquest
December 1988

Fujitsu Limited

Fujitsu's growth in most product areas over the past year has been better than the worldwide industry average growth, as shown in Table 8. Fujitsu became the sixth largest worldwide semiconductor supplier and showed 101 percent growth in analog devices.

Table 8

Fujitsu Limited
Worldwide Ranking by Semiconductor Markets
(Sales in Millions of Dollars)

	1986 Rank	1987 Rank	1987 Sales	Sales % Change 1985-1986	Industry % Change 1985-1986
Total Semiconductor	7	6	$1,801	32%	23%
Total IC	7	6	$1,660	33%	26%
Bipolar Digital	4	4	495	25%	8%
MOS Digital	5	5	1,014	31%	35%
Analog	24	17	151	101%	19%
Total Discrete	26	24	$ 70	32%	13%
Total Optoelectronics	7	9	$ 71	15%	16%

Source: Dataquest
December 1988

Fujitsu is one of the top four suppliers to Nippon Telegraph and Telephone Corporation (NTT), the former Japanese domestic telecommunications monopoly. The other three major suppliers are NEC Corporation, Hitachi, Ltd., and Oki Electric Industry Company, Limited. Fujitsu has installed telecommunications networks for NTT covering all of Japan.

Dataquest believes that approximately 20 percent of Fujitsu's semiconductors are consumed internally and approximately 20 percent are sold through distributors. Fujitsu's major domestic distributors are Hoei Electric, Fujitsu Buhin Shoji, and Kantoh Denshi. The Company's U.S. distributors include Marshall, Cetec, Sterling, Bell, and Milgray.

Table 9 shows Fujitsu's estimated 1987 semiconductor revenue by geographic region.

Fujitsu Limited

Table 9

Fujitsu Limited
Estimated Semiconductor Revenue by Geographic Region
(Millions of Dollars)
1987

	U.S.	Japan	Europe	ROW	Worldwide
Total Semiconductor	$282	$1,356	$110	$53	$1,801
Total Integrated Circuit	$257	$1,246	$110	$47	$1,660
Bipolar Digital	106	357	26	6	495
MOS	151	743	84	36	1,014
Linear	0	146	0	5	151
Total Discrete	$ 12	$ 55	$ 0	$ 3	$ 70
Total Optoelectronic	$ 13	$ 55	$ 0	$ 3	$ 71

Source: Dataquest
December 1988

Semiconductor Products and Technologies

Fujitsu is a broad-line semiconductor supplier, focusing on integrated circuits. Fujitsu's product line includes:

- Discrete semiconductors that include both power and low-noise GaAs FETs ranging from 2 GHz to 20 GHz, as well as a wide range of optical semiconductor devices such as LEDs, PINs, APDs, and laser diodes for optical fiber communications.
  - Products also include high-speed switching power transistors and Darlington transistor arrays.
- Standard logic ICs that include a range of TTL, LS TTL, ALS TTL, ECL, and CMOS families that cover simple gates to complex arithmetic logic circuits
- Analog ICs, including general-purpose ICs such as operational amplifiers and comparators to semicustom and custom ICs for audio equipment and regulators
  - Recent introductions include specialized ICs such as A/D and D/A converters and ICs for floppy disks, hard disks, and telephones.

- Memory ICs, including DRAMs, SRAMs, EPROMs, bipolar ROMs, mask ROMs, and ECL RAMS
- A microdevice family, including general-purpose microprocessors (MPUs) for 4-bit controllers, 8-bit controllers, 16-bit MPUs and low-power CMOS devices, as well as specialized ICs for peripheral control
- Custom hybrid ICs
- Bubble memories

In September 1987, IBM and Fujitsu partially resolved the suit over alleged software copying. Arbitrators ruled that Fujitsu is entitled to have access to the IBM code necessary to develop plug-compatible systems. However, Fujitsu must compensate IBM for the investment required to develop its operating system, although the exact amount has not been determined.

In May 1988, Fujitsu announced plans to increase its military business by supplying infrared seeker electronics jointly with NEC for use in a Kawasaki antitank missile system.

In July 1987, Fujitsu established an advanced products division to design and market DSP and communications controllers, as well as the SPARC chip set developed with Sun Microsystems. The new division is an outgrowth of Fujitsu's former cooperative technology and business ventures division. The Communications controller product debuts with a LAN controller that is capable of handling Ethernet and StarLan. The EtherStar IC achieved first silicon in late 1987.

In January 1988, Fujitsu Microelectronics, Inc. (FMI) appointed Richard Christopher senior vice president and general manager of its Integrated Circuits Division. FMI, which was founded in 1979 as a wholly owned U.S. subsidiary of Fujitsu Limited, markets a broad line of standard and custom devices in the United States. Mr. Christopher replaced Bob Freischlag, who became president of Fujitsu Microelectronik GmbH and reports to Taro Okabe, executive vice president and chief operating officer of FMI.

Several of Fujitsu's product highlights are described in the following subsections.

Analog

In February 1988, Fujitsu introduced the MB501 family of low-power prescalers.

Fujitsu developed a low-noise receiver amplifier using the Company's high-electron transistor technology. Fujitsu is using this technology in a new series of communications satellite earth stations.

Digital Signal Processing

In December 1987, Fujitsu offered the MB86975, a 1.8-micron CMOS adaptive filter processor (AFP). The device integrates several digital filter types in one VLSI circuit and has a clock frequency of 10 MHz.

In July 1988, Fujitsu began volume production of a 32-bit floating-point DSP with high processing speed. The speed has been achieved by adapting parallel processing architecture and large-capacity memory space.

Memory

In February 1988, Fujitsu introduced the first two devices in a series of ECL I/O BICMOS RAMs. The MBM10C500 is a 10K series ECL-compatible 256Kx1 RAM, and the MBM100C500 is a 100K series ECL-compatible RAM.

In February 1988, Fujitsu introduced the MBM27C256H, a 256K CMOS EPROM that features access times of 100ns and 120ns.

In August 1987, Fujitsu offered three models of 1Mb EPROM modules with maximum access times of 250ns. For each module, four 1Mb EPROMs and one control decoder IC are mounted on a single DIP.

In January 1988, Fujitsu offered three registered output PROMs: the MB7226 4K PROM, MB7232 8K PROM, and MB7238 16K PROM. Each features 20ns clock access times, with 25ns versions also available.

In November 1987, Fujitsu succeeded in manufacturing (on an experimental basis) a 4K SRAM incorporating HEMT technology. This device has achieved a 0.5ns access time at room temperature. The device's structure is 1,024 words x 4 bits and consists of four 1K memory cell blocks.

In January 1988, Fujitsu announced the development of a CMOS 1Mb SRAM organized 256Kx4 with read times of 18ns.

Microcomponents

In October 1987, Fujitsu's Advanced Products Division offered the MB86950, an EtherStar LAN controller chip that combines interfaces for both the Ethernet and StarLan networks on a single chip. The product is configurable for 8- or 16-bit bus interfaces and links a host system to the LAN in cost-sensitive network applications calling for connection of PCs, workstations, disk drives, printers, and other devices.

In November 1987, Fujitsu offered the MB89352, an asynchronous IC for controlling both the initiator and target ends of the small computer systems interface (SCSI).

Fujitsu Limited

In March 1988, Fujitsu Microelectronics Advanced Products Division introduced the second member of its SPARC 32-bit RISC microprocessor family. The device has an average sustained processing rate of 15 mips at a clock rate of 25 MHz.

Optoelectronic

In August 1988, using a flipchip fabrication technology, Fujitsu Laboratories developed a highly sensitive, high-speed photoreceptor optoelectronic IC. The IC enables 70 kilometers of repeaterless transmission with currently available optical fiber communications technology. The flipchip process requires simpler welding and features low-noise characteristics.

Process Technology

In October 1987, Fujitsu announced that its research laboratory developed a new method to synthesize extra-thin diamond films for LSI and VLSI circuits. Using this method, the growth speed of the film is 180 microns per hour. The laboratory plans to use the technology in 1989 to develop new devices.

Semiconductor Agreements

- AMD/MMI
  - In 1984, Monolithic Memories Inc. second-sourced Fujitsu's B-series bipolar TTL gate arrays.
- Chips and Technologies
  - In 1985, Fujitsu and Toshiba began providing foundry services for CMOS and bipolar arrays.
- Daisy Systems
  - In June 1988, Fujitsu made its FAME available on Daisy's Advansys Series of CAD/CAE systems.
- Hitachi, Matsushita, Mitsubishi, NEC, NTT, Oki, Toshiba
  - These companies have formed The Real Time Operating Nucleus (TRON) to accelerate the development of proprietary 32-bit MPU technology and operating systems for the next-generation microcomputers. TRON covers three operating systems—B-TRON for office automation equipment, I-TRON for real-time industrial systems, and M-TRON for networking with with distributed multiprocessors.

Fujitsu Limited

- Hitachi

  - The two companies will cooperate on the development of a 32-bit MPU and peripheral LSI family based on the TRON architecture.

- Intel

  - In 1984, Intel provided licensing rights of its 80186 and 80286 MPUs and the 8051 MCU to Fujitsu.

- LSI Logic

  - In 1982, LSI Logic and Fujitsu signed an agreement covering HCMOS gate arrays.

- SMC

  - In 1982, Standard Microsystems and Fujitsu cross-licensed each other's semiconductor-related patents and patent applications.

- Sun Microsystems. Wind River Systems

  - In June 1988, Fujitsu, Sun Microsystems, and Wind River Systems announced a cooperative product development effort to accelerate the use of SPARC MPU architecture in real-time markets. Mizar, a VME bus microcomputer manufacturer, will contribute hardware products based on Fujitsu's S-25 SPARC CPU. Wind River Systems will provide the software tools necessary to develop real-time applications for Mizar's SPARC target systems.

- Texas Instruments

  - In 1984, Texas Instruments second-sourced Fujitsu's gate arrays. Devices include B-240, B-350, B-600, and B-110 bipolar Schottky TTL arrays.

- Tokyo Electron

  - In 1985, Tokyo Electron began selling standard products and semicustom LSIs.

- TRW

  - In April 1983, TRW sold 49 percent of its interest in TRW-Fujitsu Co. to Fujitsu Ltd. Fujitsu has renamed the company Fujitsu Systems of America.

NONSEMICONDUCTOR PRODUCTS SUMMARY

Computers and Data Processing Systems

In fiscal 1987, revenue in the data processing area was up 8 percent over fiscal 1986. With 68 percent of Fujitsu's sales coming from computers and data processing equipment, this group is the Company's largest. Fujitsu is the largest supplier of computers to the Japanese market.

Products of this group include FACOM VP supercomputers; FACOM M very-large-scale to small-scale systems; JEF Japanese Information Processing systems; FACOM K office computers; banking and point-of-sale terminals; facsimile machines; Japanese-language word processors; and CAD/CAM systems.

The following are a few of this group's highlights:

- Shipments began in December 1986 of the FACOM M-780 model group of superlarge-scale computers.

- In March 1987, 13 models of medium- and large-scale general-purpose FACOM M-760/M-730 model groups were announced. These new entries fill out the low end of the M-780 model group.

- In January 1987, PANAFACOM Ltd. and Uzac Electronics Ltd., both Fujitsu venture businesses, signed a joint venture agreement. The agreement combines PANAFACOM's minicomputer and business personal computer business and Uzac's small business computer business. The new company, PANAFUZAC Ltd. (PFU), began operations in April 1987. In April 1987, Fujitsu and PFU completed their full lineup of the A Series 32-bit superminicomputers, which consists of seven models.

- Fujitsu announced the FF7500 digital facsimile, a high-speed plain-paper facsimile. The FF7500 offers two read mechanisms, including the conventional automatic document feeder and a new flathead scanning method; 64 shades of gray; and A-3 size recording.

Communications Systems

Fujitsu has long been a leader in the communications field. In 1965, it developed the first large-scale data communications network in Japan for the Ministry of Labor's nationwide on-line labor employment exchange system. In 1970, the Company developed a nationwide on-line banking network combining 300 bank branches and main offices for Dai-Ichi Kangyo Bank; it also developed a similar system for Japan's Federation of Bankers' Association, tying together 87 member banks and their 7,400 branches.

Fujitsu Limited

Revenue in the communications systems area increased 6 percent in fiscal 1987 over ıl 1986 to reach ¥270 billion. In fiscal 1987, the communications group was the npany's second largest group. It accounted for 15 percent of total revenue.

Products of this group include the Corporate Information Network System (COINS), ıicrocomputer-controlled telephones for home and office, integrated digital PBX ystems, mobile radio equipment for the transport industry, optical local area networks, and information network systems.

A large portion of Fujitsu's telecommunications sales are to NTT. Many of these sales consist of digital equipment for use in NTT's Information Network System (INS).

Fiscal 1987 highlights include the following:

- In February 1987, Fujitsu announced the COINS II V2 with extended functions that include the FACOM 2690 corporate network management of communications subsystems (COMS-C) and the FACOM 2890 optical local area network (LAN).

- During fiscal 1987, the FETEX-2000 Series (50 to 400 lines) and FETEX-3000 Series (600 to 16,000 lines) lineup of digital PBXs were completed.

- In March 1987, Fujitsu signed an agreement with GTE Communication Systems Corp. to establish a joint venture in the United States, named Fujitsu GTE Business Systems, Inc. (FGBS). FGBS, which began operating in April 1987, is a total supplier of small- to large-capacity PBXs.

Automotive Audio Equipment and Electronics

In the automotive audio equipment and electronics area, revenue in fiscal 1987 declined 2 percent to ¥57 billion from fiscal 1986. This group accounts for about 3 percent of total revenue. Fujitsu reported that sales of line-specific and spare parts to domestic automakers were steady. However, overall, a generally sluggish domestic market and export fluctuations caused by the strong yen kept this area at about the same level as the previous year.

Fujitsu's automotive products include car radios, electronic emission controls, electronically controlled transmission equipment, and electronic fuel injection equipment.

X

Gold Star Semiconductor, Ltd. (GSS)

Gold Star Semiconductor, Ltd.
60-1 Chungmu-ro 3-ga,
Jung-gu, Seoul 100, Korea
Telephone: 02-273-4151, Telex: GOLDSEC K22767
(Millions of Dollars Except Per Share Data)

Balance Sheet (December 31)

	1981	1982	1983	1984	1985
Financial Resources	$35.7	$40.1	$44.0	$ 55.6	$ 87.5
Long-Term Liabilities	$22.8	$36.1	$49.0	$ 68.9	$ 84.1
Shareholders' Equity	$ 7.1	$ 8.0	$23.9	$ 29.0	$ 45.2
After-Tax Return on Average Equity (%)	N/A	3.7	9.9	17.4	

Operating Performance (December 31)

	1981	1982	1983	1984	1985
Revenue	$ 5.0	$41.4	$66.3	$130.3	$203.2
Cost of Revenue	$ 5.7	$29.4	$46.5	$102.7	$171.0
SG&A Expense	$ 2.9	$ 2.7	$ 3.8	$ 8.5	$ 22.5
Pretax Income	($ 8.6)	$ 0.3	$ 2.4	$ 5.0	$ 7.8
Net Income	($ 8.6)	$ 0.3	$ 2.4	$ 5.0	$ 6.3
Average Shares Outstanding (Millions)	1.3	1.4	2.5	2.5	2.5
Per Share (Won)					
Earnings	(4,890)	169	770	1,653	
Dividends	0	0	0	0	
Book Value	(4,007)	4,615	7,783	9,492	
Price Average	N/A	N/A	N/A	N/A	
Total Employees	N/A	1,000	1,524	2,351	2,605
Exchange Rate (W/$)	700.5	748.8	795.5	827.4	870

N/A = Not Available

Source: Gold Star Semiconductor, Ltd.
Annual Reports

Gold Star Semiconductor, Ltd. (GSS)

THE COMPANY

Overview

The Lucky-Gold Star Group was founded in 1983, when the Lucky and Gold Star Groups were combined. The Lucky Group was founded in 1947 as the Lucky Chemical Company; Gold Star was founded in 1958 as the Gold Star Company, an electronics firm.

Lucky-Gold Star has 24 domestic affiliated companies and 19 overseas firms. Its products and services include chemicals, electronics, energy and resources, construction, insurance and finance, and trading. In 1985, sales were US$9.5 billion.

Gold Star Semiconductor was established in 1979. It entered a joint venture with AT&T, which owns 44 percent of GSS, in November 1980 to manufacture 1A ESS and semiconductors. The Company has three divisions--semiconductor, computer, and communications--and an R&D laboratory. In 1985, GSS saw significant growth in all business areas. The Company's total revenue reached $203 million in 1985, 56 percent more than 1984 revenue. In April 1986, Gold Star Semiconductor acquired the semiconductor operation of KIET, a government R&D organization, which is located just next to the Gold Star Gumi Plant. The newly acquired factory is now called Gumi Bipolar Plant II.

Lines of Business

The Company's major products are as follows:

- Semiconductors: transistors, linear, digital, and hybrid ICs, 8-bit MPUs, 64K SRAMs, gate arrays, 64K EPROMs, 512K and 1M ROMs, telephone ICs

- Computers: superminis, minis, micros, PCs, workstations, CAD/CAM

- Communication: 1A ESS, SLC-96, RSS, DCT, SESS, TDX-1

Gold Star Semiconductor, Ltd. (GSS)

REVENUE BY BUSINESS ACTIVITY
(Millions of U.S. Dollars)

	1981	1982	1983	1984	1985
Semiconductor	$2.1	$ 3.3	$ 6.4	$ 15.0	$ 32.8
Computer	-	$ 4.3	$ 0.3	$ 4.8	$ 21.6
ESS	$2.9	$33.8	$59.6	$110.2	$148.8

Source: Gold Star Semiconductor
Annual Reports
Dataquest
September 1987

Capital and R&D Spending

CAPITAL SPENDING
(Millions of U.S. Dollars)

	1983	1984	1985	1986*
All Plants	$ 40	$ 96	$100	$80
R&D	3	16	7	10
Total	$ 43	$112	$107	$90

*Estimated

WORLDWIDE SEMICONDUCTOR SALES
(Millions of U.S. Dollars)

	1982	1983	1984	1985	1986*
Total semiconductor	$ 3.3	$ 6.4	$15.0	$32.8	$58.8
Total IC	$ 0.8	$ 3.9	$13.0	$29.8	$54.8
Bipolar digital	-	-	1.0	7.3	14.4
MOS	-	0.1	1.0	5.0	20.9
Memory	-	-	0.0	1.0	4.4
MPU/MCU	-	0.1	1.0	2.0	3.0
Logic	-	-	-	2.0	13.5
Linear	0.8	3.8	10.0	17.5	19.5
Total discrete	$ 2.5	$ 2.5	$ 3.0	$ 3.0	$ 4.0

*Estimated

Source: Gold Star Semiconductor
Annual Reports
Dataquest
September 1987

Gold Star Semiconductor, Ltd. (GSS)

SEMICONDUCTOR DIVISION

General manager: Dr. C.S. Kim (senior managing director)

Brief history of GSS' semiconductor business:

- 1979--founded as a member of the Lucky-Gold Star Group
- 1980--started packaging business
- 1980--started semiconductor fabrication
- 1980--established joint venture and technology agreement with AT&T
- 1982--technology agreement with AT&T for digital ESS, superminicomputers, and MOS technology
- 1983--second-source agreement for Z80 MPUs with Zilog
- 1984--started production of Z80 family
- 1984--second-source agreement for 43000, 45000 gate arrays with LSI Logic
- 1984--completed MOS-I plant construction
- 1984--second-source agreement for 64K DRAMs with AMD
- 1984--completed MOS-II plant construction
- 1985--second-source agreement for LL-7000 with LSI Logic
- 1985--second-source agreement for CMOS 64K SRAM with Fairchild
- 1985--development of 512K and 1Mb ROM
- 1985--license agreement for standard cell with Barron Research
- 1986--license agreement for COMBO IC with Fairchild

Products:

- MOS memory--64K and 1M DRAM, 64K and 256K SRAM, 64K EPROM, 512K and 1M ROM
- MOS MPU--Z8, Z80 families
- Digital MOS--HC/HCT TTL, CD4000 TTL, telephone IC, ND converter

Gold Star Semiconductor, Ltd. (GSS)

- Linear bipolar--audio, video, and industrial ICs
- Digital bipolar--STTL, LSTTL, MODEMs, telephone ICs, CDI
- Semicustom--CMOS gate arrays, standard cell
- Hybrid IC--thin film
- Transistors--low-power, high-speed, medium-power, SCR/TRIAC

SEMICONDUCTOR PRODUCTION

	Bipolar and MOS I	MOS II
Address:	171 Imsu-dong, Gumi-si, Kyungbuk, Korea	533 Hogae-dong, Anyang-si, Kyungki-do, Korea
Manager:	D. H. Song	Dr. I.K. Kang
Date of first production:	February 1980/ September 1984	November 1984
Employees:	1,000	350

SEMICONDUCTOR AGREEMENTS

Partner	Country	Year	Technology
AT&T	United States	1980	Process technology 64K DRAM, 16K SRAM
Zilog	United States	1983	Z8, Z80 MCU, and MPU families
AMD	United States	1984	64K, 256K DRAM
LSI Logic	United States	1984	CMOS gate array
Fairchild	United States	1985	64K SRAM
UMI	United States	1985	HCT, TTL
Barron Research	United States	1985	Standard cell, BIMOS process

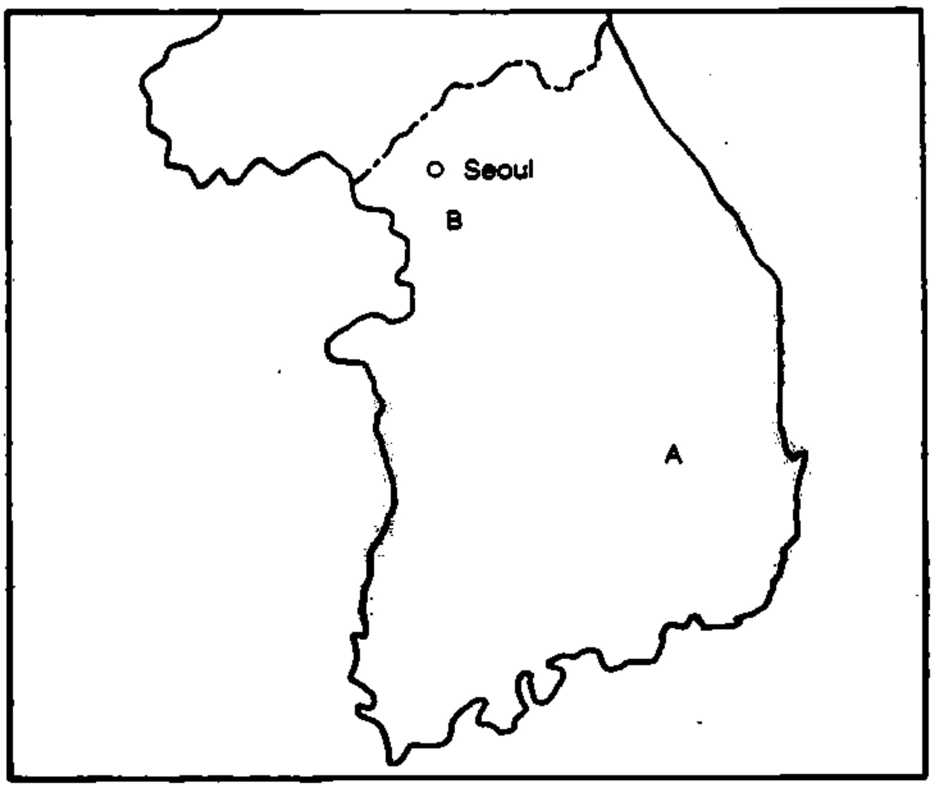
Gold Star Semiconductor, Ltd. (GSS)

MANUFACTURING FACILITIES

GSS' manufacturing facilities and their products are shown in Figure 1.

Figure 1

MANUFACTURING FACILITIES--GOLD STAR SEMICONDUCTOR



Source: Dataquest
September 1987

Hitachi, Ltd.

Hitachi, Ltd.
6, Kanda-Surugadai
4-chome, Chiyoda-ku
Tokyo, 101, Japan
(Billions of Yen)

Balance Sheet (March 31)

	1984	1985	1986	1987	1988
Total Current Assets	¥ 3,029	¥ 3,319	¥ 3,276	¥ 3,445	¥ 3,757
Cash	¥ 1,015	¥ 1,182	¥ 1,154	¥ 1,364	¥ 1,516
Receivables	¥ 945	¥ 971	¥ 971	¥ 1,011	¥ 1,081
Inventory	¥ 914	¥ 988	¥ 980	¥ 898	¥ 961
Net Property, Plant, & Eqp.	¥ 944	¥ 1,095	¥ 1,200	¥ 1,179	¥ 1,133
Depreciation	¥ 1,102	¥ 1,294	¥ 1,490	¥ 1,680	¥ 1,819
Total Assets	¥ 4,611	¥ 5,074	¥ 5,164	¥ 5,328	¥ 5,621
Total Current Liabilities	¥ 2,294	¥ 2,505	¥ 2,393	¥ 2,288	¥ 2,399
Long-Term Debt	¥ 325	¥ 323	¥ 370	¥ 489	¥ 433
Total Liabilities	¥ 2,877	¥ 3,113	¥ 3,083	¥ 3,130	¥ 3,214
Total Shareholders' Equity	¥ 1,734	¥ 1,961	¥ 2,081	¥ 2,198	¥ 2,407
Common Stock	¥ 140	¥ 140	¥ 140	¥ 141	¥ 180
Retained Earnings	¥ 1,109	¥ 1,294	¥ 1,416	¥ 1,485	¥ 1,594

Income Statement (March 31)	1984	1985	1986	1987	1988
Revenue	¥ 4,367	¥ 5,013	¥ 5,010	¥ 4,849	¥ 4,975
Domestic Sales	¥ 3,136	¥ 3,378	¥ 3,499	¥ 3,580	¥ 3,785
Overseas Sales	¥ 1,231	¥ 1,635	¥ 1,511	¥ 1,269	¥ 1,190
Cost of Sales	¥ 3,213	¥ 3,648	¥ 3,741	¥ 3,675	¥ 3,692
Gross Margin (%)	26	27	25	24	26
R&D Expense	¥ 212	¥ 268	¥ 296	¥ 308	¥ 324
SG&A Expense	¥ 581	¥ 650	¥ 667	¥ 651	¥ 708
Operating Income (Loss)	¥ 361	¥ 447	¥ 306	¥ 215	¥ 251
Interest, Net	46	62	65	43	80
Pretax Income	407	509	371	258	331
Effective Tax Rate (%)	52	53	53	54	52
Extraordinary Items, Net	(27)	(29)	(23)	(19)	(22)
Net Income	¥ 167	¥ 210	¥ 150	¥ 99	¥ 137
Avg. Shares Outstanding (M)	2,802	2,803	2,803	2,810	2,869
Employees	161,533	164,951	164,117	161,325	159,910
Capital Expenditure (¥M)	¥ 382	¥ 455	¥ 447	¥ 357	¥ 320
Exchange Rate (Yen per US$)	236	245	221	160	139

Source: Hitachi, Ltd. Annual Reports

Hitachi, Ltd.

Hitachi, Ltd.
6, Kanda-Surugadai
4-chome, Chiyoda-ku
Tokyo, 101, Japan
(Millions of Dollars)

Balance Sheet (March 31)	1984	1985	1986	1987	1988
Total Current Assets	$12,835	$13,547	$14,824	$21,531	$27,029
Cash	$ 4,301	$ 4,824	$ 5,222	$ 8,525	$10,906
Receivables	$ 4,004	$ 3,963	$ 4,394	$ 6,319	$ 7,777
Inventory	$ 3,873	$ 4,033	$ 4,434	$ 5,613	$ 6,914
Net Property, Plant, & Eqp.	$ 4,000	$ 4,469	$ 5,430	$ 7,369	$ 8,151
Depreciation	$ 4,669	$ 5,282	$ 6,742	$10,500	$13,086
Total Assets	$19,538	$20,710	$23,367	$33,300	$40,439
Total Current Liabilities	$ 9,720	$10,224	$10,828	$14,300	$17,259
Long-Term Debt	$ 1,377	$ 1,318	$ 1,674	$ 3,056	$ 3,115
Total Liabilities	$12,191	$12,706	$13,950	$19,563	$23,122
Total Shareholders' Equity	$ 7,347	$ 8,004	$ 9,416	$13,738	$17,317
Common Stock	$ 593	$ 571	$ 633	$ 881	$ 1,295
Retained Earnings	$ 4,699	$ 5,282	$ 6,407	$ 9,281	$11,468
Income Statement (March 31)	**1984**	**1985**	**1986**	**1987**	**1988**
Revenue	$18,504	$20,461	$22,670	$30,306	$35,791
Domestic Sales	$13,288	$13,788	$15,833	$22,375	$27,230
Overseas Sales	$ 5,216	$ 6,673	$ 6,837	$ 7,931	$ 8,561
Cost of Sales	$13,614	$14,890	$16,928	$22,969	$26,561
Gross Margin (%)	26	27	25	24	26
R&D Expense	$ 898	$ 1,094	$ 1,339	$ 1,925	$ 2,331
SG&A Expense	$ 2,462	$ 2,653	$ 3,018	$ 4,069	$ 5,094
Operating Income (Loss)	$ 1,530	$ 1,824	$ 1,385	$ 1,344	$ 1,806
Interest, Net	$ 195	$ 253	$ 294	$ 269	$ 576
Pretax Income	$ 1,725	$ 2,078	$ 1,679	$ 1,613	$ 2,381
Effective Tax Rate (%)	52	53	53	54	52
Extraordinary Items, Net	$ (114)	$ (118)	$ (104)	$ (119)	$ (158)
Net Income	$ 708	$ 857	$ 679	$ 619	$ 986
Avg. Shares Outstanding (M)	$ 2,802	$ 2,803	$ 2,803	$ 2,810	$ 2,869
Total Employees	161,533	164,951	164,117	161,325	159,910
Capital Expenditure (M)	$ 1,619	$ 1,857	$ 2,023	$ 2,231	$ 2,302
Exchange Rate (Yen per US$)	236	245	221	160	139

Source: Hitachi, Ltd.
Annual Reports

Hitachi, Ltd.

THE COMPANY

Executive Summary

The following paragraphs summarize significant information about Hitachi:

- Hitachi reported fiscal 1988 consolidated revenue of ¥4,975 billion, a 3 percent increase from fiscal 1987.
- Hitachi, Ltd., is the largest electronics manufacturer in Japan under the leadership of chairman, Hirokichi Yoshiyama, and president, Katsushige Mita.
- Hitachi, Ltd., is the third-largest worldwide supplier of semiconductors, with annual sales in calendar 1987 of $2,781 million.
- Hitachi retains its lead as the world's leading supplier of MOS memory products, with annual 1987 sales of $764 million.

The major shareholders of Hitachi are shown in Table 1.

Table 1

Hitachi, Ltd.
Major Shareholders

Shareholder	Percent Shares
Mitsubishi Trust	4.5%
Nippon Life Insurance	4.0%
Toyo Trust	2.9%
Mitsui Trust	2.9%
Dai-Ichi Mutual Life Insurance	2.7%
Industrial Bank of Japan	2.5%
Sanwa Bank	2.4%
Group Companies' Stockholders	2.3%
Yasuda Trust	2.2%

Source: Japan Company Handbook

Hitachi, Ltd.

OVERVIEW

Hitachi, Ltd., was founded to develop indigenous Japanese electrical power equipment manufacturing technology. The Company initially emphasized the development of heavy electrical equipment and industrial machinery. After World War II, Hitachi expanded into the consumer product area, and in the 1950s, entered the electronics field, producing computers, semiconductors, and other electronic devices.

Over the years, Hitachi continued to expand and diversify the scope of its business activities, which led to the development of the Hitachi Group. The Hitachi Group is made up of Hitachi, Ltd., domestic and overseas and its subsidiaries and affiliates, including the three major subsidiaries—Hitachi Chemical, Hitachi Metals, and Hitachi Cable. The group companies conduct business in the fields of electrical and electronic equipment, metals, metallic products, machinery, chemicals, trading, and transportation.

New technologies and products developed by Hitachi are the driving force behind its progress. The Company has consistently maintained a high level of research and development (R&D) expenditure and places special emphasis on areas with high-growth potential. Hitachi views electronics and the development of alternative energy sources as its two areas of strategic growth during the 1980s.

Hitachi is also intensifying its international activities to increase its presence as an international corporation.

Of Hitachi's outstanding stock, 13.3 percent is owned by non-Japanese parties. Hitachi is listed on the Amsterdam, Frankfurt, Hong Kong, Luxembourg, Paris, and New York stock exchanges, as well as on the eight domestic markets.

Major short- and long-term Hitachi borrowings are from Dai-Ichi Kangyo Bank, Fuji Bank, Industrial Bank of Japan, and Sanwa Bank.

OPERATIONS

Consolidated revenue of ¥4,975 billion in the period ending March 31, 1988, increased slightly from the previous year's sales of ¥4,849 billion. Net income was ¥137 billion, an increase of 38 percent from ¥99 billion in 1987.

The improved results were attributed mainly to advances in the computer segment, a recovery in the semiconductor segment, and an upswing in domestic demand. These positive factors offset declines in the Company's Power Systems and Equipment and Consumer Products sectors. Hitachi's revenue by line of business is shown in Table 2.

Hitachi, Ltd.

Table 2

Hitachi, Ltd.
Revenue by Lines of Business
(Billions of Yen)

	Fiscal Year Ending March 31				
	1984	1985	1986	1987	1988
Consumer Products	¥ 930	¥1,104	¥1,081	¥ 870	¥ 821
Industrial Machinery & Plants	730	786	835	809	829
Information & Communications Systems/Electronic Devices	1,174	1,507	1,452	1,491	1,659
Power Systems & Equipment	727	720	761	827	766
Wire & Cable, Metals, Chemicals, & Other	806	896	8 81	852	900
Total	¥4,367	¥5,013	¥5,010	¥4,849	¥4,975
Exchange Rate (Yen per US$)	¥ 236	¥ 245	¥ 221	¥ 160	¥ 139

Source: Hitachi, Ltd.
Annual Reports
Dataquest
July 1988

The electronics sector posted an 11 percent gain partly due to a demand for large computer systems from the financial and service sectors. The Company's semiconductor operations also contributed to the gain as a result of the shipment of 1Mb DRAMs and other memory devices. Hitachi is one of the top four suppliers of communication equipment to Nippon Telegraph and Telephone (NTT), along with Fujitsu Limited, NEC Corporation, and Oki Electric Industry Company Limited.

The Company's Industrial Machinery and Plants division and Other Products Division both reported sales increases in 1988. The increases were attributed to building construction growth and the public works-related sectors, two areas that benefited from the rise in domestic demand.

The Consumer Products Division showed a sales decrease in 1988 despite brisk domestic sales of audio/video equipment and related products. The decrease was due to declining prices, intense competition, and the depressing effect of the yen on exports.

Hitachi, Ltd.

International Activities

Hitachi reported a decrease in overseas revenue for the third year in a row. Overseas revenue for 1988 was ¥1,190 billion compared with ¥1,269 billion in 1987 and ¥1,511 billion in 1986. In 1980, Hitachi stated that it planned to increase exports to 30 percent of total revenue, a figure it surpassed in 1985. Since then, overseas revenue was 30 percent of total revenue in 1986, 26 percent in 1987, and 24 percent in 1988. Total revenue has increased from ¥2,937 billion in 1980 to ¥4,975 in 1988.

Hitachi is taking the following steps to improve its position as an international corporation:

- Continuing to increase R&D investment
- Improving production technology and reducing costs
- Increasing its overseas production bases
- Increasing overseas materials procurement
- Promoting cultural and technology exchanges—Hitachi set up The Hitachi Foundation to further U.S.-Japanese exchanges
- Boosting the efficiency of fund utilization

Channels of Distribution

Hitachi has developed a global network of production, exports, material and funds procurement, and a sales operation that includes eight overseas consolidated subsidiaries and liaison, sales, and service offices in most major countries of the world. The Company's worldwide sales organization consists of offices throughout North, Central, and South America; Western Europe; and Asia and Oceania. The Company's semiconductor products are marketed overseas through distributors and by Hitachi's own sales force.

In Japan, almost 70 percent of Hitachi's semiconductor products are marketed through distributors, and 30 percent are marketed by the Company's sales force, as follows:

- Hitachi distributes consumer products through Hitachi Sales Corporation, a 66-percent-owned consolidated subsidiary with sales offices throughout Japan, which in turn distributes the products through wholesalers to retail outlets.

- Computer equipment may be purchased or rented directly from the Company. Some Hitachi computers are rented through Japan Electronic Computer Co., Ltd., a rental company owned by the major Japanese computer manufacturers—Fujitsu, Mitsubishi, and NEC.

- Hitachi has three major Japanese distributors: Nissei Denshi Co., Ltd., Nissei Sangyo, and Easton Electronics.

Hitachi, Ltd.

Facilities

Hitachi's 18 Japanese semiconductor manufacturing facilities are listed in Table 3. Hitachi also has a plant in Irving, Texas, that assembles MOS memory products for sale in the United States. In February 1988, Hitachi announced that it was expanding the Texas plant into a full-scale production unit. The plant will perform wafer fabrication and test in addition to assembly. The Company expects the installation of clean rooms to be completed by December 1988 and wafer fabrication to begin by May 1989. Initially, the facility will produce 1.3-micron MOS memories, with MCUs and ASICs to be added at a later date. Hitachi assembles MOS memory products for sale in Europe in Landshut, West Germany.

Table 3

Hitachi, Ltd.
Japanese Semiconductor Manufacturing Plants

Factory	Floor Space (m^2)	Products/Function
Akita Denshi	N/A	Assembly--linear, discrete
Akita Denshi Yuwa Factory	N/A	Assembly--linear, discrete
Hitachi Chitose Factory	2,790	Assembly--MOS memory
Hitachi Device Development Center	N/A	Fab, test--bipolar digital, MOS
Hitachi Factory	N/A	Rectifiers, TTL
Hitachi Hokkai Semiconductor	N/A	Assembly, test--MOS memory
Hitachi Iruma Denshi	N/A	Assembly--MOS logic
Hitachi Iruma Goshogawara Factory	6,000	Assembly--discrete
Hitachi Oume Denshi	N/A	Assembly, test--MOS logic
Hitachi Oume Yanai Factory	N/A	Assembly--diodes
Hitachi Yonezawa Denshi	N/A	Assembly--linear, discrete
Kofu Branch Factory	13,500	Fab, assembly, test--MOS memory, MPU, logic, 256K DRAM
Mobara Factory	205,000	Fab, assembly, test--MOS memory
Musashi Factory	N/A	Fab, assembly, test--ICs, discrete, opto
Naka Factory	N/A	Fab--MOS memory
Nissin Kogyo Tsuchiura Factory	N/A	Assembly
Takasaki Factory	N/A	Fab, assembly, test--bipolar Digital, transistors
Takasaki Komoro Branch Factory	N/A	Assembly test--ICs, discrete, laser diodes

N/A = Not Available

Source: Dataquest
July 1988

Capital Spending and Research and Development Spending

Hitachi invested ¥405 billion in fiscal 1988 in plant and equipment, a 12 percent increase compared with ¥357 billion invested in fiscal 1987.

Hitachi continues to increase investment in R&D, which reflects the corporate philosophy that the development of leading-edge technology is essential to the Company's long-term growth. During fiscal 1988, the Company spent ¥324 billion on R&D, an increase of 5 percent from fiscal 1987. In fiscal 1981, R&D spending was only 3.7 percent of revenue; in fiscal 1988, R&D spending was 7 percent of revenue. Over the past several years, about half of R&D has been directed into the electronics sector.

Table 4, shows the continued commitment by Hitachi to both R&D and capital investments.

Table 4

Hitachi, Ltd.
Capital Spending and R&D Spending as a Percent of Revenue
(Billions of Yen)

	1984	1985	1986	1987	1988
Revenue	¥4,367	¥5,013	¥5,010	¥4,849	¥4,975
Capital Expenditures	¥ 382	¥ 455	¥ 447	¥ 357	¥ 320
Percent of Revenue	9	9	9	7	6
R&D Expense	¥ 212	¥ 268	¥ 296	¥ 308	¥ 324
Percent of Revenue	5	5	6	6	7
Combined Capital and R&D Spending	¥ 594	¥ 723	¥ 743	¥ 665	¥ 644
Percent of Revenue	14	14	15	13	13
Exchange Rate (Yen per US$)	236	245	221	160	139

Source: Hitachi, Ltd.
Annual Reports

Hitachi, Ltd.

Table 5 shows Hitachi's capital spending and R&D spending in dollars.

Table 5

Hitachi, Ltd.
Capital Spending and R&D Spending
(Millions of Dollars)

	1984	1985	1986	1987	1988
Revenue	$18,504	$20,461	$22,670	$30,306	$35,791
Capital Expenditures	$ 1,619	$ 1,857	$ 2,023	$ 2,231	$ 2,302
Percent of Revenue	9	9	9	7	8
R&D Expense	$ 898	$ 1,094	$ 1,339	$ 1,925	$ 2,331
Percent of Revenue	5	5	6	6	7
Combined Capital and	$ 2,517	$ 2,951	$ 3,362	$ 4,156	$ 4,633
Percent of Revenue	14	14	15	13	13
Exchange Rate (Yen per US$)	236	245	221	160	139

Source: Hitachi, Ltd.
Annual Reports

Table 6 shows Hitachi's semiconductor capital spending as a percent of the Company's semiconductor revenue by calendar year. Dataquest believes that Hitachi's semiconductor capital investment will be $385 million in calendar 1988, an increase of 85 percent from the $208 million invested in 1987.

Table 6

Hitachi, Ltd.
Semiconductor Capital Spending by Calendar Year
(Millions of Dollars)

	1983	1984	1985	1986	1987
Semiconductor Revenue	$1,277	$2,051	$1,671	$2,307	$2,781
Semiconductor Capital Spending	$ 264	$ 506	$ 387	$ 318	$ 208
Percent of Semiconductor Revenue	21%	25%	23%	14%	7%

Source: Dataquest
July 1988

Hitachi, Ltd.

In the first quarter of 1988, Hitachi announced that it intended to resume semiconductor production in the United States. The Company had stopped investing in the United States after it completed a factory building in Irving, Texas, in early 1987. Since semiconductor demand has been steadily recovering since the latter half of 1987, Hitachi has decided to resume its investment in the factory. It plans to begin fully integrated production of SRAMs, mainly 256K models, in the spring of 1989. Hitachi will be the first Japanese semiconductor maker to start fully integrated production of SRAMs in a foreign country.

Hitachi's stated attitude toward research and development is reflected in the following objectives:

- Focus strongly on the development of cutting-edge technology
- Develop original technology (i.e., not to rely on imported technology)
- Concentrate on basic research as well as on applied technology (Advanced Research Laboratory established in 1985 to develop technologies for Hitachi's long-term growth)

Hitachi operates 11 R&D centers as listed below:

- Central Research Laboratory (Kokubunji City)
- Hitachi Research Laboratory (Hitachi City)
- Mechanical Engineering Research Laboratory (Tsuchiura City)
- Energy Research Laboratory (Hitachi City)
- Production Engineering Research Laboratory (Yokohama Works)
- System Development Laboratory (Kawasaki City)
- Design Center (Kodaira City)
- Consumer Products Research Center (Yokohama City)
- Device Development Center (Kodaira City)
- Microelectronics Products Development Laboratory (Yokohama City)
- Advanced Research Laboratory

There are also independent research groups in each factory.

Hitachi, Ltd.

Hitachi also conducts research and development in cooperation with other Japanese companies:

- Hitachi and NTT will conduct research in the area of small-ring SOR (synchrotron orbital radiation) equipment. A project involving a 64Mb + a DRAM ring began in the fall of 1987.

- In 1986, Hitachi joined seven other Japanese companies (Fujitsu, Matsushita, Mitsubishi, NEC, NTT, Oki Electric, and Toshiba) to form the TRON Council (The Real-Time Operating Nucleus) to accelerate the development of proprietary 32-bit MPU technology and operating systems for next-generation microcomputers.

  - Headed by Hitachi's Kazuo Kanahara, the project is developing three operating systems capable of handling Japanese and other foreign languages.

  - These systems are B-TRON for office automation equipment, I-TRON for real-time industrial systems, and M-TRON for networking with distributed processors.

  - Hitachi, NEC, and others have already developed several I-TRON operating systems for 16-bit and 32-bit MPUs.

  - In March 1986, Hitachi announced TRON-based operating systems to be used with foreign MPUs in industrial applications. Hitachi has developed a system for Motorola's 68000.

- In February 1986, Hitachi and General Motors agreed to an extensive tie-up to pursue joint R&D and production projects in six high-technology areas: automotive parts, semiconductors and other electronics, computers, optical fibers, magnetic and other new materials, and factory automation.

- Hitachi, Toshiba Corporation, and General Electric Company are working jointly in the area of energy management.

In addition, Hitachi participates in the following government sponsored programs:

- The VLSI Research Association—a four-year program begun in 1976 and 50 percent subsidized by the Japanese government

- The Fifth Generation Computer project—eight companies that formed a joint venture to develop a 900,000-word electronic dictionary for fifth-generation computers

PRODUCTS AND MARKETS

Semiconductor Product Markets

Hitachi is the third largest worldwide semiconductor manufacturer with $2,781 million in 1987 revenue, of which 53 percent is MOS digital, see Table 7. The Company made extraordinary gains in MOS microcomponents and MOS logic. MOS microcomponent revenue grew 79 percent from $240 million in 1986 to $429 million in 1987 and MOS logic grew 137 percent from $113 million to $268 million.

Table 7

Hitachi, Ltd.
Estimated Semiconductor Revenue
(Millions of Dollars)

	1983	1984	1985	1986	1987
Total Semiconductor	$1,277	$2,051	$1,671	$2,307	$2,781
Total Integrated Circuit	$ 912	$1,569	$1,236	$1,771	$2,169
Bipolar Digital (Technology)	144	223	195	339	410
TTL	-	170	143	243	302
ECL	-	36	36	82	94
Other Bipolar Digital		17	15	14	14
Bipolar Digital (Function)	144	223	195	339	410
Bipolar Digital Memory	52	59	55	80	93
Bipolar Digital Logic	92	164	140	259	317
MOS (Technology)	638	1,167	852	1,167	1,461
NMOS	383	708	493	668	788
PMOS	4	8	3	3	2
CMOS	251	451	356	496	671
MOS (Function)	638	1,167	853	1,167	1,461
MOS Memory	500	971	662	814	764
MOS Micro Devices	85	120	110	240	429
MOS Logic	53	76	81	113	268
Linear	130	179	189	265	298
Total Discrete	$ 331	$ 430	$ 393	$ 476	$ 544
Transistor	123	155	137	174	198
Diode	164	213	194	235	268
Thyristor	17	22	22	25	29
Other Discrete	27	40	39	42	49
Total Optoelectronic	$ 34	$ 52	$ 42	$ 60	$ 68
Exchange Rate (Yen/US$)	235	237	238	167	144

Source: Dataquest
July 1988

Hitachi, Ltd.

Hitachi retained its position as the largest MOS memory supplier in 1987, with sales of $764 million. However, the amount is a 6 percent decrease from the $814 million reported in 1986. The wide gap that existed between Hitachi and all other MOS memory suppliers in 1986 is now almost nonexistent. NEC, the next largest MOS memory supplier, had 1986 MOS memory revenue of $586 million and 1987 MOS memory revenue of $707 million.

Overall, Hitachi did grow as fast as the industry as a whole. See Table 8 for Hitachi's worldwide ranking and the Company's 1986–1987 growth rate compared with the industry growth rate.

Dataquest estimates that approximately 69 percent, or $1,929 million, of Hitachi's semiconductor sales were to Japan. Approximately, 13 percent were to the United States, 7 percent to Europe, and the remaining 11 percent to the ROW countries. Table 9 shows Hitachi's semiconductor revenue by geographic region.

Table 8

Hitachi, Ltd.
Worldwide Ranking by Semiconductor Markets
(Millions of Dollars)

	1986 Rank	1987 Rank	1987 Revenue	Revenue % Change 1986-1987	Industry % Change 1986-1987
Total Semiconductor	2	3	$2,781	20.5%	23.0%
Integrated Circuits	2	2	2,169	22.5%	25.5%
Bipolar Digital	7	7	410	20.9%	8.4%
MOS Digital	2	4	1,461	25.2%	34.3%
Linear	9	9	298	12.5%	19.4%
Discrete	3	3	544	14.3%	17.0%
Opto	8	9	68	13.3%	7.4%

Source: Dataquest
July 1988

Hitachi, Ltd.

Table 9

Hitachi, Ltd.
Estimated Semiconductor Revenue by Geographic Region—1987
(Millions of Dollars)

	United States	Japan	Europe	Rest of World	Total
Total Semiconductor	$365	$1,929	$180	$307	$2,781
Integrated Circuit	320	1,474	169	206	2,169
Bipolar Digital	47	261	11	91	410
MOS	256	950	152	103	1,461
Linear	17	263	6	12	298
Discrete	20	427	7	90	544
Optoelectronic	25	28	4	11	68

Source: Dataquest
July 1988

Semiconductor Products and Technologies

Hitachi's semiconductor products span the entire range, including bipolar digital memory and logic, MOS memory, microdevices and logic, linear ICs, and all types of discrete and optoelectronic devices.

To reinforce its semiconductor business, Hitachi continued to push ahead with a vigorous program of research and development related to advanced products and also to diversify its product line. In fiscal 1986, the Company focused on expanding its range of microprocessors, gate arrays, and other logic devices while moving to bring its 1.3-micron process on-line.

Hitachi, Ltd.

The following are some of Hitachi's 1987 and 1988 product announcements:

Analog

- Hitachi developed a coder-decoder IC and a phase-locked loop (PLL) IC for coded mark inversion (CMI) communication using a 2-micron rule HIBICMOS process. The HD153201 and HD152202 function in high-speed data transmission (up to 32 Mbps) and also feature high-speed response and low-power consumption.

Application-Specific Integrated Circuits

- Hitachi's HG62E Series of CMOS gate arrays incorporate an automatic diagnostic function consisting of functions for automatic test circuit creation and test pattern generation. The series is fabricated using 1.0-micron CMOS process technology, offers a typical gate delay of 0.7ns, and is available with up to 24,000 gates.

- Hitachi made plans to enter the next-generation gate array market by commercializing a sea-of-gates technology. Several models with 20,000 to 50,000 gates were planned for sale in the spring of 1988.

Gallium Arsenide

- Under the MITI Scientific Computing Systems Program, Hitachi's Central Research Lab in Kokubunji, Tokyo, has fabricated and tested ECL-compatible 1K and 4K GaAs enhancement/depletion (E/D) mode, direct-coupled FET logic (DCFL) SRAMs. The chips have an access-time spread of less than 1ns and use conventional Schottky-coupled FET logic (SCFL) interface circuit structures for improved noise margin.

Memory

- Hitachi began 1Mb DRAM assembly at Hitachi Semiconductor, Malaysia.

- Hitachi planned to increase memory production between October 1987 and March 1988 to 30 percent of the Company's total semiconductor production. The increase will be focused on high value-added products such as 1Mb DRAMs.

- Hitachi announced plans to begin 4Mb DRAM production in 1988. The 4Mb DRAM employs a 0.8-micron CMOS process technology and offers an 80ns access time. The device has three column access functions: high-speed page mode, nibble mode, and static column mode. Bit organization is selectable from both the x1 and x4 versions. For high-density board design, the chip can be housed in a small outline J-bend package or in a zig-zag in-line package.

- Hitachi announced that it has developed a 16Mb DRAM with an access time of 60ns. The DRAM is fabricated using 0.6-micron CMOS technology and is organized 16Mbx1.

Hitachi, Ltd.

- Hitachi introduced the HD63487 Memory Interface and Video Attribute Controller (MIVAC), a single-chip graphics support device. When used with Hitachi's existing advanced CRT controller chip and Hitachi's 1Mb DRAM, the device can be used to build a low-cost graphics system in the space of a business card. Such a system can draw images into its memory at 2 million pixels per second and then transfer those images to a CRT at 33 million pixels per second.

- Hitachi is producing 64K SRAMs with an access time of 15ns. Bit configuration is available in either x1 or x4.

- Hitachi is offering the HM100500-15, a 256K SRAM with an access time of 15ns. The device is fabricated using a 1.0-micron HIBICMOS technology.

- Hitachi has developed the HM628128, a 1Mb CMOS SRAM organized 128Kx8. The device employs a 0.8-micron HICMOS process.

- Hitachi announced plans to boost production of 1Mb pseudo SRAMs as a result of increased demand from OA equipment makers. SRAMs will be increased to 100,000 units per month from the current 50,000 units at the Naka Plant in Ibaraki prefecture. The Company also announced plans to sample 4Mb pseudo SRAMs.

- Hitachi stopped production of 64K DRAMs and 64K and 128K EPROMs and increased production of 512K and 1Mb EPROMs and MCUs.

Microprocessors/Microcontrollers

- Hitachi is offering the HD64180Z, an 8-bit MPU that operates at 8 MHz. The device contains MMU, direct memory access controller, a memory refresh unit, two serial communication interfaces, two 16-bit timers, and an interrupt controller. The device is in production now.

- The G Micro Group, which consists of Fujitsu Ltd., Hitachi, and Mitsubishi Electric Corporation, developed a 32-bit MPU and three models of peripheral LSIs based on the TRON operating system. The GMICRO200, an MPU developed by Hitachi, integrates about 73,000 transistors on one chip. Hitachi plans to begin volume production in the autumn of 1988. The three peripheral LSIs, including a direct memory access controller, were developed by Fujitsu. Fujitsu and Mitsubishi also plan to begin volume production of the 32-bit MPU by licensing the Hitachi technology.

- Hitachi sampled the HD6840F controller that converts RGB video signals to LCD drive signals.

- Hitachi reported that it will discontinue production of six models of CMOS 8-bit microcontrollers that use Motorola architecture. The Company negotiated with Motorola to continue production, but did not reach an agreement. The HD63705V, HD63705Z, and HD6305Z will be discontinued as of March 31, 1990. The HD63701V, HD63701X, and HP63701Y will be discontinued as of March 21, 1991.

Optoelectronics

- Hitachi's Central Research Lab fabricated a family of three optoelectronic ICs (OEICs). The circuits include a 4-GHz laser driver, a 2.4-GHz preamp, and a 2.4-GHz gain-controlled amplifier implemented with 0.7-micron gate GaAs SAG MESFET processing. Hitachi plans to refine GaAs ICs to achieve at least 10-GHz optical transmit/receive rates.

- Hitachi developed a new plastic optical fiber capable of withstanding temperatures as high as 170 degrees centigrade. The new fiber is suitable for installation in car engine chambers or near heating equipment in buildings.

Superconductivity

- Hitachi's Central Research Laboratories created a prototype superconducting quantum interference device (SQUID) using thin-film processing and lithographic techniques similar to those used in semiconductor device production.

Manufacturing Equipment

- Hitachi developed a new technology for low-temperature dry etching, which is capable of realizing 0.3-micron circuit width. Hitachi has manufactured a low-temperature microwave plasma etching machine on an experimental basis. The Company believes that this technological breakthrough will be a major step forward toward the development of next-generation LSIs, including 64Mb DRAMs.

Semiconductor Agreements

The following is a list of Hitachi's 1987 and 1988 semiconductor agreements by year:

Fujitsu. Fujitsu and Hitachi have connected their respective digital private branch exchange (PBX) machines with NTT's large ISDN switches, the model D707, for use in telephone offices.

IR. International Rectifier agreed to license its power MOSFET patents to Hitachi. Hitachi may use and sell devices incorporating any of IR's power MOSFET products worldwide. Hitachi will pay undisclosed royalties as well as other payments.

Hitachi, Ltd.

VLSI. VLSI Technology and Hitachi signed a long-term technology alliance under which VLSI Technology will provide its ASIC design technology for use in Hitachi Semiconductor and Integrated Circuits Divisions. Hitachi will provide advanced CMOS process technology and manufacturing expertise. The technology will begin at the 1.0-micron level and continue at submicron levels. Included in the agreement are cell libraries and foundry support.

The following is a list of Hitachi's 1986 semiconductor agreements:

Fairchild. Hitachi signed a five-year agreement to become the first alternate source for Fairchild's FACT (Fairchild Advanced CMOS Technology) logic. Fairchild gave Hitachi its design data base for 20 devices.

Fujitsu. Fujitsu and Hitachi will cooperate in developing a 32-bit MPU and peripheral LSI family based on the TRON architecture. The TRON chip will be 1.0- to 1.3-micron CMOS and will integrate 700,000 transistors.

General Motors. Hitachi and General Motors agreed to an extensive tie-up to pursue joint R&D and production projects in six high-technology areas: automotive parts, semiconductors and other electronics, computers, optical fibers, magnetic and other new materials, and factory automation.

Monsanto. Hitachi agreed to share its silicon wafer manufacturing technology with Monsanto. Monsanto will send wafer engineers to Hitachi to acquire the technology necessary to manufacture products to meet Hitachi's standards.

NTT. Hitachi announced a direct-write electron beam machine capable of writing 0.1-micron circuit patterns on a wafer at a rate of one hour per wafer. The machine was jointly developed with NTT's Atsugi Laboratory, with plans for Hitachi to market the machine in the second half of 1987.

Riken. Hitachi and Riken will jointly develop the Quantum Flux Parametron, an ultrahigh-speed switching element with a 50-picosecond switching speed and 1.8-GHz clock frequency. The new device can operate without electrical voltage and has a power dissipation of one-thousandths that of a Josephson junction.

Signetics. Hitachi acquired manufacturing and sales licenses from Signetics for two telecommunication LSI models (HD68562 and HD64941) for transferring data between terminals and mainframe computers.

Toyohashi University. Hitachi Works and Toyohashi Technology and Science University announced a hybrid electron/ion beam manufacturing equipment prototype jointly developed since 1983 under the auspices of the Ministry of Education's R&D program.

Zilog. Zilog is licensed to second source Hitachi's 8-bit CMOS MPU (HD64180). Zilog will market the Z80-compatible device under the Z64180 label.

Hitachi, Ltd.

The following is a list of Hitachi's 1985 semiconductor agreements:

Hewlett-Packard. HP is allowed to manufacture 64K DRAMs using Hitachi's photomasks and 3-micron rule NMOS process. HP does not sell these devices on the open market.

Microtec. Microtec agreed to develop a microassembler, utilities, and Pascal and C compilers to run on Hitachi's first standalone in-circuit emulator for the HD64180 8-bit CMOS MPU, which is compatible with the Z80 and 8080 families.

Motorola. Motorola and Hitachi announced 2-micron HCMOS versions of the 6800; Motorola was granted a license to second source Hitachi's HD6310V and HD6303R 8-bit microcontrollers.

Signetics. Hitachi licensed its 63484 CRT controller to Signetics in exchange for Signetics' 68562 data exchange IC.

Sophia. Hitachi and Sophia Systems jointly agreed to manufacture a Systems development support system for Hitachi's original microprocessors.

SGS-Thomson. Hitachi licensed its 6300 series (CMOS 8-bit MCUs) to Thomson in return for Thomson's telecommunication ICs.

Unisys. Unisys and Hitachi agreed to a technology exchange and joint development effort to study the feasibility of using Hitachi's high-speed ICs in Sperry's 1100 system architecture; Hitachi already manufactures Sperry's personal computer.

Nonsemiconductor Products Summary

Consumer Products

Products in this division are television sets, radios, tape recorders, video tape recorders, video cameras, air conditioners, washing machines, refrigerators, microwave ovens, vacuum cleaners, space heaters, kitchen appliances, lighting fixtures, dry batteries, and audio and video tapes.

Recent highlights of this division include the following.

- Hitachi introduced the VM-C30A camcorder capable of creating a high-resolution image of 350 lines with the use of an MOS image sensor. The sensor contains 300,000 pixels and can capture colors, light, and shadow to a precise degree.

- Hitachi developed the Compatible Player VIP-35C that can be used with compact disks, laser disks, and the newly developed CD video.

- Hitachi reinforced its line of air conditioners that feature both cooling and heating functions with a new series of products that employ inverter control to maintain an environment for optimum efficiency.

Industrial Machinery and Plants

Products in the Industrial Machinery and Plants Division include rolling mill equipment, chemical plants, construction machinery, elevators, industrial robots, and refrigeration and air conditioning equipment.

In the development of new sectors, the Company is concentrating mainly on biotechnology equipment and semiconductor production equipment. Recently, Hitachi marketed a microinjector system that uses a laser beam to implant genes into cells, and a microwave plasma etch system capable of producing pattern lines as fine as 0.8– to 0.5–micron.

As part of the Company's effort to enhance its mature products, Hitachi is adding value through the incorporation of microprocessors and inverters. For example, in the construction equipment sector, Hitachi marketed a new hydraulic excavator that uses microprocessor control for optimization of engine speed and hydraulic fluid flow. The result is improved efficiency and quieter operation.

The following are a few of this division's recent highlights:

- Hitachi developed a centrifugal–type air–to–water heat pump that covers up to 3,516 kW (1,000 RT) in cooling mode and 2,791 kW (2.4 Gcal/h) in heating mode.

- Hitachi developed a hot–wire air–flow sensor for use in automobile engines. The sensor is designed to measure the air–flow mass to the engine intake manifold without compensating for air density, which can change in accordance with surrounding temperature.

- Hitachi has produced the model M5030 welding robot that emphasizes the Company's "Superior Functions, Simple Operation" philosophy. The M5030 incorporates a menu–guidance system enabling simple instruction of the robot regarding operational steps and conditions.

Information and Communication Systems and Electronic Devices

This division's products include computers, office automation (OA) equipment, semiconductors, other electronic devices, communications equipment, measuring equipment, and medical equipment. This is by far Hitachi's largest division.

- Hitachi introduced the 5.25–inch DK514–38 hard disk drive for small–scale mainframes, superminicomputers, and minicomputers. The drive features a compact size, 382–Mbyte storage capacity, and 1.8–Mbyte data transfer rate.

- Hitachi introduced the H–6916 semiconductor memory storage subsystem that replaces conventional magnetic disk drives with 1Mbit DRAMs. The unit is suited as a filing system for frequently accessed information because it handles relatively small amounts of information at high speed.

- Hitachi developed the multifunction, expandable filing system series named HITFILE650. The system uses optical disks to store information and uses either 5.25-inch disks for small capacity or 12-inch disks for larger storage needs.

- Hitachi designed the B16LX laptop personal computer that features a built-in Japanese 140,000-word ROM dictionary and a sequential kana to kanji ideograph conversion function. The B16LX comes in models with a built-in 20-Mbyte hard disk drive or with a built-in asynchronous modem (300/1,200bps) and autodialing software.

- Hitachi developed a switching module to work with NTT's ISDN network. The module can transmit two full-duplex 64 Kbps channel simultaneously and connect a maximum of eight terminals, including digital telephones, facsimile machines, and other office automation subscribers.

Power Systems and Equipment

Hitachi is a major supplier of 1,100 MW-Class boiling water reactors. In addition to BWRs, this division produces nuclear, hydroelectric, and thermal power plants; water, steam, and gas turbines; generators; transformers; circuit breakers; motors; control equipment; switchboards; and automobile parts and accessories.

The following are a few of this division's highlights:

- Hitachi, in conjunction with Toshiba Corporation, and General Electric Company, successfully developed a 1,350 MW-Class advanced boiling water reactor (ABWR). The ABWR features an improved turbine apparatus that provides economical power generation while simultaneously assuring a high level of operating safety.

- The Chubu Electric Power Co., Ltd., and Hitachi developed a 40-inch long blade for application in the last stage of a steam turbine. The blade is said to be the longest in the world for use in a 3,600-rpm turbine.

- In 1987, Hitachi delivered a 100 kW photovoltaic power generation system to the Kyushu Electric Power Co., Inc. The system is designed for use in combination with a diesel power generator and was specially developed for use in remote islands.

Wire and Cable, Metals, Chemicals, and Other Products

The products of this division include electric wire and cable, optical fiber cable, steel, cast iron products, synthetic resin materials and products, carbon and graphite products, printed circuit boards, and ceramic materials.

Hitachi, Ltd.

In October 1987, research commenced at Hitachi Chemical's Tsukuba Reseach Laboratory. The laboratory will conduct both research and production of prototypes in connection with optoelectronic materials, thin-film products, and other such developments for future products. Over the long term, the laboratory is expected to play an important role in Hitachi Chemical's effort to strengthen it competitiveness.

Hyundai Electronics Industries Co., Ltd.

THE COMPANY

Overview

The Hyundai Group was founded as a construction company in 1947. The firm is now the largest business organization in South Korea. It has worldwide operations in construction, shipbuilding, steel fabrication, automobile manufacturing, and electronics. Its 32 affiliated companies, including five in the United States, employ more than 150,000 people. Hyundai's total 1987 sales were US$19 billion.

BACKGROUND

Hyundai Electronics Industries (HEI) was established in February 1983 by the Hyundai Group. A sister company, Hyundai Electronics America (HEA), formerly Modern Electrosystems, Inc., was founded about the same time, in March 1983. HEI encompasses six technical divisions: Semiconductor Manufacturing, Semiconductor R&D, Semiconductor Assembly and Test, Information Systems, Telecommunications, and Industrial Electronics. Of these, three are related to semiconductor operations, and one is a laboratory.

MAIN PRODUCTS

The Company's main products are semiconductors, computers and peripherals, mobile telephones, communication equipment, automobile electronics, industrial instrumentation, and control systems.

Its semiconductor products include:

- CMOS memory: 16K, 64K, and 256K SRAM; 128K ROM; 1K EEPROM; 64K, 256K, and 512K EPROM; 256K and 1M DRAM
- Gate array: LL-7000 gate array

SEMICONDUCTOR DIVISIONS

Semiconductor Manufacturing Division: General Manager—Dr. K.H. Oh (senior vice president)

Semiconductor R&D Division: General Manager—Dr. K.O. Park (senior vice president)

Semiconductor Assembly and Test Division: General Manager—Y.Y. Rha (vice president)

Semiconductor Marketing and Sales Division: General Manager—T.H. Kim (senior vice president)

Hyundai Electronics Industries Co., Ltd.

SEMICONDUCTOR PRODUCTION

Address: 133–2 Ami–ri, Bubal–myun, Ichon–kun Kyungki–do, South Korea

Date of first production:
Semiconductor Plant I—October 1984
Semiconductor Plant II—July 1985
Semiconductor Plant III—September 1986
Assembly—February 1985

Employees: 2,000

Capital spending (Millions of U.S. Dollars):

	1983	1984	1985	1986	1987
All plants	$30	$131	$129	$37	$35
R&D	5	7	12	6	13
Total	$35	$138	$141	$43	$48

Design centers: Originally, Hyundai operated two design groups, one at Inchon, South Korea, and the other at HEA in the United States, serving in–house product development needs. In 1985, HEA announced the closing of engineering and manufacturing activities, which included the U.S. design center.

JOINT VENTURES/LICENSING

Partner	Country	Year	Technology
Hyundai Electronics America	United States	1983	NMOS, CMOS process
Texas Instruments	United States	1984	64K DRAM
International CMOS Technology	United States	1984	EEPROM, EPROM, PEEL
INMOS	United Kingdom	1984	256K DRAM
Western Design Center	United States	1985	8-bit, 16-bit, CMOS MPU
MOS Electronic Corp.	United States	1985	64K SRAM
Vitelic	United States	1985	256K DRAM
Vitelic	United States	1986	256K SRAM, 256K VRAM, and 1M DRAM
MOSEL	United States	1986	64K SRAM

Hyundai Electronics Industries Co., Ltd.

U.S. SISTER COMPANY

Hyundai Electronics America, Inc. (HEA) is the marketing arm of HEI, Korea.

Location: 4401 Great America Parkway, 3rd Fl., Santa Clara, CA 95054, United States

Telephone: (408) 986-9800

Telex: 278841 HEA UR

Date established: March 1983

Chief operating officer: C.S. Park

Employees: 40 (December 1985)

In October 1985, HEA closed its product development and manufacturing activities and announced that it would concentrate on marketing activities.

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Intel Corporation

Intel Corporation
3065 Bowers Avenue
Santa Clara, California 95051-8128
Telephone: (408) 987-8080
(Millions of Dollars except Per Share Data)

Balance Sheet (December 31)

	1982	1983	1984	1985	1986
Working Capital	$305.3	$ 607.8	$ 567.9	$ 717.2	$ 649.4
Long-Term Debt	$197.1*	$ 127.6	$ 146.3	$ 270.8	$ 286.6
Shareholders' Equity	$551.9	$1,121.7	$1,360.2	$1,421.5	$1,275.2
After-Tax Return on Average Equity (%)	5.8	13.9	16.0	0.1	(12.8)

Operating Performance (Fiscal Year Ending December 31)

	1982	1983	1984	1985	1986
Revenue	$899.8	$1,121.9	$1,629.3	$1,365.0	$1,265.0
U.S. Revenue	$657.5	$ 813.0	$1,169.6	$ 920.0	$ 806.0
Non-U.S. Revenue	$242.3	$ 308.9	$ 459.7	$ 445.0	$ 459.0
Cost of Revenue	$541.9	$ 624.3	$ 882.7	$ 943.4	$ 860.7
R&D Expense	$130.8	$ 142.3	$ 180.2	$ 195.2	$ 228.2
SG&A Expense	$198.6	$ 216.6	$ 316.0	$ 286.5	$ 311.3
Pretax Income	$ 30.3	$ 178.5	$ 298.1	($ 5.4)	($ 174.6)
Pretax Margin (%)	3.4	15.9	18.3	(0.4)	(13.8)
Effective Tax Rate (%)	1.0	34.9	33.5	N/A	N/A
Net Income	$ 30.0	$ 116.1	$ 198.2	$ 1.6	($ 173.2)
Average Shares Outstanding (Millions)	92.5	110.5	116.8	117.9	117.0
Per Share					
Earnings	$ 0.32	$ 1.05	$ 1.70	$ 0.01	($1.48)
Dividends	0	0	0	0	0
Book Value	$ 5.97	$ 10.15	$ 11.65	$ 12.06	$ 10.09
Price Range	$10.44-20.57	$ 18.69-45.13	$ 25.25-42.88	$ 21.75-32.00	$ 16.63-32.00
Total Employees	19,400	21,500	25,400	21,300	18,200
Capital Expenditures	$138.1	$ 145.0	$ 388.4	$ 236.2	$ 155.0

*Includes $150 million of 7 percent convertible debentures

Source: Intel Corporation Annual Reports
Dataquest
December 1987

Intel Corporation

Intel Corporation
3065 Bowers Avenue
Santa Clara, California 95051-8128
(408) 987-8080

Established: 1968

Employees: 18,200

Primary Semiconductor Products: Microprocessors, microperipherals, microcontrollers, memories, microcommunications products, and ASICs.

1986 Semiconductor Revenue: $991 million

1986 U.S. Market Share Ranking: 3rd

1986 Worldwide Market Share Ranking: 10th

EXECUTIVE SUMMARY

Background

Intel Corporation is an innovative leader in the semiconductor industry. With its invention of such important devices as the microprocessor and the EPROM (erasable programmable read-only memory), Intel helped revolutionize the computing industry. Intel has helped to create a new era of electronics by placing onto single silicon chips functions that were formerly handled by multiple devices. Building on its innovative strengths in markets where designs are the competing factor, Intel has become the world's largest microcomponent manufacturer.

In addition to being a dominant presence in the microprocessor and memory markets, Intel is an important participant in other semiconductor areas. Supporting its priority microprocessor products, Intel manufactures microcontrollers, microperipherals, EPROMs, static RAMs (random access memories), and ASICs (application-specific integrated circuits). The Company also offers products in areas such as microcommunications, systems and modules, computer design tools, and software development.

Intel Corporation

Company Milestones

The following is a list of key events in the history of Intel Corporation, listed in chronological order:

- 1968—Former Fairchild employees Robert Noyce, Gordon Moore, and Andrew Grove founded Intel Corporation in Mountain View, California.
- 1969—Intel introduced the world's first random access memory, the 1101 1,024-bit RAM, challenging the magnetic core memory market.
- 1970—The world's first dynamic random access memory (DRAM), the 1K 1103, was introduced and became Intel's first commercially successful product.
- 1970—The world's first microprocessor, the MCS-4 single-chip CPU (central processing unit) was introduced.
- 1971—Intel introduced the first programmable read-only memory (PROM), the 2,408-bit 1601; erasability was added with the 1701 erasable programmable read-only memory (EPROM).
- 1971—The Company offered public shares of stock in Intel.
- 1974—The first general-purpose microprocessor, the 8080, was produced using an NMOS process.
- 1975—Intel introduced its first CMOS RAM.
- 1976—Intel produced the first single-chip microcontroller, the 8748, incorporating a central processing unit, random access memory, program memory, and input/output circuitry on one chip.
- 1977—HMOS (high-performance MOS) process, employing on-chip substrated back-biasing, was introduced.
- 1978—The 8086 microprocessor was introduced, providing 10 times the performance of the 8080 with a 16-bit architecture.
- 1979—A million-bit bubble memory chip was introduced.
- 1980—Intel produced the world's first coprocessor, the 8087, including the first implementation of the IEEE standard for floating-point mathematics.
- 1981—Intel manufactured electrically erasable programmable read-only memories (EEPROMs), allowing reprogramming of EPROM-based systems with electricity instead of ultraviolet light.

- 1982—CHMOS (complementary, high-performance MOS) process was introduced, giving Intel products the power-saving advantages of CMOS at very high speeds.
- 1982—Intel introduced the 80286 microprocessor. The IBM Personal Computer based on 8080 8-bit architecture was introduced that same year.
- 1983—Intel became the first semiconductor manufacturer in the world to process 6-inch silicon wafers.
- 1983—Intel sold its memory systems operations to Zitel but developed the 286/310 supermicro system for OEMs.
- 1985—Intel introduced the 32-bit 80386 microprocessor.
- 1986—Intel shipped 1-megabit EPROMs in volume.
- 1987—Intel began construction of the first of four new 25,000-square-foot clean rooms in Rio Rancho, New Mexico, having completed the shell of the facility in 1986.

Acquisitions/Mergers

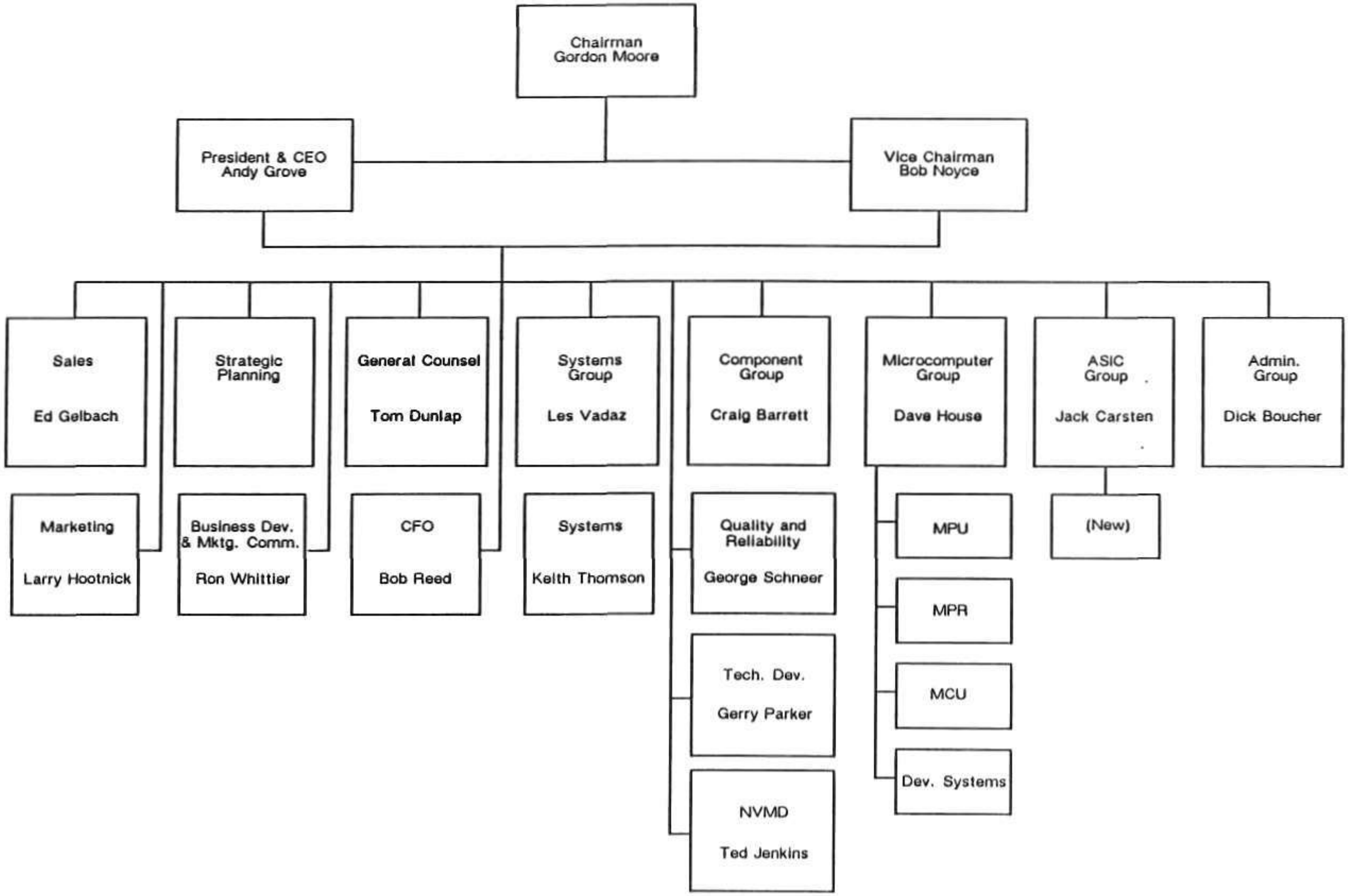
In 1973, Intel acquired Microma, Inc., the maker of the first LED continuous-display watch and timekeeping products. In 1979, the Company acquired MRI Systems of Austin, Texas, in order to gain software expertise. Both of these companies were absorbed as divisions, but their operations were eventually sold and are no longer part of Intel.

Company Organization

Intel Corporation is organized by operational function and product area, as shown in Figure 1.

Figure 1

Intel Corporation
Organization Chart



Source: Intel Corporation

PRODUCTS AND MARKETS

Semiconductor Product Markets

Intel's revenue from its semiconductor activity is shown in Table 1. Intel products include ASIC logic devices, selected memory devices, and a wide variety of microdevices including microprocessors, microcontrollers, and peripherals. Figure 2 shows percentage of revenue earned by each product type, based on 1986 revenue.

Table 2 shows semiconductor revenue as a percentage of total revenue. Intel's products, other than microcomponents and memories, include modules and systems, development tools, and software. These products are generally used with component products in networking, in designing and debugging systems, and in exploiting fully the performance capabilities of Intel components.

Intel Corporation

Table 1

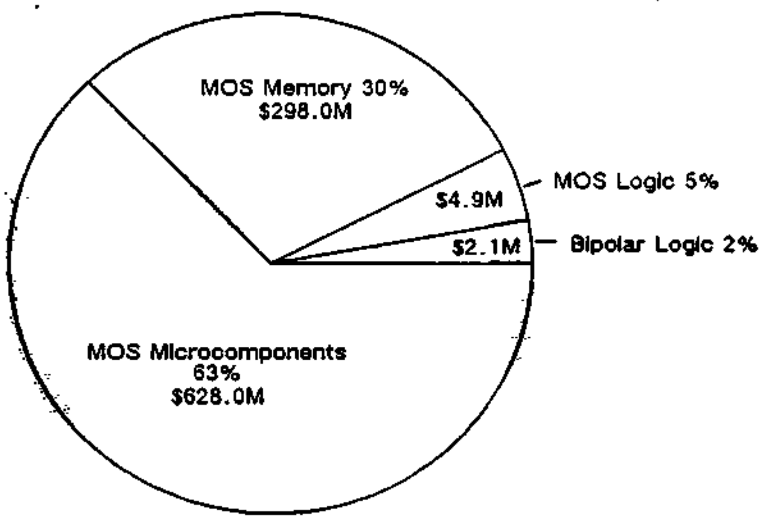
Intel Corporation
Estimated Worldwide Semiconductor Revenue
(Millions of Dollars)

	1982	1983	1984	1985	1986
Total Semiconductor	625	775	1,201	1,020	991
Total Integrated Circuit	625	775	1,201	1,020	991
Bipolar Digital (Technology)	44	55	35	22	21
TTL	44	55	35	22	21
ECL					
Other Bipolar Digital					
Bipolar Digital SWAG					
Bipolar Digital (Function)	44	55	35	22	21
Bipolar Digital Memory	17	15	5		
Bipolar Digital Logic	27	40	30	22	21
MOS (Technology)	581	720	1,166	998	970
NMOS	581	720	1,156	976	908
PMOS					
CMOS			10	12	32
MOS SWAG					
MOS (Function)	581	720	1,166	998	970
MOS Memory	290	325	380	288	298
MOS Micro Devices	258	358	743	670	628
MOS Logic	33	37	43	48	49
Linear					
Total Discrete					
Transistor					
Small Signal Transistor					
Power Transistor					
Transistor SWAG					
Diode					
Small Signal Diode					
Power Diode					
Zener Diode					
Diode SWAG					
Thyristor					
Other Discrete					
Discrete SWAG					
Total Optoelectronic					
LED Lamps					
LED Displays					
Optical Couplers					
Other Optoelectronics					
Optoelectronic SWAG					
Exchange Rate (Yen/US$)	248	235	237	238	167

Source: Dataquest
December 1987

Figure 2

Intel Corporation
Percentage of Revenue by Product
Based on 1986 Revenue



Source: Dataquest
December 1987

Table 2

Intel Corporation
Estimated Semiconductor Revenue Percent of Total Revenue
(Millions of Dollars)

	1982	1983	1984	1985	1986
Semiconductor Revenue	$625	$ 775	$1,201	$1,020	$ 991
Other Revenue	275	347	428	345	274
Total	$990	$1,122	$1,629	$1,365	$1,265
Semiconductor Percent of Total	69%	69%	74%	75%	78%

Source: Dataquest
December 1987

Manufacturing Facilities

Table 3 describes Intel's manufacturing facilities according to the classification scheme followed by Dataquest's Semiconductor Equipment and Materials Service (SEMS).

Table 3

Intel Corporation
Semiconductor Manufacturing Facilities

Factory	Type	Clean Room (Sq. Ft.)	Products	Technology
Albuquerque, NM	F	25,000	64K EPROM, ASIC 386 MPU	MOS, CMOS
Aloha, OR	FR	25,000	256K DRAM, 386 MPU	MOS
Chandler, AZ	TA	30,000	MPU, Logic cell-based wafers	MOS, CMOS
Hillsborough, OR	TA	140,000	N/A	N/A
Livermore, CA	F	24,000	32-bit MPU	MOS
Rio Rancho, NM	F	24,000	EPROM, MPU, MCU	MOS
Santa Clara, CA	FHD	24,000	80386 (CMOS)	MOS, HMOS, CMOS
Santa Clara, CA	AT	2,700	ASIC, gate array	CMOS
Tel Aviv, Israel	F	N/A	386 MPU, EEPROM	MOS
Penang, Malaysia	AT	N/A	N/A	N/A
Manila, Phil.	AT	N/A	N/A	N/A
Tsukaba, Japan	D	N/A	N/A	N/A

F = Fab
R = Research
A = Assembly
T = Test
H = Headquarters
D = Design center for custom, semicustom
N/A = Not Available

Source: Dataquest
December 1987

Capital Expenditure and R&D Spending

Table 4 shows Intel's recent research and development (R&D) and capital spending. Capital spending reached an all-time high in 1984 at 38 percent of sales; it has declined for the past two years. Meanwhile, R&D spending for strategic products has continued to increase.

Table 4

Intel Corporation
Semiconductor Capital Expenditure and R&D Spending
(Millions of Dollars)

	1982	1983	1984	1985	1986
Semiconductor Revenue	$625	$775	$1,021	$1,020	$991
Semiconductor Capital Expenditure	138	146	388	214	150
Percent of Semiconductor Revenue	22.1%	18.8%	38.0%	21.0%	15.1%
Semiconductor R&D Spending	122	132	163	175	189
Percent of Semiconductor Revenue	19.5%	17.0%	16.0%	17.2%	19.1%
Combined Capital and R&D Spending	260	278	551	389	339
Percent Increase	(2.3%)	6.9%	98.2%	(29.4%)	(12.9%)

Source: Dataquest
December 1987

MARKET ANALYSIS

1986 Summary

Intel had a difficult year in 1986. The year ended with a loss of $173 million, the first annual loss in Intel's history. Sales declined 7 percent from 1985's $1.4 billion and remained 22 percent below 1984's record sales level of $1.6 billion. A weak computer market and continued price erosion caused by industry overcapacity contributed to the lower revenue performance.

Gross margin, reaching just 32 percent in 1986, was hampered by overcapacity. This figure represented an improvement of 1 percent over the previous year, however, but it did not approach 1984's gross margin figure of 46 percent. In reaction to these conditions, Intel laid off 15 percent of its work force, closed a number of manufacturing facilities, and sold its bubble memory division. These restructuring costs represented a $60 million charge to income. Further cost-cutting measures included the closing of a component assembly facility in Barbados and the gradual discontinuation of a test plant in Puerto Rico.

While most operations were pared down and stringent discretionary spending policies were followed, semiconductor R&D spending increased slightly to $189 million—up from 1985's $175 million. Capital spending continued to decrease from the high levels of 1984 and 1985 to 15 percent of sales in 1986. These expenditures along with steady R&D spending have supported targeted growth areas like ASICs. Other tactical markets are currently being approached through the Intel Development Organization (iDO), a corporate division founded in 1983 to develop business opportunities for Intel. The iDO is fostering new business in a variety of markets including personal computer add-in boards, scientific parallel processing projects, medical imaging research, and communications networks.

Internally, Intel has focused on improving quality and reliability and increasing productivity to lower costs. For example, the defects per million (DPM) rate was significantly lowered from a rate of 1,000 DPM and higher in 1984 to less than 500 DPM in 1986. Automated systems are being employed where possible, and manufacturing management techniques have been refined to streamline production flow and reduce work in progress. Through statistical procedures that have helped to refine processes, quality has been achieved allowing many customers to forego incoming testing, thus reducing OEM manufacturing time.

Positive reception of new products has heralded high sales for 1987. The 80286 microprocessor, Intel's largest microprocessor revenue earner in 1986, continues to garner design wins. The 80386 (or 386, for short) 32-bit microprocessor has been received with great enthusiasm in the electronics industry. High performance not only positions the 386 for Intel's primary office automation market but makes it a strong contender for design wins in the growing single-user workstation market. Along with its supporting peripherals, the 386 should open new possibilities in artificial intelligence as well as scientific computing.

The following tables give a snapshot view of Intel's market standing as of 1986. Table 5 shows revenue by geographic region for the Company's broad product areas. Table 6 shows Intel's ranking among its competitors in 1985 and 1986. Industry percent change figures are based on Dataquest worldwide consumption estimates measured in dollars.

Table 5

Intel Corporation
Estimated Semiconductor Revenue by Geographic Region—1986
(Millions of Dollars)

	United States	Japan	Europe	Rest of World	Total
Total Semiconductor	629	108	214	40	991
Integrated Circuits	629	108	214	40	991
Bipolar Digital	3	3	12	3	21
Logic	3	3	12	3	21
MOS	626	105	202	37	970
Memory	157	40	86	15	298
Microdevices	445	61	102	20	628
Logic	24	4	14	2	44

Table 6

Intel Corporation
Worldwide Ranking—Semiconductor Markets
(Millions of Dollars)

	1986 Rank	1985 Rank	1986 Revenue	Revenue % Change 1985-1986	Industry % Change 1985-1986
Total Semiconductor	10	7	991	(2.8%)	24.9%
Integrated Circuits	8	5	991	(2.8%)	24.3%
Bipolar Digital	24	20	21	(4.5%)	13.7%
Logic	23	23	21	(4.5%)	14.1%
MOS	4	2	970	(2.8%)	25.4%
Memory	7	6	298	3.5%	8.1%
Microdevices	1	1	628	(6.3%)	33.1%
Logic	25	21	49	2.1%	38.5%

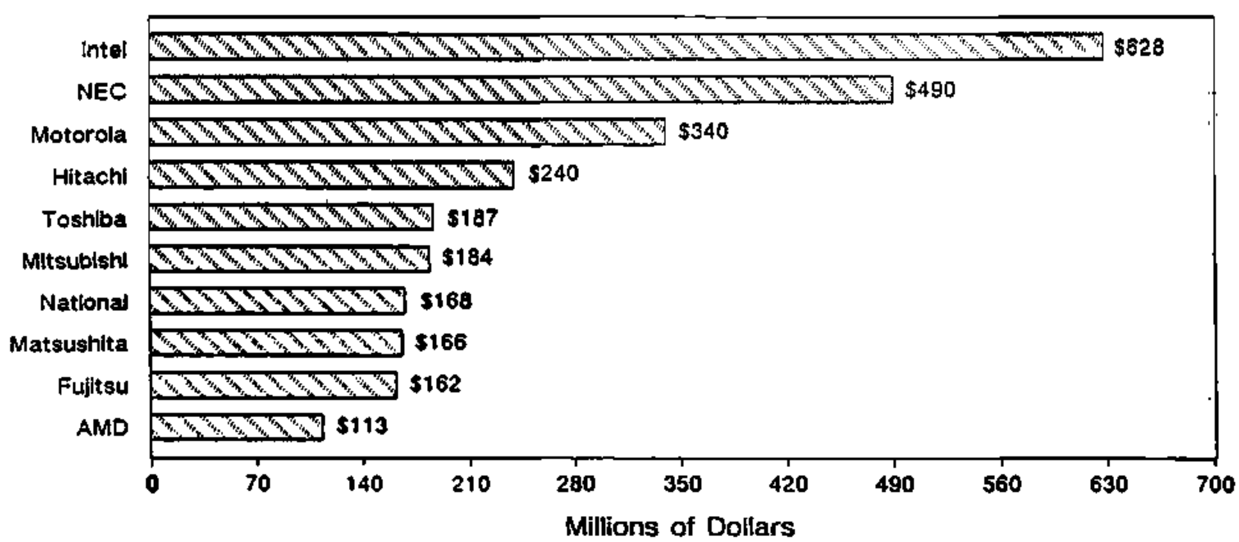
Source: Dataquest
December 1987

Microcomponents

Intel is a world leader in microcomponents. Of the $3.66 billion 1986 micro-component market, Intel garnered sales of $628 million. These sales make Intel the largest microcomponent producer in the world, ahead of strong competitors like NEC and Motorola. In this highly concentrated market, these three producers accounted for 41.0 percent of microcomponent sales in 1986. Intel's 1986 microcomponent market share was 17.8 percent, slipping from 24.4 percent but retaining its lead. Figure 3 illustrates the relative market share of the top 10 microcomponent manufacturers.

Figure 3

1986 Microcomponent Market
Top 10 Companies

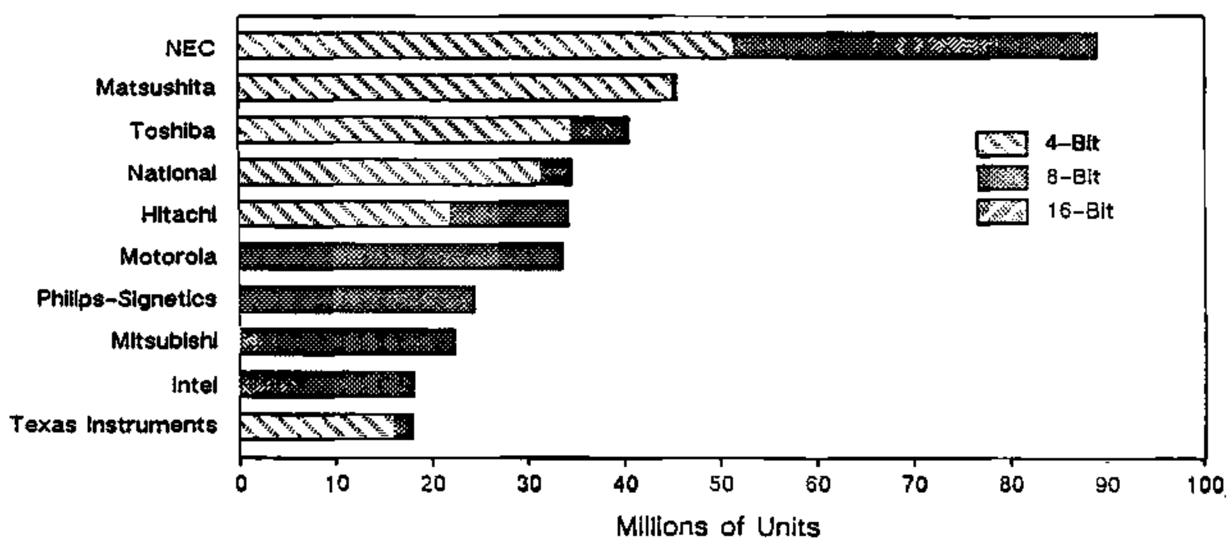


Source: Dataquest
December 1987

Of its $628 million microcomponent sales in 1986, Intel derived approximately $170 million from its 8- and 16-bit microcontroller products. NEC and Motorola dominate the 8-bit microcontroller market where Intel ranks fifth; however, Intel is the leading supplier of 16-bit microcontrollers, which are emerging products. Figure 4 shows market share in units of the major microcontroller producers by word length.

Figure 4

1986 Microcontroller Market
By Word Length



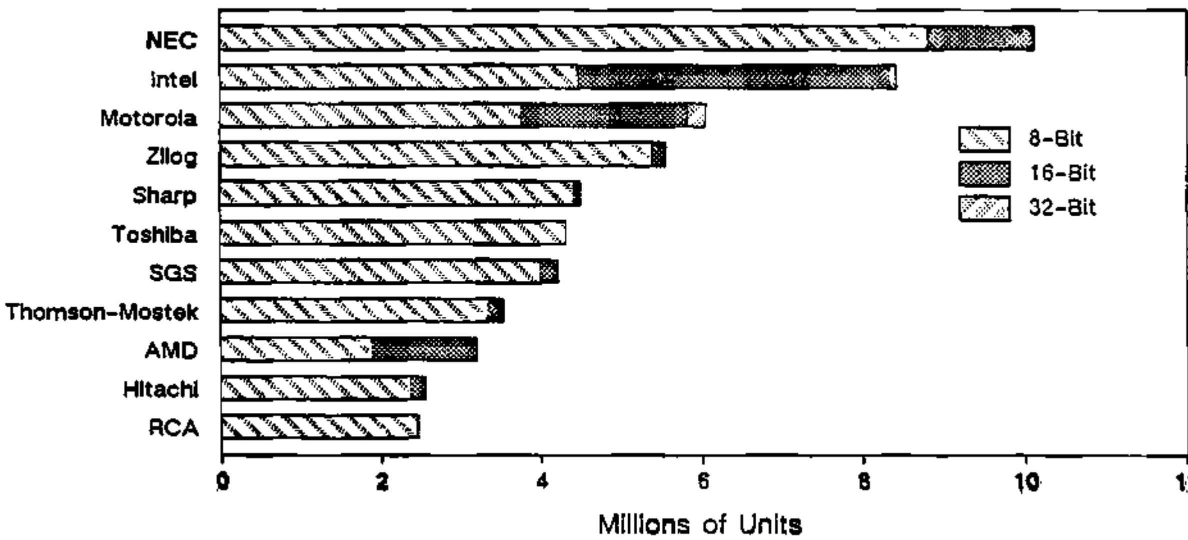
Source: Dataquest
December 1987

Intel Corporation

In 1986, Intel earned approximately $185 million in microprocessors, making it the largest supplier in the world. Intel introduced its flagship product, the 80386 32-bit microprocessor, in October 1985. The new product offers performance at 4 million instructions per second (mips). Microprocessor sales for 1986 by the top 10 companies are shown in units in Figure 5. If dollarized, Intel is the largest worldwide supplier of microprocessors.

Figure 5

1986 Microprocessor Market by Word Length



Source: Dataquest December 1987

Intel Corporation

The main reason for Intel's success with its 8086 family has been the compatibility of the chips with existing software at the binary-code level. Intel's 80386 can also run both PC-DOS and UNIX simultaneously, combining the standards of the office automation and workstation worlds.

Intel sold about $340 million in microprocessor peripherals in 1986; peripherals were the largest contributor to the Company's microcomponent revenue. These chips, including coprocessors and peripheral controllers, are designed to support Intel microprocessors in specialized functions. They are achieving wide acceptance in such areas as graphics and high-speed scientific mathematical functions as well as popular standard peripheral interfacing.

Microcommunications

A growing number of microcommunications functions are supported by Intel microcommunications chips and software. For example, Intel offers both the OpenNET local area network (LAN) and the FASTPATH LAN-to-mainframe connectivity platform. (OpenNET is a registered trademark of Intel Corporation.) In 1986, Intel and AT&T established standards for compatibility cooperation for ISDN (Integrated Services Digital Network) components, boards, and systems competing against a similar Motorola/ Northern Telecom alliance. Intel offers communications products that are compatible with the manufacturing automation protocol (MAP) established by IEEE (International Electrical and Electronics Engineers) and is determined to meet the growing demand for networked computer and automation systems. These networks are examples of Intel's growing commitment to the microcommunications market. Intel plans to offer a complete set of microcommunications solutions aimed at the growing market for voice/data communications.

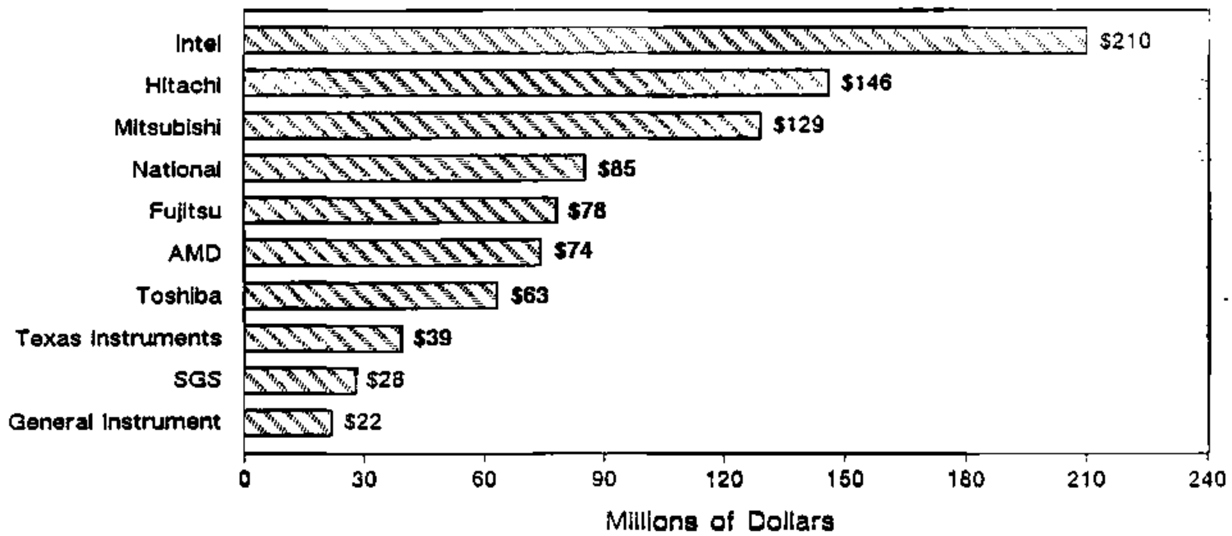
Memories

Although Intel's primary focus is microcomponents, memories are also important—in fact, Intel was the seventh largest MOS memory producer in the world in 1986. Intel manufactures EPROMs, EEPROMs, and SRAMs.

Intel's EPROM product line, with densities ranging from 16K to 1Mb in all package types, supports microprocessors as microcode or table-data storage chips. Intel has been a dominant force in the EPROM market since EPROMs were invented by Intel in 1971 and, more importantly, since EEPROMs became important support devices for microprocessors. For Intel, EPROMs are not only efficient microprogram storage locations but also technology drivers for wafer and packaging processes. For example, Intel leads the market in new packaging technology with the largest one-time programmable (OTP) plastic package sales. Although market share was lost to Texas Instruments in the late 1970s and to Japanese firms in the early 1980s, Intel has maintained its lead in EPROMs. In fact, Intel is the world's largest supplier of EPROMs, which constitute Intel's largest unit volume product. Figure 6 shows Intel's participation in the EPROM market based on sales figures from 1986 when Intel captured approximately $210 million of the $910 million market.

Figure 6

1986 EPROM Market



Source: Dataquest
December 1987

EEPROMs accounted for $15 million of Intel's 1986 revenue. Invented by Intel in 1981, EEPROMs are used primarily in data tabling applications. In addition, the use of EEPROMs is increasing in code storage applications, where they are beginning to replace EPROMs in some cases. Intel was an important participant in the $139 million 1986 EEPROM market.

Of Intel's nearly $300 million in memory sales in 1986, SRAMs accounted for approximately $30 million. Intel's SRAMs, offered in densities of from 1K to 16K, also support the systems needs of data processing and military microprocessor customers. Although it was a leading supplier of DRAMs throughout the 1970s, Intel left the DRAM market in 1985, along with a number of other U.S. semiconductor manufacturers facing increasing Japanese competition. In June 1987, however, Intel began offering its customers DRAMs produced by Samsung, a Korean semiconductor producer. Thus, through a marketing agreement, Intel customers receive a more complete selection of component products.

Intel Corporation

ASICs

Intel has recently entered the ASIC market, assigning a senior vice president to the operation in 1986. In the ASIC category, Intel currently offers cell-based ICs, gate arrays, and EPLDs (erasable programmable logic devices), supported by an integrated design environment with a complete system of CAE (computer-aided engineering) tools. In 1986, Intel's ASIC products earned it approximately $18 million out of a $2.8 billion market. While this currently ranks Intel as a small competitor in a field of more than 200 participants, Intel's resources may be a force to reckon with in the rapidly growing and changing ASIC atmosphere, especially in light of leadership in key standard product areas.

The majority of Intel's 1986 ASIC sales were in cell-based ICs, where popular microcomponent designs were leveraged in semicustom sales. Based on the 150-cell VLSiCELL library using CHMOS III 1.5-micron process specifications, available cells include logic, memory, and input/output, as well as microcontroller and microperipheral functions.

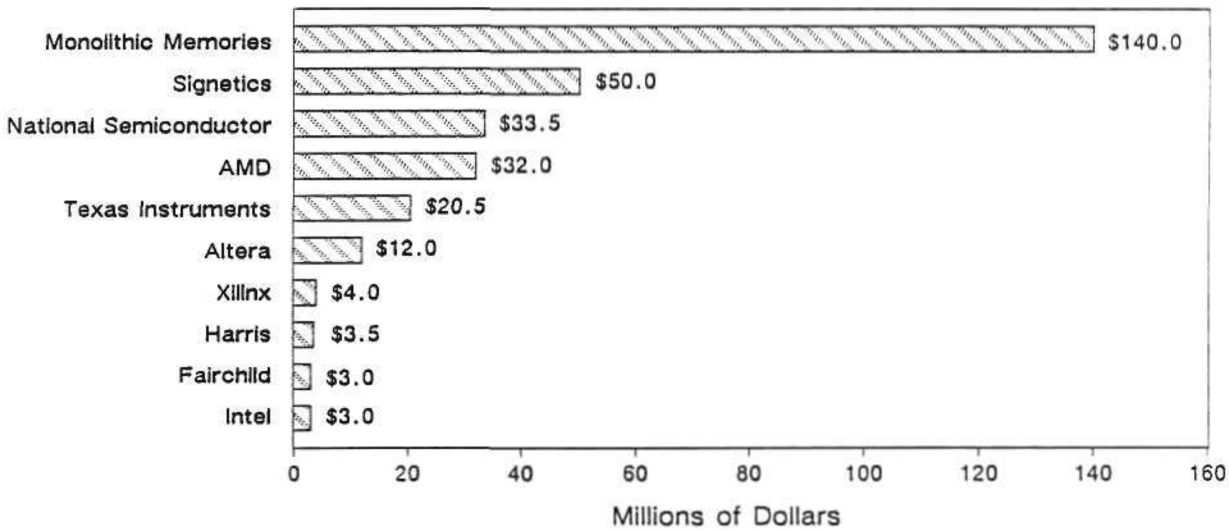
Intel's approximately $1 million in sales of gate arrays represented a small share of the $1.8 billion worldwide gate array market, which includes both merchant and intracompany sales. Gate array capabilities, with gate densities ranging from 2,500 to 19,000 gates in a 150-cell Gate Array Macrocell Library, were enhanced greatly by a joint venture agreement with IBM in October 1986. Through this agreement, Intel gained access to IBM's library of CMOS gate arrays adapted for Intel's 1.5-micron dual-metal CHMOS process. Furthermore, design tools and chip packaging techniques capable of very high pin counts will be at Intel's disposal. In return, IBM gains access to Intel's microprocessor and microperipheral cell libraries.

A second major ASIC agreement was made with Texas Instruments in July 1987. The two companies agreed to jointly develop a library of cells and gate array macrocells as well as packaging, testing, and design rules. They further agreed to develop a compatible 1.0-micron CMOS process technology to guarantee an alternate source for products developed through the venture. Combined, the resources of these leaders in the semiconductor industry amount to a powerful menu of logic, memory, and microcomponent capabilities for ASIC customers.

Intel offers six erasable programmable logic devices with densities ranging from 300 gates to 1,800 gates. In 1986, Intel earned $3 million in the $308 million programmable logic device (PLD) market. This places Intel in a tenth-place tie with Fairchild. Figure 7 demonstrates the leadership of Monolithic Memories in the PLD market.

Figure 7

1986 PLD Market



Source: Dataquest
December 1987

Market Strategy

To maintain leadership in the semiconductor industry, it is Intel's intention to:

- Continue to increase architectural superiority, particularly in its industry-standard microprocessor products
- Maintain lead in office automation applications by providing compatible products while increasing penetration of workstation markets and artificial intelligence platforms
- Maintain high revenue in a wide range of support products for its popular microprocessors including microperipherals, microcontrollers, and software
- Defend hard-won EPROM market share through decreased time to market, accelerated cost reduction, improved performance, and high quality and reliability
- Aggressively pursue the ASIC market by leveraging architectural and technical leadership and design support, along with IBM's cooperation and Texas Instruments' resources

- Target growth applications markets such as communications and automotive control systems
- Develop new business through the Intel Development Organization (iDO), leveraging Intel's component expertise beyond the components market
- Increase Intel's preferred vendor status among customers through improved reliability, quick delivery, and outstanding customer service based on close customer interaction, training, and documentation
- Support existing standards and develop new standards in all markets to ensure compatibility of products, both present and future

Distribution Channels

Intel operates a network of 38 sales offices and 15 field applications centers in 31 U.S. states. Additionally, distributors are licensed to maintain small inventories and fill smaller orders of products in 34 states. The major distributors with whom Intel does business include Almac, Arrow, Hamilton/Avnet, Kierulff, Pioneer, and Wyle. Intel has 21 sales offices located in 15 European countries and 17 independent distributors located throughout Europe. In Asia, Intel operates a sales office in Beijing, China, as well as a wholly owned Japanese subsidiary staffed by 400 people working in sales, marketing, quality control, and customer support. Intel opened ASIC design centers in Santa Clara, California; Boston, Massachusetts; and Swindon, England, in late 1986 and early 1987.

Although Intel has thousands of customers, its largest customer is International Business Machines (IBM). IBM has historically accounted for a large portion of Intel's sales as a result of applications in computer products. Of particular note is implementation of the 80X86 product family in IBM's Personal Computers. IBM accounted for roughly 20 percent of Intel's sales in 1985; in 1986, however, IBM's purchases dropped by $200 million, to just 6 percent of sales. By comparison, 1984 sales to IBM were approximately 12 percent of Intel's sales.

Application Markets

Intel products are used in a wide variety of applications. Intel's microcomponents and memory devices find their way to applications from desktop computers to telecommunications, industrial automation, computer networking, military systems, and scientific control systems.

Microprocessors manipulate data in computing systems, where they control input and output, peripheral, and memory devices. A microprocessor is the key component in many machines ranging from calculators to sophisticated computers. Microprocessor peripherals support microprocessors in their functions, offering additional capabilities for engineering, scientific, industrial, and office microcomputer applications. Microperipheral application areas include computer graphics, disk controllers, keyboards, and printers. Microcontrollers are used in computer and communications systems, robotics, electronic instrumentation, telecommunications, keyboards, printers, and home video machines. Intel's microcommunications products allow voice or data communications among engineering workstations, data-processing computers, and automated manufacturing equipment.

Intel memory products store information—instructions or data—used during system operation. Microprocessor systems generally use some off-chip memory in their broad applications from computer systems to automotive engine controls. In fact, an important and growing number of applications for microprocessors is being found in automotive systems. Most automobiles use at least one microprocessor to control basic engine operations and fuel flow. As the cost of microprocessors declines, vehicles will be made more efficient through increased use of microprocessor controls. These applications include safety and convenience applications such as headlight dimmers and climate controls, driver controls such as gauges, body controls including diagnostic and antiskid braking, and power train uses such as ignition and spark timing. Power train uses have helped make Intel's 16-bit microcontroller an extremely popular chip in automotive applications.

A second high-priority application area for Intel is communications. Building on its success with such systems as OpenNET LAN, FASTPATH, ISDN, and MAP, Intel seeks to provide complete solutions to integrated communications systems in computers—from desktop personal computers to automated manufacturing systems.

PRODUCTS AND TECHNOLOGY

Technology Strategies/R&D Activity

Even though the first products Intel shipped were bipolar memories, the Company has always concentrated on MOS. Today, Intel derives only 2 percent of its revenue from bipolar technology; MOS processes, both NMOS and CMOS, account for the remaining 98 percent. In fact, Intel has pioneered metal oxide semiconductor (MOS) technology from the time of its founding. Originally, PMOS techniques dominated the market, and Intel's initial RAM products were P-channel devices. PMOS was found to be lacking in speed when compared to NMOS-based circuits, however, and by 1972, Intel was producing NMOS products in volume. CMOS, combining P and N transistors in semiconductors, offers speeds comparable to NMOS but at much lower power requirements. These power advantages led many semiconductor producers to switch to CMOS in the early 1980s.

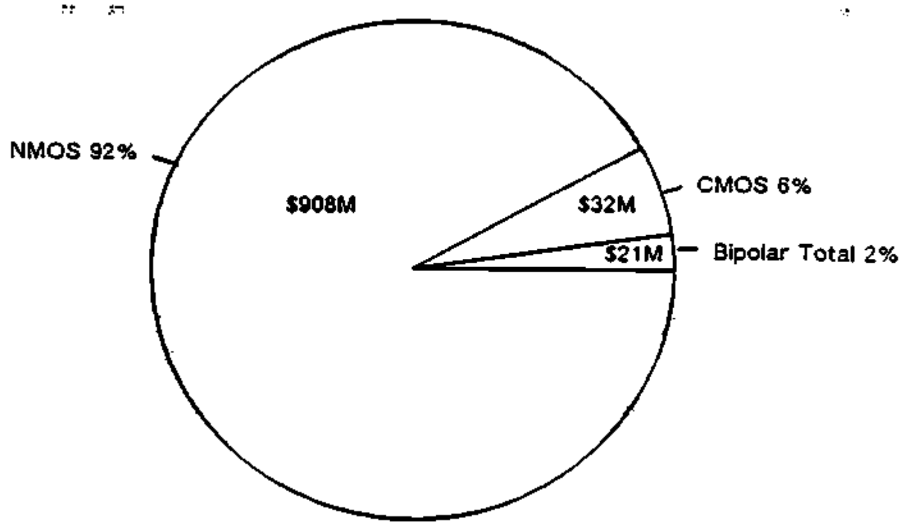
Because of cost advantages in producing its NMOS process, Intel remains mainly an NMOS manufacturer. Compared to other MOS producers, Intel earned the seventh largest MOS technology revenue in 1986, second only to rival NEC in NMOS production. In fact, in 1986, 92 percent of all Intel products were manufactured using NMOS techniques, and 94 percent of Intel MOS products were NMOS. The remaining

6 percent of CMOS devices are produced in one of two types of CMOS processes: an N-well type for memories and microcontrollers, and a P-well skewed process for microprocessors. Intel introduced its first CMOS products in 1982, with the introduction of microcontroller and telecommunications products manufactured with Intel's proprietary CHMOS high-performance process. The number of Intel products offered in CMOS technology is increasing. For example, the most recent SRAM offerings are produced in Intel's CHMOS-IV double-metal 1.0-micron high-performance polysilicon CMOS process.

Successful migration to CMOS is critical to design wins in growing low-power markets such as portable personal computers. Intel is committed to fully executing this transition, and the Company is making considerable progress with four new six-inch wafer fabs under construction in Rio Rancho, New Mexico. These are slated to be CHMOS-dedicated manufacturing facilities. Meanwhile, Intel's NMOS process, HMOS II-E, helps to maintain Intel's lead in the EPROM market. HMOS II-E utilizes advanced wafer-stepping lithography and plasma etching and is used in high-density EPROM parts. Figure 8 illustrates percentages of Intel products produced by the various technologies, based on 1986 revenue.

Figure 8

Intel Corporation
Percentage of Revenue by Technology
Based on 1986 Revenue



Source: Dataquest
December 1987

Intel Corporation

Intel led the conversion from four- and five-inch wafer processes to six-inch wafer production in 1983. As the technology for growing silicon crystals has developed, larger and larger wafers have been used in semiconductor manufacturing. With each increase in diameter comes an increase in surface area that allows for more chips to be produced at a time, resulting in lower production costs. Although Intel has encountered some difficulties during the transition in wafer sizes, it has developed the machinery and techniques required for volume six-inch wafer production and will produce the majority of 80386 microprocessors in six-inch fabs.

Recent Product Introductions

Intel Corporation's recent semiconductor product introductions include the following:

- Microprocessors
  - October 1985—Intel introduced the 80386 microprocessor.
    - Along with its supporting peripherals and software, the 386 offers downward compatibility with a $10 billion PC-DOS software base, plus the ability to run UNIX simultaneously.
    - Its high-performance capability offers multitasking, multiuser ability.
- Microcontrollers
  - May 1987—The P8742AH was added to the UPI-42 family of 8-bit microcontrollers.
    - It employs a plastic windowless OTP (one-time-programmable) package for use like an EPROM, with greater reliability and lower cost.
    - The packaging technology was developed in 1985 for Intel's P2764A, P27128A, and P27256 EPROMS.
  - September 1986—Intel introduced UPI-452 universal peripheral interface. It includes a CMOS 8051 microcontroller, FIFO buffer, DMA processor, EPROM, and RAM in a 68-pin device.
    - It is an I/O interface between MPUs and slower peripherals and communications devices, offered at both 12- and 16-MHz clock speeds.

- Microperipherals

  - February 1987—The 80387 numerics coprocessor was added to a series of support devices for the 80386. Software compatible to the 8087 and 8287, the 80387 boosts system performance to a level of 1.5 million double-precision whetstones per second, 50 percent faster than a VAX11/780.

  - February 1987—Intel introduced the 82380 integrated system peripheral. It includes the industry's first 32-bit eight-channel, high-performance direct memory access (DMA) controller; a 20-level programmable interrupt controller; four 16-bit programmable interface timers; a DRAM refresh controller; a programmable wait-state generator; and system reset logic.

    - All of this is engineered to work with the 80386 and the 82385 as a high-performance 20-MHz clock rate compute engine.

  - February 1987—The Company introduced the 82385 32-bit cache controller.

    - It is designed to store a copy of frequently accessed codes and data from main memory in a fast, local cache memory.

    - It includes optimized memory management handling memory mapping, cache misses, memory writes, cache coherency, noncacheable memory, cache flushing, and protecting software integrity.

  - May 1986—The 82786 graphics coprocessor includes a graphics processor, a display controller, a DRAM/VRAM controller, and a bus interface unit.

    - It offers hardware window capability and very high speed calculation and drawing functions.

    - It supports CDI, DGIS, CGI, and VDI graphics standards.

- Memories

  - June 1987—The M51C98 16K x 4 SRAM was approved for VHSIC qualification.

    - It offers 35ns access time and maximum power dissipation of 100mA.

    - It is produced in a CHMOS-IV 1.0-micron high-performance double-polysilicon CMOS process.

Intel Corporation

- March 1987—The 27C128 128K CMOS EPROM was introduced in 16K x 8 organization.

    . It is manufactured in Intel's CHMOS II-E process.

    . It operates with 150ns to 250ns access time consuming 100uA power during standby and 30mA when active.

- March 1986—The 32-pin 27010, 28-pin 27011, and 40-pin 27210 1Mb EPROMs were made available.

    . It was manufactured using HMOS II-E 1.4-micron design features and 150ns to 200ns access times.

    . It has Quick-Pulse advanced high-speed programming algorithm available for programming.

- January 1986—The 51C69 16-Kbit SRAM was introduced in 25ns and 30ns access time versions.

    . It was produced using Intel's CHMOS III.

    . It has 4Kx4 bit organization compatible with 4K SRAMs such as Intel's 2148 or 2149 (16K SRAMs also available in 16Kx1).

• Microcommunications

- January 1987—The 89024 2-chip modem combines the 89026 digital signal processing chip with the 89027 digital-to-analog and analog-to digital converter.

    . The 89024 supports full-duplex, synchronous/ansynchronous operation for data speeds of 0 to 2,400 bits per second (bps).

    . It has firmware compatibility with Hayes, Inc., standards.

- January 1987—Intel introduced the 82050 UART (universal asynchronous receiver/transmitter), manufactured in CHMOS for high-frequency personal computer data bus needs and having complete IBM PC AT compatibility with a 28-pin package instead of the standard 40.

Intel Corporation

Nonsemiconductor Product Summary

Sales of noncomponent products composed approximately 21 percent of Intel's 1986 sales and may increase in the future. Intel's systems products and single-board computers include Intel microprocessors and other integrated circuit products. They are used in scientific, technical, and commercial applications. By manufacturing systems, Intel offers customers a broad range of products that save small producers the cost of designing and building themselves. Furthermore, Intel gains insight into the needs and business of its systems customers.

Intel's development tools are designed to help debug hardware and software for microcomputer-based systems. These tools, which run on industry-standard host computers like the Digital Equipment Corporation VAX family or DOS-compatible personal computer systems, are invaluable to customers for the timely development of new applications for Intel products.

Another important support product for microprocessors is software. In order to fully exploit a microprocessor's architecture, real-time operating systems are required. In fact, availability of software is often a deciding factor in a microprocessor design decision. Intel generates UNIX-based systems for its 8086-based family. Furthermore, members of the 80X86 family are compatible with the $10 billion DOS software base written for it. Other examples of Intel's support of software standards is the adoption of the ISDN standard developed by AT&T and IEEE's manufacturing automation protocol (MAP).

An important segment of Intel's noncomponent products falls under the direction of the Intel Development Organization (iDO). These growth areas currently include add-on personal computer boards, high-performance scientific parallel computers, medical imaging and robotic vision systems, and networking tools.

ALLIANCES

In order to broaden its product base or increase market share, Intel has entered into a number of agreements with other semiconductor vendors and with customers. For microprocessors, customers must be ensured a steady supply of products before they design in a particular device; thus, they often demand that a second source exist. A summary of Intel's alliances is listed in Table 7, in which Company A has licensed Company B for the type of activity and products listed. Intel was quick to second-source the 80286 but has been more cautious about releasing rights on the 80386. This decision may reflect a changing attitude about transferring intellectual property in the future.

Table 7

Intel Corporation
Summary of Alliances

	Company A	Company B	Type	Products	Date
1.	Intel	AMD	SS	80X86	1981
2.	Intel	Phil-Sig	TE SS	80C49 80C511 MPR	1982
3.	Intel	Harris	TE SS	8086, 8088	1983
4.	Intel	Samsung	SS MA	MPU, MCU, MPR	Feb. 1985
5.	Intel	Toshiba	SS	Multibus MPR	Feb. 1985
6.	Intel	Zymos	SS	8-bit MPU (80C49)	Mar. 1985
7.	Altera	Intel	SS	PLDs, Gate Arrays	June 1985
8.	Intel	Signetics	TE	256K EEPROM	July 1985
9.	Intel*	Xicor	JV	EEPROM	July 1985
10.	Weitek	Intel	JV SS	Interface IC	Oct. 1985
11.	Intel	VLSI Tech	JV	MPR	Jan. 1986
12.	Intel	EDS	JV	Ind. speech w/s	Mar. 1986
13.	IBM	Intel	JV TE	ASICs	Oct. 1986
14.	Intel	AT&T	JV	Networking S/W & H/W	Oct. 1986
15.	Samsung	Intel	FA	64K, 256K EEPROMS	Feb. 1987
16.	Intel	Hyundai	SS	16K EPROMs	May 1987
17.	Samsung	Intel	MA	DRAMs	June 1987
18.	Intel	TI	JV SS	ASICs	July 1987

SS = Second Source
FA = Foundry Agreement
JV = Joint Venture
MA = Marketing Agreement
TE = Technology Exchange
* = Terminated

Source: Dataquest
December 1987

The following paragraphs contain synopses of the alliances listed in Table 7.

Intel and AMD

In 1981, Intel made a 10-year agreement with AMD to exchange, value for value, ICs that support the 8086 architecture. This agreement is involved in a lawsuit brought against Intel by AMD in 1987.

Intel Corporation

Intel and Philips-Signetics

In 1982, Intel made a seven-year technology exchange agreement with N.V. Philips-Signetics, through which Philips and Signetics gained access to Intel's CHMOS process and products employing it, including 8-bit single-chip microcomputers. Intel received technology for two Philips-developed serial buses that allow various integrated circuits in consumer products to be linked together.

Intel and Harris Semiconductor

In 1983, Intel provided Harris with architecture information on the 8086 and 8088 microprocessors and peripherals for conversion to complementary MOS designs. Harris provided Intel with its CMOS expertise, and both companies planned to produce CMOS versions of Intel's popular parts. Intel later decided to wait for its own CHMOS process to be ready to market.

Intel and Samsung

In February, 1985, Intel signed Samsung to manufacture and market a range of Intel products in Korea and to distribute others manufactured by Intel. Products for which technology was provided include microprocessors, microcontrollers, and peripherals.

Intel is exercising a foundry contract option with Samsung for the manufacture of 64K and 256K EEPROMS. The manufacture will be limited to mature densities.

Intel and Toshiba

Also in February 1985, Toshiba agreed to manufacture and market Intel's Multibus II interface ICs.

Intel and Zymos

Zymos agreed to manufacture and sell Intel's 80C49 8-bit microcontroller. Zymos will provide Intel with updated revisions for its ZyP CAD system.

Altera and Intel

This agreement follows up on a technology exchange agreement from August 1984. Intel will second-source Altera's entire family of PLDs and gate arrays.

Intel Corporation

Intel and Signetics

Intel provided its 256K EPROM technology to Signetics in September of 1985. Signetics already had a 64K EPROM on the market but did not choose to upgrade its own 64K part to a 256K version.

Intel and Xicor

In July of 1985, Intel and Xicor signed a letter of intent covering joint development of advanced EEPROMs. This also covered a second-source agreement on other undisclosed products. Intel provided the bulk of the $10 million needed to cover the costs of the joint R&D program.

Intel and Weitek

Weitek agreed to develop an interface IC that Intel will second source, for which Intel will provide foundry service on 6-inch NMOS and CMOS wafer-processing equipment.

Intel and VLSI Technology, Inc. (VLSI)

VLSI and Intel have cooperated in developing a single-chip interface for the Multibus II system bus architecture, based on Intel design. VLSI will be a manufacturer of the device, and both companies will market the component.

Intel and Electronic Data Systems

In March 1986, Intel and Electronic Data Systems (EDS), which is a General Motors Company, announced plans to develop a speech workstation product line for industrial applications. Intel is to provide technology, including vision systems, robotics, and MAP (manufacturing automation protocol); EDS will contribute resources and applications experience.

Intel and IBM

On October 6, 1986, Intel signed a multiyear technology exchange and joint development agreement with IBM. This agreement allows IBM access to Intel's cell library of industry-standard microprocessors and peripherals. In return, Intel has acquired the IBM gate array macro library with more than 150 proven macrocells.

Intel Corporation

Intel and AT&T

Intel negotiated a joint agreement with AT&T Network Systems to develop future digital network hardware and software. Intel will release several new ISDN products as part of its Advanced Telecommunications Components product family. The company could supply AT&T with the necessary interface chip sets that would eventually be integrated into the AT&T 5ESS Central Office Switch.

Intel and Hyundai

Intel selected the Korean manufacturer as the second source for its 16K EPROMs and granted Hyundai marketing rights.

Samsung and Intel

In June 1987, Intel agreed to purchase for resale 256K DRAMs from Samsung in order to offer "one-stop shopping" to its systems customers.

Intel and Texas Instruments

Intel and Texas Instruments (TI) made a wide-reaching agreement on ASICs cooperation in July 1987. Under the agreement, Intel and TI plan to jointly develop a common cell library and common gate array macro library to take advantage of TI's advanced logic and specific-application processor capabilities and Intel's microcontroller, microprocessor, and peripherals designs. Provisions for joint testing, packaging, and design rules are also included. To ensure alternate sourcing, the two companies agreed to develop compatible ASIC 1.0-micron CMOS technology.

DATAQUEST SUMMARY

Dataquest sees Intel as a leading force in the semiconductor industry. Intel's achievements in microprocessor architectures have helped make semiconductors an important part of daily life. Its recent troubles during the latest semiconductor industry slump stem from what Chairman Gordon Moore has referred to as EPCO, the Excessive Personal Computer Orgy of 1983 through 1984. In the early 1980s, a boom in office automation led desktop computer manufacturers to proliferate and caused forecasts of personal computer use and sales to soar. Intel responded by second-sourcing its popular microprocessors and other components and by aggressively expanding manufacturing capacity. Intel's 8086 family became the standard for desktop computers, and the Company's market share increased significantly. By 1985, however, the combination of a shakeout in the personal computer industry and the failure of tremendously high predictions for personal computer consumption to materialize caused a contraction in this important customer base, leaving Intel with heavy capital expenditures and declining sales volumes.

Intel Corporation

Regrouping, Intel has trimmed back nonstrategic expenditures and repositioned its product offerings. Intel counts on the continuing strength of its leadership in the microcomponents area, strong EPROM performance, and growing ASIC markets. Dataquest forecasts the following growth behavior of those markets crucial to Intel.

X

Korea Electronics Co., Ltd.

Korea Electronics Co., Ltd.
45 Namdaemun-ro 4-ga,
Jung-gu, Seoul 100-094, Korea
Telephone: 02-757-5700, Fax: 02-756-5800
(Millions of Dollars except Per Share Data)

Balance Sheet (September 30)

	1983	1984	1985	1986	1987
Financial Resources	$ 8.0	$26.1	$36.2	$ 33.2	$ 36.1
Long-Term Liabilities	$14.6	$19.9	$20.0	$ 32.2	$ 63.1
Shareholders' Equity	$10.9	$14.0	$15.8	$ 19.6	$ 23.7
After-Tax Return on Average Equity (%)	11.9	32.9	18.2	14.3	13.5

Operating Performance (September 30)

	1983	1984	1985	1986	1987
Revenue	$61.6	$84.6	$96.6	$158.2	$208.8
Cost of Revenue	$50.3	$66.5	$78.9	$138.2	$187.9
SG&A Expense	$ 6.3	$ 6.0	$ 7.3	$ 9.0	$ 10.8
Pretax Income	$ 2.0	$ 6.4	$ 4.5	$ 4.3	$ 4.6
Net Income	$ 1.3	$ 4.0	$ 2.9	$ 2.8	$ 3.2
Average Shares (Million)	2.6	2.6	2.6	4.2	1.6
Per Share (Won)					
Earnings	111.0	371.0	273.0	252.0	1,583.0
Dividends	5.0	60.0	60.0	60.0	750.0
Book Value	826.0	1,192.0	1,440.0	1,818.0	11,572.0
Price Average	1,087.0	2,450.0	2,167.0	3,140.0	34,860.0
Total Employees	2,003	2,184	2,325	2,942	2,919
Exchange Rate (W/US$)	795.5	827.4	890.2	861.4	792.3

N/A = Not Available

Source: Dongsuh Securities Co., Ltd.
Annual Reports of Listed
Companies

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Korea Electronics Co., Ltd.

BACKGROUND

Korea Electronics Co. (KEC) was established in September 1969 under a joint venture with Toshiba of Japan (South Korea, 30 percent; Toshiba, 70 percent). At that time, the company name was Toshiba Korea Co. In 1979, the ownership changed to 90 percent South Korea, 10 percent Toshiba when the company became public. The current company name was adopted in March 1974.

MAIN PRODUCTS

The Company's main products are as follows:

- Consumer: black-and-white and color television sets and monitors
- Semiconductors: linear bipolar audio and video ICs, discrete transistors, diodes, and LEDs

REVENUE BY BUSINESS ACTIVITY (Millions of U.S. Dollars)

	1983	1984	1985	1986	1987
Semiconductor	$26.4	$38.0	$42.0	$ 52.1	$ 77.1
Pellet	$ 0.5	$ 1.0	$ 1.3	$ 1.1	$ 1.1
Television/Tuner	$34.7	$45.6	$53.3	$118.8	$130.6

Source: Korea Electronics Co., Ltd.
Annual Reports
Dataquest
January 1989

Korea Electronics Co., Ltd.

WORLDWIDE SEMICONDUCTOR SALES (Millions of U.S. Dollars)

	1983	1984	1985	1986	1987
Total Semiconductor	$26.4	$38.0	$42.0	$48.9	$78.2
Total IC	$ 3.8	$ 5.0	$ 8.0	$ 9.5	$19.9
Bipolar Digital	-	-	-	-	
MOS	-	-	-	-	
Memory	-	-	-	-	
Microprocessor	-	-	-	-	
Logic	-	-	-	-	
Linear	3.8	5.0	8.0	9.5	19.9
Total Discrete	$20.1	$30.0	$32.0	$33.1	$48.4
Total Optoelectronics	$ 2.5	$ 3.0	$ 2.0	$ 6.3	$ 9.9

Source: Korea Electronics Co., Ltd.
Annual Reports
Dataquest
January 1989

SEMICONDUCTOR DIVISION

General manager: Teng Yeol Ih (managing director)

The following is a brief history of KEC's semiconductor business:

- 1970—began to produce TO-92 transistors
- May 1975—started IC assembly
- April 1976—started LED and silicon diode assembly
- December 1978—started production of transistors and diodes
- July 1983—started production of bipolar linear ICs
- 1985—had one of the world's largest assembly capacities for TO-92 transistors

Korea Electronics Co., Ltd.

Capital spending (Millions of U.S. Dollars):

	1983	1984	1985	1986	1987
Plant	$10	$34	$20	$17	$5
R&D	1	3	2	3	1
Total	$11	$37	$22	$20	$6

JOINT VENTURE/LICENSING

Partner	Country	Year	Technology
Toshiba	Japan	1970	Assembly and process technology, discrete and linear bipolar devices

Korea Electronics Co., Ltd.

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Korea Electronics Co., Ltd.

Korea Electronics Co., Ltd.
45 Namdaemun-ro 4-ga,
Jung-gu, Seoul 100, Korea
Telephone: 02-757-5700, Fax: 02-756-5800
(Millions of Dollars Except Per Share Data)

Balance Sheet (September 31)

	1981	1982	1983	1984	1985
Financial Resources	$31.3	$18.4	$ 8.0	$26.1	$36.2
Long-Term Liabilities	$ 8.3	$16.3	$14.6	$19.9	$20.0
Shareholders' Equity	$11.7	$10.8	$10.9	$14.0	$15.8
After-Tax Return on Average Equity (%)	15.8	5.1	11.9	32.9	18.2

Operating Performance (September 31)

	1981	1982	1983	1984	1985
Revenue	$50.0	$40.1	$61.6	$84.6	$96.6
Cost of Revenue	$40.0	$33.4	$50.3	$66.5	$78.9
SG&A Expense	$ 4.3	$ 4.0	$ 6 3	$ 6.0	$ 7.3
Pretax Income	$ 1.4	$ 0.4	$ 2.0	$ 6.4	$ 4.5
Net Income	$ 1.3	$ 0.4	$ 1.3	$ 4.0	$ 2.9
Average Shares (Million)	6.4	9.0	9.0	9.0	9.0
Per Share (Won)					
Earnings	152.0	51.0	111.0	371.0	273.0
Dividends	87.5	45.0	50.0	60.0	60.0
Book Value	1,188.0	1,123.0	826.0	1,192.0	1,440.0
Price Average	N/A	N/A	1,087.0	2,450.0	2,167.0
Total Employees	1,827	1,786	2,003	2,184	2,325
Exchange Rate (W/US$)	700.5	748.8	795.5	827.4	870.0

N/A = Not Available

Source: Dongsuh Securities Co., Ltd. Annual Reports of Listed Companies

Korea Electronics Co., Ltd.

THE COMPANY

Overview

Korea Electronics Co. (KEC) was established in September 1969 under a joint venture with Toshiba of Japan (South Korea, 30 percent; Toshiba, 70 percent). At that time, the company name was Toshiba Korea Co. In 1979, the ownership changed to 90 percent South Korea, 10 percent Toshiba when the company became public. The current company name was adopted in March 1974.

MAIN PRODUCTS

The Company's main products are as follows:

- Consumer: black-and-white and color television sets and monitors
- Semiconductors: linear bipolar audio and video ICs, discrete transistors, diodes, and LEDs

Revenue by Business Activity (Millions of U.S. Dollars)

	1981	1982	1983	1984	1985
Semiconductor	$27.2	$14.7	$26.4	$38.0	$42.0
Pellet	-	$ 0.1	$ 0.5	$ 1.0	$ 1.3
Television/tuner	$21.4	$24.0	$34.7	$45.6	$53.3

Source: Korea Electronics Co., Ltd.
Annual Reports
Dataquest
September 1987

Capital and R&D Spending

CAPITAL SPENDING
(Millions of U.S. Dollars)

	1983	1984	1985	1986*
Plant	$10	$34	$20	$17
R&D	1	3	2	3
Total	$11	$37	$22	$20

*Estimated

WORLDWIDE SEMICONDUCTOR SALES
(Millions of U.S. Dollars)

	1982	1983	1984	1985	1986*
Total semiconductor	$14.7	$26.4	$38.0	$42.0	$50.3
Total IC	$ 2.7	$ 3.8	$ 5.0	$ 8.0	$10.0
Bipolar digital	-	-	-	-	-
MOS	-	-	-	-	-
Memory	-	-	-	-	-
Microprocessor	-	-	-	-	-
Logic	-	-	-	-	-
Linear	2.7	3.8	5.0	8.0	10.0
Total discrete	$10.7	$20.1	$30.0	$32.0	$38.0
Total optoelectronics	$ 1.3	$ 2.5	$ 3.0	$ 2.0	$ 2.3

*Estimated

Source: Korea Electronics Co., Ltd.
Annual Reports
Dataquest
September 1987

Korea Electronics Co., Ltd.

SEMICONDUCTOR DIVISION

General manager: Dong Chang (director)

The following is a brief history of KEC's semiconductor business:

- 1970--began to produce TO-92 transistors
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- December 1978--started production of transistors and diodes
- July 1983--started production of bipolar linear ICs
- 1985--had one of the world's largest assembly capacities for TO-92 transistors

SEMICONDUCTOR PRODUCTION

Address: 149 Gongdan-dong, Gumi City, Kyungbuk, South Korea

Capacity (millions of units per year):

Product	1984	1985
Transistors	120	150
Linear ICs	2	5
Diodes	2	5
LEDs	5	10
Total	129	170

JOINT VENTURE/LICENSING

Partner	Country	Year	Technology
Toshiba	Japan	1970	Assembly and process technology, discrete and linear bipolar devices

Lattice Semiconductor Corporation

Lattice Semiconductor Corporation
15400 N. W. Greenbriar Parkway
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(Lattice Semiconductor Corporation is a privately held company; therefore, balance sheet and income statement data are unavailable.)

Lattice Semiconductor Corporation

THE COMPANY

Overview

Lattice Semiconductor Corporation was founded in April 1983 to design, develop, manufacture, and market high-performance CMOS memory and logic integrated circuits using a proprietary 1.1-micron CMOS and EE CMOS technology. The Company is located in a 120,000-square-foot facility in Beaverton, Oregon. This facility is used for design, testing, some assembly, marketing, and administration. Lattice has pioneered a line of high-speed EE CMOS programmable logic devices (PLDs), called Generic Array Logic (GAL), as direct pin-for-pin replacements for bipolar PALs. (PAL is a registered trademark of Monolithic Memories, Inc. Generic Array Logic and GAL are trademarks of Lattice Semiconductor Corporation.) The next generation, which consists of ispGAL devices, includes in-system programmability that makes logic configurable "on the fly," under software control for robotics and artificial intelligence applications.

Lattice Semiconductor supplies high-speed CMOS SRAMs for commercial and military applications. The speed is achieved by using a proprietary 1.1-micron EE CMOS process, single-ended sense amplifiers, and substrate basing. Lattice has achieved first silicon of a 256Kxl fast SRAM and will follow shortly with 64Kx4 and 32Kx8 versions. The targeted specification speed is 35ns.

Long-Term Outlook

There are several issues facing Lattice and other CMOS PLD suppliers. The first issue is emerging Japanese suppliers. With their wide experience in EPROM and EEPROM technology and with superb business skills, the Japanese could pose a threat to today's North American PLD suppliers. Another issue is that Monolithic Memories, Inc. (MMI), has brought suit against Lattice Semiconductor, charging Lattice with patent infringement. Lattice, in response, has charged MMI with intent to delay an equity financing package that Lattice was negotiating. Lattice claims that MMI's suit scared off potential equity financers. Without the necessary funding, Lattice was forced to postpone payroll, lay off a number of employees, and close offices in Paris and Germany.

Rahul Sud—Lattice founder, president, and CEO—and three others recently announced their resignations from the Company. This caused Lattice to seek not only funding but also a new president.

More recently, Lattice has taken aggressive action to resolve the above issues. The Company has signed licensing and manufacturing agreements to put itself in a better cash position. In July 1987, Lattice filed for Chapter 11 protection to reorganize the Company and restructure its debt to ensure that new funding raised would be applied toward financing the Company's ongoing operations.

Lattice Semiconductor Corporation

Management and Employees

Lattice currently employs 72 people. The Company's management is listed in Table 1.

Table 1

Lattice Semiconductor Corporation
Company Executives

Position	Name	Prior Company	Prior Position
Chairman/CEO	C. Norman Winningstad	Floating Point Systems, Inc.	Vice-Chairman (Current)
Executive VP	Raymond P. Capace	Touche-Ross International	Director Operations
VP Finance/Administration	Jan Johannessen	Investim Corporation	Financial Consultant
VP Sales/Marketing	Paul T. Kollar	Signetics	Director of National District Operations

Source: Lattice Semiconductor Corporation

Financial Information

Table 2 lists several sources that have supplied funding for Lattice. The Company anticipates another round of funding in the near future.

Table 2

Lattice Semiconductor Corporation
Sources of Funding
(Millions of Dollars)

Date	Round	Sources	Amount
December 1983	1	Floating Point Systems, Inc.; Louisiana-Pacific Corporation; C. Norman Winningstad; Harry A. Merlo; Datavekst A/S Norway; and other corporate stockholders	$2.5
July 1984	Credit	Oregon Bank; U.S. National Bank	$2.7
December 1986		Undisclosed source of financing	Undisclosed

Source: Dataquest
October 1987

Lattice Semiconductor Corporation

PRODUCTS AND MARKETS

Semiconductor Product Markets

Lattice targets rapidly expanding niche markets with high-performance EECMOS and CMOS, memory, and logic products for commercial and military applications.

Table 3 shows Lattice's estimated revenue for 1984, 1985, and 1986.

Table 3

Lattice Semiconductor Corporation
Estimated Semiconductor Revenue
(Millions of Dollars)

	1984	1985	1986
Total Semiconductor	$4.0	$3.0	$10.0
Total IC	$4.0	$3.0	$10.0
MOS Memory	4.0	2.5	8.0
MOS Logic	0	0.5	2.0

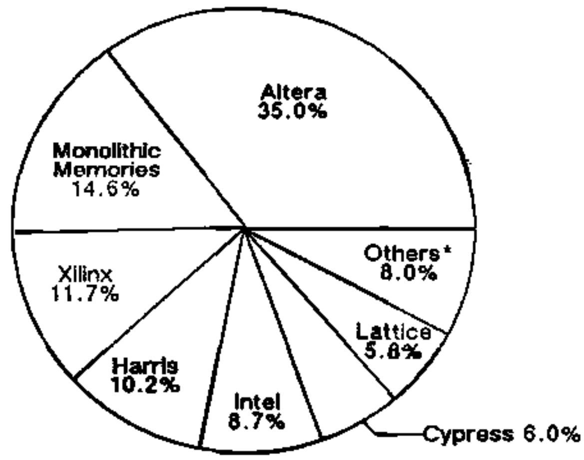
Source: Dataquest
October 1987

Lattice has positioned electrically erasable PLDs (EEPLDs) to compete with MMI's bipolar PALs. MMI, historically, has been the leading supplier of bipolar PLDs. Lattice, ultimately, would like GAL to be recognized as an industry standard, as is PAL.

Figure 1 shows the top 10 CMOS PLD suppliers in the market. Note that some of these suppliers are young start-up companies; market share for each company could change in the next three years. Success of the basic EEPLD approach has motivated many of the major bipolar PLD suppliers to consider including EEPLDs in their product portfolios. The entrance of major PLD suppliers into the EEPLD market will help expand the electrically erasable device market.

Figure 1

Estimated 1986 Market Share—CMOS PLDs



1986 Total: $34.3 Million

*Others category includes Panatech, Texas Instruments, and Gould/AMI

Source: Dataquest
October 1987

Applications and End Markets

EEPLDs are used in four market segments: electronic and data processing, communications, military, and industrial. Typical applications are as follows:

- Graphic systems—These are systems that include low power, high speed, and flexibility; glue logic and decoding are the primary uses.

- Minicomputer workstations—The PLD device count per system is high; GAL solves reliability and manufacturing problems while reducing cooling and power-supply requirements.

- PC add-on boards—They need low power to increase board density without exceeding the system power supply limits.

- VME (or equivalent) "computer on the card"—The GAL generic architecture offers superior ease of manufacturing in high-volume user applications where 100 percent yields are important; low power is also key to these applications.

- Telecommunications—Local area network (LAN) controllers use GAL devices for glue logic; they need high-speed decoders and encoders on each card, and low power is a plus.

Lattice Semiconductor Corporation

Semiconductor Products and Technology

Technology

Lattice Semiconductor uses a 1.1-micron CMOS process technology in its manufacturing. Lattice has established high-volume wafer fabrication sources in Japan and Europe; however, all final testing of wafers, including quality and reliability tests in conformance with MIL-STD 883C, is done in Lattice's Beaverton facility.

Product Lines

Programmable Logic Devices - Lattice is the first supplier of CMOS EEPLDs, also known as GAL. GAL has numerous advantages:

- EEPLD technology allows for 5-volt, in-system reconfigurability, which means that the user can change the logic, under software control in real time.
- One GAL replaces forty-two 20- to 24-pin bipolar PAL devices, simplifying inventory management and production control for the user.
- CMOS technology achieves low power consumption, while still reaching standard equivalent bipolar speeds of 20ns to 25ns.
- EEPLD is 100 percent factory tested, guaranteeing zero defects prior to shipping; this means a reduction in the number of part rejections, board failures, or system failures.

Table 4 lists the Company's products.

Table 4

Lattice Semiconductor Corporation
GAL Product List

CMOS EEPLD--GAL Programmable Logic Devices	Programming Tools Vendor	Programming Tools Model
GAL 16V8	Data I/O	29B, 60A
GAL 20V8	Stag	ZL30, ZL30A/ZL32
GAL 39V18	JMC	DRINAC P3
ispGAL 16V8	VARIX	Omni Programmer
ispGAL 20V8		

Source: Dataquest
October 1987

Memory – Lattice focuses its fast SRAM business on military and niche commercial markets with its 64K line. The Company also plans to offer 256K SRAMs and a 64K EEPROM.

Memory products now available are listed in Table 5.

Table 5

Lattice Semiconductor Corporation
SRAM Products

Device	Organization	Speed	Comment
SR64E4	16Kx4	35 to 55ns	With output enable
SR64K4	16Kx4	35 to 55ns	
SR64K8	8Kx8	35 to 45ns	

Source: Lattice Semiconductor Corporation

Semiconductor Agreements

Agreements and Alliances – Lattice Semiconductor has entered into agreements and alliances with the following:

- VLSI Technology
  - September 1984—Lattice provided technology for CMOS EEPROMs and SRAMs to VLSI Technology in exchange for foundry services at VLSI.
- Seiko–Epson and S–MOS Systems
  - January 1986—Lattice announced a manufacturing and second–source agreement, whereby Seiko–Epson acquired the license to Lattice's chip design and process technology.
- SGS
  - February 1987—Lattice announced the signing of a manufacturing and second–source licensing agreement, under which SGS will manufacture GAL products for Lattice and cooperate in the design of future products.
- National Semiconductor
  - May 1987—Lattice announced the signing of a licensing, codevelopment, and manufacturing agreement for high–speed CMOS electrically erasable PLDs.

M-N

Matsushita Electric Industrial Co., Ltd.

Matsushita Electric Industrial Co., Ltd.
1006 Kadoma, Kadoma City
Osaka 571, Japan
Telephone: 06-908-1121 Telex: J63426
(Billions of Yen except Per Share Data)

Balance Sheet (November 20)

	1982	1983	1984	1985	1986
Working Capital	¥ 676.4	¥ 767.6	¥ 911.8	¥1,011.0	¥1,080.6
Long-Term Debt	¥ 49.2	¥ 40.4	¥ 160.0	¥ 156.2	¥ 141.3
Shareholders' Equity	¥1,435.3	¥1,602.1	¥1,830.7	¥2,061.0	¥2,171.4
After-Tax Return on Average Equity (%)	9.2	11.4	13.0	6.3	7.7

Operating Performance (Fiscal Year Ending November 20)

	1982	1983	1984	1985	1986
Revenue	¥3,649.6	¥3,988.5	¥4,720.7	¥5,052.7	¥4,574.9
Japanese Revenue	¥1,964.8	¥2,127.9	¥2,431.3	¥2,549.3	¥2,566.8
Non-Japanese Revenue	¥1,684.8	¥1,860.6	¥2,289.4	¥2,503.4	¥2,008.1
Cost of Revenue	¥2,354.2	¥2,571.0	¥3,038.1	¥3,288.1	¥3,128.2
R&D Expense	¥ 151.2	¥ 174.2	¥ 200.1	¥ 240.7	¥ 250.1
SG&A Expense	¥ 917.6	¥ 991.0	¥1,106.8	¥1,203.4	¥1,134.9
Pretax Income	¥ 428.9	¥ 498.1	¥ 668.4	¥ 689.4	¥ 441.1
Pretax Margin (%)	11.8	12.5	14.2	13.6	9.6
Effective Tax Rate (%)	53.1	53.9	54.7	54.7	54.1
Net Income	¥ 157.1	¥ 182.7	¥ 238.4	¥ 246.4	¥ 163.7
Average Shares Outstanding (Millions)	1,604	1,583	1,753	1,768	1,780
Per Share					
Earnings	¥ 97.92	¥ 103.44	¥ 132.20	¥ 135.08	¥ 89.74
Dividends	¥ 10.00	¥ 9.88	¥ 11.29	¥ 10.00	¥ 10.00
Book Value	¥ 895	¥ 1,012	¥ 1,044	¥ 1,165	¥ 1,220
Price Range*	¥ 900-1,425	¥ 1,200-1,800	¥ 1,400-2,050	¥ 1,050-1,750	¥ 1,200-1,950
Total Employees	121,254	124,825	132,814	133,963	135,881
Capital Expenditures	¥ 161.0	¥ 144.5	¥ 247.8	¥ 255.1	¥ 152.8
Exchange Rate (Yen per US$)	241.5	238.1	237.4	241.8	171.7

*Price ranges are expressed in yen per common share on the Tokyo Stock Exchange. Price ranges for 1982, 1983, 1984, 1985, and 1986 are estimated by Dataquest from bar charts in the Matsushita Annual Reports.

Source: Matsushita Electric Industrial Co., Ltd., Annual Reports
Dataquest
October 1987

Matsushita Electric Industrial Co., Ltd.
1006 Kadoma, Kadoma City
Osaka 571, Japan
Telephone: 06-908-1121 Telex: J63426
(Millions of Dollars except Per Share Data)

Balance Sheet (November 20)

	1982	1983	1984	1985	1986
Working Capital	$ 2,800.8	$ 3,223.9	$3,840.8	$ 4,181.1	$ 6,293.5
Long-Term Debt	$ 203.7	$ 169.7	$ 674.0	$ 646.0	$ 822.9
Shareholders' Equity	$ 5,943.3	$ 6,728.7	$7,711.5	$ 8,523.6	$12,646.5
After-Tax Return on Average Equity (%)	9.2	11.4	13.0	6.3	7.7

Operating Performance (Fiscal Year Ending November 20)

	1982	1983	1984	1985	1986
Revenue	$15,112.2	$16,751.4	$19,885.0	$20,896.2	$26,644.7
Japanese Revenue	$ 8,135.8	$ 8,937.0	$10,241.4	$10,543.0	$14,949.3
Non-Japanese Revenue	$ 6,976.4	$ 7,814.4	$ 9,643.6	$10,353.2	$11,695.4
Cost of Revenue	$ 9,748.2	$10,798.0	$12,797.4	$13,598.4	$18,219.0
R&D Expense	$ 626.1	$ 731.6	$ 842.9	$ 995.5	$ 1,456.6
SG&A Expense	$ 3,799.6	$ 4,162.1	$ 4,662.2	$ 4,976.8	$ 6,609.8
Pretax Income	$ 1,776.0	$ 2,092.0	$ 2,815.5	$ 2,851.1	$ 2,569.0
Pretax Margin (%)	11.8	12.5	14.2	13.6	9.6
Effective Tax Rate (%)	53.1	53.9	54.7	54.7	54.1
Net Income	$ 650.5	$ 767.3	$ 1,004.2	$ 1,019.0	$ 953.4
Average Shares Outstanding (Millions)	1,604	1,583	1,753	1,768	1,780
Per Share					
Earnings	$ 0.41	$ 0.48	$ 0.57	$ 0.56	$ 0.52
Dividends	$ 0.04	$ 0.04	$ 0.05	$ 0.04	$ 0.06
Book Value	$ 3.71	$ 4.25	$ 4.40	$ 4.82	$ 7.11
Price Range*	$ 3.73-5.90	$ 5.04-7.56	$ 5.90-8.64	$ 4.34-7.24	$ 6.99-11.36
Total Employees	121,254	124,825	132,814	133,963	135,881
Capital Expenditures	$ 666.7	$ 606.9	$ 1,043.8	$ 1,055.0	$ 889.9
Exchange Rate (Yen per US$)	241.5	238.1	237.4	241.8	171.7

*Price ranges are expressed as U.S. dollar conversions of yen per common share on the Tokyo Stock Exchange. Price ranges for 1982, 1983, 1984, 1985, and 1986 are estimated by Dataquest from bar charts in the Matsushita Annual Reports, and converted to U.S. dollars according to the exchange rates given in this table.

Source: Matsushita Electric Industrial Co., Ltd., Annual Reports
Dataquest
October 1987

Matsushita Electric Industrial Co., Ltd.

THE COMPANY

Executive Summary

Matsushita Electric Industrial Co., Ltd., is the largest electronics company in Japan and one of the 50 largest industrial corporations worldwide, with fiscal 1986 sales of ¥4,574.9 billion ($26.6 billion). Matsushita's products range from consumer electronic equipment, home appliances and related products, to industrial and communications equipment, and electronic components.

Since 1983, Matsushita has instituted several programs to increase its presence as a multinational company and diversify its product line from primarily consumer electronics to include additional industrial electronic products.

Overview

Matsushita was founded as a family business in 1918 by Konosuke Matsushita, to produce and market an electric adapter plug for consumer products. The company's growth has its roots in the founding principle of Konosuke Matsushita: "To serve society by producing high-quality, high-performance goods and services that meet consumers' needs." Today Matsushita consists of more than 50 non-Japanese manufacturing subsidiaries and 36 sales companies the world over. Products are sold in more than 130 countries under well-known brand names that include National, Panasonic, Technics, and Quasar.

Long-Term Outlook

Matsushita's growth has been based largely on consumer electric and electronic products. However, sales of consumer products have been affected by increasing competition from Southeast Asian manufacturers, and by the effects of the strong yen and trade frictions on exports.

The Company's long-term goal is to maintain its leadership position in its consumer markets while expanding into the industrial electronic product market--preparing for what it believes is the coming home-information/home-automation age.

Matsushita plans to accomplish this by:

- Emphasizing developments in industrial areas that it believes are the new high-growth areas, such as--office automation (OA), new audiovisual (new AV), factory automation (FA), and semiconductors. Since 1984, the areas of industrial and components sales have increased from 25 percent in 1983 to 30 percent in 1986. These actions meet midrange goals, which the company believes will lead into the "next generation of home automation," offering a new base for future growth.

- Restructuring the Company to make the most of the integrated capabilities of the Matsushita group of companies. One step has been to end the fiscal years of most of the Matsushita Group companies on March 31, as do most of the major Japanese companies and the Japanese government.

- Increasing its presence as a multinational company by increasing overseas production.

- Reducing operating and materials-purchase costs.

Company Organization

Matsushita Electric is the parent company of the Matsushita Group. The group consists of more than 25 companies, involved mostly in electrical and electronics products. The Matsushita Group, formerly a small collection of family businesses, expanded as the home electrical appliance market boomed after World War II.

Matsushita's semiconductors are produced by a subsidiary, Matsushita Electronics Corporation (MEC), which is 65 percent owned by Matsushita Electric and 35 percent owned by N.V. Philips of the Netherlands. MEC was established in 1952. The Semiconductor Group was established in 1957, and semiconductors currently represent 45 percent of MEC's production.

Employees

At the end of the 1986 fiscal year, Matsushita Electric employed 135,881 workers. The Company is still headed by a member of the Matsushita family--Chairman Masaharu Matsushita.

Financial Information

Major Shareholders - Matsushita Electric's major shareholders are shown in Table 1.

Table 1

Matsushita Electric Industrial Co., Ltd.
MAJOR SHAREHOLDERS
1986

Shareholders	Percentage of Ownership
Sumitomo Bank	4.6%
Sumitomo Life Insurance	4.6%
Moxley and Company	4.3%
Nippon Life Insurance	4.1%
Investment and Development	3.8%
Konosuke Matsushita	2.7%
Kyowa Bank	2.0%

Source: Japan Company Handbook

Non-Japanese ownership is 18.6 percent. Matsushita is listed on the three major Japanese stock exchanges, as well as on the Amsterdam, Dusseldorf, Frankfurt, Hong Kong, New York, Pacific, and Paris stock exchanges.

Matsushita reported consolidated net earnings of ¥163.7 billion ($953.4 million) on sales of ¥4,574.9 billion for the fiscal year ending November 20, 1986. This represents a decline of 34 percent in earnings from fiscal 1985 and a 9 percent decrease in sales.

Matsushita announced that it will unify the fiscal years of most Matsushita Group companies to a March 31 closing--the date used by the Japanese government and many major Japanese companies. Matsushita's fiscal year end was formerly November 20. The period from November 31, 1986, through March 31, 1987, was a one-time, irregular fiscal year. A new 12-month fiscal year began on April 1, 1987.

Lines of Business

Matsushita's business operations are divided into the following six major product groups:

- Video equipment
- Audio equipment
- Home appliances

- Communications and industrial equipment
- Energy and kitchen-related products
- Electronic components

Matsushita showed a sales decline in nearly all product groups in 1986. The video equipment, the largest product group, reported that sales grew in Japan due to TV and VTR shipments; however, overall sales fell 20 percent, due to low non-Japanese sales. Communications and industrial equipment, the second largest group, showed a 2 percent decrease from 1985, due to a reduced demand for office-automation and factory-automation products. Electronic components showed a 2 percent decrease; however, semiconductor sales, which are included in electronic components, increased by 33 percent.

Table 2 shows Matsushita sales by product group from 1982 to 1986.

Table 2

Matsushita Electric Industrial Co., Ltd.
SALES BY PRODUCT GROUP
(Billions of Yen)

	Fiscal Year Ending November 20				
Product Group	1982	1983	1984	1985	1986
Video Equipment	¥1,341.4	¥1,443.4	¥1,726.4	¥1,890.2	¥1,502.8
Audio Equipment	484.5	480.7	478.9	452.8	391.3
Home Appliances	590.5	596.4	683.3	731.5	707.0
Communications and Industrial Equipment	452.3	588.4	783.9	880.2	859.0
Energy- and Kitchen-Related Products	180.6	187.0	193.3	192.9	207.6
Electronic Components	309.6	385.4	542.7	538.1	529.0
Other Products	290.7	307.2	312.2	367.0	378.3
Total	¥3,649.6	¥3,988.5	¥4,720.7	¥5,052.7	¥4,575.0
Exchange Rate (Yen per US$)	241.5	238.1	237.4	241.8	171.7

Columns may not add to totals shown because of rounding.

Source: Matsushita Electric Industrial Co., Ltd., Annual Reports
Dataquest
October 1987

International Activities

Non-Japanese sales in 1986 decreased 20 percent to ¥2,008.1 billion. The decline was affected by the yen's escalation, a decrease in exports to the People's Republic of China, the trade friction, and competition from newly industrialized countries. In response, Matsushita stressed exports of high-value-added products and accelerated expansion of production facilities overseas.

Non-Japanese sales in 1986 accounted for 44 percent of revenue, compared with 50 percent in fiscal 1985. These percentages are significantly higher than comparable figures for Fujitsu, Hitachi, Mitsubishi, NEC, and Toshiba; but they are not surprising if one realizes that most of Matsushita's products are consumer products and that the Company's audio and video equipment is a dominating force in international markets.

Facilities

Companywide, Matsushita has more than 50 manufacturing companies outside Japan. These companies are located in North, Central, and South America; the Far East; Oceania; Africa; and Europe. The Company also has 35 sales companies worldwide.

Matsushita Electronics Corporation has 10 semiconductor manufacturing facilities: 8 in Japan, 1 in the United States, and 1 in Singapore. These are listed in Table 3. The Company also plans to build a new U.S. semiconductor plant in the midwest sometime in 1987, although no details are available yet. Currently, hybrid assembly is performed at Matsushita Electronic Components Company in Santa Clara, California.

Two plants, built recently at Uozu, came on-line in February and April of 1985, respectively.

Table 3

Matsushita Electronics Corporation
SEMICONDUCTOR MANUFACTURING FACILITIES

Facility	Location	Function and Products
Arai Works	Niigata Prefecture	Fab, assembly, test--ICs
Kagoshima Matsushita Denshi	Kagoshima Prefecture	Assembly--optoelectronics, germanium transistors
Nagaoka Factory	Kyoto Prefecture	Fab, assembly, and test--ICs, discretes, and optoelectronics; VLSI R&D
Okayama Factory	Okayama Prefecture	Assembly--transistors
Utsunomiya Factory	Tochigi Prefecture	Assembly--silicon transistors and diodes
Toyo Dempa (Affiliate)	Kyoto Prefecture	Assembly--silicon diodes
West Denki (Affiliate)	Osaka Prefecture	Assembly--germanium diodes
Uozu Factory	Toyama Prefecture	Fab, assembly--MOS logic and MPU
Matsushita Denshi Pte.	Singapore	Assembly--silicon transistors, ICs
Matsushita Electronic Components Company	Santa Clara, CA	Assembly--custom hybrid ICs

Source: Dataquest
October 1987

Capital and R&D Spending

Slow, demand growth held 1986 capital spending to 40 percent below the 1985 level. Still Matsushita's capital spending totaled ¥152.8 billion ($889.9 million). In 1986, R&D spending increased 4 percent to ¥250.1 billion ($1,456.6 million), equal to 5.5 percent of sales.

Capital and R&D spending in 1986 totaled ¥402.9, or 9 percent of revenue. The Company invested about one-half of its R&D and capital expenditures budget in its four areas of emphasis--office automation, new audiovisual (new AV) factory automation, and semiconductors. Capital investments included investments in R&D facilities aimed at future growth, operational facilities in the Company's new areas, and modernization/ rationalization programs.

Table 4 shows Matsushita's capital and R&D spending from 1982 through 1986 in yen. Table 5 shows Matsushita's capital and R&D spending in dollars.

Table 4

Matsushita Electronics Corporation
CAPITAL AND R&D SPENDING AS A PERCENTAGE OF SALES
(Billions of Yen)

	1982	1983	1984	1985	1986
Revenue	¥3,649.6	¥3,988.5	¥4,720.7	¥5,052.7	¥4,574.9
Capital Spending	¥ 161.0	¥ 144.5	¥ 247.8	¥ 255.1	¥ 152.8
Percentage of Revenue	4.4%	3.6%	5.3%	5.1%	3.3%
R&D Spending	¥ 151.2	¥ 174.2	¥ 200.1	¥ 240.7	¥ 250.1
Percentage of Revenue	4.1%	4.3%	4.2%	4.8%	5.5%
Combined Capital and R&D Spending	¥ 312.2	¥ 318.7	¥ 447.9	¥ 495.8	¥ 402.9
Percentage of Revenue	8.5%	7.9%	9.5%	9.9%	8.8%
Percentage of Increase (Decrease)	(5.4%)	2.1%	40.5%	10.7%	(18.7%)
Exchange Rate (Yen per US$)	241.5	238.1	237.4	241.8	171.7

Source: Matsushita Electric Industrial Co., Ltd., Annual Reports
Dataquest
October 1987

Table 5

Matsushita Electronics Corporation
CAPITAL AND R&D SPENDING IN DOLLARS
(Millions of Dollars)

	1982	1983	1984	1985	1986
Revenue	$15,112.2	$16,751.4	$19,885.0	$20,896.2	$26,644.7
Capital Expenditures	$ 666.7	$ 606.9	$ 1,043.8	$ 1,055.0	$ 889.9
R&D Expense	$ 626.1	$ 731.6	$ 842.9	$ 995.5	$ 1,456.6

Source: Matsushita Electric Industrial Co., Ltd., Annual Reports
Dataquest
October 1987

Several Japanese companies cut back their capital spending for calendar year 1986 by amounts greater than 30 percent, Matsushita among them. Table 6 shows Matsushita Electronics Corporation's semiconductor capital spending for the last five years.

Table 6

Matsushita Electronics Corporation
SEMICONDUCTOR CAPITAL SPENDING BY CALENDAR YEAR
(Millions of Dollars)

	1982	1983	1984	1985	1986
Semiconductor Revenue	$427	$600	$928	$906	$1,204
Semiconductor Capital Spending	$ 36	$ 89	$371	$366	$ 144
Percentage of Semiconductor Revenue	8.4%	14.8%	40.0%	40.4%	12.0%

Source: Dataquest
October 1987

Research and Development

Matsushita has a strong ongoing commitment to R&D, focused on technologies that fulfill the needs of the coming information-oriented society.

Semiconductor R&D is conducted with the cooperation of Matsushita's various research laboratories and its semiconductor subsidiary, Matsushita Electronics Corporation. Matsushita has five semiconductor R&D laboratories. They are as follows:

- Materials Research Laboratory--Performs research and development of materials used in electronic components

- Matsushita Electronics Corporation Research Laboratory--Performs semiconductor research and development

- Matsushita Technology Research Corporation (Kanagawa prefecture), a subsidiary of Matsushita Electric Industrial Co., Ltd.

- Matsushita Electric and Matsushita Electronics have both built new VLSI laboratories; the first is at Kadoma, Osaka prefecture, and the second is at Kyoto.

VLSI research and development is also carried out at the Nagaoka Factory in Kyoto prefecture.

Matsushita's recent R&D achievements include the following:

- Development of an Integrated Work Processor (IWP) that includes a word processor, personal computer, facsimile, and copier in one workstation

- Development with NTT of a large-scale optical fiber LAN system that can transmit 100 Mbits per second

- Development of a biaspheric molded glass lens for CD player pickup, replacing the four or five ground lenses used in conventional systems

PRODUCTS AND MARKETS

Semiconductor Products and Markets

Matsushita is the largest worldwide supplier of linear ICs and the eighth largest worldwide semiconductor supplier. Estimated semiconductor revenue in 1986 was $1,204 million, as shown in Table 7. This amount represents a 33 percent increase, compared to $906 million in 1985.

Matsushita Electric Industrial Co., Ltd.

Table 7

Matsushita Electric Industrial Co., Ltd.
ESTIMATED SEMICONDUCTOR REVENUE
(Millions of Dollars)

	1982	1983	1984	1985	1986
Total Semiconductor	$427	$600	$928	$906	$1,204
Total Integrated Circuit	$250	$367	$592	$595	$ 801
Bipolar Digital (Technology)	$ 7	$ 13	$ 22	$ 21	$ 28
TTL	-	-	18	17	21
ECL	-	-	4	4	7
Bipolar Digital (Function)	$ 7	$ 13	$ 22	$ 21	$ 28
Bipolar Digital Logic	7	13	22	21	28
MOS (Technology)	$ 89	$160	$283	$269	$ 386
NMOS	50	103	184	170	238
PMOS	15	12	5	4	3
CMOS	24	45	94	95	144
MOS (Function)	$ 89	$160	$283	$269	$ 386
MOS Memory	9	29	80	58	70
MOS Microdevices	48	88	119	111	167
MOS Logic	32	43	84	100	150
Linear	$154	$194	$287	$305	$ 387
Total Discrete	$146	188	247	227	277
Transistor	$ 94	$122	$157	$140	$ 204
Small Signal Transistor	-	-	95	87	129
Power Transistor	-	-	62	53	74
Diode	$ 38	$ 52	$ 68	$ 60	$ 70
Small Signal Diode	-	-	68	60	70
Thyristor	$ 4	$ 4	$ 5	$ 4	-
Other Discrete	$ 10	$ 10	$ 17	$ 23	$ 4
Total Optoelectronic	$ 31	45	$ 89	$ 84	$ 126
LED Lamps	-	-	40	38	$ 76
Other Optoelectronic	-	-	49	46	$ 50
Exchange Rate (Yen/US$)	$248	$235	$237	$238	$ 167

Note: Columns may not add to totals shown due to rounding.

Source: Dataquest
October 1987

Linear product revenue in 1986 was $387 million, an increase of 27 percent over $305 million in 1985. The increase was less than the industry growth of 30 percent. However, Matsushita grew steadily over the last five years, overtaking National Semiconductor in 1986.

Table 8 shows the top five suppliers of linear products and their revenue for five years.

Table 8

TOP FIVE SUPPLIERS OF LINEAR PRODUCTS
(Millions of Dollars)

	1982	1983	1984	1985	1986	1986 Percentage of Market
Matsushita	$154	$194	$287	$305	$387	6.4%
National Semiconductor	$255	$374	$433	$370	$384	6.3%
Toshiba	$101	$134	$228	$235	$375	6.2%
NEC	$156	$192	$290	$300	$363	6.0%
Texas Instruments	$235	$296	$409	$335	$352	5.8%

Source: Dataquest
October 1987

The Company also grew faster than the industry growth rate for bipolar-logic devices and optoelectronic devices, as shown in Table 9. In addition, Matsushita showed increases in NMOS devices (53 percent), CMOS devices (52 percent), MOS memory (21 percent), MOS microdevices (50 percent), and MOS logic (50 percent). The rate of change in total discrete revenue was less than the industry growth rate; however, transistors, the Company's largest discrete product line, showed a 46 percent change from 1985.

Viewed against its Japanese competitors, Matsushita is the number one supplier of linear ICs and is also very strong in optoelectronics devices.

Table 9

Matsushita Electric Industrial Co., Ltd.
WORLDWIDE RANKING BY SEMICONDUCTOR MARKETS
(Millions of Dollars)

	1986 Rank	1985 Rank	1986 Semi. Revenue	Revenue % Change 1985-1986	Industry % Change 1985-1986
Total Semiconductor	8	10	$1,204	33%	25%
Total IC	11	11	801	35%	24%
Bipolar Digital	17	24	28	33%	14%
MOS Digital	9	11	386	43%	25%
Linear	1	3	387	27%	30%
Total Discrete	5	6	277	22%	25%
Total Optoelectronic	3	4	126	50%	37%

Source: Dataquest
October 1987

Dataquest believes that, in 1986, approximately 2 percent of Matsushita's semiconductor sales were to the United States, 3 percent were to Europe, 6 percent were to the ROW countries, and the largest segment (88 percent) were domestic sales. Table 10 shows the estimated geographic distribution of Matsushita's semiconductor sales.

Table 10

Matsushita Electric Industrial Co., Ltd.
ESTIMATED 1986 SEMICONDUCTOR REVENUE
BY GEOGRAPHIC REGION
(Millions of Dollars)

	United States	Japan	Europe	ROW	Total
Total Semiconductor	$27	$1,060	$ 39	$ 77	$1,204
Total Integrated Circuit	$21	735	12	33	801
Bipolar Digital	-	28	-	-	28
MOS	17	368	-	-	386
Linear	4	338	12	33	387
Total Discrete	$ 6	213	14	44	277
Total Optoelectronic	$ -	113	13	-	126

Source: Dataquest
October 1987

Semiconductor Products and Technologies

Matsushita's semiconductor product line includes the following:

- Bipolar digital logic--LSTTL and ECL
- MOS memory--CMOS and NMOS SRAMs, DRAMs, ROMs and EPROMs, MNOS nonvolatile memory
- MOS microdevice--4-, 8-, and 16-bit MPUs, MCUs, and microperipherals
- MOS logic--Standard CMOS logic, CMOS gate arrays, and standard cells
- Linear--Op amps, comparators, industrial linear ICs, D/A and A/D converters
- Discrete--Small signal and power transistors, junction FETs, thyristors, diodes, GaAs FETs
- Optoelectronic--LEDs, GaAs semiconductor lasers, microwave ICs

Other activities in the semiconductor area include the following:

- Development of dual laser-beam recrystallization technology and stacked-layer construction incorporating planarized heat dispersal for fabrication of three-dimensional LSIs
- Development of a halftone image-processing LSI
- A new bipolar-device-manufacturing process technology (SDD-1) that prevents damage during ion implantation and dry etching, with a maximum cutoff frequency of 14 GHz; 72ps propagation-delay time, unique dummy pattern process and self-matching double diffusion (SDD) process for polysilicon
- Successful manufacture of an N-channel power MOSFET at microwave length, with an operation frequency of 2.45 GHz. The MOSFET has power output of 7W and withstands voltage of 75V.

Matsushita is a leader in GaAs technology and is involved in the Japanese government-sponsored optoelectronics project. Some of the Company's recent developments in this area include the following:

- 1982--GaAlAs LED
- 1982--GaAs monolithic frequency divider using source-coupled FET logic
- 1983--4-GHz, 25mW, GaAs IC using source-coupled FET logic
- 1984--GaAs low-noise transistors for satellite broadcast reception
- 1985--A highly sensitive GaAs Hall device with 300mV Hall output voltage
- 1986--An ultrahigh-speed GaAs IC for optical transmission using an E-type FET; operation speed is 1.6 Gbps with less than 0.5W of power consumption

The following are some announcements Matsushita made in 1986 and 1987:

- GaAs
  - A GaAs wideband, low-loss, double-balanced mixer IC for operation from 50 MHz to 2 GHz
  - A GaAs laser noise canceler IC, the MEL5005

- A GaAlAs laser that achieved 28-mW output through improvements to its buried twin ridge substrate (BTRS) structure. The Company will produce the chip in volume as a 50mW device

- A GaAs op amp IC, claimed to be 100 times faster than Si op amps, for high-frequency applications, including those pertaining to video amplifiers

- An experimentally manufactured 1.0-micron stripe GaAlAs laser, which has a 15mA threshold current and 1.05 ellipticity, with a new semiconductor laser process using MOCVD

- Optoelectronics

  - The development of a second harmonic generation (SHG) device for operation at a 0.4-micron wavelength. The niobic acid lithium crystal device will be combined with YAG lasers and semiconductor lasers to implement practical hardware.

  - A new semiconductor laser, called a monolithic two-beam GaAlAs laser array, for read/write optical disk applications. The laser is capable of generating two kinds of laser optical output--one for writing and the other for reading--on a single chip.

  - A prototypical optoelectronic IC (OEIC) that combines an AlGaAs semiconductor laser with 30mW of output and a high-frequency oscillator for laser noise reduction. Forty-four elements are integrated into the device, including one semiconductor laser, 25 MESFETs, and 18 diodes, onto a chip measuring 0.35 x 1.2mm.

- Digital signal processing

  - A high-speed, high-efficiency DSP, 2-micron, double-layer-aluminum and double-layer-polysilicon CMOS process, 7.52 x 7.24mm chip, 160,000 elements, 100ns cycle times, two 4K (256x16) of RAM and 2,048x32 of instruction ROM, 100mW of power consumption

- ASICs

  - An analog cell library, including D/A and A/D converters, op amps, comparator, and analog switch

  - A megacell library, 2-micron-rule, double-aluminum CMOS process featuring 4-bit CPU and 4- and 8-bit peripherals; 1,000 transistors on a 4mm square 4-bit CPU; 2,500 to 10,000 transistors on a 4 x 8mm, 8-bit CPU peripheral

  - A GaAs gate array series, 200 to 1,000 gates

Emerging Areas

At the 1987 ISSCC, Matsushita delivered several papers on the following topics:

- A 16Mb trench-capacitor-method memory cell with error checking
- A CMOS 4Mb DRAM with a 100ns access time and 250mW to 300mW of power consumption
- A 3-D 8K SRAM utilizing multilayer monocrystal technology and heat-resistant interconnect wiring, a 120ns access time, 7.5 x 8mm, 50,000 elements, 2Kx4 structure
- Four 256K CMOS SRAMs (MN23258), 32Kx8, 70/85/100/120ns, 9.18 x 5.67mm chip, maximum power consumption of 375mW, and 40mW at 1 MHz
- A small outline package version of 256K SRAM (M5M5256P series), 100/120/150ns access times, 2mA of standby current
- Two 4Mb mask ROMs (MN234000/01), one in NMOS (250ns) and one in CMOS (200ns)
- Two 1Mb mask ROMs, 131Kx8, 250ns CMOS (MN231000) and 150ns NMOS (MN231001)
- Two 256K mask ROMs, 32Kx8, 200ns CMOS and NMOS
- A 200ns, 128K NMOS ROM
- A 150ns, 64K NMOS mask ROM
- A CMOS 32-bit MPU with on-chip cache memory

Semiconductor Agreements

Matsushita, Sharp, Sanyo, and Mitsubishi are involved in a project to develop microprocessors for parallel-processing computers that run multiple processes at the same time.

In addition, Matsushita has formed agreements with the following companies:

- Denko Company: In September 1985, Matsushita developed vertical CVD equipment for thin-film ULSIs jointly with Denko, a semiconductor equipment maker.

- Japan Compound Gum (Hayashibara): In February 1986, Matsushita Denso and Biochemical signed a production contract to have Japan Compound Gum produce water-soluble photoresist (WSP), a new material for submicron (0.6- to 0.7-micron) patterns required for 4Mb DRAMs and above. The photoresist can be used with i-line and g-line steppers. Japan Compound Gum will supply the photoresist for Matsushita Electronics. Matsushita Denso and Hayashibara, which will jointly develop WSP, will supply production technology.

- Nikon: In the first quarter of 1987, Matsushita and Nikon agreed to develop an i-line stepper and excimer laser capable of 0.8-micron geometries for 16Mb DRAMs

- NTT: In January 1986, Matsushita and NTT signed a technical cooperation agreement to jointly develop 4Mb and higher DRAMs for computer and consumer applications. The two companies will share patents and R&D facilities, and will exchange engineers.

- Philips: Matsushita Electric and Philips formed Matsushita Electronics Corporation (MEC) in 1952. The Matsushita subsidiary produces electronic components and lighting products in Japan. MEC is 35 percent owned by Philips, with the remainder held by Matsushita.

  In August 1986, Philips entrusted MEC to produce LSIs for Philips' compact disk players.

  In December 1986, Philips and Matsushita agreed to join forces to launch a new family of 8-bit CMOS microcontrollers. Under the agreement, Matsushita will manufacture and market the PCF84CXX family designed by Philips.

- SAE Corp.: In the first quarter of 1987, Matsushita and SAE (Dover, Delaware) announced that they will develop a 64-bit MPU that will operate at 10 mips, with a 50-MHz clock frequency and a 2.5cm square chip.

NONSEMICONDUCTOR PRODUCTS SUMMARY

Electronic Components

Sales in the Electronic Components Department (including semiconductors) were ¥529.0 billion ($3,081.0 million) in fiscal 1986, a 2 percent decrease from fiscal 1985. This department accounted for 12 percent of total Matsushita sales. Main products of this department include semiconductors, tubes, passive components, printed circuit boards, and lighting equipment.

Video Equipment

Sales in the Video Equipment Department were ¥1,502.8 billion ($8,752.5 million) in fiscal 1986, a decrease of 20 percent from fiscal 1985. The video equipment product group is by far Matsushita's leading product line, accounting for 33 percent of total Company sales. Major products of this department include television sets, video projection systems, VTRs, and related equipment.

Audio Equipment

Sales in the Audio Equipment Department were ¥391.3 billion ($2,279.0 million) in fiscal 1986, a decrease of 14 percent from fiscal 1985. This product group accounts for 9 percent of total Company revenue. Major products of this department include compact disk players, radios, cassette recorders, stereo equipment, tape recorders, and electronic organs.

Home Appliances

Sales in the Home Appliances Department decreased 3 percent in fiscal 1986 to ¥707.0 billion ($4,117.6 million). This product group accounts for 15 percent of total Company sales. The major products of this department include refrigerators, washers and dryers, cooking equipment, air conditioners, fans, heaters, and vacuum cleaners.

Communications and Industrial Equipment

Fiscal 1986 sales in the Communications and Industrial Equipment Department were ¥859.0 billion ($5,002.9 million), a 2 percent decrease from fiscal 1985. This department accounts for 19 percent of total Company sales. Major products include communications, measuring, and office automation equipment; industrial robots; welding equipment; and air-conditioning equipment. Matsushita has Japan's largest market share in facsimile equipment.

Energy- and Kitchen-Related Products

Sales of energy- and kitchen-related products increased 8 percent in fiscal 1986 to ¥207.6 billion ($1,209.1 million). This department represents 5 percent of Matsushita's total revenue. Main products include batteries, gas appliances, kitchen sinks and cabinets, solar cells, and solar energy equipment.

Micron Technology, Inc.

Micron Technology, Inc.
2805 East Columbia Road
Boise, Idaho 83706
Telephone: (208) 383-4000
(Millions of Dollars)

Balance Sheet (September 3)	1983	1984	1985	1986	1987
Total Current Assets	$10.7	$ 42.7	$ 26.7	$ 31.7	$ 43.7
Cash	$ 5.8	$ 19.8	$ 1.2	$ 5.1	$ 9.4
Receivables	$ 2.3	$ 11.7	$ 3.8	$ 9.0	$ 15.2
Inventory	$ 2.5	$ 7.8	$ 12.7	$ 15.6	$ 17.8
Net Property, Plant, & Eqp.	$18.4	$ 77.0	$104.5	$ 97.7	$ 84.2
Depreciation	$ 1.7	$ 7.3	$ 22.9	$ 41.3	$ 58.6
Total Assets	$29.4	$121.1	$133.0	$131.0	$129.3
Total Current Liabilities	$ 7.5	$ 29.8	$ 5.3	$ 8.3	$ 18.6
Long-Term Debt	$ 9.6	0	$ 35.6	$ 18.7	$ 13.3
Total Liabilities	$17.2	$ 31.7	$ 40.9	$ 51.9	$ 56.8
Total Shareholders' Equity	$12.2	$ 89.3	$ 92.1	$ 79.1	$ 72.6
Conv. Preferred Stock	0	0	0	0	0
Common Stock	$12.9	$ 1.8	$ 1.9	$ 2.2	$ 2.6
Retained Earnings	($ 9.9)	$ 7.9	$ 19.2	($ 14.7)	($ 37.6)

Income Statement (September 3)	1983	1984	1985	1986	1987
Revenue	$13.1	$ 87.4	$ 75.9	$ 48.9	$ 91.2
Cost of Sales	$11.9	$ 38.2	$ 63.9	$ 64.8	$ 91.4
Gross Margin (%)	9.2	56.3	15.8	(32.5)	(0.2)
R&D Expense	$ 0.2	$ 2.7	$ 6.6	$ 2.9	$ 5.3
SG&A Expense	$ 1.8	$ 7.3	$ 6.7	$ 6.8	$ 10.3
Other Expense	0	$ 1.8	$ 3.7	$ 3.0	$ 2.3
Operating Income (Loss)	($ 0.7)	$ 37.4	($ 4.9)	($ 28.6)	($ 18.2)
Interest, Net	($ 1.9)	($ 0.9)	($ 1.7)	($ 5.3)	($ 4.7)
Pretax Income	($ 2.6)	$ 36.5	($ 6.6)	($ 33.9)	($ 22.9)
Provision for Taxes (Credit)	0	$ 7.5	($ 6.7)	0	0
Extraordinary Items, Net	0	0	0	0	0
Net Income	($ 2.6)	$ 29.0	($ 0.2)	($ 33.9)	($ 22.9)
Avg. Shares Outstanding (M)	38.3	17.6	19.1	19.4	24.3
Capital Expenditures (M)	$10.6	$ 65.1	$ 43.2	$ 12.2	$ 9.6
Employees	N/A	958	722	1,080	1,479

N/A = Not Available

Source: Micron Technology, Inc., Annual Reports

Micron Technology, Inc.

THE COMPANY

Overview

Micron Technology, Inc., was established in 1978 in the state of Idaho. In 1984, the Company offered 2.1 million shares of common stock in an initial public offering that raised $25 million and reincorporated in Delaware.

Micron produces primarily 64K, 256K, and 1-megabit DRAM components, with 256K DRAMs accounting for the majority of sales in fiscal 1987. The Company is one of only two United States-based DRAM suppliers. Micron also manufactures and markets a line of add-in memory cards, a line of image sensors, electronic cameras, and the PEAK fertility monitor.

Highlights

The following are some of Micron's fiscal 1987 highlights:

- Micron shrunk the die sizes of the 64K and 256K DRAMs, increasing die per wafer by 61 and 47 percent, respectively.
- The Company increased the number of employees from 1,110 to 1,479 people.
- The Company added CMOS capability.
- The Company began production of a prototype CMOS 1Mb DRAM.
- The Company sampled a CMOS 256K SRAM.
- The Company received certification for full MIL-STD-883C compliance.
- The Company restarted Fab I, which it shut down in 1985.
- The Company offered 2.3 million shares of common stock, which were used to reduce long-term bank debt.
- The Company became a founding member of Sematech.

On October 1, 1986, Micron dismissed without prejudice a suit that it filed against six Japanese manufacturers and their U.S. subsidiaries. The suit charged the Japanese manufacturers with monopolistic and predatory pricing practices and violations of federal antitrust and antidumping laws. The complaint was filed in September 1985 in the U.S. District Court in Boise, Idaho.

Micron Technology, Inc.

Financial Information

In its fiscal 1987, which ended September 3, Micron reported revenue of $91.2 million, compared with $48.9 million in fiscal 1986. The Company reported a net loss of $22.9 million in fiscal 1987, decreasing from a net loss of $33.9 million in 1986. The increase in revenue from 1986 was attributed to a ramp-up of 256K DRAM production capacity, which matched an increase in market demand and average selling price for 256K DRAMs. Micron reported that more than 85 percent of 1987 revenue was from the sale of 256K DRAMs, compared to 1986 when 64K DRAMs made up half of the Company's revenue. DRAM products, as a whole, represented 96 percent of revenue.

In August 1986, Micron made an offering of 2.3 million shares of common stock and raised $13.4 million. In January 1987, Micron sold 3.5 million shares of common stock for $4.38 per share to a group of European investors in a private placement. The net proceeds of about $13.5 million were used for working capital and to repay borrowings under Micron's bank line of credit.

The Company reported that 82 percent of fiscal 1987 sales were in North America, 15 percent in the Far East, and 3 percent in Europe.

Management and Employees

As of September 3, 1987, Micron employed about 1,479 people. Table 1 lists the executives of the Company.

Table 1

Micron Technology, Inc.
Company Executives

Executive	Office
Joseph L. Parkinson	Chairman of the board, chief executive officer
Ward A. Parkinson	Vice chairman of the board
Juan A. Benitez	President, chief operating officer
Randal W. Chance	Executive vice president
James W. Garrett	Vice president of sales and marketing
Leslie A. Gill	Vice president of finance, treasurer
Larry L. Grant	Vice president and general counsel
Edward J. Heitzberg	Vice president of quality
Tyler A. Lowrey	Vice president of process R&D, assistant technical officer
Thomas M. Trent	Vice president of R&D, chief technical officer

Source: Micron Technology, Inc., 10K Report

Facilities

Micron's principal manufacturing, engineering, administrative, and support facility is located on a 200-acre site in Boise, Idaho. In 1986, the Company's facilities, which feature class-10 clean rooms, were certified by the Defense Electronics Supply Center (DESC) to certain military production standards. Table 2 lists Micron's semiconductor facilities.

Table 2

Micron Technology, Inc.
Facilities

Facility	Size Square Feet	Technology/Products
Fabrication Facility I	30,000	NMOS, CMOS, 5-inch wafers, 64K and 256K DRAMs
Fabrication Facility II	17,000	NMOS, CMOS, 5-inch wafers, 1Mb DRAMs and SRAMs
Test & Assembly Facility I	30,000	
Test & Assembly Facility II	48,000	

Source: Micron Technology, Inc., 10K Report

Capital and R&D Spending

Micron's capital spending in fiscal 1987 was $9.6 million, as shown in Table 3. The Company has been working to convert its facilities for 256K DRAM production and for the anticipated demand for 1Mb DRAMs.

Recent R&D activities were directed toward the design and development of a high-performance 256K SRAM, a 256K video RAM, a 1Mb DRAM using a CMOS process, and certain board level systems products. The Company also continually works to reduce the size of its DRAMs, as well as to improve its NMOS and CMOS process technologies. The Company reported R&D spending of $5.3 million in fiscal 1987.

Table 3

Micron Technology, Inc.
Fiscal 1987 Capital and R&D Spending
(Millions of Dollars)

	1983	1984	1985	1986	1987
Revenue	$13.1	$87.4	$75.9	$48.9	$91.2
Capital Expenditures	$10.6	$65.1	$43.2	$12.2	$ 9.6
Percentage of Revenue	80.9%	74.5%	56.9%	25.0%	10.5%
R&D Expense	$ 0.2	$ 2.7	$ 6.6	$ 2.9	$ 5.3
Percentage of Revenue	1.5%	3.1%	8.7%	5.9%	5.8%
Combined Capital and R&D Spending	$10.8	$67.8	$49.8	$15.1	$14.9
Percentage of Revenue	82.4%	77.6%	65.6%	30.9%	16.3%

Source: Micron Technology, Inc., Annual Reports

PRODUCTS AND MARKETS

Semiconductor Products and Markets

Micron produces primarily 64K and 256K DRAM devices and has developed devices in a broad range of configurations and package types. In 1987, Micron began to diversify its memory product line and offered 1-megabit DRAMs, 256K SRAMs, 256K video RAMS, and a variety of SIMM memory modules.

According to Dataquest, Micron's semiconductor calendar revenue in 1987 was $115 million, as shown in Table 4. In 1986, Micron ranked 10th in the 64K segment, 7th in 256K density, 10th at the 1Mb level, and 10th overall in the DRAM market.

As a result of the U.S.-Japan Semiconductor Trade Agreement, U.S. tariffs on the 64K DRAM increased the demand for Micron's devices and hurt the firm's Japanese competitors in terms of production planning and price competitiveness. At the 256K level, the foreign market value (FMV) system means added revenue from the sale of 256K DRAMs whenever the U.S. price falls below the FMV floor price. The FMV system also provides Micron with an opportunity to develop into a competitive supplier of 1Mb DRAMs.

Micron Technology, Inc.

Table 4

Micron Technology, Inc.
Estimated Worldwide Semiconductor Revenue by Calendar Year
(Millions of Dollars)

	1983	1984	1985	1986	1987
Total Semiconductor	$24	$117	$36	$63	$115
Total Integrated Circuit	$24	$117	$36	$63	$115
MOS (Technology)					
NMOS	$24	$117	$36	$63	$115
MOS (Function)					
MOS Memory	$24	$117	$36	$63	$115

Source: Dataquest
March 1988

Semiconductor Revenue by Region

Sales within the United States in 1987 were $94 million, representing 82 percent of Micron's annual semiconductor revenue. Sales to ROW countries were $17 million, about 15 percent of total semiconductor revenue; sales to Japan were $4 million, making up the remainder.

Channels of Distribution

The Company's products are marketed directly to computer manufacturers and through an international network of distributors and sales representatives. Among Micron's distributors are Anthem Electronics Inc., Hallmark Electronics, and Wyle Laboratories Electronic Marketing Group.

Semiconductor Products and Technologies

Technologies

Micron's 64K and 256K DRAMs are manufactured using a double-poly NMOS process technology. In 1987, the Company began to use a 1-micron CMOS process to develop its newest products, the 1Mb DRAM and a 256K SRAM.

Product Lines

Current products include 64K and 256K DRAMs, which are available in a wide variety of packages. New products include 1Mb DRAMs, 256K SRAMs, and the first member in a family of dual-port video RAMs (VRAMs). Micron began to offer prototypes of the 256K VRAM in December 1987. It is a dual-port DRAM that consists of a 64Kx4 DRAM combined with a 256x4 serial access memory. Micron plans to make a 1Mb version in the second half of 1988.

Table 5 is a list of Micron's products, all of which are available now.

Table 5

Micron Technology, Inc.
Products

Device	Organization	Speed
DRAMs		
MT4264	64Kx1	120-200ns
MT1128	128Kx1	120-200ns
MT4065/MT4067	64Kx4	100-200ns
MT1256/MT1259	256Kx1	100-200ns
MT4C256/MT4C257	256Kx4	100-150ns
Memory Modules		
MT8066	64Kx8	120-200ns
MT9066	64Kx9	120-200ns
MT4257	256Kx4	100-200ns
MT8257	256Kx8	100-200ns
MT9257	256Kx9	100-200ns

Source: Micron Technology, Inc.

Products are available in both surface-mount and through-hole-compatible packages. Customers have a choice of either plastic or ceramic packages, as well as dual-in-line (DIP), zig-zag in-line (ZIP), or single-in-line (SIP) packages; single-in-line memory modules (SIMM); plastic-leaded chip carriers (PLCC); and small-outline J-leaded packages (SOJ).

Micron Technology, Inc.

Semiconductor Agreements

Micron has the following agreements:

- ITT/STC—In January 1983, Micron granted ITT Industries, Inc., a worldwide nonexclusive license to manufacture and sell 64K DRAMs. The agreement called for ITT to pay Micron royalties for four years, at which time ITT will have a fully paid, nonexclusive license.
  - In April 1983, ITT assigned its license rights to Standard Telephones and Cables PLC (STC), as a result of the sale of ITT's U.K. division to STC.
- Samsung Semiconductor and Telecommunications Co., Ltd.—In June 1983, Micron granted Samsung a license for 64K DRAMs; the agreement included an option for Micron's 256K DRAM.
  - In February 1986, Micron filed a suit against Samsung and its U.S. subsidiary, charging a breach of the agreement and seeking a permanent injunction prohibiting further manufacture and sale of DRAM products.
  - In May 1986, Samsung filed a counterclaim, seeking damages totaling $30 million and alleging that Micron failed to comply with various terms of the agreement.
  - In June 1986, the companies entered into a settlement agreement. The licensing agreement was terminated and Samsung agreed to cease manufacturing certain 64K DRAMs based on technology received from Micron.
  - In return, Samsung granted Micron a license to manufacture and sell certain 64K SRAM and 64K EEPROM products in exchange for a 1.0 percent royalty on sales.
  - Samsung also purchased a 2.7 percent interest in Micron for $5 million and an AMBYX burn-in test system.
- Commodore Electronics Ltd.—In May 1984, Micron granted Commodore a license to manufacture and use the 64K DRAM for internal purposes only. This agreement is no longer in effect.
- National Semiconductor Corporation—In November 1984, National purchased a license to manufacture and sell Micron's 64K DRAM for about $5 million. The deal included an option on a 512K DRAM.

- Barvon Research, Inc. (BRI)—In November 1985, Micron purchased a minority equity interest in BRI, a privately held corporation specializing in the design and sale of ASIC devices based on CMOS process technology. As part of the agreement, BRI will design a number of ASICs, which Micron will manufacture and sell. BRI will also give Micron access to its CMOS design and development expertise.

System-Level Products

Micron also offers a line of system-level products including the MicronEye and Idetix industrial vision systems, the King's Castle and Queen's Bishop personal computer memory boards, the AMBYX burn-in and test oven, and the PEAK Ovulation Predictor. These products give Micron new uses for its memory products and open up markets and distribution channels such as retail markets.

The IS32 OpticRAM image sensor is a solid-state device capable of sending an image and translating it to digital, computer-compatible signals. It consists of a 64K DRAM packaged with a transparent glass lid. The device is the primary component of Micron's electronic camera product, the MicronEye. In 1986, the Company introduced its second-generation image-sensing device, the IS256 OpticRAM derived from its 256K DRAM. The device is used in Micron's Idetix, a recently introduced electronic camera. The Idetix gives vision to a computer and is used in machine vision systems.

The AMBYX System consists of three components. The AMBYX TBT-32000 burn-in and test oven's total capacity is 32,768 devices that may be tested and burned-in at one time. The AMBYX TBT-2000 is an engineering burn-in test station that performs thermal conditioning and functional testing with parametric verification of the DRAM's various configurations. The station can be programmed for specific production applications. The AMBYX single-board test station allows the user to perform multifunctional tests on a single board of DRAMs.

Micron Medical, incorporated in 1986 as a wholly owned subsidiary of Micron Technology, has embarked on a marketing plan for its first product, the PEAK Ovulation Predictor. The PEAK is a medical instrument designed to assist in the timing of conception and the study of biological infertility. Micron Medical will also develop instrumentation for use in the medical field.

Mitsubishi Electric Corporation

Mitsubishi Electric Corporation
Mitsubishi Denki Bldg., 2-3, Marunouchi 2-chome
Chiyoda-ku, Tokyo, 100, Japan
Telephone: (03) 218-2111; Telex: J24532
(Billions of Yen)

Balance Sheet (March 31)	1983	1984	1985	1986	1987
Total Current Assets	¥ 994	¥1,089	¥1,248	¥1,205	¥1,285
Cash	¥ 170	¥ 183	¥ 209	¥ 211	¥ 268
Receivables	¥ 415	¥ 432	¥ 483	¥ 460	¥ 456
Inventory	¥ 251	¥ 279	¥ 357	¥ 400	¥ 370
Net Property, Plant, and Equipment	¥ 233	¥ 283	¥ 325	¥ 388	¥ 409
Depreciation	¥ 318	¥ 366	¥ 430	¥ 500	¥ 578
Total Assets	¥1,421	¥1,586	¥1,816	¥1,833	¥1,943
Total Current Liabilities	¥ 864	¥ 980	¥1,088	¥1,064	¥1,133
Long-Term Debt	185	189	257	216	205
Total Liabilities	¥1,116	¥1,242	¥1,430	¥1,370	¥1,433
Total Shareholders' Equity	¥ 305	¥ 343	¥ 386	¥ 463	¥ 507
Conv. Preferred Stock	0	0	0	0	0
Common Stock	¥ 79	¥ 83	¥ 87	¥ 118	¥ 139
Retained Earnings	¥ 151	¥ 184	¥ 219	¥ 234	¥ 230

Income Statement (March 31)	1983	1984	1985	1986	1987
Revenue	¥1,558	¥1,741	¥2,035	¥2,109	¥2,108
Domestic Sales	¥1,190	¥1,271	¥1,461	¥1,518	¥1,596
Overseas Sales	¥ 367	¥ 469	¥ 574	¥ 592	¥ 512
Cost of Sales	¥1,154	¥1,306	¥1,521	¥1,612	¥1,625
Gross Margin (%)	26	25	25	24	23
R&D Expense	¥ 53	¥ 61	¥ 77	¥ 89	¥ 95
SG&A Expense	¥ 251	¥ 278	¥ 312	¥ 324	¥ 319
Operating Income (Loss)	¥ 86	¥ 84	¥ 99	¥ 65	¥ 33
Interest, Net	(¥ 12)	(¥ 2)	¥ 1	¥ 7	¥ 5
Pretax Income	¥ 74	¥ 82	¥ 99	¥ 72	¥ 38
Effective Tax Rate (%)	55	55	55	63	76
Extraordinary Items, Net	¥ 2	¥ 2	¥ 3	¥ 3	¥ 1
Net Income	¥ 35	¥ 39	¥ 47	¥ 30	¥ 11
Avg. Shares Outstanding (Millions)	1,577	1,598	1,620	1,714	1,864
Employees	64,432	65,904	68,745	71,479	73,536
Capital Spending	¥ 73	¥ 115	¥ 133	¥ 154	¥ 126
Exchange Rate (Yen per US$)	249	236	245	221	160

Source: Mitsubishi Electric Corporation
Annual Reports
Dataquest
February 1988

Mitsubishi Electric Corporation

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Telephone: (03) 218-2111; Telex: J24532
(Millions of Dollars)

Balance Sheet (March 31)	1983	1984	1985	1986	1987
Total Current Assets	$3,993	$4,613	$5,093	$5,452	$ 8,029
Cash	$ 683	$ 775	$ 853	$ 956	$ 1,675
Receivables	$1,666	$1,833	$1,970	$2,080	$ 2,853
Inventory	$1,009	$1,181	$1,457	$1,812	$ 2,314
Net Property, Plant, and Equipment	$ 934	$1,201	$1,326	$1,758	$ 2,559
Depreciation	$1,276	$1,551	$1,756	$2,260	$ 3,614
Total Assets	$5,706	$6,719	$7,412	$8,294	$12,147
Total Current Liabilities	$3,471	$4,151	$4,442	$4,815	$ 7,083
Long-Term Debt	$ 745	$ 803	$1,051	$ 975	$ 1,278
Total Liabilities	$4,480	$5,264	$5,836	$6,197	$ 8,957
Total Shareholders' Equity	$1,226	$1,455	$1,576	$2,097	$ 3,166
Conv. Preferred Stock	0	0	0	0	0
Common Stock	$ 318	$ 353	$ 353	$ 532	$ 870
Retained Earnings	$ 606	$ 782	$ 893	$1,058	$ 1,438

Income Statement (March 31)	1983	1984	1985	1986	1987
Revenue	$6,255	$7,376	$8,305	$9,545	$13,172
Domestic Sales	$4,780	$5,387	$5,964	$6,868	$ 9,972
Overseas Sales	$1,475	$1,989	$2,341	$2,677	$ 3,200
Cost of Sales	$4,636	$5,536	$6,210	$7,293	$10,159
Gross Margin (%)	26	25	25	24	23
R&D Expense	$ 211	$ 257	$ 314	$ 403	$ 591
SG&A Expense	$1,010	$1,176	$1,275	$1,468	$ 1,995
Operating Income (Loss)	$ 346	$ 357	$ 402	$ 294	$ 209
Interest, Net	($ 49)	($ 9)	$ 2	$ 34	$ 30
Pretax Income	$ 297	$ 348	$ 405	$ 328	$ 239
Effective Tax Rate	55	55	55	63	76
Extraordinary Items, Net	$ 7	$ 7	$ 11	$ 15	$ 9
Net Income	$ 141	$ 165	$ 192	$ 136	$ 66
Avg. Shares Outstanding (Millions)	1,577	1,598	1,620	1,714	1,864
Employees	64,432	65,904	68,745	71,479	73,536
Capital Spending	$ 292	$ 486	$ 541	$ 698	$ 789
Exchange Rate (Yen per US$)	249	236	245	221	160

Source: Mitsubishi Electric Corporation
Annual Reports
Dataquest
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Mitsubishi Electric Corporation

THE COMPANY

Overview

Mitsubishi Electric Corporation (hereafter referred to as Mitsubishi) began in 1898 as a heavy electrical equipment plant adjacent to the Nagasaki Shipyard. A related plant was set up in 1905 at Mitsubishi Shipbuilding's Kobe Works. In 1921, these two units were consolidated to form Mitsubishi Electric Manufacturing Company. During the Company's early years, it established heavy electrical equipment factories throughout Japan. In 1923, a technical cooperation agreement was made with Westinghouse Electric International; production of consumer goods began in the 1930s.

In 1958, Mitsubishi established separate groups for heavy machinery, electronics, consumer products, and overseas business. The Semiconductor Marketing Division began in 1972, and the Computer Marketing Division was founded in 1976. Mitsubishi is the fourth largest Japanese electronics company, following Matsushita, Hitachi, and Toshiba.

Mitsubishi has been a major supplier of electronic equipment to the Japan Defense Agency for more than 20 years. The Company produces missiles and electronics for use in land, sea, and air vehicles; active phased-array radar used in fire-control systems; the next-generation warning control radar; and computers for fighter planes. Mitsubishi also was the prime contractor for 9 of the 18 satellites launched by Japan's National Space Development Agency.

Company Organization

Mitsubishi is a member company of the Mitsubishi Group. The Mitsubishi Group is a continuation of the pre-World War II Mitsubishi Zaibatsu, which began in 1870 as a small shipping company called Tsukumo Shokai. By the time the war began, the Mitsubishi Zaibatsu was the second largest in Japan, after the Mitsui Zaibatsu. After the war, the zaibatsu were dissolved; however, the Mitsubishi Zaibatsu companies reorganized into one of the largest and most powerful industrial groups in Japan.

Mitsubishi employs 73,536 people under the leadership of Chairman Nihachiro Katayama and President Moriya Shiki.

Mitsubishi Electric Corporation

Financial Information

Mitsubishi's major shareholders are listed in Table 1.

Table 1

Mitsubishi Electric Corporation
Major Shareholders

Shareholders	Percent of Shares
Meiji Mutual Life Insurance Company	4.2%
Mitsubishi Trust & Banking Corporation	3.7%
Nippon Life Insurance Company	3.7%
Mitsubishi Bank, Limited	3.3%
Mitsui Trust & Banking Corporation	2.5%
Daiwa Securities Co., Ltd.	2.4%
Mitsubishi Electric Group Employees Shareholding Union	2.0%
Norin Chukin Bank	1.9%

Source: Japan Company Handbook

Of Mitsubishi's outstanding stock, 7.9 percent is foreign-owned. Mitsubishi is listed on the three major Japanese stock exchanges, as well as on the Amsterdam and Frankfurt stock exchanges.

Net income of the Company decreased to ¥11 billion in fiscal 1987 from ¥30 billion in fiscal 1986. The factors affecting net income were: virtually no change in revenue from fiscal 1986, a ¥13 billion increase in cost of sales, and a ¥16 billion increase in other expenses that reflected heavy foreign exchange losses in the period.

Mitsubishi's main lines of business are the following:

- Heavy Machinery
- Industrial Products and Automotive Equipment
- Information and Communication Systems and Electronic Devices
- Consumer Products

Mitsubishi Electric Corporation

Sales in the Information and Communications Systems and Electronic Devices Groups (including semiconductors) represented about 27 percent of revenue and rose 10 percent to ¥562 billion in fiscal 1987. The increase was attributed to high domestic sales volumes that overcame the depressed sales in exported personal computers.

Sales in the Heavy Machinery Group were ¥562 billion in fiscal 1987, a decrease of 3 percent from fiscal 1986. This group accounted for 27 percent of Mitsubishi's total sales.

The Industrial Products and Automotive Equipment Group had sales of ¥387 billion in fiscal 1987, a decrease of 5 percent from fiscal 1986. The group accounted for 18 percent of total Mitsubishi sales; it is the Company's smallest product group.

Sales in the Consumer Products Group were ¥595 billion in fiscal 1987, a decrease of 2 percent from 1986. This group accounted for 28 percent of Mitsubishi's total sales, and it is the Company's largest product group.

Table 2 shows Matsushita's revenue by lines of business for 1983 through 1987.

Table 2

Mitsubishi Electric Corporation
Revenue by Lines of Business
(Billions of Yen)

	Fiscal Year Ending March 31				
	1983	1984	1985	1986	1987
Heavy Machinery	¥ 512	¥ 548	¥ 577	¥ 582	¥ 562
Information and Communications and Electronic Devices	310	401	573	512	564
Industrial Products and Automotive Equipment	315	333	368	405	387
Consumer Products	421	459	517	610	595
Total	¥1,558	¥1,741	¥2,035	¥2,109	¥2,108
Exchange Rate (Yen per US$)	249	236	245	221	160

Source: Mitsubishi Electric Corporation
Annual Reports
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Mitsubishi Electric Corporation

International Operations

Overseas sales, which were ¥512 billion, accounted for 24 percent of Mitsubishi's 1987 sales. This amount represents a decline of 14 percent from 1986. To remain competitive in its overseas markets, the Company is boosting offshore production and is expanding the number of its facilities.

Facilities

Mitsubishi currently maintains four manufacturing plants in North America: a newly constructed color television and cellular mobile telephone plant in Braselton, Georgia; a color television plant in Santa Ana, California; a television picture tube plant in Ontario, Canada; and a semiconductor plant in Durham, North Carolina. A fifth plant in Mason, Ohio, is scheduled to begin production in 1988. This plant will manufacture automotive parts and control units for use in electronics, electrical parts, and audio equipment.

Mitsubishi has nine semiconductor plants in Japan and one in the United States. These plants are listed in Table 3.

Table 3

Mitsubishi Electric Corporation
Semiconductor Manufacturing Facilities

Location	Floor Space (Square Meters)	Function and Products
Kita-itami Works, Hyogo Prefecture	116,834	Fab, assembly, test--MOS logic, discretes
Kumamoto #1-Kumamoto, Kumamoto Prefecture (Kita-itami Works)	13,000	Assembly, test--ICs
Kumamoto #2-Kikuchi, Kumamoto Prefecture (Kita-itami Works)	16,000	Fab, test--ICs
Fukuoka Handotai Factory, Fukuoka Prefecture	13,000	Fab, assembly, and test--bipolar logic discretes
Fukuoka New Plant, Fukuoka Prefecture	10,000	Fab, assembly, test

(Continued)

Table 3 (Continued)

Mitsubishi Electric Corporation
Semiconductor Manufacturing Facilities

Location	Floor Space (Square Meters)	Function and Products
Saijo Industrial Park, Ehime Prefecture (Kita-itami Works)	22,000	Fab, test--64K DRAMS
Saijo Factory #2, Ehime Prefecture (Kita-itami Works)	N/A	Fab, assembly, test--256K DRAMs
Semiconductor Laboratory, Hyogo Prefecture	N/A	Fab, test--discretes, optoelectronics
Kagami Plant, Kochi Prefecture	N/A	Fab, assembly, test--CMOS microdevices
Mitsubishi Semiconductor U.S.A., North Carolina	20,000	Assembly, test--MOS 64K and 256K DRAM

N/A = Not Available

Source: Dataquest
February 1988

Capital and R&D Spending

Mitsubishi's corporate capital spending decreased from ¥154 billion to ¥126 billion in fiscal 1987. When combined, capital spending and R&D spending have been consistently running about 10 percent of total revenue, as shown in Table 4. Table 5 shows capital and R&D spending in U.S. dollars.

Mitsubishi Electric Corporation

Table 4

Mitsubishi Electric Corporation
Capital and R&D Spending—1986
(Billions of Yen)

	1983	1984	1985	1986	1987
Revenue	¥1,558	¥1,741	¥2,035	¥2,109	¥2,108
Capital Spending	¥ 73	¥ 115	¥ 133	¥ 154	¥ 126
Percent of Revenue	5%	7%	7%	7%	6%
R&D Expense	¥ 53	¥ 61	¥ 77	¥ 89	¥ 95
Percent of Revenue	3%	3%	4%	4%	4%
Combined Capital and R&D Spending	¥ 125	¥ 175	¥ 209	¥ 243	¥ 221
Percent of Revenue	8%	10%	11%	11%	10%
Exchange Rate (Yen per US$)	249	236	245	221	160

Table 5

Mitsubishi Electric Corporation
Capital and R&D Spending—1986
(Millions of Dollars)

	1983	1984	1985	1986	1987
Revenue	$6,255	$7,376	$8,305	$9,545	$13,172
Capital Spending	$ 292	$ 486	$ 541	$ 698	$ 789
Percent of Revenue	5%	7%	7%	7%	6%
R&D Expense	$ 211	$ 257	$ 314	$ 403	$ 591
Percent of Revenue	3%	3%	4%	4%	4%
Combined Capital and R&D Spending	$ 503	$ 743	$ 855	$1,101	$ 1,380
Percent of Revenue	8%	10%	11%	11%	10%
Exchange Rate (Yen per US$)	249	236	245	221	160

Source: Mitsubishi Electric Corporation
Annual Reports
Dataquest
February 1988

Turning to the semiconductor area, Dataquest estimates that Mitsubishi made capital investments totaling $120 million in calendar year 1986 (see Table 6). This amount represents 11 percent of Mitsubishi's semiconductor revenue. In recent years, Mitsubishi has built two semiconductor plants at Saijo on Shikoku Island. The facilities were the first semiconductor plants to be built there and are used specifically for producing 64K, 256K, and 1Mb DRAMs.

Table 6

Mitsubishi Electric Corporation
Semiconductor Capital Spending—1986 Calendar Year
(Millions of Dollars)

	1982	1983	1984	1985	1986
Semiconductor Revenue	$340	$505	$964	$662	$1,140
Semiconductor Capital Spending	$ 80	$132	$274	$261	$ 120
Percent of Revenue	24%	26%	28%	39%	11%

Source: Dataquest
February 1988

The Company also built a plant in Durham, North Carolina, which began operation in the first half of 1985. It was built for the assembly of 64K and 256K DRAMs. In January 1987, the Company announced that it will build a full-scale semiconductor production facility in North Carolina in the near future. Plans include employing approximately 40 engineers and investing $32.1 million in plant construction.

Research and Development

In fiscal 1987, Mitsubishi's research and development (R&D) spending was ¥95 billion, a 6.2 percent increase over fiscal 1986 R&D spending of ¥89 billion.

Mitsubishi maintains nine R&D laboratories, as follows:

- Central Research Laboratory (Hyogo Prefecture)—Basic research in mechanical, electrical, optical, and biological technology
- Product Development Laboratory (Hyogo Prefecture)—Development of new electronic and mechatronic parts
- Consumer Electronics Development Laboratory (Osaka Prefecture)—Development of consumer electronics products and mass-production technologies

- Manufacturing Development Laboratory (Hyogo Prefecture)—Research and development of production-line automation and other technologies; testing of materials and components
- Consumer Products Research Laboratory (Kanagawa Prefecture)—Development of home automation electronic systems; testing of products and packaging
- LSI Development Laboratory (Hyogo Prefecture)—Research and development of ICs and discretes; new product development (A new VLSI Development Wing was added in fiscal 1986.)
- Information Systems and Electronics Development Laboratory (Kanagawa Prefecture)—Overall development of information systems and equipment
- Industrial Design Center (Kanagawa Prefecture)—Industrial design activities concerning all Mitsubishi products
- Materials Engineering Laboratory (Hyogo Prefecture)—Research and development of materials and electronic devices

Mitsubishi has established five target areas for research and development: factory automation, data processing systems, communications, audio visual products, and electronic devices. Recent projects include:

- The MELCOM PSI Computer with inference capability; processes the PROLOG computer language
- A gallium arsenide semiconductor laser capable of switching between two different wave lengths in response to the amount of electrical current input
- A teleconferencing system that can send and receive voice, visual, and facsimile transmissions over a single phone circuit
- A successful continuous test run of a molten carbonate fuel cell for 10,000 hours (The goal is to raise the length of time to between 25,000 and 40,000 hours.)
- Five types of MELCARD IC cards

PRODUCTS AND MARKETS

Semiconductor Product Markets

Mitsubishi, the first commercial Japanese electronics firm to develop an integrated circuit, was the largest 64K DRAM supplier in 1986, with 18 percent of the market. The Company also is one of the top three suppliers of 256K and 1Mb DRAMs.

Mitsubishi Electric Corporation

As shown in Table 7, $569 million, or 50 percent, of Mitsubishi's 1986 semiconductor sales were MOS devices. By far the largest product family was MOS memory, with sales of $305 million, or 27 percent of total Mitsubishi semiconductor sales. In addition to DRAMs, Mitsubishi is the third largest supplier of MOS EPROMs, with 14 percent of the market in 1986.

Mitsubishi's semiconductor sales in all product areas showed growth greater than the industry growth rate, as Table 8 illustrates.

In the microcomponent area, Mitsubishi announced that it planned to begin full-scale 16-bit microcontroller (MCU) production at its Kochi plant in September. The Kochi plant, which began operating in late 1986, had been operating only assembly lines for the device. Mitsubishi, which had been using 16-bit MCUs only for internal use, also announced that it will begin producing 16-bit MCUs for industrial use. Plans involved offering a 16-bit single-chip MCU, the 3700 series, on the market late in 1987. A vertically integrated production system for 32-bit MCUs is planned for 1989 at the Kochi plant.

Table 7

Mitsubishi Electric Corporation
Estimated Worldwide Semiconductor Revenue
(Millions of Dollars)

	1982	1983	1984	1985	1986
Total Semiconductor	340	505	964	662	1,140
Total Integrated Circuit	244	384	766	504	913
Bipolar Digital (Technology)	44	68	123	75	134
TTL			99	59	104
ECL			21	14	28
Other Bipolar Digital			3	2	2
Bipolar Digital (Function)	44	68	123	75	134
Bipolar Digital Memory					
Bipolar Digital Logic	44	68	123	75	134
MOS (Technology)	137	247	541	323	569
NMOS	114	186	463	256	449
PMOS	9	12	5	2	3
CMOS	14	49	73	66	117
MOS (Function)	137	247	541	323	569
MOS Memory	81	158	370	147	305
MOS Microdevices	25	54	156	122	180
MOS Logic	31	35	15	55	84
Linear	63	69	102	106	210

(Continued)

Table 7 (Continued)

Mitsubishi Electric Corporation
Estimated Worldwide Semiconductor Revenue
(Millions of Dollars)

	1982	1983	1984	1985	1986
MOS (Function)	137	247	541	323	569
MOS Memory	81	158	370	147	305
MOS Microdevices	25	54	156	122	180
MOS Logic	31	35	15	55	84
Linear	63	69	102	106	210
Total Discrete	94	119	185	140	197
Transistor	33	38	56	64	89
Small Signal Transistor			56	64	89
Power Transistor					
Diode	19	15	23	3	4
Small Signal Diode			3	3	4
Power Diode			20		
Zener Diode					
Thyristor	25	15	23	37	52
Other Discrete	17	51	83	35	52
Total Optoelectronic	2	2	13	18	30
LED Lamps			4		
LED Displays					
Optical Couplers					
Other Optoelectronics			9	18	30
Exchange Rate (Yen per US$)	248	235	237	238	167

Source: Dataquest
February 1988

Mitsubishi Electric Corporation

Table 8

Mitsubishi Electric Corporation
Company Growth Rate Compared to Industry Growth Rates
(Millions of Dollars)

	1985	1986	Company % Change (1985-1986)	Industry % Change (1985-1986)
Total Semiconductor	$662	$1,140	72%	25%
Total IC	$504	$ 913	81%	24%
Bipolar Digital	75	135	80%	14%
MOS Digital	323	569	76%	25%
Linear	106	210	98%	30%
Total Discrete	$140	$ 198	41%	25%
Total Optoelectronic	$ 18	$ 29	61%	37%

Source: Dataquest
February 1988

The Company's total MCU production, including 4-bit and 8-bit models and peripheral chips, was recently increased from 10 million units to between 12 million and 13 million units per month. The Company plans to increase MCU production again to 15 million units by year end.

In September 1987, Mitsubishi announced that it plans a full-fledged advance into the power semiconductor market. The Company planned to begin importing thyristors and power diodes from Powerex in late 1987 or early 1988. Powerex is a joint venture between Mitsubishi, General Electric, and Westinghouse. The devices will be used for general- purpose welding machines and sequencers. Sales in the first year are targeted at ¥1 billion to ¥2 billion ($7 million to $14 million).

Dataquest believes that approximately 10 percent of Mitsubishi's 1986 semiconductor sales were to the United States, 5 percent were to Europe, 1 percent were to Rest of World, and the remaining 84 percent were domestic sales. Table 9 shows the estimated geographic distribution of Mitsubishi's semiconductor sales.

Table 9

Mitsubishi Electric Corporation
Estimated Semiconductor Revenue by Region—1986
(Millions of Dollars)

	United States	Japan	Europe	ROW	World
Total Semiconductor	$114	$961	$53	$12	$1,140
Total Integrated Circuit	$106	$751	$47	$ 9	$ 913
Bipolar Digital	10	120	2	2	134
MOS	94	427	45	3	569
Linear	2	204	0	4	210
Total Discrete	$ 6	$184	$ 4	$ 3	$ 197
Total Optoelectronic	$ 2	$ 26	$ 2	0	$ 30
Exchange Rate (Yen per US$)	167	167	167	167	167

Source: Dataquest
February 1988

Channels of Distribution

Dataquest believes that approximately 80 percent of Mitsubishi's semiconductor products are sold domestically in Japan through distributors. The Company's major distributors are Ryoyo Electric, Ryoden Shoji Co., Ltd., and Kyoei Sangyo. Approximately 15 percent of Mitsubishi's sales are captive.

In the United States, Mitsubishi sells semiconductors through Mitsubishi Electronics America, Inc., headquartered in Sunnyvale, California, and through distributors. In Europe, Mitsubishi has sales offices in most of the major countries and also sells through distributors.

Semiconductor Products and Technologies

Mitsubishi's semiconductor product line includes the following:

- Bipolar digital logic—Low-power Schottky TTL (LSTTL) and ALSTTL
- MOS memory—64K, 256K, and 1Mb DRAMs; NMOS and CMOS SRAMs; ROMs; and EPROMs

- MOS microcomponents—Second-sourcing of Intel microcontrollers in NMOS and CMOS, 8-bit CMOS and NMOS microperipherals, and original 8-bit microprocessors

- MOS logic—CMOS and ECL gate arrays

- Linear—Transistor arrays, op amps, voltage comparators and regulators, timer ICs, and current drivers

Mitsubishi also manufactures gallium arsenide (GaAs) field-effect transistors (FETs). Recent developments in the Company's semiconductor activities are presented in the following paragraphs.

Memory

Highlights of Mitsubishi's memory activities include the following:

- Two 1Mb CMOS EPROMs (MSM27C100K/101K); 1.5-micron silicon gate process; 150/200/250ns; 263mW power consumption in operation and 6mW at standby

- A 256K CMOS EPROM (M5M27C256K-12) 32Kx8; 1.5-micron process; 120/150/250ns

- A 250ns 4Mb ROM (M5M23C400P/FP) 256Kx16 and 512Kx8; 165mW power consumption during operation and 550mW at standby; eight memory cell layers consisting of eight memory transistors; 1.2-micron process

- A 34ns 1Mb CMOS SRAM using triple polysilicon; announced at ISSCC 1987

- A 480K CMOS field memory (M5M4C500L) that allows a TV or VTR to simultaneously record and play back pictures; 320 x 256 x 6-bit structure; 5.0mm x 10.08mm chip; NTSC and PAL method; also capable of storing one TV screen at a time

ASICs

Highlights of Mitsubishi's ASIC activities include the following:

- An ECL gate array that reduces software error to 1/100 of conventional devices; noise circuit added to reduce error rates

- Two 1.3-micron rule CMOS gate array versions: the M6002X featuring alternating internal gate and wiring, 224 to 1,773 gates; the M6003X featuring 4,778 to 47,376 gates, VTM system (basic cells laid over all internal gates, enlarging built-in ROM and RAM capacity), gate isolation system, 1.1ns per gate, DIP, shoe-link DIP, QFP, PLCC, and PGA packages

Mitsubishi also announced that it is augmenting its ASIC operations by expanding its ASIC Design Engineering Center, where the Company is refining planning techniques and CAD tools to assist electronic equipment designers in the design of LSI devices.

Microcomponents

Highlights of Mitsubishi's microcomponent activities include the following:

- A proprietary 32-bit MPU (HF32/300) developed with Fujitsu and Hitachi as part of the TRON project; 20 Mips and 4-Kbyte cache memory; supports UNIX System 5 and ITRON; commercialization in late 1988
- Three CMOS MCUs: the M50930FP0, with 4 Kbytes of ROM and 128 bytes of RAM; the M50931FP, with 4 Kbytes of RAM; and the M50932FP, with 8 Kbytes of ROM and 512 bytes of RAM
- A CMOS 4-bit MCU with built-in character display function (M50436-SP) for voltage synthesizers, 16 characters x 3 lines for color selection, 6 x 7 dots, 64 character types, and 4 character sizes
- Four MCUs with system reset circuits (M5290P/5292P), +5V and +/-12V power outputs, and 4.2V current
- An 8-bit CMOS parallel-processing MPU (M5M80C85AP/AFP-2) with 2.0-micron rule, 12,000 transistors, and 0.8ms instruction cycle
- An I/O interface LSI (M5M82C255ASP) and four 2K RAMs with built-in I/O port and timer; I/O interface with one general I/O port and two special-purpose ports with 24 I/O lines for transferring data to 8-bit and 16-bit CPUs

Mitsubishi is one of the companies participating in the Japanese government-sponsored Supercomputer and Optoelectronics Projects. These projects involve research and development of gallium arsenide (GaAs) field-effect transistors (FETs) and memory devices. The Company has made several technological innovations in GaAs, including the following:

- Mitsubishi is producing GaAs solar cells at the Kita-itami Works; much of the production will be used in the CS-3, a communications satellite to be launched in 1988 by the National Space Development Agency of Japan.
- In October 1987, Mitsubishi announced that its LSI R&D Laboratory is developing a low-voltage 4Kx4 GaAs SRAM under the MITI Scientific Computing Systems Program. The device uses a 1.0-micron E/D DCFL self-aligned gate (SAG) MESFET process and dual-layer metal.
- The Company has developed a planar-type diode that simplifies the process of producing OEICs; it includes a transverse junction stripe (TJS) laser embedded in a GaAs substrate produced using a reduced pressure and a flat layer of GaAs and AlGaAs films on GaAs substrate.

Mitsubishi Electric Corporation

- Mitsubishi has developed a surface-light-emitting GaAsAl diffraction lattice junction semiconductor laser for optocomputers; it has transverse junction stripe (TJS) structure for transverse mode control and distributed feedback (DFB) structure for vertical mode control, continuous oscillation at 867.2nm wavelength, and 3mW output vertically from the substrate surface.

- The Company has developed five 14-GHz high-output GaAs FETs (MGFK series) with 0.3- to 5.5-watt output, 5.5dB to 0.8dB noise factor, and 14.0- to 14.5-GHz frequency range, using MBE process technology. They are intended for use as signal amplifiers in communications satellites.

- Mitsubishi has developed a high-output GaAs amplifier IC, 2.45W output at 28-GHz band, for use in ground station amplifiers for satellite communications systems.

- Mitsubishi has developed a mass-production technology for HEMT GaAs FETs using e-beam epitaxy and a proprietary low-noise process to deposit thin films of AlGaAs and other III-V compound materials on a GaAs substrate.

Image Sensors

Mitsubishi has developed an infrared CCD sensor with 260,000 elements on a 1.6mm x 1.2mm chip, capable of detecting 3.0- to 5.0-micron wavelengths. It is intended for use in defense equipment and night-vision cameras.

Semiconductor Agreements

Mitsubishi is involved in the following licensing, second-sourcing, and joint-venture agreements:

- Matsushita, Sanyo, and Sharp—A joint development agreement has been established with Matsushita, Sanyo, and Sharp to jointly develop microprocessors for parallel-processing computers.

- General Electric (GE) and Westinghouse—In 1986, Mitsubishi, GE, and Westinghouse formed a joint venture to manufacture and sell power transistors, diodes, and thyristors. Mitsubishi is financing 10 percent of the venture, named Powerex, while the two U.S. companies are each contributing 45 percent.

- Dai Nippon Printing Co., Ltd., Hoya Corporation, Toppan Printing Co., Ltd., and ULVAC Coating Corp.—In June 1986, Mitsubishi's LSI Development Laboratory provided Dai Nippon Printing, Hoya, Toppan Printing, and ULVAC Coating with photomask manufacturing technology using molybdenum silicide. The four companies will pay contract fees and royalties based on their production volumes.

- Intel Corporation—In June 1986, Mitsubishi agreed to provide foundry services for Intel. Mitsubishi second-sources Intel's 8086 product line.

- LSI Logic Corporation—In June 1986, Mitsubishi agreed to provide foundry services for LSI Logic.

- Nihon MRC Co., Ltd.—In October 1986, Mitsubishi invested in Nihon MRC for 25 percent ownership. Nihon MRC is a subsidiary of Materials Research Corporation (MRC) of the United States; Mitsubishi will sell MRC equipment in Japan.

- Semicon Systems, Inc.—In June 1986, Mitsubishi invested ¥200 million in Semicon Systems. Mitsubishi sent three directors to Semicon Systems, which will change its name to Dia Semicon Systems.

- Standard Microsystems Corporation (SMC)—In February 1985, Mitsubishi and SMC agreed to a global nonexclusive cross-licensing of each other's semiconductor patents and patent applications.

- Texas Instruments (TI)—In December 1986, Mitsubishi and TI agreed to mutually supply logic ICs on an OEM basis. TI will supply high-speed bipolar TTLs; Mitsubishi will ship low-power CMOS logic. Texas Instruments sells Mitsubishi-made 64K EPROMs in TI packaging.

Nonsemiconductor Products Summary

Information and Communications Systems and Electronic Devices

In addition to semiconductors, major products of this group include office automation equipment, computers and peripherals, satellites, optical fiber communication, local area networks (LANs), and value added networks (VANs).

Mitsubishi considers communications to be its most important field. A key product in this area is a video teleconferencing system. The Company is also marketing satellite communication systems to private companies. Another recent innovation in digital communications is a packet multiplexer that connects computers and terminal units to a switching packet network.

Efforts in electronic products include three satellite projects: the Engineering Test Satellite-V (ETS-V) was scheduled to launch in August 1987, two communication satellites (CS-3a and CS-3b) were scheduled for launch in February and August 1988, and the Earth Resources Satellite (ERS-1) was scheduled for launch in 1991. Mitsubishi is also a founder of the Institute for Unmanned Space Experiment Free Flier, established in 1986, which is constructing Japan's first unmanned space laboratory. Long-term plans involve the development of new materials and biotechnological experiments in space factories, which could lead to the establishment of actual space factories.

Information processing systems include general-purpose, small business, and personal computers in addition to other systems. In small business computers, the Company introduced the M3300 series workstation (an advanced 16-bit personal computer). A 32-bit workstation was developed in fiscal 1987. Mitsubishi also developed an artificial intelligence computer, the MELCOM PSI.

Heavy Machinery

Major products of this group include generators, motors, nuclear power equipment, transformers, circuit breakers, marine and industrial electric equipment and systems, industrial computer systems, railcar electric and electronic equipment and systems, numerical control equipment, electrical discharge and electrochemical machines, lasers, elevators, escalators, moving walks, and automatic building-cleaning systems.

Industrial Products and Automotive Equipment

Major products of this group include small and medium-size motors, controllers, watt-hour meters, relays, chemical products, rafts and boats, electrical automotive equipment and accessories, automobile radios, stereos, air conditioners, refrigeration equipment, factory automation equipment, and robotics. During fiscal 1986, the Company entered into a joint venture with Mikuni Corporation and Robert Bosch GmbH to jointly establish Nippon Injector, a company that will manufacture electronic fuel-injection systems for automobile engines. A new plant, located in Odawara, began production in spring 1987.

Consumer Products

Major products of this group are TVs, VCRs, radios, stereo equipment, air conditioners, heaters, fans, refrigerators and other kitchen appliances, washers and dryers, vacuum cleaners, hair dryers, fluorescent and mercury-vapor lamps, home computers, and home automation equipment.

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Motorola, Inc.

Motorola, Inc.
1303 E. Algonquin Road
Schaumberg, Illinois 60196
Telephone: (312) 397-5000
(Millions of Dollars except Per Share Data)

Balance Sheet (December 31)	1983	1984	1985	1986	1987
Working Capital	$ 894	$1,001	$ 924	$ 868	$1,039
Long-Term Debt	$ 262	$ 531	$ 705	$ 334	$ 344
Shareholders' Equity	$1,948	$2,278	$2,284	$ 2,754	$3,008
After-Tax Return on Average Equity (%)	13.5	16.5[1]	3.2	7.7	10.7

Operating Performance (Fiscal Year Ending December 31)	1983	1984	1985	1986	1987
Revenue	$4,328	$5,534	$5,443	$ 5,888	$6,707
U.S. Revenue[2]	$3,219	$4,083	$4,000	$4,123.5	$4,465
Non-U.S. Revenue[2]	$1,109	$1,451	$1,443	$1,764.5	$2,242
Cost of Revenue[3]	$2,546	$3,140	$3,390	$ 3,625	$4,029
R&D Expense	$ 336	$ 419	$ 457	$ 481	$ 524
SG&A Expense	$1,110	$1,472	$1,464	$ 1,431	$1,659
Pretax Income	$ 309	$ 466	$ 45	$ 265	$ 416
Pretax Margin (%)	7.1	8.4	0.8	4.5	6.2
Effective Tax Rate (%)	21.0	25.1	N/A	26.8	26.0
Net Income	$ 244	$ 387	$ 72	$ 194	$ 308
Average Shares Outstanding (Millions)	117.0	118.5	119.0	126.5	128.9
Per Share					
Earnings	$ 2.09	$ 3.27	$ 0.61	$ 1.53	$ 2.39
Dividend	$ 0.53	$ 0.61	$ 0.64	$ 0.64	$ 0.64
Book Value	$16.49	$19.19	$19.14	$ 21.48	$23.27
Price Range	$27.33- $50.00	$29.25- $46.92	$29.25- $40.75	$ 33.63- $ 50.00	$35.00- $74.00
Total Employees	88,800	99,900	90,200	94,400	97,700
Capital Expenditure	$ 406	$ 783	$ 641	$ 567	$ 658

N/A = Not Available
[1]Excludes cancellation of DISC taxes.
[2]Dataquest estimates
[3]Cost of Revenue shown includes depreciation and excludes R&D expense.

Source: Motorola, Inc., Annual Reports
Dataquest
December 1989

SUMMARY

Motorola is the largest semiconductor producer based in the United States. Founded in 1928 for the purpose of manufacturing automobile radios, Motorola has grown from a radio equipment and communications manufacturer to a $6.7 billion Fortune 100 company with operations in diverse electronics markets. In 1947, the name of the Company was changed from the Galvin Manufacturing Corporation to Motorola, Inc. Semiconductor operations were established in 1948, early in the history of the semiconductor industry, instigated by automobile radio applications. Today, Motorola maintains one of the broadest product lines of all semiconductor manufacturers and offers electronics products in other sectors as well.

Motorola operates in cutting-edge areas of semiconductor technology, contributing greatly to its portfolio of 77,000 products. For example, it has offered application-specific integrated circuit (ASIC) services for longer than any other semiconductor supplier, manufactures digital signal processing (DSP) products, and earns high revenue from the popular 68000 family of microcomponents. At the same time, Motorola has maintained a broad presence in the semiconductor industry by continuing to produce commodity parts such as diodes, thyristors, transistors, optoelectronics, and the less sophisticated linear devices. Motorola has capitalized on the departure of many semiconductor manufacturers from markets based on decade-old technology.

Motorola is a company with worldwide manufacturing, sales, and marketing. Besides semiconductors, which account for nearly one-third of Motorola's revenue, Motorola produces communications products, information systems products, government electronics products, and other electronic systems. Motorola's Communications Products Sector, which earns slightly more than its Semiconductor Products Sector, manufactures mobile and portable two-way FM radio and radio-paging systems. The Information Systems Group produces high-speed modems and other data transmission devices. Motorola's Government Electronics Group produces military and space electronic equipment, including communications systems and control systems. Motorola also produces automotive and industrial electronic products, cellular radio/telephone systems, and end-user computer systems for data processing and office automation applications. Components from the Semiconductor Products Sector are used in the products manufactured by the Company's other groups. These are often designed in cooperation with the equipment groups.

Company Milestones

The following are significant events in Motorola's history, listed in chronological order:

- 1928—Paul Galvin founded the Galvin Manufacturing Company (now Motorola, Inc.) to manufacture car radios.
- 1940—Galvin Manufacturing Company (Motorola) pioneered commercial two-way radio communications as a manufacturer of the walkie-talkie.
- 1954—The semiconductor research group in Phoenix, Arizona, produced Motorola's first solid-state component, a power transistor for use in automobile radios.
- 1956—The semiconductor group achieved division status, opening a large-scale manufacturing facility.
- 1957—Motorola manufactured the first auto rectifiers allowing alternators to replace DC generators.

- 1965—The first mass-produced epitaxial transistors were developed allowing low-cost "planar" devices.
- 1965—The first ECL devices were manufactured.
- 1966—The first practical all solid-state color TV (Quasar) was introduced.
- 1967—An IC center opened for design and production of complex integrated circuits in Mesa, Arizona.
- 1970—Motorola offered full computer-aided design (CAD) support and custom products with the introduction of the MOS Polycell LSI system and library. This made Motorola one of the first ASIC producers.
- 1971—The MECL-III high-speed logic product line debuted, and Motorola produced its first random access memories (RAMs).
- 1973—Construction of the MOS manufacturing facility in Austin, Texas, began.
- 1973—Motorola employed a gate array technology to bipolar large-scale integration to increase the density of ICs.
- 1974—The Quasar television/consumer products division sold to Matsushita, marking Motorola's departure from consumer electronics.
- 1975—Motorola's first microprocessor, the MC6800, was produced in volume, second-sourced by Hitachi and AMI.
- 1975—"Switchmode" power transistors were added to the discrete product line employing Motorola's proprietary glass passivation process. "Glassivation" improved yields and reliability for transistors and thyristors.
- 1979—Motorola was the first to introduce a 64K 5-volt EPROM. The MC68000 16-bit microprocessor with a 32-bit general register architecture and MC6809 8-bit microprocessor were introduced.
- 1980—The industry's first thin-film hybrid power amplifier modules were produced.
- 1981—Motorola established its first ASIC design center in San Jose, California.
- 1982—The MCA 1300 ALS extended macrocell array library with a 1,300-gate semi-custom logic device was produced.
- 1983—Motorola introduced the industry's first low-noise, high-gain gallium arsenide (GaAs) field-effective transistor (FET), well suited to cellular radio applications.
- 1984—Motorola produced the MC68020 32-bit microprocessor in volume, using a 2-micron HCMOS process. Includes 200,000 transistors to address up to 4 billion bytes of memory with 2.5-mips performance.
- 1984—ASIC division was established.
- 1984—The cellular radio program commenced.
- 1985—Began sale of pagers into Japan—the only non-Japanese company to receive such approval.
- 1985—BIMOS technology was employed in macrocell array with 6,000 gates.

- 1986—Motorola entered the digital signal processor (DSP) arena with two general-purpose chips, the DSP56000 and the DSP56001, aimed at speech recognition, speech synthesis, and graphics applications.
- 1987—Motorola achieved first silicon for the MC68030 32-bit microprocessor with on-chip memory management unit (MMU).
- 1988—Won coveted Malcolm Baldridge quality award.

Corporate Management of Motorola Semiconductor Products Sector Management

A new era was ushered in for Motorola management with the announcement of the eventual succession of Robert Galvin, 64-year-old son of the founder and current chairman of the board. George M.C. Fisher and Gary L. Tooker will eventually replace the current leadership of Mr. Galvin, William J. Weisz, and John F. Mitchell. In January 1988, Mr. Fisher, former president and assistant general manager of the Communications Sector, became president and chief executive officer, and Mr. Tooker, former president and general manager of the Semiconductor Sector, became senior executive vice president and chief operating officer. In the Semiconductor Products Sector, James A. Norling replaced Mr. Tooker as general manager of the sector.

The Company's Semiconductor Products Sector Management is as follows:

- James A. Norling—Executive vice president and general manager, Semiconductor Products Sector
- Thomas D. George—Senior vice president and assistant general manager, Semiconductor Products Sector
- Andre Borrel—Senior vice president and general manager, International Semiconductor Group
- Gordon C. Chilton—Senior vice president and general manager, Discrete and Special Technologies Group
- Murray A. Goldman—Senior vice president and general manager, Microprocessor Products Group
- Gary M. Johnson—Senior vice president and general manager, Standard Logic and Analog Integrated Circuits Group
- Geno Ori—Senior vice president and director, customer relations
- Charles E. Thompson—Senior vice president and sector director, World Marketing
- Weldon D. Douglas—Corporate vice president and general manager, Low-Frequency Power Transistor/Thyristor and Electronic Materials Division
- Lawrence L. Gartin—Corporate vice president and director, Sector Finance
- Brian O. Hilton—Corporate vice president and marketing director, North America
- George A. Needham—Corporate vice president and general manager, Final Manufacturing and Equipment Engineering Group
- Michael J. Pollak—Corporate vice president and general manager, Logic Integrated Circuits Division

- David L. Pulatie—Corporate vice president and sector director, Personnel
- Hector Ruiz—Corporate vice president and director of technology management
- Dedy Saban—Corporate vice president and general manager, European Semiconductor Group
- Paul J. Shimp—Corporate vice president and director, Sector Support Operations
- C.D. Tam—Corporate vice president and general manager, Asia/Pacific Semiconductor Products Division
- Barry Waite—Corporate vice president and assistant general manager, European Semiconductor Group
- Scott Shumway—Vice president and director of quality

Acquisitions

The Company's acquisitions are listed below in chronological order:

- 1974—Motorola acquired Topsil A/S (Denmark), a silicon foundry.
- 1974—Optoceram, Inc. (Albuquerque, New Mexico) was acquired to build Motorola's ceramic materials technology.
- 1977—Motorola acquired Codex (Boston, Massachusetts), a maker of modems and multiplexers.
- 1982—Motorola acquired Four-Phase Systems, Inc. (Mountain View, California), an information-processing company.
- 1982—Motorola acquired outstanding shares in Toko K. K. (Japan), which has become Motorola's Japanese MOS IC division.
- 1986—STORNO A/S (Denmark) was acquired. STORNO, formerly owned by General Electric, manufactures land-mobile communications systems and cellular subscriber equipment with plants in Denmark, England, and West Germany.

Financial Information

The semiconductor segment is just one electronics industry segment in which Motorola participates. The Company also operates a Communications Sector, an Information Systems Group, and a Government Electronics Group, as well as several other growth area groups such as the Cellular Group (see the section entitled "Nonsemiconductor Product Summary"). Table 1 shows Motorola's Semiconductor revenue compared with these other segments of business as reported in the Motorola 1987 annual report. The slight discrepancy between Dataquest's estimated revenue for semiconductor products and the revenue earned by Motorola's Semiconductor Products Sector is due to production of semiconductor products by other of Motorola's sectors or groups. This additional production is included in Dataquest's estimates for semiconductor revenue at estimated merchant market value, even if used in-house.

Table 1

Motorola, Inc. Revenue by Lines of Business
(Millions of Dollars)

	1983	1984	1985	1986	1987
Semiconductor	$1,612	$2,240	$1,667	$1,807	$2,193
Communications	1,620	1,864	2,016	2,243	2,515
Information Systems	514	481	428	465	528
Government Electronics	369	441	496	526	540
Other Products	324	698	995	1,029	1,141
Adjustments	(111)	(190)	(159)	(182)	(210)
Total	$4,328	$5,534	$5,443	$5,888	$6,707

Source: Motorola, Inc.
Annual Reports

Motorola's 1987 revenue increased 14 percent, to $6.71 billion from $5.89 billion the prior year. Earnings increased significantly, to $308 million from $194 million in 1986, an increase of 58.8 percent. The Company reported that the Communications and Semiconductor Sectors, and Information Systems and Cellular Groups contributed to the increased level of sales, new orders, and profits.

SEMICONDUCTOR OPERATIONS

Motorola products fall into a number of broad product areas as listed appear below:

- Logic—This includes standard logic devices and ASICs. ASICs include custom products, cell-based integrated circuits, gate arrays, and dedicated functions.
- Memories—These include dynamic random-access memories (DRAMs) and static random-access memories (SRAMs).
- Microcomponents—These include microcontrollers, microprocessors, and microperipherals and digital-signal processors.
- Linear—This includes analog signal conditioners, data converters, and amplifiers, voltage regulators, comparators, interface, special automotive and special consumer devices.
- Discrete—This includes transistors, diodes, thyristors, and other discrete devices.
- Optoelectronic—This includes optical couplers and other optoelectronic devices.

Motorola has one of the broadest product lines in the industry, offering devices in all the categories listed above.

Manufacturing Facilities

Table 2 describes Motorola's manufacturing facilities according to the classification scheme followed by Dataquest's Semiconductor Equipment and Materials Service (SEMS).

Table 2

Motorola, Inc.
Semiconductor Manufacturing Facilities

Factory	Type*	Clean Room (Sq. Ft.)	Products	Technology
Austin, TX	F	22,000	CMOS logic, MOS digital/ analog, ASICs	CMOS, HMOS, HCMOS
Austin, TX	F	14,900	MOS digital/analog, MCUs	Silicon gate, HMOS, HCMOS
Austin, TX	F	26,600	FSRAMs, complex MPUs, MOS digital/analog	HCMOS
Austin, TX	R	26,600	N/A	MOS
Mesa, AZ	F	23,700	MPUs	HMOS, HCMOS
Mesa, AZ	F	26,000	ASICs, DRAMs, MOS digital/analog	HCMOS, BiCMOS
Mesa, AZ	F	33,700	Telcom, regulator, op amps, automotive	Bipolar linear BIMOS
Mesa, AZ	F	30,500	Bipolar logic	Bipolar MMT, MOSAIC
Mesa, AZ	F	24,600	Gate arrays, logic	MOSAIC, BIMOS
Mesa, AZ	R	25,000	N/A	Bipolar
Aizu, Japan	F	23,800	Logic, power, std. cells, MCUs, memory	Silicon gate, HMOS, HCMOS, SMARTpower
Sendai, Japan	F	26,000	DRAMs, SSRAMs, FSRAMs, ASICs, MCUs	HCMOS
E. Kilbride, Scotland	F	25,600	MCUs, logic, MOS digital/ analog	Metal and silicon gate, HMOS
E. Kilbride, Scotland	F	34,000	MPUs, memory	HCMOS
Toulouse, FR	F	22,000	Telecom, consumer, regulators, op amps, auto	Bipolar linear, MOSAIC
Toulouse, FR	F	8,700	Power products	Bipolar power
Toulouse, FR	F	5,800	Rectifiers	Bipolar
Guadalajara, Mexico	F	1,400	Power products	Bipolar power
Phoenix, AZ	F	22,000	Power products	Bipolar power
Phoenix, AZ	F	13,000	RF power products	Bipolar
Phoenix, AZ	F	30,000	Small signal sensors	Bipolar
Phoenix, AZ	F	11,000	Thyristors	Bipolar
Phoenix, AZ	F	15,000	TMOS power	Bipolar
Phoenix, AZ	F	25,000	Zeners, rectifiers	Bipolar
Phoenix, AZ	R	12,000	N/A	Bipolar
Seremban, Malaysia	F	6,000	Small signal	Bipolar

*F = Fab, R = Research
N/A = Not Available

Source: Dataquest
December 1989

Capital Expenditure and R&D Spending

Table 3 shows Motorola's recent semiconductor R&D and capital spending. Capital spending reached an all-time high in 1984 at $412 million. Combined with all-time high R&D spending for the same year, the two expenditures were equal to 25 percent of the record revenue in 1984. Capital spending tapered off for 1985 and 1986 but, due to depressed sales, increased to 29 percent of sales in 1985. This spending was applied primarily toward productivity- and quality-enhancing equipment. Meanwhile, R&D spending for strategic products has continued to increase. In 1986, capital expenditure contributed primarily to the conversion of Motorola fabs to CMOS from other MOS processes. As the semiconductor industry shows increasing robustness in 1988, capital spending is expected to increase by as much as 30 percent.

PRODUCTS AND MARKET

1987 Summary

According to Dataquest estimates, the Company's semiconductor revenue in 1987 was $2.43 billion, an increase of 20 percent over 1986. This compares with worldwide semiconductor industry growth of 25 percent, based on Dataquest's semiconductor consumption estimates measured in dollars. U.S. companies grew just 8 percent as a whole in 1986, and the top 10 U.S. companies averaged 6 percent growth in revenue. Motorola's Semiconductor Products Sector earned a pretax 1987 operating profit of $171 million, well below 1984's $373 million.

Table 3

Motorola, Inc.
Semiconductor Capital Expenditure and R&D Spending
(Millions of Dollars)

	1983	1984	1985	1986	1987
Semiconductor Revenue	$1,647	$2,319	$1,830	$2,025	$2,430
Semiconductor Capital Expenditure	$ 174	$ 412	$ 330	$ 250	$ 350
Percentage of Semiconductor Revenue	10.6%	17.8%	18.0%	12.3%	14.4%
Semiconductor R&D Spending	$ 155	$ 176	$ 192	$ 199	$ 207
Percentage of Semiconductor Revenue	9.4%	7.6%	10.5%	9.8%	8.5%
Combined Capital and R&D Spending	$ 329	$ 588	$ 522	$ 420	$ 562
Percent Increase	14.2%	78.7%	(11.2%)	(19.5%)	33.8%

Source: Dataquest
December 1989

For the Semiconductor Products Sector, Motorola attributes improved performance in 1987 to higher sales and major customer service and manufacturing improvements. Sales increased in all geographic areas, with the stronger yen enhancing Japanese sales significantly. The fastest-growing application areas included the industrial and communications segments, while federal/military sales were down. Product sales were led by microprocessors and memories.

Motorola added significant products to all lines, including the 68030 second-generation, 32-bit microprocessor, which has been well received by makers of scientific workstations, multiuser office computers, robotics, communications systems, and military products. In addition to peripherals and coprocessors for the 68020 and 68030, shipments of the DSP56001, a general-purpose DSP, began. The Company also entered the fast SRAM market with a new HCMOS family of SRAMs that range in density from 16K to 256K.

In ASICs, Motorola introduced a family of CMOS gate arrays, ranging in density from 6,000 to 100,000 gates. A library of advanced 2-micron HCMOS logic arrays in densities up to 8,500 gates was introduced, as well as a 10,000-gate bipolar ECL gate array, to compete in the ultrahigh performance market. Also introduced was an 8,000-gate BIMOS array.

The following tables provide details of Motorola's participation in the semiconductor market. Table 4 shows the Company's semiconductor revenue by product area and technology from 1983 through 1987; Table 5 gives this detail for 1987 by region; and Table 6 indicates how Motorola ranked in these various categories for 1986 and 1987.

Market Positioning

Memories

Motorola was once a significant player in the memory market, consistently ranking among the top 10 producers worldwide. Currently, the company manufactures DRAMs and PROMs using bipolar technology, and EPROMs, EEPROMs, DRAMs, and SRAMs using MOS technology, employing ECL in both DRAMs and PROMs and TTL in DRAMs. Motorola earned an estimated $96 million in memory revenue. Although Motorola withdrew from the DRAM market in early 1985, DRAMs remain the Company's largest revenue-producing product in memories, as Motorola packages and markets DRAM dice manufactured by Toshiba. Of the Company's estimated $86 million from MOS memory products, DRAM revenue amounted to approximately $61 million, making Motorola the number 10 supplier of DRAMs in a worldwide market of $2.6 billion in 1987. Through another joint venture with Toshiba, Motorola plans to begin production of memory and microprocessor products from a Japanese facility in mid-1988.

Increasing priority has been given to Motorola's SRAM family, from which Motorola earned approximately $18 million in 1987. The SRAM market is divided into slow and fast SRAMs. Fast SRAMs are defined as parts with access times of less than 70ns; parts with greater access times fall into the slow category. Motorola participation in the slow SRAM market has been declining, while revenue for fast SRAM sales have been on the increase. Dataquest estimates that Motorola's fast SRAM revenue was almost $16 million in a 1987 market of $418 million. Motorola offers SRAM parts in NMOS in 2K and 16K densities ranging in speed from 55ns to 35ns. In 1987, a family of high-performance CMOS SRAMs was added to Motorola's product line, including 4K, 8K, 16K, and 64K densities with speeds up to 25ns.

Table 4

Motorola, Inc.
Worldwide Semiconductor Revenue
(Millions of Dollars)

	1983	1984	1985	1986	1987
Total Semiconductor	$1,647	$2,319	$1,830	$2,025	$2,430
Integrated Circuits	$1,150	$1,693	$1,281	$1,403	$1,754
Bipolar (Technology)	$ 258	$ 456	$ 379	$ 393	$ 429
TTL	150	283	237	246	245
ECL	96	160	134	144	179
Other Bipolar Digital	12	13	8	3	5
Bipolar (Function)	$ 258	$ 456	$ 379	$ 393	$ 429
Digital Memory	15	18	16	11	10
Digital Logic	243	438	363	382	419
MOS (Technology)	$ 697	$ 967	$ 668	$ 728	$ 986
NMOS	440	635	378	280	346
PMOS	N/A	N/A	N/A	N/A	N/A
CMOS	257	332	290	448	640
MOS (Function)	$ 697	$ 967	$ 668	$ 728	$ 986
MOS Memory	223	314	100	51	86
MOS Micro Devices	210	291	272	342	519
MOS Logic	254	362	296	335	381
Linear	$ 195	$ 270	$ 234	$ 282	$ 339
Total Discrete	$ 482	$ 607	$ 532	$ 604	$ 652
Transistor	$ 308	$ 374	$ 321	$ 361	$ 390
Small Signal Transistor	159	186	152	N/A	N/A
Power Transistor	149	188	169	N/A	N/A
Diode	$ 133	$ 167	$ 155	$ 176	$ 182
Power Diode	86	104	94	N/A	N/A
Zener Diode	47	63	61	N/A	N/A
Thyristor	$ 26	$ 33	$ 27	$ 32	$ 34
Other Discrete	$ 15	$ 33	$ 29	$ 35	$ 46
Total Optoelectronic	$ 15	$ 19	$ 17	$ 18	$ 24
Optical Couplers	12	16	14	N/A	N/A
Other Optoelectronic	3	3	3	N/A	N/A
Exchange Rate (Yen per US$1)	234	237	238	167	144

N/A = Not Available

Source: Dataquest
December 1989

Table 5

Motorola, Inc.
Estimated Semiconductor Revenue by Geographic Region—1987
(Millions of Dollars)

	United States	Japan	Europe	Rest of World	Total
Total Semiconductor	$1,522	$170	$478	$260	$2,430
Integrated Circuits	$1,111	$162	$309	$172	$1,754
Bipolar (Technology)	$ 295	$ 39	$ 61	$ 34	$ 429
Digital Memory	7	-	1	2	10
Digital Logic	288	39	60	32	419
MOS (Technology)	$ 656	$ 87	$165	$ 78	$ 986
Memory	60	4	11	11	86
Microcomponents	339	49	95	36	519
Logic	257	34	59	31	381
Linear	$ 160	$ 36	$ 83	$ 60	$ 339
Total Discrete	$ 396	$ 8	$164	$ 84	$ 652
Total Optoelectronic	$ 15	-	$ 5	$ 4	$ 24

Source: Dataquest
December 1989

Table 6

Motorola, Inc.
Worldwide Ranking—Semiconductor Markets

	1986 Rank	1987 Rank	1987 Revenue	Revenue % Change 1986-1987	Industry % Change 1986-1987
Total Semiconductor	4	4	$2,430	20.0%	23.0%
Integrated Circuits	5	5	$1,754	25.0%	25.9%
Bipolar (Technology)	5	5	429	9.2%	8.3%
Digital Memory	9	9	10	(9.1%)	0.3%
Digital Logic	3	3	419	9.7%	9.6%
MOS (Technology)	6	6	$ 986	35.4%	35.3%
Memory	18	15	86	(68.6%)	35.3%
Microcomponents	3	3	519	51.8%	40.3%
Logic	3	3	381	13.7%	31.5%
Linear	9	8	$ 339	20.2%	19.1%
Total Discrete	1	2	$ 652	7.9%	13.2%
Total Optoelectronic	20	21	$ 24	33.3%	16.3%

Source: Dataquest
December 1989

In EPROMs, Motorola currently offers a 64K-NMOS device. Sales of Motorola's EPROM devices peaked in 1979 at 9 percent of the market, but have been declining since then to an estimated $1.2 million in a 1987 market totaling $1.3 billion. Motorola scrapped plans for a 256K CMOS EPROM in mid-1987 and is unlikely to introduce a 1-Mbit part. However, it is expected that EPROM capability will be preserved to support manufacturing technology and ASIC product offerings.

Microcomponents

Motorola is a leading participant in the microcomponents market. The Company has been a long-time supplier of proprietary microprocessors, microcontrollers, and microperipherals to this market. With estimated revenue of $519 million in an approximately $5 billion market, it ranks as the third-largest microcomponent manufacturer in the world. Motorola has consistently ranked as the number three supplier to this market, behind Intel and NEC. Intel claimed market share of about 21.0 percent in 1987, NEC had 11.5 percent, and Motorola was a close third with 10.6 percent.

Among the segments that make up the microcomponents market, Motorola has a strong position in microcontrollers and high-end microprocessors. It is the leading supplier of 8-bit microcontrollers in terms of units shipped. The Company's 68HC11 has gained very favorable market acceptance. A leading application for these 8-bit MCUs is in automotive. The Company is also prominent in high-end microprocessors where it has a full line of products, including high-performance floating-point coprocessors and DSP support. Motorola had a head start in the emerging 32-bit microprocessor market with its 68020/68030 devices. Because the 68000 microprocessor, a 16-bit microprocessor introduced in 1979, had a 32-bit internal architecture, Motorola was able to upgrade 16-bit data bus paths to a full 32-bit architecture with the 68020 two years before its competitors. In early 1987, Motorola produced silicon for the 68030, a second-generation 32-bit microprocessor that incorporated such functions as a paged MMU, an instruction cache, and a data cache with burst-fillable mode in a Harvard-style architecture. These devices have found homes in a variety of applications, including business systems, artificial intelligence platforms, robotics, telecommunications, multiprocessor systems, military products, and most prominently, in technical workstations.

During 1988, Motorola also introduced its contender in the 32-bit RISC microprocessor market, the 88000. Also of significance was the joint announcement with Data General of an agreement to create an ECL version of the 88000 MPU that the companies claim will allow 100-mips performance by 1991, thus bringing mainframe computer power to users at personal computer price/performance levels. In April 1988, the '88 Open Consortium was created by leading computer hardware and software vendors to promote and establish the success of Motorola's 88000 RISC architecture. Through this approach, the consortium expects to drive standards for this architecture prior to implementation of the product. Software will be portable across a wide range of computing platforms, allowing equipment manufacturers to concentrate on hardware solutions.

Motorola numbers among several companies that have recently entered the growing DSP market. By leveraging leadership in analog technology as well as having extensive digital experience, Motorola introduced two general-purpose DSPs in 1986. These devices manipulate data that has been converted from analog into digital signal form. Application areas include speech processing, music, geophysics, radar, sonar, image processing and communications. Most DSPs are currently being sold into the military or telecommunications markets. The three leading manufacturers of single-chip DSP devices are Texas Instruments, NEC, and Fujitsu, in that order. Combined, they accounted for more than 70 percent of 1987's revenue of $98 million for this market segment. Analog Devices, AT&T, and Motorola form the core group of the next level of single-chip DSP suppliers. Although Dataquest estimates that Motorola's revenue from this segment is less than $10 million, the company has adopted strategies designed to secure its long-term commitment to this market. A recent product announcement of note was the NeXT computer from Steven Jobs, which incorporated Motorola's 32-bit, 25-MHz 68030 microprocessor, a 68882 floating-point unit, and the 56001 DSP.

Logic

Motorola offers a variety of logic products in standard logic, gate arrays, and custom products. The Company has long been a leading producer of standard logic circuits, producing a variety of products in TTL, ECL, and CMOS technologies. In 1987, Motorola garnered approximately $396 million of an estimated $2.9 billion market, placing it in third place worldwide, after Texas Instruments and National Semiconductor.

The majority of Motorola standard logic sales are produced using bipolar technologies in the LSTTL and FAST (Fairchild Advanced Schottky TTL) families of TTL logic of the MECL10K, MECL10KH, and MECL-III families of ECL logic. These accounted for approximately $282 million of Motorola's standard logic product revenue, ranking Motorola third worldwide in bipolar standard logic. Sales of MOS standard logic products amounted to about $114 million, placing the company second only to Toshiba in this product area. In packaging, Motorola is investing in the tooling to switch from DIP to surface-mount packaging, which Dataquest estimates will reach parity in terms of units in 1990.

Motorola's participation in ASICs focuses primarily on gate arrays, particularly on bipolar gate arrays. Motorola ranks number five among worldwide gate array suppliers after Fujitsu, NEC, LSI Logic, and Toshiba. Motorola's gate array revenue of $109 million is generated primarily from bipolar gate arrays, where it is the number-two supplier worldwide. In fact, with revenue of $93 million, Motorola was the world's largest supplier of ECL gate arrays to the merchant market in 1987. In 1987, the Company introduced one of the industry's fastest and densest ECL arrays, a 10,000-gate ECL array operating at 100ps internal gate delays. According to Dataquest estimates, Motorola's MOS gate arrays generated $16 million in revenue. In the area of BiCMOS, which is forecast to have the fastest compound annual growth rate (CAGR) of the ASIC product segment at almost 81 percent from 1987 to 1992, the Company has made a recent product introduction of a 7,500-gate BiCMOS array. Through a joint development agreement with NCR, Motorola was in the process of developing a standard cell product offering until the Company announced in September 1988 that it was restructuring its approach to its standard cell operations in the merchant market. Motorola views its standard cell operation not as a standalone business, but rather as a methodology that each of the product groups can use to support its market needs. Motorola has no programmable logic device offering at this time.

Linear

Motorola produces a wide selection of linear devices in bipolar, CMOS, and combined bipolar/CMOS processes. The Company is a broad-line supplier and participates in the markets for amplifiers, regulators, interfaces, comparators, data converters, telecom ICs, consumer ICs, and other analog circuits. By Dataquest estimates, Motorola is among the top five world suppliers of regulators, interfaces, comparators, and telecom ICs.

With $339 million in analog revenue out of the $7.3 billion, Motorola is the eighth-largest supplier of analog devices in the world. Of U.S. companies, only National Semiconductor and Texas Instruments earned more revenue from analog devices in 1987 than Motorola.

Discrete and Optoelectronics

Although many semiconductor producers have abandoned discrete products for later-generation devices, Motorola remains an important force in single components, or single-component functions in a single package, such as transistors, diodes, and thyristors. In a market dominated by Japanese companies, Motorola has long been the leading supplier and was dislodged from the number-one position only in 1987 by Toshiba. Motorola's 1987 discrete revenue amounted to $652 million in a total market valued at $6.6 billion.

Within the discrete market, Motorola holds strong positions in all the major product areas. Producing both power transistors and small-signal transistors (SSTs) in TMOSFET and bipolar technologies, Motorola's revenue of $390 million makes the company the second largest transistor producer in the world. Motorola's 1987 market share was almost 12 percent, compared with Toshiba's approximately 13 percent. Motorola holds third place in the diode market with revenue of $182 million, after Hitachi and Toshiba. Motorola's market share in this market was approximately 9 percent as compared with Hitachi and Toshiba, which held almost 13 percent and 10 percent, respectively. The Company's strengths are in Zener and power diodes. Motorola's thyristor revenue amounted to $34 million in 1987, positioning the company after Powerex, Toshiba, and Mitsubishi. Other discrete product revenue for the Company totaled $46 million.

In addition to its major mature product families, new products are being developed, bringing new technologies and opportunities to the Motorola portfolio. These new technologies often combine discrete and integrated circuit technologies to provide new products containing substantial added value. Examples of these include integrated sensing devices, SMARTpower ICs, complex IC optocouplers and monolithic microwave ICs (MMICs). Among the exciting growth areas in the discrete group are RF products. Since Motorola's acquisition of TRW's RF division, the Company is the leading supplier. RF products include modules for CATV (Cable TV) and cellular radio applications, EFTs, and power MOSFETs.

Motorola's optoelectronic products include emitter/detectors, optocouplers, optointerrupters, and fiber-optic switches and components. However, with revenue of $24 million, Motorola is a small player in the $1.7 billion optoelectronics market.

Business Strategies

In order to retain its position as the preeminent U.S. semiconductor producer, Motorola has instituted as part of its company-wide goals, the following imperatives:

- Best-in-class customer service
- Manufacturing excellence
- Success in Japan

- New product and process technology
- Consistent, superior financial performance
- Worldwide market share gains

These imperatives feed into the Company's overriding objective of providing total customer satisfaction. Some of Motorola's plans relating more specifically to products and technology include the following:

- Continue to maintain the broadest product line in the industry, keeping a balanced diversity of products
- Increase public recognition of 68020 and 68030 superiority to competitive microprocessor products while continuing architectural leadership in microprocessors
- Grow market share in microprocessors as technical workstations become less and less expensive
- Maintain low manufacturing costs by doing things right the first time (The Company has instigated a program of manufacturing excellence to reduce cycle times, to design for manufacturability, and to reduce scrap.)
- Employ state-of-the-art CMOS, bipolar, and BiCMOS technologies where they are most appropriate, and push densities to the highest manufacturable levels
- Use ASIC alliances and growing gate array and macrocell libraries to increase market share of the quickly growing ASIC market
- Build on its strong presence in recently opened Japanese markets through its relationship with Toshiba and vigorous independent efforts
- Increase its presence in growth areas of the semiconductor industry, such as DSP, new materials, and other frontier sectors

Channels of Distribution

Motorola has more than 104,000 semiconductor sales accounts in the United States. The following network of Motorola sales offices operates throughout the world, including field applications engineering at each site:

- 46 sales offices in 29 U.S. states
- 5 sales offices in 4 Canadian provinces
- 14 sales offices in 9 European countries
- 10 sales offices in 6 Asian nations (including 4 in Japan)
- 6 sales offices in 5 other countries

Furthermore, Motorola maintains six intracompany sales offices in Arizona, Florida, Illinois, and Texas for sales of semiconductor products to other sectors of the Company. In fact, Motorola's captive use of semiconductors includes components used by the systems group of the Information Systems Group to produce board-level systems products and end-user computing systems. Within the Communications Sector, semiconductors purchased from the Semiconductor Sector as well as communications circuits it manufactures are used in communications products. Intersegment sales, primarily of semiconductors, were $156 million in 1987, according to the Motorola annual report. This compares with $121 million in 1986, $113 million in 1985, i.e., 7.1 percent, 6.7 percent, and 6.8 percent of semiconductor sales for each of those years, respectively.

Sales to distributors account for approximately 20 percent of Motorola's sales. Motorola maintains relationships with Almac, Anthem, Bell, Future Electronics, Hallmark, Hamilton/Avnet, Kierulff, Lionex, Pioneer-Standard, Schweber, and Times. A special arrangement with Times and Future Electronics allows Motorola to sell to distributors without return privileges, thereby offering commodity pricing. Motorola is encouraging all its distributors to enter into this commodity program, but the program is meeting resistance from risk-shy distributors.

Motorola contracts four independent design centers and three distributors throughout the country to handle some of its ASIC support along with corporate facilities and centers in San Jose (California), Japan, Israel, and Hong Kong. The independent design centers are Custom Silicon Inc. (Boston, Massachusetts), Electronic Technology Corp. (Cedar Rapids, Iowa), Silicon System Inc. (Raleigh, North Carolina), and Texas Arrays (Dallas, Texas). Pico Design (Santa Clara, California) is wholly owned by Motorola. Distributors involved in ASIC support include Hamilton/Avnet in San Jose and Boston; Schweber in Irvine (California), Boston, Atlanta (Georgia), Minneapolis (Minnesota), and Long Island (New York); and Hallmark, in Dallas (Texas) and Boston.

To improve communications with customers, Motorola has established electronic bulletin boards for many product lines. These boards allow users to post questions, suggestions, and information about applications, product performance, or availability and keep Motorola close to customer concerns. This new strategy complements Motorola's extensive traditional training programs and literature offerings.

Technology Strategies/R&D Activity

Motorola is a technology leader in devising processes and procedures oriented toward high-volume manufacturing. For example, Motorola's microprocessor products are designed to be manufactured in a single-layer metal silicide process that minimizes problems associated with ramping up multilayered production processes. Motorola's involvement in the government VHSIC (very high speed integrated circuit) program led it to develop a 1.25-micron CMOS process, and currently to develop a 0.5-micron CMOS process as well as advanced bipolar technology. With the broadest range of products in the industry, Motorola also maintains a broad range of process technologies. From high-performance bipolar (such as the latest MOSAIC process) to high-speed, low-power CMOS, to new BiCMOS processes combining the two, Motorola processes run the gamut of available technologies.

In bipolar technologies, Motorola has recently introduced the next generation of MOSAIC technology. Currently, 1.5-micron bipolar ECL gate arrays with 10,000 gates can be purchased. These have power dissipation as low as 1mW and gate delays as low as 150ps. The density and performance of MOSAIC III exceeds MOSAIC I and II, significantly increasing density by four times, yet increasing die size just 40 percent. Furthermore, 1-micron MOSAIC IV is expected to be implemented in producing 20,000-gate arrays with gate delays as low as 50ps. These processes build on the MOSAIC II process, which introduces walled emitter structures to achieve gate arrays of 400ps. MOSAIC III improves on this process by using a polyelectrode transistor design combining a p+ polysilicon for extrinsic-based doping and the base electrode, and n- polysilicon for the emitter. A proprietary edge-defined technique is used to allow fabrication of submicron emitter widths without the use of submicron lithography. Polysilicon resistors reduce node resistance and allow for tape-automated bonding.

Motorola has been a leader in CMOS since the early 1980s, when semiconductor manufacturers recognized the potential for CMOS's power and density advantages to gain significant market share. In fact, Motorola earned 32 CMOS patents during CMOS's emerging years between 1971 and 1982. Since 1982, 33 more patents have been granted to Motorola for CMOS techniques. Furthermore, all designs for microprocessors have been in CMOS since 1984, significantly ahead of the competition. Motorola's HCMOS process has been in production since 1983, offering 1.7-micron geometries and speeds up to 20 MHz. This performance is achieved through a single-layer metal process with silicide that causes fewer production snags and increases yields.

Remaining on the cutting edge of technology, Motorola has developed a BiCMOS process that is currently being used in gate arrays and will be implemented in fast SRAMs in the near future. This process combines a 2-micron n-well CMOS structure with a p-type epitaxial bipolar transistor featuring walled polysilicon emitters as used in Motorola's advanced MOSAIC bipolar process. This combination, incorporating silicided gate, source, and drain structures and two layers of metal interconnection, requires 14 mask steps, 3 of which are for bipolar structures. The result is an array with 6,000 gates, with power dissipations of 50mW/MHz compared to CMOS's 70mW/MHz. A submicron BiCMOS process is in development stages.

Motorola has remained on schedule with transitions in wafer size facilities. In July 1985, Motorola's first 6-inch wafers were processed at the East Kilbride, Scotland, facility. Additional 6-inch fabs are planned, and construction of the Toshiba joint-venture 6-inch fab was completed in early 1988 as scheduled, and is in silicon production.

ALLIANCES

Motorola has entered into a number of agreements with other semiconductor vendors and with customers. Alliances are viewed as a necessary component of its semiconductor strategy because no single company can keep up with every technology and because they serve to foster closer customer-vendor relationships. A summary of Motorola's alliances is listed in Table 7, in which Company A has licensed Company B for the type of activity and products listed.

Synopses of the alliances listed between Motorola and other semiconductor manufacturers or between Motorola and customers are listed in the following subsections.

Motorola and Data General

Motorola and Data General signed an agreement to develop an ultrahigh-speed version of the Motorola 88000 RISC MPU family using ECL technology. The result will be an 88000-compatible processor chip set allowing system implementations operating in excess of 100 mips.

Motorola and Omnirel

Motorola and Omnirel announced plans for joint introduction of power MOSFET devices intended for military/high-reliability applications. The product will be offered in isolated TO-258AA and TO-257AA hermetic packages, whose outlines are similar to the industry standard TO-218 and TO-220 plastic packages.

Table 7

Motorola, Inc.
Summary of Alliances

Company A[1]	Company B[1]	Type	Products	Date
Motorola	Data General	JD	MPUs	April 1988
Motorola	Omnirel	JD	Military MOSFETs	March 1988
Motorola	Unisoft	SI	Software	Feb. 1988
Motorola	Signetics	SS	MPUs	Dec. 1987
Motorola	Toshiba	TE	DRAMs	Dec. 1987
Motorola	FutureNet	CAD	Design software	Nov. 1987
Motorola	Tangent Systems, Toshiba	CAD	Gate array	Nov. 1987
National	Motorola	TE	TAB packaging	April 1987
Motorola	SEEQ	JD	EEPROM MCU	Dec. 1986
Motorola	Toshiba	TE, JV	MPUs, DRAMs, SRAMs	Dec. 1986
Fairchild	Motorola	SS	FACT logic	Oct. 1986
Motorola	Silicon Systems	JV	ASIC	Aug. 1986
ILSI	Motorola	SS	Gate array	June 1986
Motorola	Toshiba	JV	Semicustom	June 1986
Motorola	Northern Telecom	JV	ISDN, MPR	May 1986
Motorola	Hitachi	SS	MPUs	Sept. 1985
Motorola	Toko Electric	SS	Linear ICs	Sept. 1985
NCR Corp.	Motorola	JV	ASIC	July 1985
Motorola	Thomson/Mostek	SS	68000 MPR	April 1985
Linear Technology	Motorola	TE		Jan. 1985
Toshiba	Motorola	FA, MA	DRAMs	Jan. 1985
Motorola	Hitachi	SS	CMOS 8-bit MCU	Jan. 1985
Motorola	Hitachi	SS	MCU	Nov. 1984
Motorola	SGS-Thomson	SS	MPU	Sept. 1984
Motorola	Toshiba	SS	Linear ICs	April 1984
Motorola	TRW	JV	VHSIC CMOS	1984
Motorola	Honeywell,	JV	VHSIC bipolar	1984
AMD (MMI)	Motorola	SS	PLD	1983
Motorola	Philips-Signetics	SS	68000 MPU family	1983
Motorola[2]	Mostek	SS	68000 MPU family	1983
Motorola	Hitachi	SS	MPU	1977

Note: JD = Joint Development, SI = Common Specifications, TE = Technology Exchange,
SS = Second Source, FA = Foundry Agreement, JV = Joint Venture,
MA = Marketing Agreement, TE = Technology Exchange
[1]Where possible, when technology or whatever is applicable is changing hands, we have tried to designate the giver as Company A and the recipient as Company B.
[2]Terminated

Source: Dataquest
December 1989

Motorola and Unisoft

Motorola and Unisoft unveiled a binary compatibility standard (BCS) for Motorola's 68020, 68030, and 68040 MPUs. Motorola also acquired an equity position in Unisoft. Under the agreement, Unisoft will deliver ports derived from UNIX System V for Motorola's 68000 and 88000 family platforms. Unisoft will act as Motorola's exclusive agent for future products based on UNIX System V.

Motorola and Signetics

Signetics is now the sole second source for Motorola's 68010 16-bit MPU. The SCN68010 features virtual memory operations and comes in 8.0-MHz, 10.0-MHz, and 12.5-MHz versions.

Motorola and Toshiba

Motorola is installing Toshiba's CMOS process for submicron geometries at its MOS 6 wafer fab in Mesa, Arizona. Motorola is completely reconstructing the fab, and GCA is upgrading about 20 of MOS 6's existing steppers to be compatible with its submicron 8500 stepper line. The upgrade allows Motorola to produce 4Mb DRAMs, 1Mb SRAMs, or high-density microcomponents.

Toshiba and FutureNet

Motorola will bundle its 62A gate array library with design software from FutureNet as part of a low-priced ASIC starter kit for novice users. It will be marketed through Motorola's distribution channels.

Motorola and Tangent Systems, Toshiba

Tangent Systems signed a one-year channel-less CAD tool agreement with Motorola and Toshiba that will increase gate utilization to 70 to 80 percent. Toshiba will use the CAD tools to place and route its TC110G family of 1.5-micron CMOS gate arrays with 5,330- to 129,042-gates; Motorola will use the CAD tools with its MAX family.

National and Motorola

National Semiconductor licensed Motorola to use its tape-automated bonding (TAB) packaging technology in April 1987. The move appears to be part of National's effort to promote the technology, which is useful in high-volume devices and will eventually be employed for high-pin-count ASIC devices.

Motorola and SEEQ

SEEQ and Motorola signed an engineering development agreement to develop a high-performance EEPROM microcomputer.

Motorola and Toshiba

In December 1986, Motorola and Toshiba signed an extensive five-year agreement. The two companies agreed to invest equally in a joint venture to be called Tohoku Semiconductor Corporation. Furthermore, a three-way technology transfer of microprocessors, memories, and new products developed in the venture will occur. Toshiba will purchase Motorola microprocessors for resale, and as Motorola's opportunities in the Japanese market increase, technology transfers will be made. Tohoku is to produce 256K, 1Mb, and 4Mb DRAMs and 256K and 1Mb SRAMs from Toshiba, and 8-bit, 16-bit, and eventually 32-bit MPUs from Motorola.

Fairchild and Motorola

Motorola is serving as a second source for Fairchild's low-power Schottky TTL.

Motorola and Silicon Systems, Inc.

Motorola and Silicon Compilers, a San Jose CAD/CAE company, have banded together to combine design ability and fabrication expertise to meet the needs of the ASIC market. Motorola's 1.25- and 2-micron HCMOS processes will be supported on Silicon Compilers Genesil Silicon Development System. Motorola will manufacture products developed on the Genesil system, which offers the first complete automation of VLSI circuit design.

Integrated Logic Systems and Motorola

Motorola has signed up with yet another source for semicustom design, taking a license from Integrated Logic Systems, Inc. The ILSI line of gate array products is being evaluated as a complement to Motorola's 62A series.

Motorola and Toshiba

In June 1986, Toshiba agreed to produce semicustom ICs based on Motorola specifications and to supply the chips to Motorola on an OEM basis.

Motorola and Northern Telecom

Motorola and Northern Telecom agreed to collaborate in the research and development of components for ISDN. These include interface transceiver ICs. Motorola will supply manufacturing expertise, and Northern Telecom will offer systems design expertise.

Motorola and Hitachi

Motorola and Hitachi made an alternate-source agreement for a CMOS 68000MPU.

Motorola and Toko Electric Co.

Motorola and Toko Electronic Co. made an alternate-source agreement for Motorola's ICs for AM stereo receiver signal decoders.

NCR and Motorola

In June 1985, an agreement was made between NCR and Motorola to swap production and to cooperate to provide and design systems employing semicustom chips. The agreement covers both current and future semicustom products. NCR and Motorola also agreed to develop a joint library of more than 140 2-micron CMOS standard cells offering high-density, high-speed versions of many of the basic functions and high-drive cells of the p-well library, with analog cells to come. They further intend to develop 1.5- to 1.2-micron geometries.

Motorola and Thomson/Mostek

In April 1985, Motorola reached a product-exchange agreement covering peripheral chips for the 68000 microprocessor with Mostek and its parent, Thomson C.S.F. Semiconducteurs.

Linear Technology Corporation and Motorola

Motorola and LTC signed a seven-year agreement granting each other rights to several patents. LTC gained rights to several Motorola patents; Motorola gained rights to patents obtained and filed during the term of the agreement, which expires in 1991. LTC also makes specific lump-sum payments to Motorola through 1991.

Toshiba and Motorola

In early 1985, Motorola agreed to package, assemble, and market DRAM dice manufactured by Toshiba.

Motorola and Hitachi

In January 1985, Motorola licensed Hitachi to produce the HD6301V and HD6303R 8-bit microcomputers, which are compatible with the MC6801.

Motorola and SGS-Thomson

Motorola selected Thomson (now SGS-Thomson) as the first alternate source for the 32-bit 68020 MPU.

Motorola and Toshiba

Toshiba will second-source Motorola's C-Quam AM-Stereo recorder IC.

Motorola and TRW

Through the government's VHSIC program, Motorola has joined a number of leading semiconductor vendors in developing high-performance products. Motorola and TRW have been jointly commissioned to develop a 0.5-micron CMOS technology.

Motorola and Honeywell

In another VHSIC project (see "Motorola and TRW" above), Motorola and Honeywell have been jointly commissioned to develop a 0.5-micron bipolar technology.

AMD (Monolithic Memories, Inc.) and Motorola

Motorola was licensed in 1983 to produce a wide variety of MMI's PLDs.

Motorola and Philips-Signetics

In 1983, Motorola signed Philips-Signetics as a second source for the 68000 microprocessor family.

Motorola and Mostek (Acquired by Thomson, CSF in 1985)

Mostek became a licensed alternate source for the 68000 microprocessor family in 1983. The five-year agreement stipulated that after two years of Motorola production, Motorola would provide Mostek with mask sets, tooling, and documentation for the microprocessor as well as two peripheral chips in exchange for products and technology of comparable value. Motorola terminated the contract in December 1985 and filed a suit against Mostek for patent infringement. The case was settled out of court with Mostek's then parent, United Technologies, paying $20 million to Motorola.

Motorola and Hitachi

Second-source agreement involves Motorola's 8-bit microprocessors.

NONSEMICONDUCTOR PRODUCT SUMMARY

As mentioned previously, semiconductors account for approximately 30 percent of Motorola's sales. The only segment of its business that earns more is the Communications Product Sector, which earned 37 percent of the Company's 1987 revenue. The Communications Sector produces a wide variety of radio communications equipment, including base stations, digital voice communications systems, high-frequency single-banded radio systems, mobile/portable data communications and FM two-way radio communications systems, and radio-paging systems. Motorola can claim the distinction of being the first foreign supplier to join Japanese competitors in selling to Japan's National Telephone Company, Nippon Telegraph and Telephone Company (NTT). Other lines of business within the Communications Products Sector include closed-circuit television systems, communications control centers, electronic and command control systems, health care communications systems, portable data terminals, signaling and remote control systems, and test equipment. Motorola is a market leader in radio-paging equipment, with a broad base of successful products. Motorola automated dispatch systems are also very popular in such diverse industries as transportation and appliance servicing.

Motorola's Government Electronics Group, which earned 8 percent of Motorola's revenue in 1987, produces systems for weapons control and intelligence applications. Defense weaponry products include battlefield management systems, countermeasure systems, drone command and control systems, electronic defense systems, electronic fuse systems, electronic positioning and tracking systems, fixed and satellite communications systems, intelligent display terminals and systems, and missile and aircraft instrumentation. Products often used in intelligence applications include satellite data systems, satellite power electronics, satellite survey and positioning systems, secure communications, surveillance radar systems, survival transceivers, tracking and command transponder systems, antenna and microwave systems, video processing systems and products, and tactical communications. Much of this work is done under contracts that have been won through an increasingly competitive bidding process. The Government Electronics Group's longest-running production effort is a U.S. Navy target-detecting device for the Navy's Standard Missile. Other key projects include a joint-service radar-based surveillance system (Joint STARS), the STU III future secure voice system telephone instrument for the National Security Agency, and an RF receiver subsystem for the joint Air Force/Navy Integrated Electronic Warfare System (INEWS) in a cooperative effort with Saunders Corp. and General Electric.

The Information Systems Group, which earned 8 percent of Motorola's 1987 revenue, manufactures and markets modems and data networking/communications products. The Information Systems Group includes Universal Data Systems and the Codex unit, acquired in 1977. These include digital service/channel service units, distributed communications processors, electronic data switches, leased-line modems, limited distance modems, switched network modems, local area network products, multiplexers, network control and management systems, protocol converters, and x.25 concentrators. Codex participation in helping to establish the Integrated Service Digital Network (ISDN) standard for terminal connectivity networks has been a key activity for the unit. Universal Data System's Sync-Up line of IBM-compatible plug-in cards is an efficient method of adding modem and terminal emulation capabilities to personal computers.

Motorola's Automotive and Industrial Electronics Group makes a wide variety of electronics products for use in automobile production and as components for automotive systems. Serving Motorola's flagship market, this division has declined in importance compared with other Motorola divisions. Products of the Automotive and Industrial Electronics Group include automotive and industrial sensors, CRT display monitors in color and monochrome, electronic and electromechanical instrumentation, electronic appliance controls, electronic engine controls, electronic motor controls, ignition systems, transmission controls, vehicle charging systems, vehicle monitoring and recording systems, vehicle theft-deterrent systems, and voltage regulators.

Motorola's General Systems Group includes Motorola's Cellular Group and Motorola Computer Systems, which was acquired in 1982 when it was called Four-Phase Systems. The Cellular Group produces mobile and portable subscriber products and telephone systems, conventional car telephone systems, electronic mobile exchanges, IMTS car telephones, and low-density cellular base stations. Motorola is a leader in the fast-growing cellular telephone industry. Further inroads have been made in developing cellular relay systems that will allow cellular telephones to work over long distances.

Motorola Computer Systems produces microcomputer board-level products, microcomputer systems and peripherals, microprocessor development system hardware and software, minicomputer systems and peripherals, OEM operating systems, and software for distributed data processing and office information applications. Motorola Computer Systems has reaped disappointing profits in its years with Motorola experiencing an operating loss in 1986 and 1987.

Motorola's overall emphasis on the various product areas may be changing with the new top management. Both the Communications and Semiconductor Products Sectors will have a voice in the executive office. New top management reaffirms a commitment to the communications group as well as recognition of the strength of the semiconductor product sector. The transition is expected to be very smooth, however, and policies and strategies will certainly be consistent with past leadership.

National Semiconductor Corporation

National Semiconductor Corporation
2900 Semiconductor Drive
Santa Clara, California 95052-8090
Telephone: (408) 721-5000
TWX: 910-339-9240
(Millions of Dollars)

Balance Sheet (May 31)	1984	1985	1986	1987	1988
Total Current Assets	$ 599.6	$ 608.4	$ 549.4	$ 771.2	$1,041.8
Cash	$ 27.8	$ 12.2	$ 21.8	$ 189.1	$ 147.2
Receivables	$ 264.4	$ 244.7	$ 220.8	$ 269.2	$ 401.5
Inventory	$ 223.1	$ 223.4	$ 205.8	$ 270.1	$ 417.0
Net Property, Plant, & Eqp.	$ 510.3	$ 757.9	$1,360.8	$1,384.5	$1,541.1
Depreciation	$ 435.2	$ 531.1	$ 654.9	$ 750.6	$ 857.5
Total Assets	$1,156.0	$1,410.5	$1,295.4	$1,445.7	$1,777.0
Current Liabilities	$ 404.2	$ 375.8	$ 353.4	$ 527.7	$ 669.8
Long-Term Debt	$ 24.2	$ 225.9	$ 123.4	$ 35.7	$ 37.3
Total Liabilities	$ 537.0	$ 729.3	$ 578.4	$ 617.7	$ 763.4
Total Shareholders' Equity	$ 619.0	$ 681.2	$ 652.7	$ 828.0	$1,013.6
Conv. Preferred Stock	-	-	$ 0.1	$ 0.1	$ 0.1
Common Stock	$ 43.5	$ 44.5	$ 45.3	$ 51.3	$ 53.9
Retained Earnings	$ 242.6	$ 285.8	$ 187.1	$ 89.4	$ 142.1

Income Statement (May 31)	1984	1985	1986	1987	1988
Revenue	$1,655.1	$1,787.5	$1,478.1	$1,867.9	$2,469.7
Cost of Sales	$1,146.3	$1,258.5	$1,096.9	$1,319.1	$1,732.9
Gross Margin (%)	31	30	26	29	52
R&D Expense	$ 158.5	$ 204.6	$ 222.4	$ 218.9	$ 280.2
SG&A Expense	$ 247.6	$ 264.9	$ 276.5	$ 310.3	$ 378.0
Other Expense	-	-	-	$ 15.0	-
Operating Income (Loss)	$ 102.7	$ 59.5	($117.7)	$ 4.6	$ 78.6
Interest, Net	($ 1.3)	$ 7.7	$ 21.6	$ 19.3	$ 3.8
Pretax Income	$ 101.4	$ 51.8	($ 139.3)	$ 14.7	$ 74.8
Effective Tax Rate	45	34	N/A	N/A	-
Extraordinary Items, Net	$ 7.8	$ 8.8	$ 56.8	$ 4.2	-
Net Income	$ 64.0	$ 43.2	($ 93.4)	($ 23.4)	$ 62.7
Average Shares Outstanding (Millions)	85.3	89.9	89.8	91.7	110.8
Capital Expenditure	$ 278.1	$ 400.6	$ 116.9	$ 94.7	$ 198.9
Employees	41,700	37,100	30,800	29,200	37,700

N/A = Not available due to a negative pretax income.

Source: National Semiconductor Corporation
Dataquest
December 1989

THE COMPANY

Background

National Semiconductor Corporation is one of the top 10 semiconductor manufacturers in the world. The Company was formed in 1959 in Danbury, Connecticut, as a manufacturer of transistors. In 1967, when Charles E. Sporck was named president and CEO, the Company moved its headquarters to Santa Clara, California, and began producing proprietary integrated circuits (ICs). In the 1970s, National added systems to its product line.

The Company's stated goals are to establish long-term partnerships and a customer-driven orientation, and to focus on significant fast-growing market segments and advanced technology. These goals are elaborated on in the "Business Strategies" section of this profile.

Organization

Near the end of fiscal 1986, the Company reorganized into two core business units—semiconductors and systems. The Semiconductor Group is engaged in the development, manufacture, and sale of integrated circuits, discrete devices, hybrid circuits and subsystems, electronic packaging, and other services and supplies for the semiconductor industry.

The Information Systems Group (ISG) manufactures and markets computer systems based on proprietary circuits, IBM-compatible computer products and services, and point-of-sale systems. ISG consists of three operations—National Advanced Systems (NAS), Datachecker Systems Inc., and the Microcomputer Products Division.

In 1989, National will undergo significant organizational changes with the sales of Datachecker and NAS. On February 1, 1989, National announced the establishment of a new operating division, the VLSI Division, which will combine the Company's microprocessor, microcontroller, advanced peripherals, and interface groups. Figure 1 depicts National's organizational structure, effective as of February 6, 1989.

Acquisitions, Mergers, and Divestitures

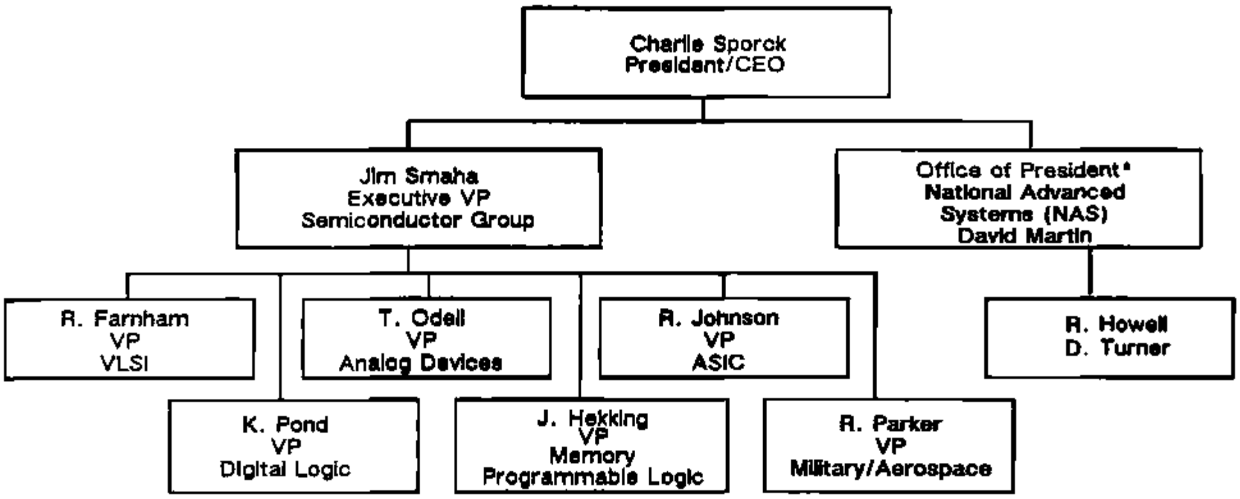
On October 7, 1987, National announced that it had closed the transaction with Schlumberger Ltd. for the purchase of Fairchild Semiconductor Corporation. National acquired Fairchild for $122 million worth of stock and warrants. Schlumberger transferred all assets to National with the exception of Fairchild's wafer fabrication facilities in Nagasaki, Japan, and Wasserburg, West Germany. Through the acquisition of Fairchild, National Semiconductor emerges as a more formidable supplier to the worldwide semiconductor market.

In December 1988, National announced the sale of its subsidiary, Datachecker, to ICL for $90 million. Also announced was an agreement in principle to license certain patents and trademarks to STC, ICL's parent company, for use in retail systems. ICL will assume ownership of Datachecker during the third quarter of 1989, subject to government approval.

National announced on February 27, 1989, the sale of NAS for $398 million in cash to Hitachi, which manufactures the mainframe computers NAS sells, and Electronic Data Systems (EDS), a General Motors subsidiary that integrates computer systems for corporations. The Dow Jones News Wire reported that Hitachi would own 80 percent of the new joint venture, while EDS would control 20 percent.

Figure 1

National Semiconductor Corporation
Organizational Structure



*As of March 1989, an agreement has been signed between National and a joint venture created by Hitachi Ltd. and Electronic Data Systems (EDS) for the sale of NAS.

0005198-1

Source: National Semiconductor Corporation

Financial Information

National has achieved profitability in every quarter from fourth quarter 1987 through the end of fiscal year 1988. Net earnings for 1988 were $62.7 million, compared with the previous year's loss of $23.4 million. A 32 percent revenue increase was experienced, with 1988 sales reaching $2,469.7 million.

The Company reported increases in sales in all regions. Sales to the Americas increased by 24 percent from $1,334 million in 1987 to $1,655 million in 1988. Sales to Europe rose 31 percent from $583 million in 1987 to $765 million in 1988; sales to Asia gained 54 percent from $547 million in 1987 to $845 million in 1988.

Lines of Business

As previously noted, National Semiconductor comprises two business units—the Semiconductor Group and the Information Systems Group. A five-year revenue history for the Company, broken out by business unit, is shown in Table 1.

Table 1

National Semiconductor Corporation
Revenue by Lines of Business

	Fiscal Year Ending May 31				
	1984	1985	1986	1987	1988
Semiconductor Group	$1,107	$1,159	$842	$981	$1,422
Percentage of Revenue	67%	65%	57%	52%	57%
Information Systems Group	$ 571	$ 647	$644	$902	$1,067
Percentage of Revenue	34%	36%	44%	48%	43%

Source: National Semiconductor Corporation

Semiconductor Group

In 1988, component sales increased 45.1 percent to $1,417.9 million compared with $976.9 million in 1987. The Semiconductor Group returned to profitability in 1988 with operating income of $62.8 million compared with an operating loss of $4.7 million in 1987. Increased sales coupled with higher gross margins and lower research and development expenses as a percentage of sales contributed to improved operating results in 1988, according to the Company.

Information Systems Group (ISG)

Sales by the ISG increased 18.0 percent in 1988 to $1,051.8 million. This sales growth primarily was due to higher sales of the NAS AS/XL and AS/VL Alliance Generation Series of mainframes and peripherals.

Despite sales increases in 1988, operating income declined 8.7 percent from $38.1 million in 1987 to $34.8 million in 1988. Reduced gross margins and increased research and development costs relative to sales contributed to this decline.

Facilities

National Semiconductor operates manufacturing facilities in the United States, Scotland, and Israel. Table 2 describes the locations, technologies, and products of the Company's fabrication sites.

Table 2

National Semiconductor Corporation
Manufacturing Facilities

City	Type	Clean Room Gross (Sq. Ft.)	Products	Technology
Arlington	F	25,000	Arrays MPR MPU Adv. Log.	CMOS
Danbury	F	10,000	Dig. ICs, discretes	Bipolar MOS
Santa Clara	P	5,000	EEPROMs	CMOS
	P	5,000	Arrays mem. development	Bipolar
	F	17,000	Adv. and commercial LINs	Bipolar M2
	F	7,500	LOG	Bipolar
	F	17,000	PLDs	Bipolar CMOS
	P	7,000	LIN arrays	Bipolar
	F	7,500	LOG	Bipolar
	F	8,000	PLD	Bipolar CMOS
	P	10,000	All R&D functions	Bipolar CMOS, MOS BiCMOS
	NF	9,000	LIN	Bipolar
	NP	4,000	VHSIC 10K arrays	MOS
Tucson	A	40,000	N/A	N/A
West Jordan	F	30,000	Telecom MPUs	CMOS
	F	20,000	LOG MPUs	MOS
	F	30,000	Flash EEPROM MPU SRAMs	CMOS
Greenock,	F	10,000	Linear arrays	MOS
Scotland	F	15,000	Standard logic	
	F	10,000	Linear	Bipolar
Migeal-Ha-Emek, Israel	F	20,000	32-Bit MPUs	CMOS

N/A = Not Available
F = Fab
P = Pilot Line
NF = Nondedicated Foundry Service Available
NP = Nondedicated Foundry Service Available Pilot Line

Source: Dataquest
December 1989

CAPITAL AND R&D SPENDING

Capital Spending

Dataquest estimates that National's capital spending increased 12 percent in calendar year 1988 to $200 million from $157 million in 1987. The Company projects capital spending of $300 million for fiscal year 1989.

Currently, National is constructing and equipping a number of facilities. Fab lines based on 5-inch CMOS wafers are being outfitted in West Jordan, Utah, and South Portland, Maine. Lines running 6-inch CMOS wafers are being readied in West Jordan; Arlington, Texas; Santa Clara, California; and Migeal-Ha-Emek, Israel. In Greenock, Scotland, a 6-inch bipolar logic line is being built. Puyallup, Washington, lines being readied include 4-inch bipolar and 4-inch BiCMOS. Construction for 6-inch BiCMOS is taking place in Puyallup, as is construction in Arlington for 6-inch CMOSII. Bipolar and CMOS have been somewhat capacity limited. With these additional facilities, National plans to address both current and future needs.

R&D Spending

In 1988, National invested $240 million in research and development programs, representing an increase of 14 percent over 1987, as shown in Table 3. According to National, the percentage of R&D spending relative to revenue will drop along with the actual dollar amount spent in 1989. An effort will be made to maximize R&D expenditure through agreements and consortia.

SEMICONDUCTOR OPERATIONS

Technology

Core technologies include CMOS and bipolar. The Company intends to add to its next-generation emitter-coupled logic (ECL) family and enhance ASPECT2, an advanced bipolar process technology acquired through the purchase of Fairchild. Fairchild's BiCMOS process complements National's advanced CMOS process. In BiCMOS, National has indicated that it will add LSI blocks to the family.

Table 3

National Semiconductor Corporation
Capital and R&D Spending as a Percentage of Revenue
Semiconductor Group
(Millions of Dollars)

	1984	1985	1986	1987	1988
Revenue	$1,213.0	$925.0	$1,427.0	$1,506.0	$1,700.0
Capital Expenditure	$ 495.0	$319.0	$ 223.0	$ 157.0	$ 200.0
Percentage of Revenue	41%	35%	16%	10%	12%
R&D Expenditure	$ 158.5	$187.0	$ 190.0	$ 213.0	$ 240.0
Percentage of Revenue	14%	20%	13%	14%	14%
Combined Capital and R&D Spending	$ 653.5	$506.0	$ 413.0	$ 370.0	$ 440.0
Percentage of Revenue	54%	55%	29%	25%	26%
Percentage of Increase or Decrease	(82%)	(23%)	(18%)	(10%)	19%

Note: Columns may not add to totals shown because of rounding.

Source: Dataquest
December 1989

Investment in core technologies is a strong theme within National. The Company has indicated that it will focus on adding modules to core processes to facilitate a die shrink path without redesigning products. This will enable the Company to respond rapidly to the market and customer demand.

Product Lines

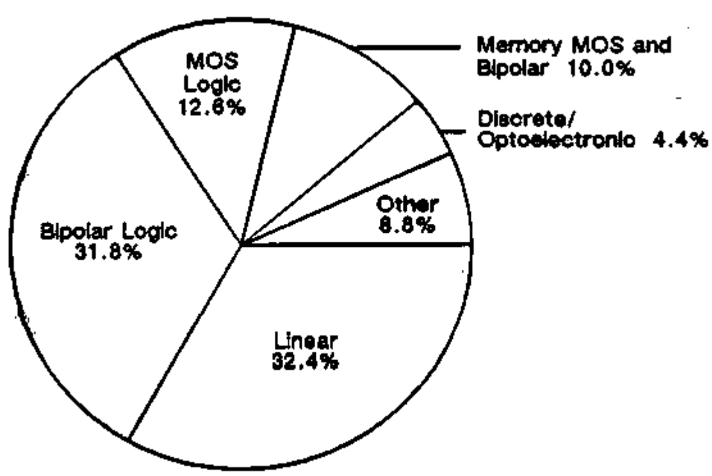
The Semiconductor Group offers linear, microcomponent, ASIC, memory, and logic products. Linear products represented nearly one-third of National's sales in 1988, as shown in Figure 2. Table 4 provides a five-year history of revenue by product type. The Company achieved growth in 1988 nearly comparable to that of the industry as a whole in only two areas, bipolar digital and linear products, as revealed in Table 5. Table 6 shows that U.S. sales account for more than 50 percent of National's revenue.

Linear Devices

National, a broad-line supplier of linear products, was ranked number two worldwide in 1987 and 1988 for all linear devices. The Company is ranked number one in the U.S. linear market and is a major supplier to the European market. This is a strongly profitable area in which National expects to see good growth. In the monolithic IC portion of the linear market, which grew approximately 20 percent in 1988 to $7.4 billion, National was the worldwide leader. Additionally, National was the top-ranked supplier of amplifiers and regulators. Sales of linear devices, at $550 million in 1988, contributed nearly one-third of the Company's semiconductor revenue.

Figure 2

National Semiconductor Corporation
Semiconductor Revenue by Product Area



Total = $1700 Million

0005198-2

Source: Dataquest December 1989

Table 4

National Semiconductor Corporation
Worldwide Semiconductor Revenue
(Millions of Dollars)

	1984	1985	1986	1987	1988*
Total Semiconductor	$1,213	$925	$1,427	$1,506	$1,700
Total Integrated Circuit	$1,153	$882	$1,363	$1,431	$1,625
Bipolar Digital (Technology)	$ 290	$194	$ 511	$ 521	$ 575
TTL	283	190	450	420	450
ECL	7	4	61	72	100
Other Bipolar Digital	-	-	-	29	25
Bipolar Digital SWAG	-	-	-	-	-
Bipolar Digital (Function)	$ 290	$194	$ 511	$ 521	$ 575
Bipolar Digital Memory	35	12	64	45	35
Bipolar Digital Logic	255	182	447	476	540
Bipolar Digital SWAG	-	-	-	-	-
MOS (Technology)	$ 430	$318	$ 355	$ 415	$ 500
NMOS	227	110	149	90	125
PMOS	8	3	-	-	-
CMOS	195	205	206	325	365
MOS SWAG	-	-	-	-	-
MOS (Function)	$ 430	$318	$ 355	$ 415	$ 500
MOS Memory	110	50	57	80	135
MOS Microdevices	115	106	122	140	150
MOS Logic	205	162	176	195	215
MOS SWAG	-	-	-	-	-
Linear	$ 433	$370	$ 497	$ 495	$ 550
Total Discrete	$ 45	$ 37	$ 64	$ 75	$ 75
Transistor	45	37	33	40	40
Diode	-	-	31	35	35
Total Optoelectronic	$ 15	$ 6	-	-	-
LED Lamps	5	2	-	-	-
LED Displays	10	4	-	-	-

*Based on preliminary market share data.
Note: Difference relates to National's purchase of Fairchild.

Source: Dataquest
December 1989

Table 5

National Semiconductor Corporation
Worldwide Ranking in Semiconductor Market by Calendar Year

	1987 Rank	1988 Rank	1987 Revenue	Revenue % Change 1987-1988	Industry % Change 1987-1988
Total Semiconductor	8	11	$1,700	12.9%	32.9%
Total IC	8	9	$1,625	13.6%	37.6%
Bipolar Digital	2	2	575	10.4%	9.1%
MOS Digital	11	13	500	20.5%	54.4%
Linear	2	2	550	11.1%	16.1%
Total Discrete	22	25	$ 75	0	13.6%
Total Optoelectronic	-	-	-	-	24.2%

Source: Dataquest
December 1989

Table 6

National Semiconductor Corporation
Estimated 1988 Semiconductor Revenue by Region
(Millions of Dollars)

	U.S.	Japan	Europe	ROW	Total World
Total Semiconductor	$915	$135	$390	$260	$1,700
Total Integrated Circuit	$880	$135	$385	$225	$1,625
Bipolar Digital	335	63	110	67	575
MOS	250	34	130	86	500
Linear	295	38	145	72	550
Total Discrete	$ 35	0	$ 5	$ 35	$ 75

Source: Dataquest
December 1989

With the purchase of Fairchild, National acquired the technology for the CMOS Linear Application Specific Integrated Circuit (CLASIC) analog ASICs. National considers CLASIC to be the fastest-growing portion of the Company's semiconductor product line. In March 1988, National announced its entry into the video digital-analog converter (DAC) market with a device used for PC graphics. It utilizes a bipolar CMOS process to achieve high performance and is a pin-for-pin fully functional replacement for the industry standard Inmos IMSG176. A mark of strength for National is having 150 cells in its standard linear library.

Memory

Worldwide sales of National's memory products amounted to $11,447 million in 1988, and National ranked sixth worldwide in the number of memory units sold. Sales of bipolar digital and MOS memory represented approximately 10 percent of National's sales in 1988. The Company experienced a 36 percent growth in memory, with revenue increasing from $125 million in 1987 to $170 million in 1988. According to National, sales are expected to exceed $200 million in 1989.

With the acquisition of Fairchild, National gained technology for 256Kx1 BiCMOS high-speed SRAMs with ECL input/output (I/O) levels. Being among the leaders in BiCMOS will allow National to remain on par with the Japanese producers in the SRAM business. Nearly 80 percent of National's revenue in memories comes from MOS products. National is focusing on ECL I/O for the speed and drive benefits it provides. Marketing efforts are directed toward supercomputers and mainframe and cache memory.

National introduced a CMOS line of 64K fast SRAMs for use in the Electronic Data Processing (EDP), telecommunications, and industrial markets. The CMOS devices have speeds in the range of 25 to 35 nanoseconds.

National produces 16K to 256K EPROMs primarily for telecommunications and EDP. The Company has a Flash agreement with SEEQ Technologies through 1996; this agreement paves the way for the two companies to quickly market a family of high-density, competitively priced Flash memory products. Also, a new submicron Flash process module will be developed and incorporated in National's most advanced core memory process. This module will support the manufacture of 2Mb and 4Mb Flash EPROMs and EEPROMs.

Microcomponents

National is ranked eleventh among the worldwide suppliers of microcomponents. Dataquest estimates National's microcomponent sales at $150 million in calendar year 1988, an increase of about 7.2 percent from 1987. Microprocessors (MPUs) are produced in 8-,16-, and 32-bit configurations. National introduced the 32032 32-bit MPU in 1983. It was followed by the 32332—a higher-performance, next-generation 32-bit MPU resulting from a need for an architectural upgrade—which is three times faster than the 32032 and has full 32-bit addressing. In April 1987, National unveiled the 32532 MPU that represents a next step in performance evolution from the midrange 32332. In the area of high-end processing, National announced its next generation of 32-bit MPUs with the 32764. The 32764 will be upwardly compatible with the previous 32000-family processors. Along with its standard 8- and 16-bit microcontroller products, National offers 16- and 32-bit proprietary MCU configurations. National continued expansion of its MCU products in 1988. In April, National announced the availability of the industry's first CMOS 16-bit MCU megacell in its standard cell library. This megacell, called HPC Core, is the basis of the Company's family of high-performance microcontrollers available as standard products. With the HPC, National is the second leading supplier of 16-bit microcontrollers. The HPC 16400, announced in October, is an extension of the core technology. This product contains added circuitry to support ISDN (Integrated Services Digital Network) system functions as well as a range of other data communications applications. A CMOS support chip for the HPC 16900 was unveiled in June. It allows use with external memory, freeing I/O pins crucial to I/O-intensive MCU applications such as industrial control, commercial security systems, and HVAC (heating, ventilation, and air conditioning) control systems.

National has added a high-performance, 8-bit MCU based on the existing COP800 family, which is targeted at the industrial control market. The new MCU features increased I/O and interrupt capabilities and processor-independent pulse-width modulation (PWM) timers.

With the 32532, National brings the memory management unit (MMU) on-chip and has implemented separate data and instruction caches, while reducing the number of cycles per operation. The 32532 is designed using 1.5-micron CMOS technology.

In the peripheral area, National introduced two dozen LSI and VLSI circuits during its 1987 fiscal year. The chips included a 4Mb DRAM controller and a multichip set for high-performance video graphics and printer applications. National accounts for this product revenue under the category of advanced digital and peripheral interface, now part of the newly created VLSI Division.

The 1987 introduction of the DP8500-AGCS (Advanced Graphics Chip Set) marks the entrance of a new architecture and a new family of devices designed for the data processing market. In 1988, National entered the laser printer market with the new NS32cG16 Raster Printer Processor. In targeting this new market, National demonstrates increased design focus on task-specific products.

The Company's pricing strategy reflects efforts to be highly competitive on a value-relative-to-performance basis. National is seeking to increase its product development focus on proprietary products in order to become a strong primary supplier for its customers. Microcomponents are considered to be a major investment area for National.

ASICs

National's ASICs include bipolar TTL PLDs, MOS and bipolar gate arrays, and MOS cell-based ICs (CBICs). Nearly 90 percent of the Company's ASIC sales are for data processing, communications, and industrial applications. ASICs represented 13 percent of National's semiconductor sales for calendar year 1988.

ASIC gate arrays and BiCMOS also are considered a major investment area for National, and these areas are expected to show the greatest long-term growth. ASICs, exclusive of programmable logic devices (PLDs) and CLASIC, are expected to be operationally profitable in early 1989.

Recent product additions include an ECL CBIC for use in high-performance computers and a 180-cell unloaded gate array with access delays of 160 picoseconds, manufactured using a technology developed by Fairchild.

Packaging

The Company offers a wide range of surface-mount devices including small-outline (SO) packages, plastic chip carriers, and both lead and leadless ceramic chip carriers. National also commercialized tape-automated bonding (TAB). In April 1987, National licensed its TAB packaging technology to Motorola, thus enabling National to promote this technology, which is useful in high-volume devices. National ships more TAB packages than all other suppliers combined. In 1986, National developed a high-density, high-lead-count, surface-mount component to be offered as part of a totally integrated manufacturing system. TAPEPAK, as this product is called, combines TAB and a protective outer ring. The package is being used for 40-lead linear devices.

Semiconductor Product Alliances

National has entered into a wide range of agreements with other semiconductor vendors. Alliances are seen as a necessary component of the Company's strategy because no single company can keep up with every technology. A summary of National's alliances is presented in Table 7.

Table 7

National Semiconductor Corporation
Summary of Alliances

	Company A	Company B	Type	Products	Date
1.	National Semiconductor	VLSI Technology	FAB	EPROM	April 1985
2.	Micron Technology Inc.	National Semiconductor	SS	DRAM	Nov. 1984
3.	National Semiconductor	Synertek	SS	EEPROM	July 1984
4.	National Semiconductor	Eurotechnique	SS	EPROM	March 1983
5.	Oki	National Semiconductor	FAB	DRAM	Jan. 1983
6.	Texas Instruments	National Semiconductor	TE	PLD	Jan. 1985
7.	National Semiconductor	Motorola Inc.	TE	TAB	April 1987
8.	Sierra	National Semiconductor, Chartered Semiconductor Corporation	JV	N/A	Nov. 1987
9.	National Semiconductor	Sierra, Chartered Semiconductor Corporation	JV	N/A	Nov. 1987
10.	National Semiconductor	Sierra	JD	N/A	Jan. 1987
11.	SEEQ	National Semiconductor	JD	EEPROM	Oct. 1987
12.	National Semiconductor	Toshiba	PR	N/A	Nov. 1987
13.	Motorola, Inc.	National Semiconductor	SS	N/A	Nov. 1987
14.	National Semiconductor	Motorola, Inc.	SS	N/A	Nov. 1987
15.	National Semiconductor	Mitsubishi Electric Corp.	IV	N/A	Nov. 1987
16.	Seattle Silicon	Silicon Compilers, National Semiconductor	CAD	N/A	Oct. 1987
17.	Micrel Inc.	National Semiconductor	SS	N/A	Dec. 1987
18.	National Semiconductor	Data I/O, FutureNet	CAD	N/A	Nov. 1987
19.	National Semiconductor	Canon	C	N/A	Dec. 1987
20.	National Semiconductor	FutureNet	CAD	N/A	Nov. 1987
21.	Genesis	National Semiconductor	FAB	N/A	Dec. 1987
22.	National Semiconductor	Krysalis	JD	FRAM	Dec. 1987
23.	SGS	National Semiconductor	JD	N/A	Oct. 1983
24.	Chips & Technologies	National Semiconductor	JD	N/A	Nov. 1986
25.	IBM	National Semiconductor	TE	N/A	May 1984
26.	National Semiconductor	Oki	FAB	N/A	July 1985
27.	National Semiconductor	Texas Instruments	TE	N/A	May 1984

(Continued)

Table 7 (Continued)

National Semiconductor Corporation
Summary of Alliances

	Company A	Company B	Type	Products	Date
28.	National Semiconductor	Sierra	TE	N/A	July 1984
29.	National Semiconductor	Synertek	SS	N/A	July 1984
30.	National Semiconductor	Xerox	TE	N/A	1986
31.	National Semiconductor	NMB Semiconductor	FAB	SRAM	Sept. 1986
32.	National Semiconductor	Intl. Microelectronic Products	TE	N/A	1984
33.	National Semiconductor	Intl. Microelectronic Products	SS	Gate Array	March 1985
34.	National Semiconductor	Lattice Semiconductor	JD	PLD	April 1987
35.	National Semiconductor	Linear Technology Corporation	TE	N/A	July 1986
36.	Sensym	National Semiconductor	TE	N/A	
37.	National Semiconductor	Three-Five	INV	N/A	Sept. 1987
38.	National Semiconductor	Weitek Corp.	SS	N/A	Oct. 1985
39.	Vantage Analysis Systems, Inc.	National Semiconductor	JD	N/A	June 1988
40.	Gateway Design Automation Corp.	National Semiconductor	JD	N/A	June 1988
41.	Cadence Design Systems	National Semiconductor	JD	N/A	June 1988
42.	National Semiconductor	Aspen, Cypress Semiconductor Corporation	PR	N/A	Aug. 1988
43.	SGS	National Semiconductor	JD	N/A	Sept. 1988

1. National Semiconductor and VLSI Technology—National Semiconductor supplied CMOS EPROM technology to VLSI Technology. VLSI manufactured the part and supplied wafers to National.
2. Micron Technology Inc. and National Semiconductor—National Semiconductor purchased a license to manufacture and sell Micron's 64K DRAMs for about $5 million. The deal included an option on a 512K DRAM. As of January 1985, National had not decided whether or not to build the part in production volume.
3. National Semiconductor and Synertek—National Semiconductor and Synertek signed an agreement in July of 1984, under which National would serve as a licensed alternate source for Synertek's 2K EEPROM.
4. National Semiconductor and Eurotechnique—National Semiconductor transferred technology for its 16K and 32K CMOS EPROMs to Eurotechnique in 1983.
5. Oki and National Semiconductor—In late 1983, Oki Electric supplied its 64K dynamic RAM technology to National Semiconductor. National allocated about half of its 64K DRAM output to Oki. National planned to market the Oki DRAM, using a National label and part number.
6. Texas Instruments and National Semiconductor—National is to produce TI's IIFPLA839/840 programmable logic array. In exchange, TI will produce National's ultrafast ECL PAL.

(Continued)

Table 7 (Continued)

National Semiconductor Corporation
Summary of Alliances

7. National Semiconductor and Motorola, Inc.—National Semiconductor licensed Motorola to use its TAB packaging technology in April 1987. The move appears to be part of National's effort to promote the technology. The technology is useful in high-volume devices and will eventually be employed for high pin-count ASIC devices.
8. Sierra and National Semiconductor, Chartered Semiconductor Corporation—Sierra contributed its proprietary Triple Technology CMOS process and technical management, while National contributed CMOS process and technical support to construct the clean room facility.
9. National Semiconductor and Sierra, Chartered Semiconductor Corporation—A new company, named Chartered Semiconductor Corporation, was formed as a result of a joint venture between Sierra Semiconductor (17 percent), National Semiconductor (9 percent), and Singapore Technology Corporation (74 percent). The new company will fabricate and test CMOS wafers and ASIC devices primarily for Sierra and National. Chartered is located in a 17,000-square-foot facility in the Singapore Science Park. Initial capacity will be 5,000 6-inch wafers per month.
10. National Semiconductor and Sierra—National and Sierra jointly developed a family of core architecture 8-bit CMOS MCU products. Additional products will include EE, UART, and A/D functional blocks. The 8-bit MCU core will be available in standard cell form from both companies. The companies serve as second sources to each other and independently fabricate the devices.
11. SEEQ and National Semiconductor—SEEQ and National signed a four-year exclusive technology and manufacturing agreement to develop and market a new family of CMOS Flash EEPROMs. The companies will share technology and marketing rights to SEEQ's 512K and 1Mb and to National's 256K Flash EEPROMs. Both companies will manufacture the products.
12. National Semiconductor and Toshiba—National settled its copyright dispute with Toshiba. At issue was whether or not Toshiba copied National's UART chips. Under the agreement, National will not press its copyright claim. Toshiba will buy UARTs from National for internal use and will sell them in Japan to help National increase its market share in Japan. Toshiba also will supply National with some of its chip-packaging technology.
13. Motorola, Inc. and National Semiconductor—In November 1987, Motorola became the first domestic alternate source for the Fairchild Advanced CMOS Technology (FACT) family. Motorola will alternate-source a total of 108 FACT devices.
14. National Semiconductor and Motorola, Inc.—Motorola will second-source the National/Fairchild FACT line of standard logic. Motorola will receive all 108 members of the Fairchild Advanced CMOS Technology line and give National 42 yet-to-be-determined members of its logic lines. The agreement aligns Motorola with National/Fairchild, GE Solid State, and others in favor of the standard end-pin architecture, and against TI and Signetics, which have been fostering a center pin to lessen noise generated voltage swings.
15. National Semiconductor and Mitsubishi Electric Corp.—Mitsubishi will repackage National's NS32000 family of 32-bit MPUs and sell the MPUs and support tools on an OEM basis in Japan. National hopes the Mitsubishi connection will open a variety of embedded control design wins in Japan for the 3200 family. The deal also opens up the possibility for future joint R&D related to the TRON project.

(Continued)

Table 7 (Continued)

National Semiconductor Corporation
Summary of Alliances

16. Seattle Silicon and Silicon Compilers, National Semiconductor—National signed contracts with Seattle Silicon and Silicon Compilers aimed at developing advanced technology products for the military. National has already shipped products as a result of the Silicon Compiler agreement. Products include National's first 1.2-micron VHSIC IC using Silicon Compilers' silicon compilation process.
17. Micrel Inc. and National Semiconductor—Micrel will manufacture CMOS metal gate versions of three discontinued National Semiconductor rad-hard logic families. Micrel will receive National's original tooling for the rad-hard logic CD4000 Series and MM54CXX Series, and MM54C9XX special function/LSI device families. National will receive royalties. National will continue to make commercial and MIL-STD-883C Class B versions but Micrel will take over all MIL-STD-883C Class S versions.
18. National Semiconductor and Data I/O, FutureNet—National and Data I/O have signed an exclusive agreement in which National's PLD, gate array, and cell libraries will be supported on FutureNet's PC workstation. National will market them.
19. National Semiconductor and Canon—Canon has worked with National on a version of the 32532 optimized for laser printer control.
20. National Semiconductor and FutureNet—National announced that its symbol library for the Company's family of ASICs is available on FutureNet's IBM PC-based workstation.
21. Genesis and National Semiconductor—National Semiconductor signed Genesis as a Canadian design center for its CMOS ASIC products. National will prototype and produce all CMOS ASIC devices designed by Genesis. The agreement covers National's 2.0- and 1.5-micron technologies. National will do foundry work also for Genesis customers who design custom cells not included in the National libraries.
22. National Semiconductor and Krysalis—Krysalis signed a seven-year technology exchange agreement with National Semiconductor for the joint pursuit of UniRAM technology. National will provide product engineering, manufacturing, and marketing support. Initially, National will supply base wafers based on a 2-micron process. Krysalis will complete fabrication of the wafers through packaging, test, and burn-in.
23. SGS and National Semiconductor—SGS and National agree to exchange linear products and cooperate on future products. SGS gave National mask generation tapes and rights to produce two dual power op amps for DC motors and a quad op amp. National gave SGS tapes and rights to produce a dual-output voltage regulator for MPU systems and two low-noise stereo preamps for car cassette applications.
24. Chips & Technologies and National Semiconductor—National will manufacture CMOS ICs for Chips under a five-year fabrication services agreement. National is Chips' first U.S. source. Production will take place at National's 6-inch wafer fab facility in Arlington, Texas.
25. IBM and National Semiconductor—Standard cell/technology exchange whereby NSC received IMP's design-automation system and IMP received NSC's latest CMOS technology.
26. National Semiconductor and Oki—Exchange of Oki's 64K DRAM technology for NSC's manufacturing capacity.
27. National Semiconductor and Texas Instruments—TI and NSC signed a long-term agreement covering advanced 32-bit MPUs and peripherals. TI also acquires the right to manufacture NSC's high-end microprocessor line, the Series 3200.

(Continued)

Table 7 (Continued)

National Semiconductor Corporation
Summary of Alliances

28. National Semiconductor and Sierra—Sierra and National signed a technology exchange agreement covering selected advanced CMOS products and processes. Sierra leased a facility from National to develop its process and manufacture products, using its own equipment and employees.
29. National Semiconductor and Synertek—NSC became licensed second source for Synertek's 2-Kbit EEPROM.
30. National Semiconductor and Xerox—NSC will exchange ASIC design, tooling, and software for Xerox products.
31. National Semiconductor and NMB Semiconductor—National contracted NMB to manufacture fast SRAMs at the Tateyama fab. This agreement is no longer in effect.
32. ICI Array Technology and National Semiconductor—National and ICI Array signed an agreement under which ICI Array will use National's design systems and process specifications to develop proprietary ASICs.
33. National Semiconductor and International Microelectronic Products—IMP and National Semiconductor signed a five-year technology exchange and second-source agreement transferring IMP's cell-based designs in exchange for National's multiple-layer metal silicon-gate CMOS process, as well as future CMOS processes.
34. National Semiconductor and International Microelectronic Products—IMP to second source National's 2-micron gate arrays.
35. National Semiconductor and Lattice Semiconductor—National Semiconductor made a minority capital investment in LSC and licensed its GAL technology. The five-year agreement includes codevelopment of denser architectures of both standard and in-system programmable GALs, as well as a new line of FPLAs and sequencer devices.
36. National Semiconductor and Linear Technology Corporation—National and LTC entered into a patent license agreement granting LTC rights to products under two National BIFET patents. National was granted rights to LTC's BIFET-related patents, including those filed through 1992. LTC pays royalties.
37. Sensym and National Semiconductor—Sensym second-sourced the National Semiconductor transducer product line.
38. National Semiconductor and Three-Five—National participated in Three-Five's second round of financing.
39. National Semiconductor and Weitek Corp.—Weitek licensed National Semiconductor to design, manufacture, and market an interface chip.
40. Vantage Analysis Systems, Inc. and National Semiconductor—National and Vantage agreed to codevelop a VHDL translator for ASIC simulation models. Vantage will provide its VHDL technology and compiler interface, and National's ASIC Division will develop translators for various in-house simulators.
41. Gateway Design Automation Corp. and National Semiconductor—National and Gateway Design Automation Corp. signed a corporate agreement that promotes standardization on Gateway's Verilog R hardware description language. National will initially use Verilog-XL R in its simulation tools for standard product development. National will also package and resell Gateway's verification and test software as part of its ASIC design automation system.

(Continued)

Table 7 (Continued)

National Semiconductor Corporation
Summary of Alliances

42. Cadence Design Systems and National Semiconductor—National and Cadence Design Systems signed three agreements. The first agreement is a technology partnership involving collaboration on an IC design system. Second, Cadence will supply software to National's engineering organization for use in its workstations. The third agreement enables National to develop and market a fourth-generation ASIC design automation system (named DA4) using IC design products from Cadence.
43. National Semiconductor and Aspen, Cypress Semiconductor Corporation—National filed a complaint for injunctive relief and monetary damages against Cypress Semiconductor Corp. and Aspen Semiconductor Corp. Also named was Narpat Bhandari, the former president of Aspen. The complaint alleges that defendants conspired to misappropriate trade secrets, specifically relating National's ASPECT process and other related VLSI technologies.
44. SGS and National Semiconductor—SGS-Thomson and National Semiconductor are codeveloping ISDN devices.

N/A = Not Available

Source: Dataquest
December 1989

NONSEMICONDUCTOR PRODUCT SUMMARY

The Information Systems Group (ISG) is engaged in the development, manufacture, sales, and servicing of a variety of digital electronic systems.

National Advanced Systems (NAS), currently a wholly owned subsidiary of National Semiconductor, supplies a broad range of mainframe systems and peripherals. Pending completion of its sale, NAS will become a jointly owned and independently operated entity of Hitachi and EDS. NAS' products currently include intermediate- and large-scale mainframes and software and utilities. Storage products include single- and double-capacity disk drives, the 7480 Cartridge Tape systems, and the 7900 semiconductor disk.

Datachecker, currently a wholly owned subsidiary, manufactures and sells point-of-sale (POS) systems and applications software. Pending completion of the sale, ICL will become the owner of Datachecker.

BUSINESS STRATEGIES

In an attempt to broaden its product lines with the hope that the Company could better weather the periodic downturns in the semiconductor market, National created its ISG. The Company indicated that it would strive to maintain a balance between its Semiconductor Group and ISG. Although the revenue from ISG matched that of the Semiconductor Group in 1987, the ISG has not contributed in the way it was expected. Datachecker, for example, has found its point-of-sale market moving from proprietary to standard systems. Coupled with production delays, this situation has reduced the competitiveness of this subsidiary. The declining value of the dollar against the yen has resulted in less-than-expected decreases in the cost of NAS' computers and peripheral equipment purchased from Hitachi. This, along with decreases in selling prices for such equipment, has had an adverse effect on NAS' operating margins. The announced divestiture of the bulk of the ISG marks the beginning of National's renewed focus on its mainstay business—the development, manufacture, and sales of semiconductor products. Customer-oriented product development and leading-edge technology will be the direction of the future for National.

National is taking a long-term position in ASICs by emphasizing development and steady growth in MOS cell-based ICs (CBICs) and gate arrays. This will enable the Company to capitalize on the forecast growth in these areas. Strategically, National is moving toward a high-complexity, low-volume, high-margin position in the market.

National has had difficulty targeting the PC market, where software is a dominant factor. The Company believes that the future microcomputer market will show the most growth in embedded control because such products will provide the an advantage of customizing capability. Each design can also carry a broad range of National's products with it.

NEC Corporation

NEC Corporation
33-1, Shiba 5-chome
Minato-ku, Tokyo 108, Japan
(Billions of Yen except Per Share Data)

Balance Sheet (March 31)

	1983	1984	1985	1986	1987
Working Capital	¥ 48.9	¥ 160.4	¥ 202.6	¥ 132.4	¥ 275.8
Long-Term Debt	¥ 282.0	¥ 359.3	¥ 428.7	¥ 420.1	¥ 524.5
Shareholders' Equity	¥ 286.6	¥ 409.1	¥ 477.4	¥ 498.1	¥ 514.3
After-Tax Return on Average Equity (%)	11.5	10.9	14.1	5.6	3.0

Operating Performance (Fiscal Year Ending March 31)

	1982	1983	1984	1985	1986
Sales	¥1,443.1	¥1,761.9	¥2,258.4	¥2,334.7	¥2,449.7
Japanese Sales	¥ 945.7	¥1,145.2	¥1,477.9	¥1,559.6	¥1,754.5
Non-Japanese Sales	¥ 498.4	¥ 616.7	¥ 780.5	¥ 775.1	¥ 695.2
Cost of Sales*	¥ 808.6	¥1,206.1	¥1,515.6	¥1,578.6	¥1,701.6
R&D Expense**	¥ 72.9	¥ 92.1	¥ 131.7	¥ 165.0	¥ 191.6
SG&A Expense	¥ 282.0	¥ 340.0	¥ 433.1	¥ 444.3	¥ 464.3
Pretax Income	¥ 63.8	¥ 86.5	¥ 139.5	¥ 117.8	¥ 58.1
Pretax Margin (%)	4.4	4.9	6.2	5.0	2.4
Effective Tax Rate (%)	58.3	55.6	56.1	83.1	78.3
Net Income	¥ 33.0	¥ 44.6	¥ 67.1	¥ 27.2	¥ 15.0
Average Shares Outstanding (Millions)	1,150	1,177	1,309	1,380	1,397
Per Share					
Earnings	¥ 28.70	¥ 37.41	¥ 51.26	¥ 19.70	¥ 10.71
Dividends	¥ 6.52	¥ 7.75	¥ 8.53	¥ 9.02	¥ 9.00
Book Value	¥ 249	¥ 346	¥ 365	¥ 361	¥ 368
Price Range#	¥ 550-850	¥ 800-1,425	¥ 925-1,350	¥ 900-1,400	¥ 1,200-2,490
Total Employees	73,080	78,389	90,102	95,796	101,227
Capital Expenditures	¥ 203.7	¥ 208.2	¥ 369.5	¥ 293.3	¥ 193.6
Exchange Rate (Yen per US$)	249.1	235.7	245.3	220.8	159.5

*Cost of Sales has been restated from 1984 and 1985.
**In 1982, an unknown amount of additional R&D expense is included in Cost of Sales.
#Estimated from graph in the NEC Annual Report and restated for 1983, 1984, and 1985.

Source: NEC Corporation Annual Reports
Dataquest
June 1988

NEC Corporation

NEC Corporation
33-1, Shiba 5-chome
Minato-ku, Tokyo 108, Japan
(Millions of Dollars except Per Share Data)

Balance Sheet (March 31)

	1983	1984	1985	1986	1987
Working Capital	$ 196	$ 681	$ 826	$ 600	$ 1,729
Long-Term Debt	$1,132	$1,524	$1,748	$ 1,903	$ 3,288
Shareholders' Equity	$1,151	$1,736	$1,946	$ 2,256	$ 3,224
After-Tax Return on Average Equity (%)	11.5	10.9	14.1	5.6	3.0

Operating Performance (Fiscal Year Ending March 31)

	1983	1984	1985	1986	1987
Sales	$5,793	$7,475	$9,207	$10,574	$15,359
Japanese Sales	$3,796	$4,859	$6,025	$ 7,063	$11,000
Non-Japanese Sales	$1,997	$2,616	$3,182	$ 3,511	$ 4,359
Cost of Sales	$3,246	$5,117	$6,179	$ 7,149	$10,668
R&D Expense*	$ 290	$ 390	$ 538	$ 747	$ 1,201
SG&A Expense	$1,132	$1,443	$1,766	$ 2,012	$ 2,911
Pretax Income	$ 256	$ 367	$ 569	$ 534	$ 364
Pretax Margin (%)	4.4	4.9	6.2	5.0	2.4
Effective Tax Rate (%)	58.3	55.6	56.1	83.1	78.3
Net Income	$ 132	$ 189	$ 274	$ 123	$ 94
Average Shares Outstanding (Millions)	1,150	1,177	1,309	1,380	1,397
Per Share					
Earnings	$ 0.12	$ 0.16	$ 0.19	$ 0.19	$ 0.07
Dividends	$ 0.03	$ 0.03	$ 0.03	$ 0.04	$ 0.06
Book Value	$ 1.00	$ 1.47	$ 1.49	$ 1.63	$ 2.31
Price Range**	$ 2.21-3.41	$ 3.39-6.05	$ 3.77-5.50	$ 4.08-6.34	$ 7.52-15.61
Total Employees	73,080	78,389	90,102	95,796	101,227
Capital Expenditures	$ 818	$ 883	$1,506	$ 1,328	1,214
Exchange Rate (Yen per US$)	249	236	245	221	160

*Cost of Sales has been restated for 1984 and 1985.
**In 1982, an unknown amount of additional R&D expense is included in Cost of Sales.
#Estimated from graph in the NEC Annual Report and restated for 1983, 1984, and 1985.

Source: NEC Corporation Annual Reports
Dataquest
June 1988

NEC Corporation

OVERVIEW

NEC Corporation (known as Nippon Electric Company, Ltd., prior to April 1, 1983) was founded in 1899 as a manufacturer of telephone sets and switchboards. Initial capitalization came from what later became Western Electric Company (then called International Standard Electric Corporation of the United States).

NEC views itself as a "C&C" company. C&C is the integration of computer and communications using such core technologies as digital communications, fiber optics, computers, semiconductors, speech recognition and synthesis, and software engineering. NEC's lines of business—communications, computers, electron devices, and home electronics—are synergistically organized under this concept, which was first advocated in 1977.

NEC is a member company of the Sumitomo Group, which comprises 21 nucleus companies, of which NEC is the only electric and electronics concern.

NEC and its 48 consolidated subsidiaries employ 101,227 people worldwide under the leadership of its chairman, Koji Kobayashi, and president, Tadahiro Sekimoto.

Highlights

Company highlights include the following:

- NEC reported revenue of ¥2,449.7 billion in fiscal 1987, an increase of 4.9 percent.
- NEC is the largest worldwide semiconductor supplier, with sales of $3,193 million.
- NEC achieved sales increases in all of its semiconductor product areas.
- More than 63 percent of NEC's 1986 semiconductor sales—approximately $2,009 million—were MOS devices.
- In 1986 and 1987, NEC was the largest 256K DRAM supplier.

The major shareholders of NEC Corporation are listed in Table 1.

Foreign ownership of NEC is 9.8 percent. NEC is listed on the Amsterdam, Frankfurt, London, Basel, Zurich, and Geneva stock exchanges, as well as on the three major Japanese exchanges.

NEC Corporation

Table 1

NEC Corporation
Major Shareholders

Shareholders	Percent of Shares
Sumitomo Life Insurance	7.3%
Sumitomo Bank	4.9%
Sumitomo Trust	4.3%
Nippon Life Insurance	3.2%
Dai-Ichi Mutual Life Insurance	3.1%
Sumitomo Marine and Fire Insurance	2.8%

Source: NEC Corporation
Annual Report
July 1988

OPERATIONS

NEC reported consolidated revenue of ¥2,449.7 billion for the fiscal period ending March 31, 1987, an increase of 4.9 percent from 1986. Net earnings were ¥15.0 billion.

NEC is organized into 11 operating groups that cover the Company's four basic lines of business. The operating groups are as follows:

- Research and Development Group
- C&C Software Development Group
- Production Engineering Development Group
- Switching Group
- Transmission and Terminals Group
- Radio Group
- Information Processing Group
- Semiconductor Group
- Electronic Component Group

- Home Electronics Group
- Special Projects Group

The Research and Development Group conducts basic and applied research in electronic materials and devices, systems, software, and other areas. The Production Engineering Development Group is in charge of developing and upgrading NEC manufacturing technologies. The other operating groups are responsible for product development, design, and manufacturing.

NEC's main lines of business are communications, computers and industrial electronic systems, electron devices, and home electronics. Revenue for each line of business is shown in Table 2.

Table 2

NEC Corporation
Revenue by Product Area
(Billions of Yen)

	Fiscal Year Ending March 31					CAGR
	1983	1984	1985	1986	1987	1983-1987
Communications	¥ 524.5	¥ 572.9	¥ 659.9	¥ 747.0	¥ 699.9	7.5%
Computers and Industrial Electronic Systems	355.8	538.0	721.5	855.2	1,012.1	29.9%
Electron Devices	358.5	425.1	596.0	441.3	417.0	3.9%
Home Electronics	148.7	169.8	188.5	179.0	188.3	6.1%
Other	55.6	56.1	92.5	112.2	132.4	24.2%
Total Revenue	¥1,443.1	¥1,761.9	¥2,258.4	¥2,334.7	¥2,449.7	14.1%
Exchange Rate (Yen per US$)	¥249.1	¥235.7	¥245.3	¥220.8	¥159.5	

Source: NEC Corporation Annual Reports
Dataquest
June 1988

NEC Corporation

MARKETING

In order to increase its market penetration, NEC markets its products aggressively. Dataquest believes that 70 to 80 percent of the Company's products are sold domestically (in Japan) through distributors. NEC has 10 distributors in Japan, the top 4 of which are Ryosan, Sanshin, Satori, and Shinko. Approximately 22 percent of NEC's semiconductor production is consumed internally.

Other major Japanese companies, such as Fujitsu and Hitachi, have set up partnerships with U.S. and European computer manufacturers through OEM agreements. NEC recently joined this trend through joint ventures with Honeywell-Bull and Honeywell-NEC Supercomputers.

Internationally, NEC markets its products through its own network of regional sales offices, as well as through distributors.

NEC is one of the largest suppliers to Nippon Telegraph & Telephone Corporation (NTT) and the Japanese government. It has four marketing groups, as follows, each corresponding to a particular customer and market sector:

- NTT Sales—responsible for business with Nippon Telephone and Telegraph Corporation
- Government Sales—responsible for marketing to Japanese governmental agencies
- Domestic Sales Group—responsible for Japanese private sector sales
- International Operations Group—which handles overseas marketing and manufacturing

INTERNATIONAL ACTIVITIES

Overseas sales, at ¥695.2 billion, accounted for 28 percent of total sales in fiscal 1987, a 10.3 percent decrease from the previous year. In 1983, overseas sales accounted for 35 percent of total revenue. Overseas sales grew at a CAGR of 8.7 percent from 1983 to 1987, whereas domestic sales grew at a CAGR of 16.7 percent during the same period.

The Company attributes the fiscal 1987 drop in overseas sales to the following:

- Financial difficulties in oil-producing countries stemming from lower oil prices
- The continued appreciation of the yen
- The rising protectionism in the United States

NEC Corporation

Asia and Oceania

NEC has 9 plants, 14 marketing and service affiliates, and many liaison offices in Asia and Oceania.

North America

North America is NEC's largest overseas market. NEC has eight U.S. affiliates, including five consolidated subsidiaries, as follows:

- NEC America, Inc., headquartered in Melville, New York
- NEC Electronics Inc., headquartered in Mountain View, California
- NEC Home Electronics (U.S.A.) Inc., in Wood Dale, Illinois
- NEC Industries, Inc., in New York City
- NEC Information Systems, Inc., in Boxborough, Massachusetts

The Company also operates sales and liaison offices throughout the United States.

Latin America

NEC has six affiliates in Latin America. The Company's presence in Latin America is felt mainly through its communications systems, including digital switching systems, satellite communications earth stations, and mobile telephone systems.

Europe

NEC has 13 affiliates throughout Europe. DRAMs, microcomponents, and custom circuits have been produced at the Livingston, Scotland, plant since October 1982.

Middle and Near East and Africa

NEC has two affiliates in this region.

FACILITIES

Japan

NEC has 16 Japanese semiconductor plants, which are listed in Table 3. Table 4 lists the Company's overseas semiconductor plants. NEC established a new fab line for compound semiconductors at NEC Kansai Ltd. in 1987.

Table 3

NEC Corporation
Japanese Semiconductor Manufacturing Facilities

Location	Floor Space (m^2)	Function/Products
NEC Akita, Ltd.	4,800	Assembly, Test--Linear, Discretes
NEC Chugoku, Ltd.	33,000	Fab, Assembly, Test--MOS Memory, Micro
NEC Fukui, Ltd.	23,461	Assembly, Test--Linear, Discretes, MOS
NEC Fukuoka, Ltd.	6,275	Assembly, Test--MOS
NEC Kagoshima, Ltd.	24,000	Assembly, Test--Discretes, Optoelectronics
NEC Kansai, Ltd., Yokkaichi Plant	7,000	Fab, Assembly, Test--Diodes
NEC Kansai, Ltd., Denki Ohtsu Plant	88,000	Fab, Assembly, Test--MOS, Discretes, Linear
NEC Kumamoto, Ltd.	13,200	Assembly, Test--MOS Memory
NEC Kyushu, Ltd.	64,000	Fab, Assembly, Test--MOS
NEC Oita, Ltd.	8,097	Assembly, Test--MOS Memory
Sagamihara Works	133,861	Fab, Assembly, Test, R&D--MOS
Tamagawa Works	292,382	Fab, Assembly, Test, R&D--MOS Memory
NEC Yamagata, Ltd., Takahata Works	6,582	Assembly, Test--MOS, Linear, Discretes
NEC Yamagata, Ltd., Tsuruoka Works	N/A	Fab--Linear, Discretes, MOS
Yamagata Electronics Ltd.	4,200	Assembly, Test--MOS, Bipolar, Discretes
NEC Yamaguchi, Ltd.	160,000	Fab, Assembly, Test--MOS Memory
Kitanippon Electronics Co., HQ Plant	5,000	Assembly, Test--MOS, Bipolar
Kitanippon Electronics Co., Fuchu Factory	5,000	Assembly, Test--Discretes
Ohtsuki Works	20,000	Fab, Assembly, Test--Optoelectronics
NEC Kansai Ltd.	N/A	Compound Semiconductors
Tsukuba R&D Center	20,000	Basic Research
Hara Seiki Industry Co., Ltd.	8,000	Assembly, Test--MOS Memory
Kyushu Denshi Co., Ltd.	5,123	Assembly, Test--MOS Memory Fab, Assembly, Test--LEDs
Kyushu Nissei Denshi Co., Ltd.	3,600	Assembly, Test--MOS Memory, MPU
Naito Denshi Kogyo Co., Mano Factory	5,000	Assembly, Test--Discretes
Naito Denshi Kogyo Co., Hana Factory	6,982	Assembly, Test--Discretes

N/A = Not Available

Source: Dataquest
June 1988

Table 4

NEC Corporation
Overseas Semiconductor Manufacturing Facilities

Location	Floor Space (m^2)	Products/Function
Ang Mo Kio, Singapore	N/A	Assembly--Memory, Linear
County Meath, Ireland	2,000	Assembly, Test--ICs
Livingston, Scotland	12,120	Fab, Assembly--ICs
Mountain View, CA, U.S.A.	N/A	Assembly--ICs
Roseville, CA, U.S.A.	36,585	Fab, Assembly, Test--ICs
Sao Paulo, Brazil	N/A	N/A
Selangor, Malaysia	4,300	N/A
Hong Kong	N/A	N/A

N/A = Not Available

Source: Dataquest
June 1988

In November 1986, NEC announced plans to increase VLSI production in Europe by linking its factories in Ireland and Scotland. The Scotland factory will begin fabrication of 1Mb DRAMs in October 1988. Assembly and test will be performed at both facilities.

The Company has cut back on SRAM production at Yamaguchi Nippon Denki, its major memory production base, and has begun microprocessor production at that plant in order to cope with demand.

To cope with the appreciation of the yen, NEC is shifting much of its assembly operation offshore, to Singapore and Malaysia. It plans to establish a new factory in Singapore to strengthen IC production in Southeast Asia. The new factory will have 5,000 square meters of floor space and will be built at the site of NEC Electronics Singapore with an investment of ¥1.5 billion. The plant will produce memory and linear ICs. Construction will be completed in June 1988.

CAPITAL AND R&D SPENDING

NEC's capital and R&D spending is shown in Table 5. Table 6 shows Dataquest's calendarized estimates of NEC's semiconductor capital spending.

In fiscal 1987, NEC's research and development (R&D) expenditure was ¥191.6 billion, an increase of 16 percent over the previous year. R&D expense has grown from 5 percent of sales in 1983 to 8 percent of sales in 1987.

More than 9,400 of NEC's employees are engaged in research, development, and engineering. The Company's R&D policy is to invest in projects that can be successfully commercialized and will contribute to the development of C&C systems. In fiscal 1987, NEC focused on developing and strengthening its technology in new materials. Flexible manufacturing systems and production control development continued.

Table 5

NEC Corporation
Capital and R&D Spending as a Percent of Revenue
(Billions of Yen)

	1983	1984	1985	1986	1987
Revenue	¥1,443.1	¥1,761.9	¥2,258.4	¥2,334.7	¥2,449.7
Capital Spending	¥ 203.7	¥ 208.2	¥ 369.5	¥ 293.3	¥ 193.6
Percent of Revenue	14.1%	11.8%	16.4%	12.6%	7.9%
R&D Spending	¥ 72.9	¥ 92.1	¥ 131.7	¥ 165.0	¥ 191.6
Percent of Revenue	5.1%	5.2%	5.8%	7.1%	¥ 7.8%
Combined Capital and R&D Spending	276.7	300.3	501.2	458.3	¥ 385.2
Percent of Revenue	19.2%	17.0%	22.2%	19.6%	15.7%
Percent Increase	31.4%	8.5%	66.9%	(8.6%)	(15.9%)
Exchange Rate (Yen per US$)	¥ 249.1	¥ 235.7	¥ 245.7	¥ 220.8	159.5

Source: NEC Corporation
Annual Reports
Dataquest
June 1988

NEC Corporation

Table 6

NEC Corporation
Semiconductor Capital Spending by Calendar Year
(Millions of Dollars)

	1983	1984	1985	1986	1987
Semiconductor Revenue	$1,413	$2,251	$1,984	$2,638	$3,193
Semiconductor Capital Spending	$ 247	$ 544	$ 517	$ 180	$ 195
Percent of Semiconductor Revenue	17%	24%	26%	7%	6%

Source: Dataquest
June 1988

In September 1987, the Company separated the software development labs from the R&D Group to form the C&C Software Development Group.

There are seven separate R&D laboratories, as follows:

- Fundamental Research Laboratories—Basic research in electronic materials and devices
- Microelectronics Research Laboratories—R&D in high-speed semiconductors, charge-coupled devices, man-machine interface devices, new memories, and electronic sensors
- Opto-Electronics Research Laboratories—R&D of optoelectronic devices, optical information processing, fiber-optic communications, and laser applications
- C&C Systems Research Laboratories—Basic technology R&D for public, business, and home C&C systems
- C&C Information Technology Research Laboratories
- Resources and Environment Protection Research Laboratories—Research on environmental protection, energy safeguarding, and recycling of resources
- Material Development Center
- Scientific Computer Center

Production engineering labs include the following:

- Plastic Engineering Laboratory
- Production Facilities Development Division
- Production Engineering Laboratory

All of the laboratories are located in or near Kawasaki City, Kanagawa (just south of Tokyo). NEC also maintains a Scientific Computer Center, which provides in-house users with comprehensive scientific computing services.

Major recent developments include the following:

- Josephson junction—NEC successfully formed a Josephson junction using a barium-yttrium-copper-oxide, single-phase superconductor at 90 degrees Kelvin.
- 720-GHz, frequency-tunable, single-wavelength semiconductor laser—Characterized by low transmission loss in the 1.55-micron wavelength, this semiconductor laser will be used as the light source for frequency division multiplexing optical heterodyne transmission systems, optical switching systems, and other applications.
- Expert systems for diagnosis of telephone switching systems—Based on AI technology, this system will help maintenance personnel locate and repair faulty parts in telephone switching systems.
- RX-616 real-time OS with UNIX interface—By combining its previously developed original RX-616 real-time operating system (OS) with the non-real-time OS UNIX of AT&T, NEC developed this new OS for use with its V60 and V70 32-bit MPUs.

PRODUCTS AND MARKETS

Semiconductor Product Markets

In 1987, NEC maintained its position as the world leader in semiconductor sales, with sales of $3,193 million.

NEC is a leader in the DRAM market. In 1986 and 1987, NEC was the world's largest 256K DRAM supplier, with 129.4 and 132.1 million units shipped, respectively. NEC is not a leader in the 1Mb DRAM market, however; 1986 shipments of 1Mb DRAMs were approximately 5,000 units, and 1987 shipments were about 1.5 million units.

NEC Corporation

An estimated 63 percent of NEC's 1987 semiconductor sales were MOS devices. The largest product family in 1987 was MOS memory, with sales of $707 million. MOS logic sales sales grew 24.9 percent and microcomponent devices grew 28.4 percent, as shown in Table 7.

Table 7

NEC Corporation
Worldwide Semiconductor Revenue
(Millions of Dollars)

	1983	1984	1985	1986	1987
Total Semiconductor	$1,413	$2,251	$1,984	$2,638	$3,193
Total Integrated Circuit	$1,093	$1,838	$1,603	$2,154	$2,630
Bipolar Digital (Technology)	$ 115	$ 134	$ 129	$ 176	$ 197
TTL		104	95	125	139
ECL		22	26	41	51
Other Bipolar Digital		8	8	10	7
Bipolar Digital (Function)	$ 115	$ 134	$ 129	$ 176	$ 197
Bipolar Digital Memory	22	23	26	32	35
Bipolar Digital Logic	93	111	103	144	162
MOS (Technology)	$ 786	$1,414	$1,174	$1,615	$2,009
NMOS	636	1,125	908	1,195	1,411
PMOS	25	32	22	12	10
CMOS	125	257	244	408	588
MOS (Function)	$ 786	$1,414	$1,174	$1,615	$2,009
MOS Memory	343	713	470	586	707
MOS Microdevices	237	411	375	490	629
MOS Logic	206	290	329	539	673
Linear	$ 192	$ 290	$ 300	$ 363	$ 424
Total Discrete	$ 293	$ 379	$ 351	$ 439	$ 512
Transistor	162	205	179	225	260
Diode	88	114	105	136	161
Thyristor	21	28	29	34	39
Other Discrete	22	32	38	44	52
Total Optoelectronic	$ 27	$ 34	$ 30	$ 45	$ 51
Exchange Rate (Yen/US$)	235	237	238	167	144

Source: Dataquest
June 1988

Table 8 shows NEC's rank in semiconductor areas.

Table 8

NEC Corporation
Worldwide Ranking by Semiconductor Markets
(Sales in Millions of Dollars)

	1986 Rank	1987 Rank	1987 Revenue	Revenue % Change 1986-1987	Industry % Change 1986-1987
Total Semiconductor	1	1	$3,193	21.0%	23.0%
Total IC	1	1	$2,630	22.1%	25.5%
Bipolar Digital	8	8	197	11.9%	8.4%
MOS Digital	1	1	2,009	24.4%	34.3%
Linear	4	4	424	16.8%	19.4%
Total Discrete	4	4	$ 512	16.6%	17.0%
Total Optoelectronics	12	12	$ 51	13.3%	7.4%

Source: Dataquest
June 1988

Dataquest believes that in 1987 approximately 10 percent of NEC's semiconductor sales were to the United States, 8 percent to Europe, 9 percent were to the Rest of World, and the remaining 73 percent were domestic sales. Table 9 shows the estimated geographic distribution of NEC's semiconductor sales.

Table 9

NEC Corporation
Estimated Geographic Distribution
of Semiconductor Sales in 1987
(Millions of Dollars)

	United States	Japan	Europe	Rest of World	Total
Total Semiconductor	$335	$2,315	$257	$286	$3,193
Total IC	$326	$1,894	$252	$158	$2,630
Bipolar Digital	7	174	4	12	197
MOS Digital	317	1,369	225	98	2,009
Linear	2	351	23	48	424
Discrete	$ 6	$ 379	$ 4	$123	$ 512
Optoelectronics	$ 3	$ 42	$ 1	$ 5	$ 51

Source: Dataquest
June 1988

Semiconductor Products and Technologies

Prior to 1985, the largest portion of NEC's integrated circuits (31.7 percent) were MOS memory devices; the Company entered the ASIC market in 1982 with gate arrays. In 1978, NEC purchased Electronic Arrays (now NEC Electronics, Inc.), a U.S. ROM supplier, in order to penetrate the U.S. ROM market.

In mid-1982, the Company expanded its activity in the United States to include gate arrays. With the 1984 completion of the new plant in Roseville, California, all U.S. gate array assembly activities were transferred to that facility. The Roseville facility also manufactures 256K SRAMs in addition to most of the Company's 256K DRAMs. Future plans for Roseville fabrication and/or assembly and test include production of 1Mb ROMs, 1Mb DRAMs, V-Series MPUs, microperipherals, and DSP.

NEC Corporation

During 1987, NEC introduced several new products, including the following:

- A digital audio CMOS 6-bit D/A converter, the uPD6355G
  - The device contains all the necessary functions for digital output D/A conversion in one chip. The chip features 0.016 percent resolution and a 0.007 percent (standard) distortion factor.
- A 16-bit single-chip MCU, the V35, which is available with ROM, EPROM, or without nonvolatile memory
- A floppy disk controller, the uPD72067, which has a built-in circuit for data separation
  - The CMOS device operates from a single 1.5V power supply and features power consumption of 50mW in operation and 0.01mW in standby mode.
- A family of eight GaAs digital ICs designed for DSP applications above 1 GHz and packaged in hermetic ceramic DIP
- A 1.5-micron BICMOS gate array, the uPD6700, which features 10,348 gates, 0.8ns delay time, and is latch-up free
- Two models of TV signal-processing LSI, the uPC1800CA and the uPC1810CA
  - The devices include all the necessary functions for color TV signal processing on a single chip.
- Seven models of small, two-pin, minimold diodes that measure 2.5mm x 1.25mm x 0.9mm
- A series of 8- and 16-bit single-chip MCUs
- Five models of GaAs logic ICs that operate at 2 GHz and are compatible with ECL logic
- An original 32-bit MPU, the V70, which is manufactured using a 1.5-micron double-layer aluminum CMOS process and integrates 385,000 transistors on a single chip
- Two models of operational amplifiers, the uPC815C/D and uPC816C/D, which feature offset voltage of 10uV and ultralow noise of 2.7V/route Hz
- A general-purpose, 8-Kbyte, single-chip cache memory, the uPD43608R, which is manufactured using a 1.3-micron CMOS process and double-layer aluminum wiring technology

NEC Corporation

Technology Developments

In 1987, NEC also announced several technology developments, including the following:

- A ring counter based on 0.8-micron gate-enhancement mode doped channel heterostructure MISFET (E-DMT) devices
  - Room temperature speed/power was observed as 24ps/1.4mW per counter stage. Measuring loading effects were 12.6ps per fanout and 1ps per fF of capacitive load.
- A CML SSI logic using AlGaAs/GaAs heterostructure bipolar transistors (HBTs) formed by molecular beam epitaxy
  - The structures consist of 0.15-micron emitters, 0.1-micron bases, and 0.5-micron collectors, all formed by a self-aligned fabrication process.
- A vertical-to-surface transmission electrophotonic (VSTEP) device that has enabled NEC to achieve low power consumption in its photodynamic memory operation

At the 1987 ISSCC, NEC introduced several new developments, including the following:

- An oversampling A/D converter macrocell with rail-to-rail input voltage capability
- A CMOS analog and digital masterslice LSI
- A real-time microprogrammable video signal LSI
- An 8-Kbyte intelligent cache memory
- A character string search processor

NEC began sample shipments of its original V Series microprocessors in the fall of 1984. Volume shipments of the V20 and V30 (8- and 16-bit) began in the first quarter of 1985. During 1987, NEC shipped approximately 1.2 million units of the V20 and 995,000 units of the V30. In 1987, the Company introduced the V70 32-bit MPU and shipped about 5,000 units. Although the V20 and V30 are supersets of the 8086 and 8088, NEC is still shipping the latter parts. In 1987, its 8088 shipments were approximately 583,000 units.

NEC Corporation

Intel and NEC have been in a legal dispute over microcode copyright infringement for more than three years. Intel claims that the V20/30 microcode infringes on Intel's copyright. In 1986, Judge Ingram of the U.S. federal court ruled on two parts of the suit, as follows:

- He ruled that microcode is copyrightable.
- He ruled that Intel has not waived its right to copyright protection of the 8086/88 microcode.

However, in 1987, Judge Ingram removed himself from the case because of his ownership of a small quantity of Intel stock. He invalidated his two rulings, and the case will now start over with a new judge.

Wide acceptance of NEC's V Series in the United States is highly dependent on a favorable judgment in the infringement case. While the case drags on, speculation is mounting as to whether Intel is secretly working on its own "V Series," i.e., chips that are supersets of its current microprocessor offerings.

Semiconductor Agreements

NEC has several licensing, second-sourcing, and joint venture agreements, including the following:

- Corvus Systems—NEC and Corvus Systems are involved in joint development of a CMOS single-chip controller.
- Digital Research—NEC has a joint-marketing agreement with Digital Research regarding a CP/M operating system f the V Series.
- Matra-Harris—NEC will supply 16-bit single-chip MCU technology to Matra-Harris, which will then produce and market two models of the chip.
- Matra-Harris—Matra-Harris second sources NEC MPUs.
- Oki—NEC has developed a CMOS signal processor (uPD77C20) with Oki.
- Sharp—NEC and Sharp agreed to jointly develop and produce V Series microperipherals. Under the agreement, NEC will provide its original microperipherals to Sharp on an OEM basis, while Sharp will develop new MPRs for NEC.
- Sharp and Sony—Sharp and Sony have been announced as second sources for the NEC V Series.

- Standard Microsystems Corp.—Standard Microsystems second-sources NEC controller chips in a cross-licensing and technology-exchange agreement.
- Sophia Systems—NEC is also involved in the joint development of MPU support systems for the V Series with Sophia Systems.
- Tektronix—Tektronix will market V Series MPU support systems for NEC, according to a joint venture agreement.
- Yokogawa Hewlett-Packard—NEC and Yokogawa Hewlett-Packard are involved in the joint development of MPU support systems for the V Series.
- Zilog—Zilog has licensed NEC to manufacture and market the Z80,000 32-bit microprocessor.
- Zilog—NEC has licensed Zilog to manufacture and market its V Series microprocessors.

NONSEMICONDUCTOR PRODUCTS SUMMARY

Communications Systems and Equipment

NEC is Japan's largest producer of communications equipment and ICs. Communications sales for fiscal 1987 were ¥699.9 billion, a decrease of 6 percent from fiscal 1986. This line of business accounted for 29 percent of total sales and is the Company's second-largest product division.

Major sectors of this division are fiber-optic communications, digital switching systems, cable and radio transmission, facsimiles, mobile communications, defense electronics, teleconference systems, microwave and satellite communications systems, and laser communications equipment. This division also manufactures telephone sets.

NEC is one of the largest suppliers of communications equipment to Nippon Telegraph and Telephone Corporation (NTT), formerly Japan's domestic telecommunications monopoly, as well as to the new common carriers (NCCs) that were created as a result of Japan's market liberalization.

Highlights of this division during fiscal 1987 were as follows:

- A highly automated fiber-optic transmission system plant was completed in Otsuki, near Tokyo.
- The APEX 2400L Automatic Call Distribution system, Japan's first large-capacity PBX system, was introduced.

Computers and Industrial Electronic Systems

Sales of computers and industrial electronic systems were ¥1,021.1 billion in fiscal 1987, an increase of 18 percent over fiscal 1986. This division accounted for 41 percent of total sales and is the Company's largest and fastest-growing product line. Major sectors of this division are the ACOS series of computers, supercomputers, minicomputers, small business computers, peripherals and terminals, software, industrial electronic systems, personal computers, medical electronic equipment, robots, and CAD/CAM and CAE systems.

Highlights of this division during 1987 were as follows:

- The addition of the NEC system 930, 910, and 830 to the Company's lineup of giant mainframe computers
  - This series features high-speed logic ICs, advanced networking capabilities, and business software packages.
- The formation of Honeywell-NEC Supercomputers Inc., which is a 50-50 venture to market NEC America SX-1, SX-2, and SX-1E supercomputers in North America

Electron Devices

Sales of electron devices were ¥417.0 billion in fiscal 1987, a decrease of 6 percent from fiscal 1986. The Electron Devices Division accounted for 17 percent of total sales.

Products of this division include semiconductors; electron, microwave, color picture, and display tubes; plasma display panels; semiconductor lasers; laser application devices; and bubble memories.

Home Electronics

The Home Electronics Division had sales of ¥188.3 billion in fiscal 1987, an increase of 5 percent from the previous year. This division accounted for 8 percent of total sales.

Products of this division include television sets, VCRs, audio equipment, lighting products, kitchen appliances, and air conditioners.

Fiscal 1987 highlights of this division include the following:

- NEC Technologies (UK) Ltd. was established near Birmingham, England, as a wholly owned subsidiary to manufacture VCRs, printers, and color television sets for the European market.

- NEC introduced the VC-D7HF, the world's first VCR with a noise-reduction capability to improve picture quality through digital technology.

Other Operations

Sales from other operations were ¥132.4 billion, an increase of 18 percent from fiscal 1986. This sector accounted for only 5 percent of total sales. Products of this sector include electrical connectors, aircraft electronics, measuring and testing systems, vacuum equipment, VAN services, and maintenance of communications systems.

During fiscal 1987, an NEC subsidiary, Ando Electric Company, Limited, completed development of the DIC-9035B VLSI testing system. The system has a high-speed, 200-MHz testing and 512 I/O pin capability.

9-P

N.V. Philips' Gloeilampenfabrieken

N.V. Philips' Gloeilampenfabrieken
Groenewoudseweg 1
5621 Ba Eindhoven
The Netherlands

N.V. Philips' Gloeilampenfabrieken is a European company. Although not privately owned, balance sheet and income statement data are unavailable.

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N.V. Philips' Gloeilampenfabrieken

THE COMPANY

Overview

N.V. Philips Gloeilampenfabrieken consists of a widely diversified group of companies, engaged primarily in the manufacture and distribution of electronic and electrical products, systems, and equipment. Philips was founded in 1891 in Eindhoven, The Netherlands, and has grown from a small incandescent lamp factory to a leading worldwide manufacturer of consumer and industrial products. Philips ranks 28th among the international Fortune 500.

Organization

N.V. Philips' Gloeilampenfabrieken (Philips Industries) functions as the primary holding company for the Philips group of companies. Responsibility for management of the Philips group lies with the Board of Management, which is supported by Philips International B.V. and comprises the management and international policy-making departments of the product divisions together with corporate staff departments.

In December 1986, the US Philips Trust was terminated in order to create a more integrated world organization. All assets of the trust passed to N.V. Philips, including all shares in Signetics Corporation and the 42 percent of shares in North American Philips Corporation (NAPC). In 1988, N.V. Philips announced a reorganization of its U.S. activities, including the creation of a new company. The new corporation, named Consolidated Electronics Industries Corporation, will include a number of businesses under NAPC whose activities are unrelated to Philips' product divisions as well as NAPC's defense systems activities.

After assuming control of the American operations, Philips listed shares on the New York Stock Exchange under the symbol PHG. In May 1987, 20.75 million shares were issued and sold at NLG 48.60 and in the United States at $24.00.

Philips employs approximately 366,700 people and is structured along two lines—organization by product and by country. The Company has national organizations in more than 60 countries that are generally wholly owned subsidiaries, varying from marketing organizations to integrated manufacturing and marketing concerns. Product-related activities are grouped into six sectors, which are also used by Philips for financial reporting. Sales by product sector are shown in Table 1.

Table 1

N.V. Philips Gloeilampenfabrieken
Estimated Revenue by Product Sector
(Millions of Guilders)

Product Sector	Fiscal Year Ending December 31 1983	1984	1985	1986	1987
Lighting	F 6,348	F 7,471	F 7,910	F 6,771	F 6,481
Consumer Electronics	11,639	12,417	16,732	16,831	16,534
Domestic Appliances	5,090	6,114	6,639	6,291	6,331
Professional Products and Systems	14,386	15,931	17,520	15,686	14,336
Components	6,257	8,550	8,069	7,379	7,345
Miscellaneous	2,795	3,321	3,175	2,079	1,688
Total Revenue	F 46,515	F 53,804	F 60,045	F 55,037	F 52,715

Source: N.V. Philips Gloeilampenfabrieken
Annual Reports
Dataquest
November 1988

Since January 1, 1985, Philips has been organized operationally into product divisions within the six major product sectors. The product divisions are:

- Lighting
- Consumer Electronics
- Home Interactive Systems
- Domestic Appliances and Personal Care
- Telecommunications and Data Systems
- Defense and Control Systems
- Medical Systems
- Elcoma
- Industrial and Electro-Acoustic Systems (I & E)

International Operations

Philips operates in more than 100 countries. The Company has its own operations in more than 60 countries and operates through agents in the others. The Company's worldwide aim is to conduct 30 percent of its business in each of the three "centers of competence"—Europe, North America, and the Pacific Basin—within the next 10 years.

Philips is structured as a matrix organization. Each of the national organizations is divided into product divisions and several main supply groups (as listed under the "Organization" subsection). These national organizations and product divisions operate together as equal partners, but they exercise substantial autonomy for maximum marketing adaptability.

Philips is currently engaged in several cooperative activities worldwide. Some of its cooperative activities that are not consolidated are as follows:

- AT&T International—A joint venture with AT&T International (ATTI) to develop, produce, and market public telecommunications network products. The venture is called AT&T and Philips Telecommunications (APT). Philips recently sold 10 percent of the APT shares to ATTI, raising ATTI's share to 60 percent, with the remainder held by Philips.

- Grundig AG—Philips holds 31.6 percent of the capital stock of Grundig AG, a producer of consumer electronic products. Grundig is a major customer of the Components sector of Philips. Effective August 1984, Philips agreed to provide funds for financing Grundig's losses, if any, and to guarantee the payments of dividends. Accordingly, Philips includes all of Grundig's results in its financial statements.

- Matsushita Electronics Corporation—Philips has a 35 percent interest in Matsushita Electronics Corporation (MEC), which produces electronic components and lighting products in Japan. The other 65 percent is held by Matsushita Electric Industrial Company Ltd. of Japan. In 1987, the cooperative effort was extended for a period of 10 years.

- Du Pont de Nemours & Company—In 1986, Philips and Du Pont Optical Company (PDO) was formed as a joint venture with E.I. Du Pont de Nemours & Company of the United States with each partner having a 50 percent interest. PDO is engaged in manufacturing and marketing optical media for consumer and professional applications. Worldwide headquarters for PDO are located in The Netherlands.

- R.R. Donnelly & Sons Company—Philips established joint ventures with R.R. Donnelly & Sons Company (United States) and Toppan Printing Company Ltd. (Japan) to promote the development of software for interactive compact disks.

- Willi Studer AG—Philips has a joint venture with Willi Studer AG (Switzerland) to research and develop professional compact disk systems for radio and television studios.
- Robert Bosch GmbH—Philips and Robert Bosch GmbH (Federal Republic of Germany) established the BTS-Broadcast Television Systems GmbH in which Philips has a 30 percent interest.

Recently, Philips made the following announcements:

- In June 1986, Philips agreed to a joint-venture agreement with Gold Peak Industries of Hong Kong to produce and market automotive audio equipment for the Far East.
- In February 1987, Philips invested £9 million pounds in the expansion of its Bishopsbriggs plant in Glasgow, Scotland, to prepare for the launch of its digital private telephone exchange in the United Kingdom.

Table 2 presents estimates of Philips' sales by geographic area in 1987.

Table 2

N.V. Philips Gloeilampenfabrieken
Estimated Sales by Geographic Area
(Millions of Guilders)

	1986	1987
The Netherlands	F 3,676	F 3,444
Europe (excluding The Netherlands)	28,884	28,919
North America	13,372	11,801
Latin America	3,070	3,019
Africa	1,104	1,018
Asia	3,617	3,535
Australia and New Zealand	1,314	979
Total Sales	F 55,037	F 52,715

Source: N.V. Philips Gloeilampenfabrieken
Annual Reports
Dataquest
November 1988

N.V. Philips' Gloeilampenfabrieken

Semiconductor Facilities

Philips' and Signetics' worldwide semiconductor plant locations are listed in Table 3. Recently, Philips made the following changes:

- Philips announced that advanced lithography has been installed from The Netherlands into Signetics' Alburquerque, New Mexico, facility, where EPROM processes are ramping up EPLD production. The Alburquerque and Eindhoven sites will be major foundries for Signetics and Elcoma.

- In December 1986, Philips announced that it was building a $50 million highly automated liquid crystal display production center in Heerlen, The Netherlands.

- In April 1986, Philips moved its Philips Electronic Building Elements Industries Ltd. (PEBEI) operations from the Kaohsiung Export Processing Zone into a new factory in the Nantze Export Processing Zone as part of a plan to step up production of both ICs and passive components. PEBEI now consists of three divisions: IC Assembly and Test, Passive Components Division, and a recently launched IC design center.

Table 3

N.V. Philips Gloeilampenfabrieken
Semicondcutor Plant Locations

Philips Location	Size (Sq. Ft.)	Products and Technologies
Recife, Brazil	N/A	Assembly and testing of ICs
Sao Paulo, Brazil	N/A	Assembly and testing of discretes
Caen, France	N/A	Integrated circuits: bipolar digital (ECL, TTL), bipolar analog, consumer; discrete devices: power transistors; optoelectronic products
Hong Kong	N/A	Assembly and testing of transistors and diodes

(Continued)

Table 3 (Continued)

N.V. Philips Gloeilampenfabrieken
Semicondcutor Plant Locations

Philips Location	Size (Sq. Ft.)	Products and Technologies
Nijmegen, The Netherlands	N/A	CMOS standard logic families, CMOS custom/semicustom, CMOS analog; bipolar analog; consumer; HF transistors, power transistors; small signal diodes; lasers; assembly for ICs
Sittard, The Netherlands	N/A	N/A
Stadskanaal, The Netherlands	N/A	Diodes
Manila, Philippines	N/A	Assembly and testing of transistors, diodes, and optoelectronic products
Barcelona, Spain	N/A	Assembly and testing of small signal diodes and small signal transistors
Zurich, Switzerland	N/A	ICs: CMOS for clocks, watches, telecommunications, CMOS memories, CLIPS; assembly for small outline packaging
Kao-Hsiung, Taiwan	N/A	Assembly and testing of ICs
Southampton, United Kingdom	N/A	NMOS ROMs; dedicated consumer logic
Stockport, United Kingdom	N/A	Power transistors, power diodes
Signetics		
Sunnyvale, California	1,107,300	Wafer fabrication; MOS and bipolar ICs
Tokyo, Japan	15,600	Testing only

(Continued)

Table 3 (Continued)

N.V. Philips Gloeilampenfabrieken
Semicondcutor Plant Locations

Philips Location	Size (Sq. Ft.)	Products and Technologies
Seoul, Korea	148,700	Assembly and testing
Albuquerque, New Mexico	238,300	Wafer fabrication; MOS ICs
Bangkok, Thailand	107,600	Assembly and testing
Orem, Utah	171,000	Wafer fabrication-bipolar ICs, assembly; testing of logic and bipolar memory products
Hamburg, West Germany	N/A	NMOS microprocessors, controllers, memories; bipolar analog consumer ICs; small signal transistors; varicap diodes

N/A = Not Available

Source: Dataquest
November 1988

Capital Spending

In 1987, expenditures for property, plants, and equipment amounted to F 4,756 million, approximately 9 percent of total sales. Table 4 illustrates investment by product sector.

Capital investment by geographic area is shown in Table 5.

Table 4

N.V. Philips Gloeilampenfabrieken
Capital Investment by Product Sector
(Millions of Guilders)

Product Sector	1983	1984	1985	1986	1987
Lighting	F 239	F 368	F 523	F 486	F 398
Consumer Electronics	358	570	843	860	852
Domestic Appliances	129	216	268	314	267
Professional Products and Systems	528	677	722	865	740
Components	710	1,341	1,509	1,393	1,717
Miscellaneous	177	234	199	215	168
Other	350	437	477	534	614
Total	F 2,491	F 3,843	F 4,541	F 4,667	F 4,756

Source: N.V. Philips Gloeilampenfabrieken
Form 20-F
Dataquest
November 1988

Table 5

N.V. Philips Gloeilampenfabrieken
Capital Investment by Geographic Area
(Millions of Guilders)

Region	1983	1984	1985	1986	1987
The Netherlands	F 597	F 799	F 1,245	F 1,410	F 1,463
Europe (excluding The Netherlands)	1,024	1,573	2,070	2,093	2,156
North America	560	1,026	767	691	572
Latin America	115	121	113	157	212
Africa	20	25	26	16	17
Asia	119	212	268	275	311
Australia and New Zealand	56	87	52	25	25
Total	F 2,491	F 3,843	F 4,541	F 4,667	F 4,756

Source: N.V. Philips Gloeilampenfabrieken
Form 20-F
Dataquest
November 1988

Semiconductor Capital Spending

From calendar 1979 to 1981, Signetics' semiconductor capital spending in North America rose from $50 million to $115 million as Signetics expanded its Orem, Utah, facility. In 1986, Signetics spent $60 million, up 20 percent from the 1985 level of $50 million, as shown in Table 6. Approximately 83 percent, or $50 million, of its 1986 expenditures was for equipment. Signetics' 1987 spending was $90 million, which was used to bring Fab 23 in Alburquerque, New Mexico, on line in 1988. This new fab runs 6-inch CMOS, 1-micron wafers.

Table 6

Philips-Signetics
Semiconductor Capital Spending in North America
(Millions of Dollars)

1981	1982	1983	1984	1985	1986	1987
$115	$55	$58	$133	$50	$60	$90

Source: Dataquest
November 1988

Research and Development

Philips spent F 4,364 million, or 8.3 percent of sales, on R&D in 1987. The Company employs about 4,700 people in R&D, including more than 1,500 graduate scientists. The Philips Research Laboratories, in Eindhoven, houses half of the total research staff and carries out the majority of the research activities for Philips. In addition, the Company has major research laboratories in the following locations:

- Philips Research Labs—Redhill, Surrey, England
- Laboratories d'Electronique et de Physique Appliquee (LEP)—Limeil-Brevannes, France
- Philips Forschungslaboratorium (PFA)—Aachen, West Germany
- Philips Forschungslaboratorium (PFA)—Hamburg, West Germany
- Philips Research Laboratory Brussels (PRLB)—Brussels, Belgium
- Philips Laboratories—Briarcliff Manor, New York
- Philips Research Laboratories Sunnyvale (PRLS)—Sunnyvale, California

A small research group in Belgium specializes in software research.

Semiconductor-related R&D includes the following:

- Continuing research into gallium arsenide products, including methods for growing gallium arsenide and indium-phosphide ingots; methods for depositing thin layers such as vapor-phase, liquid-phase, molecular beam epitaxy, and metal organic chemical vapor deposition; ion implantation techniques; and aids for design and characterization of devices

- Cooperation with other European companies and universities under the auspices of the ESPRIT program

- The Megaproject, a five-year, $470 million joint-research project with Siemens to develop a submicron CMOS process technology

  - The program has resulted in a prototype 1Mb SRAM device. Related work is carried out in the development of computer-aided design.

  - A special R&D center, built at Eindhoven for the Megaproject program, was opened in December 1986. The new center was built at a cost of more than $220 million and includes both design and technology facilities.

- A $12 million research project launched in December 1986 by Philips and four Dutch universities to develop a prototype of a parallel processing computer

  - The four-year program will receive a $2 million government subsidy, with the balance coming from Philips. About 20 researchers will be employed on the project.

- The formation of a $2.9 million R&D company, Silicon Software Systems, Ltd., in Dublin, Ireland

  - The new company will develop digital signal processing and image processing ICs and software for use in consumer products and for worldwide sales.

Semiconductor Product Markets

Combined, Philips-Signetics is the seventh largest worldwide semiconductor manufacturer. Revenue for calendar year 1987 was $1,603 million, an 18 percent increase from calendar year 1986. Table 7 shows Dataquest's estimates of the combined worldwide semiconductor revenue for Philips and Signetics.

Philips-Signetics achieved growth greater than the industry growth rate in two areas—linear and total discrete. Table 8 shows the worldwide semiconductor ranking for Philips-Signetics based on Dataquest's estimated semiconductor revenue.

Table 7

N.V. Philips Gloeilampenfabrieken
Signetics Corporation
Estimated Worldwide Semiconductor Revenue by Product Line
(Millions of Dollars)

	1983	1984	1985	1986	1987
Total Semiconductor	$917	$1,325	$1,065	$1,361	$1,603
Total Integrated Circuit	$694	$1,090	$ 808	$1,028	$1,187
Bipolar Digital (Technology)	$344	$ 589	$ 372	$ 389	$ 406
TTL	320	551	337	363	380
ECL	22	37	34	22	25
Other Bipolar Digital	2	1	1	4	1
Bipolar Digital (Function)	$344	$ 589	$ 372	$ 389	$ 406
Bipolar Digital Memory	89	121	80	61	61
Bipolar Digital Logic	255	468	292	328	345
MOS (Technology)	$155	$ 266	$ 228	$ 312	$ 342
NMOS	103	187	138	179	178
CMOS	52	79	90	133	164
MOS (Function)	$155	$ 266	$ 228	$ 312	$ 342
MOS Memory	27	32	35	14	18
MOS Micro Devices	45	104	64	85	100
MOS Logic	83	130	129	213	224
Linear	$195	$ 235	$ 208	$ 327	$ 439
Total Discrete	$204	$ 217	$ 232	$ 298	$ 390
Transistor	124	131	142	169	233
Diode	74	78	81	119	137
Thyristor	5	6	9	7	10
Other Discrete	1	2	--	3	10
Total Optoelectronic	$ 19	$ 18	$ 25	$ 35	$ 26
Exchange Rate (Yen per US$)	235	237	238	167	144

Source: Dataquest
November 1988

Table 8

Philips-Signetics
Worldwide Ranking by Semiconductor Markets
(Sales in Millions of Dollars)

	1986 Rank	1987 Rank	1987 Sales	Sales % Change 1986-1987	Industry % Change 1986-1987
Total Semiconductor	8	7	$1,603	18%	23%
Total IC	8	10	$1,187	16%	26%
Bipolar Digital	6	6	406	5%	8%
MOS Digital	13	14	342	10%	35%
Linear	6	4	439	34%	19%
Total Discrete	5	5	$ 390	31%	13%
Total Optoelectronics	16	20	$ 26	(10%)	16%

Source: Dataquest
November 1988

Table 9 shows Philips-Signetics' semiconductor revenue by geographic region.

Table 9

N.V. Philips Gloeilampenfabrieken
Signetics Corporation
Estimated Worldwide Semiconductor Revenue by Region—1987
(Millions of Dollars)

	U.S.	Japan	Europe	ROW	Worldwide
Total Semiconductor	$392	$40	$930	$241	$1,603
Total Integrated Circuit	$359	$39	$618	$171	$1,187
Bipolar Digital	237	15	97	57	406
MOS	45	3	262	32	342
Linear	77	21	259	82	439
Total Discrete	$ 31	$ 1	$290	$ 68	$ 390
Total Optoelectronic	$ 2	-	$ 22	$ 2	$ 26

Source: Dataquest
November 1988

N.V. Philips' Gloeilampenfabrieken

Semiconductor Products and Technologies

Elcoma is Philips' semiconductor and passive components operation. During 1988, Philips Elcoma will become Philips Components. The product range of Philips Components covers components for display systems, passive components, discrete semiconductors, ICs, components for broadcasting, electro-optical devices, and materials.

Signetics Corporation

Signetics Corporation manufactures ICs for a wide range of applications, including many that meet military specifications. It employs more than 8,000 people and maintains its headquarters in Sunnyvale, California.

Signetics maintains a very close relationship with Philips Components, even though Signetics is officially a separate organization. Philips Research Laboratory Sunnyvale (PRLS), California, comes under the auspices of Philips' research in Eindhoven, although it is part of Signetics. PRLS also works closely with other research establishments in the United States, namely Stanford University and the University of California at Berkeley.

Signetics maintains its own marketing network that includes 34 sales offices in the United States, Japan, and Canada, as well as 30 representatives and authorized distributors in 150 locations. In addition, 60 Philips national sales organizations market Signetics circuits in various countries around the world.

Signetics offers a wide range of products in six product areas, as follows:

- Digital logic—TTL/LSI, FAST, ALS, 10K/100K/100S ECL, 4000 Series, HC/HCT, ACL, LSI
- Microcomponents—NMOS/CMOS/bipolar microcontrollers, I2C micro-controllers, 68000, microperipherals
- Memory—PROMs, EPROMs, bipolar RAMs
- ASICs—Programmable logic, ECL gate array, CMOS SystemCell
- Linear—Amplifiers, communication and video devices, power conversion, interface/data conversion, I2C, automotive

Highlights of Philips' and Signetics' recent announcements are summarized in the following subsections.

N.V. Philips' Gloeilampenfabrieken

Analog

- In May 1988, Signetics announced the NE/SA604A and NE/SA605 high-performance, low-power FM RF/IF ICs with high-sensitivity, wide AC bandwidth. The devices are designed for applications such as cellular phones, RF data communications, intermediate frequency (IF) amplifiers, spectrum analyzers, broadband LANs, and other performance-oriented RF products.

ASICs

- In January 1988, Signetics introduced the PLC16V8 Series PLD family, which is the Company's first PLD offering. The CMOS family consists of four quarter-power and half-power 20-pin EPROM-based devices.

- In June 1988, Signetics introduced the PLHS16L8B and PLHS18P8B PLDs, which feature maximum propagation delay of 15ns.

- In July 1988, Signetics unveiled the PLUS173D 24-pin PLD with a worst-case propagation delay of 12ns.

Memory

- In November 1986, Philips offered its first EEPROM, the PCF8582. The 256x8 CMOS device is designed in a floating-gate technology and targets data processing, automotive, and battery-powered consumer product applications.

- In November 1986, Philips offered the 27C256, a 256K CMOS EPROM. It joins a 64K CMOS UV EPROM, which was offered in July 1986. Philips plans to use the newly acquired CMOS EPROM technology, the result of a technology agreement with Intel, to develop other products in its Programmable Products Group.

- In July 1987, Philips announced that it had produced a functional submicron 1Mbit SRAM in its research facilities in The Netherlands, achieving its first major goal under the Megaproject. The device, which was produced using a CMOS process with a six-transistor cell, has access times of 25-ns at 20 MHz.

- In February 1988, Signetics introduced the 74HC/HCT40105 and 74HC/HCT7030, the first in a family of FIFO registers. The former is a 4-word x 16-bit part, whereas the latter is a 9-bit x 64-word part.

- In May 1988, Signetics announced the 74F1764 and 74F1765 series of 1Mb DRAM controllers that offer synchronous single- and dual-port operation at 100 MHz. The devices also provide arbitration, signal timing, and refresh address generation for 40ns DRAMs.

Microcomponents

- In December 1987, Signetics announced that it is now the sole second source for Motorola's 68010 16-bit MPU. The SCN68010 features virtual memory operations and comes in 8-MHz, 10-MHz, and 12.5-MHz versions.

- In 1987, Signetics offered the SC87C451, an MCU that Signetics claims is the first EPROM-based MCU with 7 ports. The ports add 24 more I/O pins to the 87C51 design, bringing the total count to 56.

- In January 1988, Philips offered the PCB83C652, a general-purpose 8-bit MCU featuring an I2L-bus interface, 8K ROM, and 256 bytes of volatile data RAM. Both memories are expandable to 64K off-chip.

- In February 1988, Philips introduced the 83C552, an MCU for automotive applications. The device features a two-line I2L-bus interface and five 8-bit I/O ports, plus one input port targeted at automotive applications, especially ignition, injection system, and gearbox.

- In March 1988, Signetics announced two high-speed, enhanced video display controllers. The SCN2672T ("Turbo") and the SCN264T are higher-speed versions of two video controllers that bear the same part numbers but offer improvements in performance.

- In June 1988, Signetics introduced the S87C51, a CMOS single-chip, 8-bit MCU. The device is a direct functional replacement for Intel's 87C51/80C51 MCU products.

- In June 1988, Signetics introduced the PLS159A, a programmable logic sequencer with an 18.2-MHz operating frequency. The PLS159A supports complex state machines and controller functions.

Process Technology

- In November 1987, Signetics announced that it plans to have a fast BICMOS technology that will be used for PLD and linear parts by the end of 1988. The development is a result of the research by Philips Research Laboratory Sunnyvale (PRLS).

- In November 1987, Signetics announced that it has been working on a 1-micron CMOS process that is compatible with Texas Instrument's EPIC process. The process uses double-metal layers, silicides, and 1.2-micron drawn gate lengths. Signetics and TI have a goal of producing truly interchangeable logic parts.

Semiconductor Agreements

Philips-Signetics has formed numerous alliances with companies worldwide. Some of these alliances are described in the following list:

- ASM—In August 1988, Philips announced plans to acquire the controlling interest in its joint-lithography venture, ASM Lithography, from Advanced Semiconductor Materials (ASM).

- AMCC—In 1979, Applied Micro Microcircuits Corp. licensed Signetics to alternate-source the Q700 Quick-Chip series in exchange for Signetics' 8A-1200 gate array family.

- Bosch—In December 1987, Philips and Bosch announced that they will cooperate in the area of a standard serial communication link for automotive applications.

- General Instrument—In June 1983, General Instrument and Philips agreed to develop a new line of nonvolatile memory devices that support the Philips 12C bus standard.

- Hitachi—In October 1985, Hitachi received Signetics' communication controller; Signetics received Hitachi's CRT controller.

  In June 1986, Signetics gave Hitachi the rights to produce and sell its communication application LSI chips, HD68562 and HD64941.

- Intel—In 1982, Intel and Philips-Signetics signed a seven-year technology exchange agreement that gave Philips-Signetics access to Intel's CHMOS process and products, including 8-bit single-chip microcomputers. Intel received two Philips-developed serial buses.

  In 1985, Intel licensed Philips to alternate-source Intel's 8095 16-bit MCU and provided its 256K EPROM technology to Signetics.

- LTC—In July 1984, LTC and Signetics signed a three-year agreement that grants Signetics the right to purchase die in wafer form and manufacturing rights for three precision op amps and other unnamed products. Signetics provided LTC with certain small-outline packaging services.

- Matsushita—In December 1987, Matsushita and Philips renewed their business cooperation agreement for a 10-year period.

  In December 1986, Philips and Matsushita agreed to join forces to launch a new family of 8-bit CMOS microcontrollers. Under the agreement, Matsushita will manufacture and market the PCF84CXX family designed by Philips.

- Motorola—In 1983, Motorola signed Philips-Signetics as a second source for the 68000 microprocessor family.

- Plessey—In June 1987, Elcoma and Plessey Semiconductors agreed to codevelop a I2L bus-controlled phase-locked-loop (PLL) synthesizer circuit for television tuning. Both companies will make the device but will market it independently.

- S3—In 1988, Philips established Silicon & Software Systems (S3) Inc., in which Philips has a majority interest. S3 specializes in the design of ICs and software for DSP applications aimed at the consumer and information area.

- Siemens—In 1984, Siemens and Philips joined a venture to develop marketable 1Mb and 4Mb DRAMs. Siemens and Philips provided $400 million; the Dutch government provided $90 million, and the West German government provided $135 million.

  Also in 1984, Siemens and Philips agreed to a joint venture to set up a semiconductor fabrication plant in Holland to produce 4Mb RAMs. This venture involved an investment of approximately $10 million.

- SMH—In July 1987, Philips and the Societe Suisse de Microelectronique d'Horlogerie (SMH), a Swiss watchmaker, agreed in principle to merge their Swiss semiconductor operations into a joint venture. SMH will hold a majority stake in the new company, which will include assets of its own technology division and Philips Faselec AG affiliate. The joint venture focuses on circuits for the watch industry and niche markets for low-power telephony and consumer circuits.

- Soviet Union—In February 1988, Philips agreed to a $13.7 million deal to help the Soviet Union make semiconductors. Philips will supply the Soviet Ministry for Electronic Engineering with parts and technological expertise to manufacture semiconductors for consumer products such as color televisions.

- Synertek—In January 1985, Synertek's dual-port RAM technology was sold to Signetics after Synertek shut down.

- TSMC—In 1986, Philips took a 27.5 percent interest in Taiwan Semiconductor Manufacturing Corporation (TSMC). The remainder is held by the Taiwan government and Taiwanese firms. Philips has an option to purchase a controlling interest in TSMC.

- TI—In 1984, Texas Instruments and Signetics agreed to develop an Electronic Design Intercharge Format (EDIF).

  In 1985, TI and Signetics agreed to cooperate on a 1-micron CMOS logic family.

In January 1986, Texas Instruments and Philips-Signetics agreed to codevelop and manufacture an advanced CMOS logic (ACL) family.

In May 1986, European Silicon Structures, Philips-Elcoma, and Texas Instruments agreed to cooperate on the SystemCell cell-based library.

In February 1987, ES2, TI, and Philips signed an agreement covering the manufacture of the SystemCell. TI and Philips will supply volume parts; ES2 will provide prototypes and low-volume quantities.

In April 1988, Signetics and TI agreed to codevelop an ACL family with 47 new functions.

- Vitelic—In April 1986, Philips and Vitelic agreed to a broad-ranging agreement that gave Vitelic access to Philips' process technology. Vitelic will design a family of high-performance CMOS SRAMs for manufacture, use, license, and sale by both companies.

- VLSI Technology—In May 1988, Philips International and VLSI Technology announced an agreement that covers CAD design software, foundry services, cell libraries, and gate arrays. VLSI will provide IC design software for use in Philips' operations. Philips will provide foundry services.

NONSEMICONDUCTOR PRODUCTS SUMMARY

Philips product sectors offer a wide range of products, as described in the following paragraphs.

Lighting

The Lighting and Batteries sector produces incandescent lamps, high- and low-pressure gas discharge lamps, luminaires, lighting projects, appliances for photographic purposes and photoflash lamps, batteries and solar collectors, glass, diamond drawing dies, wires, and other components.

Consumer Electronics

This product sector includes the Consumer Electronics product division, the Home Interactive Systems group, and Polygram B.V. Major product categories in this sector are television and radio receivers, video and audio recorders, playback equipment for sound and vision, projection television, video cameras, video games, magnetic tape, home computers, and hearing aids.

Domestic Appliances

This product sector comprises the Major Appliance division and the Domestic Appliances and Personal Care division. Products include washing machines and dryers, dishwashers, refrigerators and freezers, cooking appliances, vacuum cleaners, floor polishers and electric irons, food preparation machines, mixers and other small kitchen appliances, microwave ovens, coffee makers, toasters and grills, heating appliances and fans, clocks, electric shavers, solaria, and other personal care products.

In August 1988, Philips and Westinghouse agreed to combine their appliance lines, which will have a projected annual revenue of $6 billion. Whirlpool will control the company, which will assume all of Philips' worldwide appliance lines in January 1989 and retain an option to buy out Philips later. The company will be headed by Willem G. Meyer, senior managing director of Philips Major Domestic Appliance operation.

Professional Products and Systems

This product sector comprises the Medical Systems division, Industrial and Electro-Acoustic Systems division, Telecommunication and Data Systems division, and Defense and Control Systems division. In 1986, Philips sold Felton & Guilleaume Energietechnik GmbH and significantly reduced its interests in Unidare p.l.c. and NKF Kabel B.V. Products include telecommunications systems, cable products and systems, defense systems, small computer systems, electronic office equipment, medical systems for diagnosis and therapy, instruments for laboratories and industry, television studio and transmitting equipment and cable television, audiovisual communication and security systems, machines, instruments, and tools.

Components

The activities in this field are conducted by the Elcoma division and by the Subsystems and Peripherals group. This sector produces integrated circuits, transistors and diodes, passive components, displays, CD-ROMs, digital optical recording systems, and magnetic tape drives.

Miscellaneous

The Miscellaneous product sector encompasses a number of activities not covered by the basic program of the other product sectors. These include activities that were acquired in the takeover of other companies, mainly those in France, the United States, and Australia. Products in this sector include equipment for satellite and spacecraft, antennae and communications systems for satellite television, musical instruments, and pharmaceuticals.

Oki Electric Industry Company, Limited

Oki Electric Industry Company, Ltd.
7-12, Toranomon 1-chome, Minato-ku
Tokyo, 105, Japan
Telephone: (03) 501-3111
(Billions of Yen)

Balance Sheet (March 31)	1983	1984	1985	1986	1987
Total Current Assets	¥195.5	¥233.7	¥274.9	¥279.2	¥336.5
Cash	¥ 54.4	¥ 62.5	¥ 62.6	¥ 71.3	¥ 99.6
Receivables	¥ 70.7	¥ 84.2	¥ 95.1	¥104.2	¥124.6
Inventory	¥ 67.5	¥ 83.5	¥112.8	¥ 98.7	¥106.4
Other Current Assets	¥ 2.8	¥ 3.5	¥ 4.5	¥ 5.0	¥ 5.9
Net Property, Plant, and Eqp.	¥ 60.2	¥ 77.8	¥113.6	¥110.9	¥104.6
Depreciation	¥ 72.4	¥ 84.5	¥109.1	¥139.5	¥162.1
Other Assets	¥ 25.9	¥ 29.1	¥ 33.4	¥ 41.8	¥ 50.1
Total Assets	¥281.5	¥340.6	¥421.9	¥431.9	¥491.2
Total Current Liabilities	¥166.6	¥213.5	¥234.9	¥217.3	¥266.9
Long-Term Debt	¥ 73.6	¥ 62.2	¥110.3	¥120.7	¥115.4
Other Liabilities	¥ 0.6	¥ 1.1	¥ 1.4	¥ 5.8	¥ 5.7
Total Liabilities	¥240.8	¥276.7	¥346.6	¥343.7	¥388.0
Total Shareholders' Equity	¥ 40.7	¥ 63.9	¥ 75.4	¥ 88.2	¥103.2
Conv. Preferred Stock	0	0	0	0	0
Common Stock	¥ 20.2	¥ 26.2	¥ 27.9	¥ 32.2	¥ 38.3
Other Equity	¥ 13.3	¥ 25.3	¥ 29.9	¥ 45.7	¥ 52.3
Retained Earnings	¥ 7.1	¥ 12.4	¥ 17.6	¥ 10.3	¥ 12.5
Total Liability and Equity	¥281.5	¥340.7	¥422.0	¥431.9	¥491.2

Income Statement (March 31)	1983	1984	1985	1986	1987
Revenue	¥279.7	¥345.4	¥417.5	¥392.6	¥407.4
Domestic Sales	¥207.3	¥243.7	¥287.5	¥290.6	¥307.4
Overseas Sales	¥ 72.4	¥101.7	¥130.0	¥102.0	¥100.0
Cost of Sales	¥ 03.9	¥243.2	¥296.0	¥293.9	¥315.3
Gross Margin (%)	27	30	29	25	23
R&D Expense	¥ 11.5	¥ 14.6	¥ 16.6	¥ 16.2	¥ 17.5
SG&A Expense	¥ 47.2	¥ 58.9	¥ 73.8	¥ 70.1	¥ 71.1
Other Operating Expenses	¥ 0.8	¥ 3.1	¥ 2.5	¥ 0.8	(¥ 9.3)
Total Operating Expenses	¥263.4	¥319.8	¥388.9	¥381.0	¥394.6
Operating Income (Loss)	¥ 16.2	¥ 25.5	¥ 28.7	¥ 11.6	¥ 12.8
Interest, Net	(¥ 7.8)	(¥ 7.5)	(¥ 8.2)	(¥ 9.4)	(¥ 8.8)
Pretax Income	¥ 8.5	¥ 18.0	¥ 20.4	¥ 2.2	¥ 4.0
Income Taxes	¥ 6.3	¥ 8.7	¥ 11.1	¥ 3.1	¥ 1.7
Effective Tax Rate (%)	74	48	54	140	43
Extraordinary Items, Net	¥ 0.4	(¥ 0.1)	(¥ 0.2)	(¥ 0.1)	(¥ 0.2)
Net Income	¥ 2.5	¥ 9.2	¥ 9.2	(¥ 1.0)	¥ 2.2
Average Shares Outstanding (Millions)	392	427	454	470	491
Employees	15,658	17,027	18,134	18,649	19,375
Capital Spending	¥ 27.7	¥ 37.5	¥ 67.7	¥ 34.6	¥ 23.1
Exchange Rate (Yen per US$)	249	236	245	221	160

Source: Oki Electric Industry Company, Ltd.
Annual Reports
Dataquest
February 1988

Oki Electric Industry Company, Ltd.
7-12, Toranomon 1-chome, Minato-ku
Tokyo, 105, Japan
Telephone
Twx: 501-3111
(Millions of Dollars)

Balance Sheet (March 31)	1983	1984	1985	1986	1987
Total Current Assets	$1,352	$ 990	$1,122	$1,263	$2,103
Cash	$ 400	$ 265	$ 255	$ 322	$ 623
Receivables	$ 501	$ 357	$ 388	$ 471	$ 779
Inventory	$ 427	$ 354	$ 460	$ 447	$ 665
Other Current Assets	$ 24	$ 15	$ 18	$ 23	$ 37
Net Property, Plant, and Eqp.	$ 420	$ 330	$ 464	$ 502	$ 654
Depreciation	$ 651	$ 358	$ 446	$ 631	$1,013
Other Assets	$ 201	$ 123	$ 136	$ 189	$ 313
Total Assets	$1,973	$1,443	$1,722	$1,954	$3,070
Total Current Liabilities	$1,072	$ 905	$ 959	$ 983	$1,668
Long-Term Debt	$ 463	$ 263	$ 450	$ 546	$ 721
Other Liabilities	$ 23	$ 5	$ 6	$ 26	$ 36
Total Liabilities	$1,558	$1,173	$1,415	$1,555	$2,425
Total Shareholders' Equity	$ 414	$ 271	$ 308	$ 399	$ 644
Conv. Preferred Stock	0	0	0	0	0
Common Stock	$ 154	$ 111	$ 114	$ 146	$ 239
Other Equity	$ 210	$ 107	$ 122	$ 207	$ 327
Retained Earnings	$ 50	$ 53	$ 72	$ 47	$ 78
Total Liability and Equity	$1,973	$1,444	$1,722	$1,954	$3,070

Income Statement (March 31)	1983	1984	1985	1986	1987
Revenue	$1,123	$1,464	$1,704	$1,777	$2,546
Domestic Sales	$ 833	$1,033	$1,174	$1,315	$1,921
Overseas Sales	$ 291	$ 431	$ 531	$ 462	$ 625
Cost of Sales	$ 819	$1,030	$1,208	$1,330	$1,971
Gross Margin (%)	27	30	29	25	23
R&D Expense	$ 46	$ 62	$ 68	$ 74	$ 109
SG&A Expense	$ 189	$ 250	$ 301	$ 317	$ 444
Other Operating Expenses	$ 3	$ 13	$ 10	$ 4	($ 58)
Total Operating Expenses	$1,058	$1,355	$1,587	$1,724	$2,466
Operating Income (Loss)	$ 65	$ 108	$ 117	$ 53	$ 80
Interest, Net	($ 31)	($ 32)	($ 34)	($ 43)	($ 55)
Pretax Income	$ 34	$ 76	$ 83	$ 10	$ 25
Income Tax	$ 25	$ 37	$ 45	$ 14	$ 11
Effective Tax Rate (%)	74	48	54	140	43
Extraordinary Items, Net	$ 1	0	($ 1)	0	($ 1)
Net Income	$ 10	$ 39	$ 37	($ 4)	$ 14
Average Shares Outstanding (Millions)	392	427	454	470	491
Employees	15,658	17,027	18,134	18,649	19,375
Capital Spending	$ 111	$ 159	$ 276	$ 157	$ 144
Exchange Rate (Yen per US$)	249	236	245	221	160

Source: Oki Electric Industry Company, Ltd.
Annual Reports
Dataquest
February 1988

Oki Electric Industry Company, Limited

THE COMPANY

Overview

Oki Electric Industry Company, Limited, was established in 1881 as a pioneering Japanese telephone manufacturing company by Kibataro Oki, formerly a maker of traditional Japanese swords and armor. In 1916, the Company began quantity production of radio communications equipment. Today, Oki is a leading producer of advanced telecommunications systems, data processing systems, and electronic devices, including semiconductors. Oki began manufacturing semiconductors in the early 1960s, and was the first Japanese company to manufacture green LEDs.

Oki is a member company of the Fuyo Group, a relatively young industrial group formed after World War II. (Fuyo is another name for Mount Fuji.) The Fuyo Group is composed of companies that have close financial relations with Fuji Bank. The presidents of the 29 group companies constitute the group's policy-making council, or "Fuyo-Kai." In addition, there are group councils consisting of vice presidents and planning department managers. Hitachi, Ltd., and Nissan Motor Company are members of the Fuyo-Kai, but both companies have also formed their own groups. The Fuyo Group member companies tend to be more independent of the group than companies in such large industrial groups as Mitsubishi and Sumitomo. Marubeni is the Fuyo Group's central trading firm.

Company Organization

In fiscal 1987, Oki created the Research and Development Group. This new group coordinates the activities of the newly formed Digital Communications and Semiconductor Technologies Laboratories.

In fiscal 1986, the Advanced Products and Systems Group was established to focus on strengthening the Company's capabilities in the market for integrated electronic systems. This group oversees the activities of the newly created Integrated Systems and Electroacoustics Systems Division.

In 1986, the Company upgraded its office automation (OA) strategic business unit to division status. The unit will supervise the development, production, and marketing of Oki's OA products. The OA division will also cooperate with the Company's other divisions to combine their products into multifunctional OA systems. This is essentially the same philosophy practiced by NEC, with its "C&C" (Computer and Communication) approach.

In addition to the above-mentioned groups, Oki is organized by Electronic Devices Industry Group (including semiconductors), the Telecommunications Systems Industry Group, and the Information Processing Systems Industry Group.

Oki Electric Industry Company, Limited

Management and Employees

Oki employs 19,375 people under the leadership of its president and chief executive officer, Namio Hashimoto, and executive vice president, Nobumitsu Kosugi.

Financial Information

Major Shareholders

Oki's major shareholders are listed in Table 1.

Major short- and long-term borrowings are from Fuyo Group financial institutions (Fuji Bank, Yasuda Trust and Banking, Yasuda Mutual Life Insurance, and Yasuda Fire and Marine Insurance).

In its fiscal 1987, Oki reported a consolidated net income of ¥2.2 billion compared with a ¥1.0 billion loss in fiscal 1986. Sales were ¥407.4 billion in the period, increasing 4 percent from ¥392.6 billion.

Table 1

Oki Electric Industry Company, Limited
Major Shareholders

Shareholders	Percentage of Shares
Yasuda Mutual Life Insurance Company	8.5%
Meiji Mutual Life Insurance Company	6.5%
Dai-Ichi Mutual Life Insurance Company	5.8%
Fuji Bank	4.5%
Yasuda Trust and Banking Company	3.7%
Yasuda Fire and Marine Insurance Company	2.6%

Source: Oki Electric Industry Company, Limited
Annual Reports
Dataquest
February 1988

Revenue by Lines of Business

Revenue by line of business is shown in Table 2. The Telecommunications Systems and Electronic Devices Groups have both increased their shares of business. The Office Automation Industry Group is not yet broken out in the Company's financial reporting.

Table 2

Oki Electric Industry Company, Limited
Revenue by Major Line of Business
(Billions of Yen)

	Fiscal Year Ending March 31				
	1983	1984	1985	1986	1987
Telecommunications Systems	¥ 79.8	¥ 76.4	¥ 94.1	¥ 99.3	¥112.0
Information Processing Systems	139.4	178.4	203.6	196.7	194.3
Electronic Devices	46.8	74.8	100.0	80.1	84.8
Other	13.7	15.8	19.8	16.5	16.3
Total Sales	¥279.7	¥345.4	¥417.5	¥392.6	¥407.4
Exchange Rate (¥ per US$)	249	236	245	221	160

Source: Oki Electric Industry Company, Limited Annual Reports
Dataquest
February 1988

International Activities

Overseas sales accounted for 25 percent of Oki's total consolidated revenue in fiscal 1987. The compound annual growth rate (CAGR) for overseas sales was 7 percent from 1983 to 1987, while domestic sales grew at a CAGR of only 8 percent.

Oki has 10 overseas subsidiaries and affiliates, including four in the United States, two in Singapore, two in West Germany, one in Taiwan, and one in Hong Kong. The Company's semiconductor operations overseas are handled by Oki Semiconductor Group in Santa Clara, California, and Oki Electric Europe GmbH in Dusseldorf, West Germany. Oki also maintains nine overseas liaison and sales offices, including one in Beijing, China.

Oki Semiconductor Group, the United States-based semiconductor division of Oki Electric, is an important part of Oki's operations. Oki Semiconductor was established in 1978 as a division of Oki Electric Overseas Corp., a wholly owned subsidiary of Oki Electric. In 1980, Oki Semiconductor became an autonomous company and a direct subsidiary of Oki Electric. Oki Semiconductor has built a factory in Sunnyvale, California, for assembly and test. Oki Semiconductor originally subcontracted wafer fabrication and assembly to several U.S. companies, but subsequently ended this arrangement. The Company has reorganized its U.S. organization so that Oki Semiconductor Group is now a division of Oki America, Inc.

Facilities

Oki has six semiconductor manufacturing facilities in Japan, in addition to a U.S. assembly and test facility. These are listed in Table 3. Oki has added a GaAs production line at its Hachioji factory, and plans to start production of GaAs devices for car telephones, other telecommunications, and measuring equipment by the end of this year. Oki has acquired a site near Sendai, Miyagi prefecture, for a new VLSI factory. The new factory is scheduled to begin operation in 1987 and will be a 6-inch wafer fab.

Table 3

Oki Electric Industry Company, Limited
Semiconductor Manufacturing Facilities

Location	Function and Products
Chichibu Factory Saitama Prefecture (Est. 1975)	Assembly--ICs and discretes
Hachioji LSI Factory, Tokyo Metropolis (Est. 1961) (GaAs line added 1986)	Fab and test--ICs and discretes; GaAs
Miyazaki Oki Denki Miyazaki Prefecture (Est. 1981; 2nd line added 1984)	Fab and test--MOS memory, microdevices, logic
VLSI Pilot Production Plant Tokyo Metropolis (Est. 1983)	R&D--VLSI Fab and test--MOS ICs
Honjyo Factory Saitama Prefecture (Est. 1984)	Assembly and test--linear ICs
Yoshikawa Semiconductor Miyazaki Prefecture (Est. 1985)	Assembly and test--ICs
Sendai Factory Miyagi Prefecture (Est. 1987)	Fab--VLSI (6-inch wafers)
Sunnyvale Factory California (Est. 1984)	Assembly and test--ICs

Source: Dataquest
February 1988

Capital and R&D Spending

Oki's capital spending for its fiscal 1987 was ¥23.1 billion, a decrease of 33 percent, as shown in Table 4. Table 5 shows Oki's corporate capital and R&D spending in dollars. Dataquest estimates that Oki made semiconductor capital investments of $60 million in calendar 1986 (see Table 6).

Table 4

Oki Electric Industry Company, Limited
Capital and R&D Spending
(Billions of Yen)

	Fiscal Year Ending March 31				
	1983	1984	1985	1986	1987
Revenue	¥279.7	¥345.4	¥417.5	¥392.6	¥407.4
Capital Spending (Billions)	¥ 27.7	¥ 37.5	¥ 67.7	¥ 34.6	¥ 23.1
Percentage of Revenue	10%	11%	16%	9%	6%
R&D Expense	¥ 11.5	¥ 14.6	¥ 16.6	¥ 16.2	¥ 17.5
Percentage of Revenue	4%	4%	4%	4%	4%
Combined Capital and R&D Revenue	¥ 39.2	¥ 52.1	¥ 84.3	¥ 50.8	¥ 40.6
Percentage of Revenue	14%	15%	11%	11%	10%
Exchange Rate (¥ per US$)	249	236	245	221	160

Source: Oki Electric Industry Company, Limited
Annual Reports
Dataquest
February 1988

Oki Electric Industry Company, Limited

Table 5

Oki Electric Industry Company, Limited
Capital and R&D Spending
(Millions of Dollars)

	Fiscal Year Ending March 31				
	1983	1984	1985	1986	1987
Revenue	$1,123.1	$1,463.5	$1,704.2	$1,776.2	$2,546.3
Capital Spending (Millions)	$ 111.2	$ 158.9	$ 276.3	$ 156.6	$ 144.2
Percentage of Revenue	10%	11%	16%	9%	6%
R&D Expense	$ 11.5	$ 14.6	$ 16.6	$ 16.2	$ 17.5
Percentage of Revenue	4%	4%	4%	4%	4%
Combined Capital and R&D Revenue	$ 39.2	$ 52.1	$ 84.3	$ 50.8	$ 40.6
Percentage of Revenue	14%	15%	11%	11%	10%
Exchange Rate (¥ per US$)	249	236	245	221	160

Source: Oki Electric Industry Company, Limited
Annual Reports
Dataquest
February 1988

Table 6

Oki Electric Industry Company, Limited
Semiconductor Capital Spending

	Calendar Year				
	1982	1983	1984	1985	1986
Billions of Yen	¥ 11	¥ 11	¥ 26	¥ 26	¥ 10
Millions of Dollars	$ 44	$ 47	$110	$109	$ 60
Exhange Rate (¥ per US$)	248	235	237	238	167

Source: Dataquest
February 1988

Research and Development

Oki's total research and development (R&D) expenditure for fiscal 1986 was ¥17.5 billion, or 4 percent of revenue.

In fiscal 1987, Oki boosted its R&D effort by increasing its number of laboratories from two to four. The new Semiconductor Technology Laboratory conducts research on 16-megabit DRAMs.

Oki operates a research facility at its Hachioji plant. One of the top priorities is development of prototype 4Mb and 16Mb DRAMs. In fiscal 1986, the Company established a ULSI Research Center on this site to conduct R&D on submicron technologies.

Recent R&D results include the refinement of technologies for mass production of GaAs ICs, the development of a series of multipurpose DSPs for use in ISDN systems, and the refinement of high-power semiconductor laser technologies for fiber-optic transmission systems.

PRODUCTS AND MARKETS

Semiconductor Product Markets

Oki has more than 20 years of experience in all phases of semiconductor design and manufacturing. Oki's semiconductor organization is part of the Electronic Devices Industry Group.

The Company manufactures devices encompassing a broad range of integrated circuits, discrete devices, and optoelectronics. The Company makes devices with the following processes: CMOS, PMOS, NMOS, TTL, I^2L, and ECL; and specialty products that include sensor arrays, optical couplers, and LED lamps. New specialty products include speech recognition and synthesis chips.

Oki has more than 19 years of experience in CMOS integrated circuit manufacturing, including digital logic devices, digital watch and clock circuits, linear CMOS devices (including audio and radio phase-lock receivers), frequency synthesizers, and random-access memories.

Oki's semiconductor sales increased by 42 percent in 1986, to $437 million, as shown in Table 7. The bulk of Oki's semiconductors are MOS devices (85 percent), about 54 percent of which are CMOS. The Company also produces a small number of bipolar digital logic and linear ICs. Discrete and optoelectronic devices make up 5 percent of Oki's output.

Dataquest believes that Oki shipped approximately 19 million 256K DRAMs and 15,000 1Mb DRAMs in 1986.

Table 7
Oki Electric Industry Company, Ltd.
Estimated Worldwide Semiconductor Revenue
(Millions of Dollars)

	1982	1983	1984	1985	1986
Total Semiconductor	129	229	362	307	437
Total Integrated Circuit	121	216	343	289	413
Bipolar Digital (Technology)	14	17	25	22	29
TTL	-	-	20	-	-
ECL	-	-	5	5	1
Other Bipolar Digital	-	-	-	17	28
Bipolar Digital (Function)	14	17	25	22	29
Bipolar Digital Logic	14	17	25	22	29
MOS (Technology)	106	197	315	264	371
NMOS	42	78	141	110	137
PMOS	5	5	1	-	-
CMOS	59	114	173	154	234
MOS (Function)	106	197	315	264	371
MOS Memory	59	101	149	91	89
MOS Micro Devices	6	19	46	45	69
MOS Logic	41	77	120	128	213
Linear	1	2	3	3	14
Total Discrete	4	3	4	4	6
Transistor	4	1	-	-	-
Other Discrete	-	2	4	4	6
Total Optoelectronic	4	10	15	14	18
LED Lamps	-	-	4	4	3
Optical Couplers	-	-	-	-	1
Other Optoelectronics	-	-	11	10	14
Exchange Rate (¥ per US$)	248	235	237	238	167

Source: Dataquest
February 1988

As shown in Table 8, Oki's growth has been much higher than the industry average in all products except linear ICs and discretes. However, the Company has chosen to focus its R&D, manufacturing, and sales efforts on products with high growth potential, i.e., MOS and bipolar digital ICs, and optoelectronics.

Table 8
Oki Electric Industry Company, Limited
Semiconductor Growth by Product Markets
(Millions of Dollars)

	1985 Sales	1986 Sales	Sales % Change 1985-1986	Industry % Change 1985-1986
Total Semiconductor	$307	$438	42%	25%
Total IC	289	414	43%	24%
Bipolar Digital	22	29	32%	14%
MOS Digital	264	371	41%	25%
Linear	3	14	367%	30%
Total Discrete	4	6	23%	25%
Total Optoelectronics	14	18	29%	37%

Source: Dataquest
February 1988

Table 9 shows Oki's estimated 1986 semiconductor revenue by geographic region. Dataquest estimates that approximately 40 percent of Oki's semiconductor sales are overseas, with about 23 percent, or $101 million, in the United States; 8 percent in Europe; and 9 percent in Rest of World (ROW). Approximately 60 percent of semiconductor revenue is from Japan.

Table 9

Oki Electric Industry Company, Ltd.
Semiconductor Revenue by Region—1986
(Millions of Dollars)

	United States	Japan	Europe	ROW	World
Total Semiconductor	$101	$264	$ 34	$ 39	$438
Total Integrated Circuit	101	241	34	38	414
Bipolar Digital Devices	-	28	-	1	29
MOS Devices	101	199	34	37	371
Linear	-	14	-	-	14
Total Discrete	-	6	-	-	6
Total Optoelectronic	-	17	-	1	18

Source: Dataquest
February 1988

Application Markets

Oki is a major supplier of CMOS logic to the automotive and watch markets. The Company supplies approximately 30 percent of the world watch chip market.

Other end markets of Oki's semiconductors include home computers (for games), factory automation, and smart cards.

Channels of Distribution

Oki has two major semiconductor distributors in Japan: Nihon Denso Industry Co., Ltd., and Ashitate Electric. Dataquest believes that more than 40 percent of Oki's Japanese semiconductor sales are made through distribution. In the United States, sales are made mainly through Oki Semiconductor Group; less than 2 percent of U.S. sales are made through distribution. Approximately 17 percent of Oki's semiconductor sales are captive.

Oki Electric Industry Company, Limited

Semiconductor Products and Technologies

In MOS memory, Oki makes DRAMS, mask ROMs, and SRAMs (in order of sales volume). The Company ships approximately equal amounts of 4- and 8-bit MCUs. The 4-bit MCUs are used mainly in compact disk players. The 8-bit MCU applications include telecommunications, keyboard controllers, and instrumentation.

Recently announced new Oki products and technologies include the following:

- Memory
  - A CMOS 1Mb EPROM with 120ns access time and 1.5-micron line width
  - A CMOS 1K EEPROM, 2.5mA in operation and 100uA at standby, 64x16 or 128x8 configuration, developed with Catalyst Semiconductor, Inc.
  - A 16K CMOS EEPROM, MSM28C16A, 150ns, floating-gate memory cell
  - A 64K CMOS EEPROM, MSM28C64A, 8Kx8, 64K SRAM/64K EPROM-compatible, 120/150ns
  - Two 1Mb DRAMs using a proprietary buried stack capacitor cell technology, 100/120ns, 1Mbx1 page and nibble mode or 256Kx4 page mode
  - A pseudovirtual 4Mb CMOS DRAM, 512Kx8, 160/95ns read times
  - A general-purpose 4Mb DRAM, 4Mbx1 or 1Mbx4, 65ns read time
  - Three CMOS 256K SRAMs, SRM20256LC/LS/LM, 100/120ns 32Kx8, TTL-compatible
  - A 1Mb CMOS ROM with 15mA active operating current and 100A standby current (Access time is 250ns; the part is TTL-compatible and interfaces easily with the 80C86/88 CMOS MPUs.)
  - A CMOS 4Mb mask ROM with 200ns access time, 1.5-micron line width; available in 260Kx16 or 520Kx8 structure

- Microcomponents
  - A CMOS single-chip MCU with a 16-bit CPU as a core and an 8-bit external interface
  - A single-chip 8-bit CMOS MCU with EEPROM, MSM61580, 5.5 x 4.5mm chip, 8-Kbyte program ROM, 512-byte ROM; for IC cards
  - A single-chip 4-bit CMOS MCU, MSC6458, with built-in 24-output optical display driver for audio equipment
- Gallium Arsenide
  - A superhigh-speed optoelectronic IC (GaAs/GaAlAs heterojunction OEIC) for parallel processing of optical computers; 1ns switching speed
  - A "reverse HEMT" with AlGaAs and GaAs layers on an AlGaAs substrate; 0.7-micron geometries
- ASICs
  - Four 1.5ns CMOS gate arrays with 3,100, 4,400, 6,000, and 8,000 gates
  - A standard cell library containing 84 logic cells, RAMs, ROMs, and PLAs in variable bit lengths, using a 2-micron CMOS process (gate delay time is 1.7ns; RAM access time is 30ns)

In early 1987, Oki announced that it is expanding its design facility located in Sunnyvale, California, with $2.5 million in CAD equipment including an Amdahl 5840 mainframe and DEC VAX 11-785. The center is also adding workstations including those made by Calma, Daisy, Futurenet, Mentor, and Valid Logic.

The expanded design hardware is capable of schematic capture, logic and timing simulation, automatic layout for both gate arrays and standard cells, design and electrical rule checking, automatic test program generation, and full-custom design.

Emerging Areas

A primary focus of Oki's strategies for long-term growth is the development of leading-edge products, such as 4Mb and 16Mb DRAMs. The Company also views GaAs and other new materials as key to achieving dramatic advances in semiconductor technology. Currently, the Company is refining technologies that allow mass production of GaAs devices. At the 1986 ISSCC, Oki presented a paper on an analog front-end LSI for 2,400-baud, split-band, full-duplex modems, using a pulsed digital-to-analog conversion technique.

Licensing and Joint Ventures

Oki is involved in the following semiconductor licensing and joint venture agreements:

- Casio, Hitachi, NEC—In January 1985, Casio agreed to design custom ICs that will be produced by Hitachi, NEC, and Oki.

- Catalyst Semiconductor—In cooperation with Catalyst Semiconductor of the United States, Oki has developed a CMOS 8-bit MCU with built-in EEPROM—chip size is 5.0mm x 4.5mm, and is adaptable to an IC card.

- Exel Microelectronics—In March 1985, Exel and Oki Electric reached an agreement whereby Oki will be a second source for Exel's 16K NMOS EEPROM.

- Intel Corporation—In March 1984, Intel and Oki signed a licensing agreement allowing Oki to manufacture and sell the 8086, 8088, 8051, 8085, and peripheral chips in CMOS for captive use.

- National Semiconductor—In late 1983, Oki Electric supplied its 64K dynamic RAM technology to National Semiconductor. National allocated about half its 64K DRAM output to Oki. National planned to market the Oki DRAM, using a National label and part number. (This agreement is no longer in effect.)

- NEC Corporation—In February 1986, NEC and Oki announced a jointly developed CMOS version of an NMOS high-performance signal processor currently produced by NEC, with one-fifth the power consumption of the MuPD7720.

- Silicon Systems—In October 1986, Oki established a partnership with Silicon Systems of the United States whereby Oki will produce and market single-chip modem ICs developed by Silicon Systems.

- Standard Microsystems—In June 1984, Standard Microsystems and Oki agreed to a cross-license of all patents and patent applications.

- Thomson-CSF—In October 1984, Thomson and Oki signed an alternate-source agreement covering gate arrays and high-density MOS memory. (All the gate array devices will use the same or compatible software and will be marketed by Oki and Thomson worldwide.)

- Voest Alpine AG—Oki and Voest agreed to a joint venture to produce 256K DRAMs, MPUs, and gate arrays. The venture is 49 percent capitalized by Oki—the overall deal is estimated to be worth approximately $285 million. (This agreement is no longer in effect.)

Nonsemiconductor Products

Electronic Devices Industry Group

Sales of electronic devices were ¥85 billion in fiscal 1987, a 6 percent increase from fiscal 1986. This represents about 21 percent of total sales. In addition to semiconductors, products include printed circuit boards, plasma display panel units, and reed relays and switches.

In fiscal 1987, Oki introduced the MSC2304, a large-capacity, IBM-compatible memory module that features high processing speed.

Telecommunications Systems Industry Group

Sales of telecommunications systems were ¥112 billion in fiscal 1987, a 13 percent increase from fiscal 1986. This accounted for 28 percent of total sales. Products include switching systems, facsimile equipment, telephone sets, modems, and transmission systems.

In fiscal 1987, Japan deregulated its telecommunications industry. Oki capitalized on the opportunity and increased sales of its D70, a digital switching system, and the iM2000, a digital multiplexer used in private branch exchanges. In fiscal 1988, Oki will concentrate on upgrading its Oki Digital Information Network in preparation for its eventual connection to Japan's ISDN and to other countries' telecommunications networks.

In August 1986, Oki shifted production of cellular mobile telephones to Atlanta, Georgia, using locally procured parts.

Information Processing Systems Industry Group

Fiscal 1987 sales of the Information Processing Systems Division were ¥194 billion, a 1 percent decrease from fiscal 1986. Sales accounted for 48 percent of total company sales. Information processing products include computers and peripherals, banking systems, medical electronics systems, teleprinters, telemetry and telecontrol systems, and point-of-sale systems.

In fiscal 1987, Oki introduced several products that meet the needs of domestic banks and other financial institutions preparing for the eventual introduction of 24-hour banking services in Japan. Oki's if100, introduced in fiscal 1986, achieved strong sales. The if100 is a 32-bit workstation featuring multiuser, multitask operation and computer-aided design and multimedia card with multiple modems. The if100 will play a central role in Oki's development of expert systems and other artificial intelligence applications.

Oki announced that it will manufacture dot-matrix printers for the European market at a new plant near Glasgow, Scotland, starting December 1987. A substantial proportion of the parts will be procured in the United Kingdom, with local content to be increased steadily in the years ahead.

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Raytheon Company

Raytheon Company
141 Spring Street
Lexington, Massachusetts 02173
Telephone: (617) 862-6600
(Millions of Dollars except per Share Data)

Balance Sheet (December 31)

	1982	1983	1984	1985	1986
Working Capital	$ 671	$ 685	$ 695	$ 438	$ 457
Long-Term Debt	$ 68	$ 99	$ 86	$ 75	$ 49
Shareholder's Equity	$1,712	$1,887	$1,979	$1,929	$1,955
After-Tax Return on Average Equity (%)	18.6	17.1	17.6	19.0	19.5

Operating Performance (Fiscal Year Ending December 31)

	1982	1983	1984	1985	1986
Revenue	$5,217	$5,631	$5,996	$6,409	$7,308
U.S. Revenue	$3,701	$4,276	$4,854	$5,381	$6,057
Non-U.S. Revenue	$1,516	$1,355	$1,142	$1,028	$1,251
Cost of Revenue	$4,211	$4,516	$4,815	$5,066	$5,843
R&D Expense	$ 170	$ 218	$ 236	$ 260	$ 254
SG&A Expense	$ 465	$ 512	$ 526	$ 592	$ 662
Pretax Income	$ 490	$ 497	$ 545	$ 600	$ 652
Pretax Margin (%)	9.4	8.8	9.1	9.4	8.9
Effective Tax Rate (%)	40.0	38.0	37.6	37.3	39.7
Net Income	$ 319	$ 300	$ 243	$ 376	$ 393
Average Shares Outstanding (Thousands)	84,654	84,933	84,825	82,167	77,696
Per Share Data					
Earnings	$ 3.77	$ 3.53	$ 2.87	$ 4.57	$ 5.60
Dividends	$ 1.40	$ 1.40	$ 1.45	$ 1.60	$ 1.75
Book Value	$20.28	$22.30	$23.46	$24.14	$26.39
Price Range	$28.25-49.88	$41.38-57.50	$34.75-48.88	$39.38-55.63	$52.38-71.75
Total Employees	72,000	76,100	73,300	73,000	75,000
Capital Expenditures	$ 224	$ 254	$ 414	$ 342	$ 346

Source: Raytheon Company
Annual Report
Dataquest
October 1987

Raytheon Company

THE COMPANY

Executive Summary

Raytheon Company is a $7.3 billion company active in a wide range of business lines including commercial and government electronics, aviation, appliances, energy services, construction equipment, and publishing. Over the past 20 years, the Company has diversified its business base by adding more commercial areas to balance its growing sales to the U.S. government.

Its principal business is the design, engineering, manufacture, and servicing of advanced electronic devices, equipment, and systems for both commercial and government customers.

Overview

The Company was incorporated in Cambridge, Massachusetts, in 1922 as American Appliance Company and adopted its present name in 1925. The Company reincorporated in Delaware, in 1928. Currently, it employs 75,000 people worldwide.

Raytheon is one of the largest defense contractors and is known as a reliable supplier of systems to the military, particularly for aerospace applications. The Department of Defense (DOD) listed Raytheon as the seventh largest DOD prime contractor in 1986. The U.S. government accounted for 53 percent of Raytheon's total revenue and approximately 50 percent of Raytheon's Semiconductor Division sales in 1986.

Company Organization

Raytheon is engaged in 5 lines of business composed of 9 operating groups and 12 major operating subsidiaries with more than 80 plants and laboratories in 26 states. The Company's nine operating groups are:

- Research and Development
- Engineering
- Various Staff Departments
- Missile Systems Division
- Government Group

Raytheon Company

- Commercial Group (includes Semiconductor Division)
- Appliances Group
- Energy Services Group
- Aircraft Group

Lines of Business

Raytheon reported consolidated revenue for fiscal year ending December 31, 1986, of $7,308 million, an increase of 14 percent compared with $6,409 million in 1985. Net income was $393 million, an increase of 5 percent compared with $376 million in 1985.

Raytheon showed an increase in each of its five lines of business: electronics, aircraft products, energy services, major appliances, and other lines. Defense electronics systems paced the growth in Electronics, which accounted for 59 percent of 1986 revenue. Table 1 shows Raytheon's revenue by lines of business.

Table 1

Raytheon Company
REVENUE BY BUSINESS LINES
(Millions of Dollars)

	Fiscal Year Ending December 31				
	1982	1983	1984	1985	1986
Electronics	$2,952	$3,301	$3,399	$3,794	$4,343
Aircraft Products	568	642	723	743	868
Energy Services	1,124	926	680	651	744
Major Appliances	565	710	797	785	876
Other Lines	304	358	397	436	477
Total	$5,513	$5,937	$5,996	$6,409	$7,308

Source: Raytheon Company Annual Report
Dataquest
October 1987

Raytheon Company

Sales to the government, which have been primarily to the DOD, were $3.9 billion in 1986 and $3.4 billion in 1985, representing 53 percent of total sales in 1986 and 52 percent in 1985. Of these sales, $324 million in 1986 and $282 million in 1985 represent purchases made by the government on behalf of non-U.S. governments.

Raytheon's backlog of orders at December 31, 1986, was almost $7.8 billion compared with approximately $6.5 billion at the end of 1985, as shown in Table 2. The 1986 amount includes funded backlog of $5.4 billion from the U.S. government, compared with $4.5 billion at the end of 1985.

Table 2

Raytheon Company
BACKLOG BY LINES OF BUSINESS
(Millions of Dollars)

	1985	1986
Electronics	$5,345	$6,431
Aircraft Products	758	799
Energy Services	263	374
Major Appliances	24	35
Other Lines	109	127
Total Backlog	$6,499	$7,766
U.S. Government-Funded Backlog Included in Total Backlog	$4,542	$5,448

Source: Raytheon Company Annual Report

International Activities

In 1986, $1,251 million or 17 percent of the total revenue was sold to customers outside the United States, compared with $1,028 million, or 16 percent, in 1985. Raytheon sometimes uses sales representatives and distributors in connection with non-U.S. sales.

Raytheon Company

Facilities

Raytheon's principal facilities occupy approximately 27.6 million square feet. Table 3 shows the locations of Raytheon's semiconductor facilities.

Table 3

Raytheon Company
SEMICONDUCTOR MANUFACTURING FACILITIES*

Location	Size/ Square Feet	Technology/Products
Massachusetts		
Andover	80,000	CMOS-VHSIC, ASIC, radiation hardening capability
Andover	110,000	GaAs MMICs
Lexington	7,500	GaAs-ASIC, MMIC
Lexington	1,500	Research facility
Northborough	3,500	GaAs MESFETs, linear
California		
Mountain View	N/A	Gate arrays
Mountain View	6,000	Discretes and small signal transistors
Mountain View	7,000	Bipolar-linear and ASICs

*Nonsemiconductor facilities are located in Alabama, Arkansas, California, Colorado, Connecticut, Florida, Illinois, Iowa, Kansas, Kentucky, Massachusetts, New Hampshire, New Mexico, New York, Ohio, Oklahoma, Pennsylvania, Rhode Island, South Carolina, Tennessee, Wisconsin, Canada, and Europe.
N/A = Not Available

Source: Dataquest
October 1987

In June 1986, Raytheon began construction on a new 110,000-square-foot monolithic microwave IC (MMIC) facility in Andover, Massachusetts. It will cost $45 million and be located adjacent to Raytheon's VHSIC-level plant.

Capital Spending and R&D Spending

Raytheon's combined capital and research and development (R&D) spending was $600 million in 1986, which accounted for 8.2 percent of revenue. Capital spending for 1986 was $346 million, which was used to add and expand engineering facilities, including those in Rhode Island and Massachusetts. Raytheon also began construction of a $45 million center for the development and production of gallium arsenide monolithic microwave integrated circuits.

Table 4 shows Raytheon's capital and R&D spending.

Table 4

Raytheon Company
CAPITAL AND R&D SPENDING AS A PERCENT OF REVENUE
(Millions of Dollars)

	Fiscal Year Ending December 31				
	1982	1983	1984	1985	1986
Revenue	$5,217	$5,631	$5,996	$6,409	$7,308
Capital Spending	224	254	414	342	346
% of Revenue	4.3	4.5	6.9	5.3	4.7
R&D Spending	170	218	236	260	254
% of Revenue	3.3	3.9	3.9	4.1	3.5
Combined Capital and R&D Spending	394	472	650	602	600
% of Revenue	7.6	8.4	10.8	9.4	8.2
% Increase	(12.4)	19.8	37.7	(7.4)	(0.3)

Source: Raytheon Company Annual Reports
Dataquest
October 1987

Raytheon Company

During 1986, Raytheon's company-sponsored R&D was $254 million, compared with $260 million in 1985. These expenditures were principally for product development for the government and for aircraft products.

In addition to company-sponsored R&D, Raytheon derived net sales of $689.3 million from U.S. government contracts for R&D in 1986. The principal customers of Raytheon's research, development, and engineering capabilities are the U.S. government and other contractors to the government.

Approximately 12,900 employees were actively engaged in research and development at the end of 1986.

PRODUCTS AND MARKETS

Semiconductor Product Markets

The Raytheon Semiconductor Division (SCD) revenue in 1986 was $89 million, a 13 percent increase compared with $79 million in 1985. The division remained profitable throughout the semiconductor market decline partly because it has strong sales to military contractors. Semiconductor sales to the DOD accounted for approximately 50 percent of the SCD's sales in 1986.

The growth of Raytheon's semiconductor business was due to a 34 percent increase in sales of bipolar digital products from $32 million in 1986 to $43 million in 1986, as shown in Table 5. Within the bipolar segment sales of its bipolar logic products increased 83 percent, from $12 million in 1985 to $22 million in 1986. (The industry average growth for bipolar logic products was 14 percent). Memory product sales rose 5 percent from $20 million to $21 million.

SCD offers full military processing of products designed expressly for military/aerospace performance. Government certification allows Raytheon to supply Class B and QPL devices in accordance with the requirements of MIL-STD-38510. Both the older 883B Rev B and updated 883B Rev C standards are available. Raytheon supports MIL-S-19500 with discrete products, and JAN, JANTX, and JANTXV with transistor products. SCD provides devices and also integrates the devices into systems that it supplies to the DOD.

Raytheon Company

Table 5

Raytheon Company
WORLDWIDE SEMICONDUCTOR REVENUE
(Millions of Dollars)

	1982	1983	1984	1985	1986
Total Semiconductor	$52	$65	$95	$79	$89
Total Integrated Circuit	34	44	76	60	72
Bipolar Digital (Technology)	14	14	40	32	43
TTL	14	14	40	32	43
Bipolar Digital (Function)	14	14	40	32	43
Bipolar Digital Memory	6	6	10	20	21
Bipolar Digital Logic	8	8	30	12	22
Linear	20	30	36	28	29
Total Discrete	$18	$21	$19	$19	$17
Transistor	18	19	13	14	16
Small Signal Transistor	17	19	13	14	16
Power Transistor	1	2	-	-	-
Other Discrete	-	-	6	5	1

Source: Dataquest
October 1987

Semiconductor Products and Technologies

Raytheon offered its first gate arrays in 1974 and began offering ECL and CMOS devices in 1987.

Products include linear, ECL and CMOS arrays, standard linear ICs, bipolar programmable read-only memories (PROMs), digital ICs, and small signal transistors. New product developments focus on field and factory programmable products that optimize solutions to customer systems applications.

SCD's key strategies are stated as:

- Semicustom focus for all new technologies
- Radiation hardness development

- Classified manufacturing development
- Continued support of military-specified parts and QPLs
- Development of field-programmable logic devices

To provide cutting-edge technology for its programs, SCD built a Microelectronics Center (MEC) in Andover, Massachusetts, in 1983. The center is used for designing and fabricating CMOS ICs at the VHSIC Phase-I level. It is an 80,000-square-foot semiconductor facility and features 8,500-square-foot class 10 and 8,600-square-foot class 100 clean rooms. The adjacent MMIC facility will produce devices capable of operating as amplifiers at microwave frequencies, and will be used as transmitters and receivers in radar, electronic warfare, and communication equipment and systems that Raytheon produces for defense applications.

Product Lines

Linear ICs

SCD provides a broad range of linear ICs, including data conversion, operational amplifiers, voltage references, voltage regulators, comparators, timers, decoders, and oscillators. In the tradition of linear suppliers, SCD has forged a niche-oriented marketing strategy that targets military as well as high-performance segments of the commercial marketplace. For example, SCD supplies a precision dual op amp for low-end signal conditioning and instrumentation applications. The device offers good DC input specifications and low-noise characteristics for applications that need low offset voltage and low-temperature coefficients. These devices meet both military and commercial specifications, and are available in both plastic and ceramic 8-pin "Mini-DIPs."

A quad-programmable voltage comparator IC is another recent product introduction that reflects SCD's strategy for the military and commercial linear IC marketplace. This product integrates four "139"-type micropower voltage comparators on a single chip. The programmability gives users the ability to control power dissipation through adjustment in the supply current drain. Significant applications include battery-powered circuits, threshold/zero crossing detectors, and digital interface circuits. Power consumption is 10 microwatts per comparator at a power supply voltage of 5 volts and programming current of 0.5 microamp. This product represents SCD's long-term linear IC strategy, which focuses on field and factory programmable applications primarily for the military but also for commercial applications.

A third new product for high-performance military and commercial usage is a high-speed digital-to-analog converter that offers a plus/minus 1.0 percent voltage reference. This device can upgrade designs for the industry standard

AD565. Specific applications range from high-speed display drives and high-speed control systems to analog-to-digital converters for both military and commercial users.

SCD has also been developing controller and switching regulator ICs for power supplies.

Application-Specific ICs

Raytheon introduced its first TTL array in 1974, followed by a 300-gate device in 1978 used in Patriot and Sparrow missiles. In 1982, Raytheon offered bipolar integrated Schottky TTL configurable gate arrays having from 836 to 2,400 gates with 2.3 propagation gate delays.

Today, SCD is penetrating the ASIC market with a five-fold product offering--linear arrays, TTL arrays, ISL arrays, ECL arrays, and CMOS arrays.

At present, its strongest product offering is a new family of ECL arrays that are the result of an agreement with Bipolar Integrated Technology. The new arrays are the CGA40E12 with 8,001 equivalent gates and the CGA70E18 with 12,540 equivalent gates. They are manufactured using BIT1 technology, which features a 2-micron design rule. Power consumption for the arrays is 300 microwatts per gate, which contributes to a speed-power product of less than 0.1 picojoules per gate.

In March 1987, SCD introduced a family of high-performance CMOS gate arrays ranging from 880 to 10,013 equivalent gates and having 1.4ns typical gate delays. Manufactured with an advanced 2-micron dual-layer metal technology and designated as the RL7000, the product family is a second source of LSI Logic's LL7000 series of HCMOS logic arrays, which has eight masterslice options. Raytheon uses LSI Logic's LDS software system to design the arrays, which ensures compatibility of products developed.

The Company also expanded its family of semicustom analog ICs with a new linear array that contains 15 independent gain cells. The RLA160 is a flexible VLSI linear macrocell array that provides the user with the versatility of predesigned programmable analog cells. These cells can be converted into a variety of analog functions such as current sources, voltage references, detector/amplifier circuits, voltage-to-current sources, data conversion circuits, active filter, and timers. The device can replace a printed circuit board with as many as 15 analog devices of 10 transistors each, 240 binarily-weighted thin-film transistors, and a bandgap voltage reference. The RLA160 is manufactured with an advanced, proprietary dual-layer metal bipolar process.

Raytheon's ISL configurable gate array (CGA) family consists of an uncommitted configurable logic array of integrated Schottky logic (ISL) elements and LS TTL-compatible input/output (I/O) buffers.

Bipolar LSI Memory Products

SCD supports a line of from 2K to 64K bipolar PROMs. All devices are available in military and commercial versions and have a power-saving SPROM option. The SPROM features automatic power-down that turns off most of the internal circuitry when the device is not in use, offering a power savings of 70 percent. A new 64K device fabricated with an oxide isolated vertical fuse bipolar process will be offered in the near future.

Mature Product Line

SCD's mature product line includes a logic line and small signal transistors. The market offers the opportunity for suppliers to garner higher ASPs on the mature products as other suppliers abandon the marketplace. Raytheon will continue to make these lines available as long as a sizable demand for them exists.

Semiconductor Agreements

The following is a list of Raytheon's semiconductor agreements.

AMD — In 1975, Raytheon received a license to second-source AMD's 2900 bipolar PROM.

ECD — In 1984, Energy Conversion Devices Inc. (ECD) agreed to an exclusive two-year agreement to license certain proprietary technologies to Raytheon. Raytheon developed prototype semiconductor devices that are based on ECD's amorphous materials techniques.

LSI Logic — In January 1986, LSI Logic and Raytheon Semiconductor announced a five-year agreement that allows Raytheon to act as a second source for the LL7000 Series Logic Array. The arrays use 2-micron HCMOS technology and range up to 10,000 gates. LSI Logic will also provide its proprietary LDS software system.

The agreement provides Raytheon Semiconductor with an immediate market presence in CMOS technology and expands Raytheon's strong position in bipolar arrays.

BIT — In July 1986, SCD and Bipolar Integrated Technology, Inc. (BIT), announced an agreement that gives SCD access to BIT's advanced bipolar BIT1 process. BIT1 is based on emitter-coupled logic (ECL), which is used in a wide range of high-speed computing systems. Raytheon and BIT will also develop a family of ECL gate arrays and standard cell devices for production with the BIT1 process. Raytheon will use its computer-aided design and engineering (CAD/CAE) facilities and BIT will perform wafer fabrication.

TI

In January 1987, Raytheon and Texas Instruments (TI) formed a joint venture to aid in developing and producing large quantities of microwave/millimeter wave monolithic integrated circuit (MIMIC) components for the DOD.

Total funding for this four-phase program, which will run from 1987 to 1992, is planned to be in excess of $135 million. The U.S. Naval Air Systems Command has awarded approximately $1 million to the Raytheon-TI partnership for the Concept Definition Phase, or Zero Phase.

The components will have applications in radar, communications, smart weapons, and electronic warfare systems.

The joint venture allows the companies to share information and tap each others' specialized capabilities. Together, Raytheon and TI's 3-inch wafer fab lines have processed more than 100 MIMIC designs. TI's Defense Systems and Electronics Group will use its new 40,000-square-foot GaAs MIMIC pilot line facility to execute the program.

NJR

In April 1987, Raytheon and New Japan Radio (NJR) revised their technical assistance contract into one based on equal rights and reciprocity. Each must pay license and other fees when it manufactures and markets a product developed by the other, and both will have the right to market the new products worldwide. NJR requested the revision to the agreement, which was established as a joint venture in 1961. Since then, NJR has become technologically independent.

Mosaic Systems

In May 1987, Raytheon made a $1 million investment in Mosaic Systems of Troy, Michigan, through Raytheon Ventures. The investment gave Raytheon an ownership position of approximately 12 percent. Mosaic has developed a patented technique for packaging and programmably interconnecting IC elements. The universally programmable silicon circuit board (UNIPRO SCB) could compete with and, in some applications, replace ceramic substrates.

Raytheon Company

NONSEMICONDUCTOR PRODUCTS SUMMARY

Electronics

Raytheon's electronics business area accounts for 59 percent of the Company's total revenue. Products, excluding semiconductors, include missile systems, surveillance radars, air traffic control systems, military communications equipment, shipboard systems, sonar, electronic countermeasures, and commercial products, including medical and marine equipment.

Aircraft Products

Beech Aircraft Corporation, a wholly owned subsidiary of Raytheon, designs, manufactures, and sells a broad range of single- and twin-engine piston and turboprop aircraft and jet planes for the general aviation market.

Beech is also an aerospace contractor producing a variety of military aircraft and missile targets.

Major Appliances

Raytheon manufactures and sells refrigerators, freezers, central heaters and air conditioners, combination microwave and electric or gas ranges, washing machines and dryers, and other home appliances, through its subsidiaries Amana Refrigeration, Inc., Caloric Corporation, and Speed Queen Company.

Energy Services

Through its subsidiaries, The Badger Company, Inc., United Engineers & Constructors International, Inc., and Seismograph Service Corporation, Raytheon designs, constructs, and maintains petroleum, petrochemical, chemical processing, electrical generating, speciality process, pharmaceutical, biotechnology and industrial plants, and conducts worldwide exploration and related services for the oil and gas industries.

In November 1986, Raytheon's subsidiary, United Engineers and Constructors, acquired the domestic operations of Stearns Catalytic World Corporation. Stearns Catalytic is a leader in the field of power and industrial plant maintenance.

Raytheon Company

Other Lines

A Raytheon subsidiary, Cedarapids, Inc., designs and manufactures a wide range of equipment for the road building and construction industries.

Raytheon Service Company (RayServe) offers worldwide engineering, installation, operation, maintenance, resource recovery, and training services, and supports and maintains other complex military and industrial systems. RayServe also provides maintenance and engineering services for many Raytheon air defense, commercial air traffic control, and marine radar systems.

The D.C. Heath Division of Raytheon publishes school and college text and reference books, educational software, and Caedmon voice recordings.

X

Samsung Semiconductor and Telecommunications Co., Ltd. (SST)

Samsung Semiconductor and Telecommunications Co., Ltd.
150 Taepyung-ro 2-ga,
Jung-gu, Seoul 100, Korea
Telephone: 02-771-78, Telex: K24377
(Millions of Dollars Except Per Share Data)

Balance Sheet (December 31)

	1981	1982	1983	1984	1985
Financial Resources	$34.3	$64.1	$104.3	$385.5	$652.5
Long-Term Liabilities	$25.7	$26.7	$ 56.6	$201.8	$378.3
Shareholders' Equity	$14.3	$25.4	$ 37.7	$ 85.8	$ 90.8
After-Tax Return on Average Equity (%)	22.6	14.4	8.6	12.5	10.5

Operating Performance (December 31)

	1981	1982	1983	1984	1985
Revenue	$68.5	$92.1	$132.0	$216.3	$302.7
Cost of Revenue	$47.1	$68.1	$104.3	$155.9	$224.4
SG&A Expense	$ 5.7	$ 8.0	$ 18.9	$ 27.8	$ 27.9
Pretax Income	$ 2.9	$ 2.7	$ 5.0	$ 12.1	$ 11.9
Net Income	$ 2.9	$ 2.7	$ 2.5	$ 7.3	$ 7.3
Average Shares (Million)	11.4	16.3	26.0	60.0	60.0
Per Share (Won)					
Earnings	174.0	125.0	109.0	141.0	135.5
Dividends	0	0	0	100.0	100.0
Book Value	539.0	1,091.0	1,090.0	1,020.0	1,347.0
Price Average	N/A	N/A	N/A	1,758.0	1,377.0
Total Employees	N/A	N/A	N/A	6,871	8,455
Exchange Rate (W/US$)	700.5	748.8	795.5	827.4	870.0

N/A = Not Available

Source: Samsung Semiconductor and Telecommunications Co., Ltd. Annual Reports

Samsung Semiconductor and Telecommunications Co., Ltd. (SST)

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Samsung Semiconductor and Telecommunications Co., Ltd. (SST)

THE COMPANY

Overview

The Samsung Group was founded in 1938, making it one of the oldest private businesses in Korea. Samsung has grown into a conglomerate of 26 affiliated companies with more than 120,000 employees. Samsung provides such products and services as processed foods, textiles, electronics, heavy industrial products, construction, hotels, insurance, precision instruments, and trading. The Samsung Group's 1985 sales were more than US$14 billion.

The Samsung Group took over the Korea Telecommunications Company (KTC) in 1980. KTC was a wholly owned government corporation established in 1977 to modernize the South Korean communications network. In 1982, the Samsung Group merged its telecommunications operations with another of its subsidiaries, Korea Semiconductor Inc., a manufacturer of CMOS watch chips since 1974. The new entity was renamed Samsung Semiconductor and Telecommunications Company (SST).

SST has three divisions: telecommunications, computers, and semiconductors. SST also maintains an R&D facility and an affiliated group company, Samsung Semiconductor, Inc. (formerly Tristar Semiconductor), located in the United States.

MAIN PRODUCTS

SST's main products include ESS, PAB, telephone sets, key telephones, facsimiles, modems, computers, optical fiber and cables, and semiconductors.

REVENUE BY LINES OF BUSINESS (Millions of U.S. Dollars)

	1981	1982	1983	1984	1985
ESS	$56.6	$69.7	$78.4	$114.0	$150.4
PABX	$ 4.0	$ 6.0	$ 9.1	$ 17.3	$ 12.4
Telephone	-	$ 0.7	$ 5.4	$ 12.0	$ 31.3
Facsimile	-	-	$ 1.6	$ 3.1	$ 5.1
Modem	-	-	$ 0.1	$ 0.4	$ 0.6
Minicomputer	-	-	-	$ 0.8	$ 3.1
Key Telephone	-	-	-	$ 0.8	$ 4.1
Semiconductors	-	$ 4.8	$25.9	$ 60.0	$ 95.0

Samsung Semiconductor and Telecommunications Co., Ltd. (SST)

Capital & R&D Spending

Plant	1983	1984	1985	1986*
Buchon	$15	$ 52	$ 60	$ 30
Suwon	24	108	120	70
R&D	5	16	40	27
Total	$44	$176	$220	$127

*Estimated

WORLDWIDE SEMICONDUCTOR SALES
(Millions of U.S. Dollars)

	1982	1983	1984	1985	1986*
Total semiconductor	$4.8	$25.9	$60.0	$95.0	$170.0
Total IC	$3.7	$14.0	$33.0	$75.0	$144.3
Bipolar digital	-	-	-	-	-
MOS	3.2	9.9	25.0	55.0	117.4
Memory	-	-	3.0	21.0	N/A
Microprocessor	-	-	-	-	-
Logic	3.2	9.9	22.0	34.0	N/A
Linear	0.5	4.1	8.0	20.0	$ 26.9
Total discrete	$1.1	$11.9	$27.0	$20.0	$ 25.7
Total optoelectronic	-	-	-	-	-

*Estimated
N/A = Not Available

Source: Samsung Semiconductor and Telecommunications Co., Ltd. Annual Reports
Dataquest
September 1987

Samsung Semiconductor and Telecommunications Co., Ltd. (SST)

SEMICONDUCTOR DIVISION

General manager: K.H. Kim (senior managing director)

Brief history:

- 1974--established as Korea Semiconductor, Inc.
- 1974--successfully produced LSI for electronic watches
- 1978--started producing linear ICs
- 1978--developed color-signal ICs
- 1983--established U.S. subsidiary in Santa Clara, California
- 1984--completed construction of VLSI plant
- 1984--succeeded in pilot production of the 64K DRAM
- 1984--shipped 64K DRAM sample
- 1984--developed 16K EEPROM and 16K SRAM
- 1984--developed 256K DRAM
- 1985--shipped 256K DRAM samples
- 1985--completed construction of 256K DRAM facility and R&D center
- 1985--developed the 64K SRAM

Products:

- MOS logic--watch chip, calculator chip, HCT/AHCT
- MOS memory--64K DRAM, 256K DRAM, 16K SRAM, 64K SRAM, 16K EEPROM, 64K EEPROM, 16K EPROM, 64K EPROM, 128K EPROM
- MOS MPU--4-bit, 8-bit, and Intel second source
- Linear IC--audio, video, industrial, telecom, and consumer ICs
- Transistors--S/S, power MOSFET, bipolar power
- ASIC--gate array, linear-analog

Samsung Semiconductor and Telecommunications Co., Ltd. (SST)

SEMICONDUCTOR PRODUCTION

	Buchon Plant	Suwon Plant
Address:	82-3, Dodang-dong, Buchon, Kyunggi-do, Korea	San 24, Nongsuh-ri, Kiheung-myun, Yongin-gun, Kyunggi-do, Korea
Manager:	J. S. Won	Y. W. Lee
Date of first production:	December 1974	April 1984
Employees (October 1986)	2,450	1,900

U.S. subsidiary: Samsung Semiconductor, Inc. (SSI), the product development and marketing arm of SST, Korea

President: Dr. Sang Joon Lee

Address: 5150 Great America Parkway, Santa Clara, CA 95054

Telephone: (408) 980-1630

Telex: 339544 KORSEM SNTA

Date established: July 1983

Employees: 201

Investment: $60 million ($30 to $40 million in facilities)

Products: DRAM, SRAM, EPROM, EEPROM, custom, semicustom

Capacity: 10,000 5-inch wafers per month

Design centers for internal product development are located at both the Buchon Plant, Suwon R&D Center, and SSI in the United States. In the spring of 1985, SST established a joint venture agreement with National Semiconductor of the United States to open a design center at the Buchon Plant. This facility designs gate arrays and other semicustom products for National Semiconductor and for customers in Korea. In 1986, the Buchon Design Center was relocated to Seoul.

Employees: approximately 15 at Seoul only

Samsung Semiconductor and Telecommunications Co., Ltd. (SST)

JOINT VENTURES/LICENSING

Partner	Country	Year	Technology
Sharp	Japan	1982	4-bit MPU
DITTI	Germany	1982	CMOS, linear IC, bipolar transistor
Micron Technology	United States	1983	64K, 256K DRAM
Sharp (Japan)	Japan	1983	MOS process
Samsung Semiconductor	United States	1984	16K EEPROM, 64K DRAM, 16K SRAM
DITTI	Germany	1984	CZT process
Samsung Semiconductor	United States	1985	64K SRAM, 256K DRAM, EPROM, EEPROM
Intel	United States	1985	8-bit MPU, MCU
National Semiconductor	United States	1985	Gate array
Zytrex	United States	1985	CMOS standard logic
Intel	United States	1986	EPROM
Ixys	United States	1986	Power MOSFET

Samsung Semiconductor and Telecommunications Co., Ltd. (SST)

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Texas Instruments, Incorporated

Texas Instruments, Incorporated
13500 N. Central Expressway
Dallas, Texas 75265
Telephone: (214) 995-2011
(Millions of Dollars except Per Share Data)

Balance Sheet (December 31)

	1983	1984	1985	1986	1987
Working Capital	$ 221	$ 446	$ 402	$ 668	$ 1,316
Long-Term Debt	$ 225	$ 381	$ 382	$ 191	$ 487
Shareholders' Equity	$1,203	$ 1,541	$ 1,428	$ 1,727	$ 2,246
After-Tax Return on Average Equity (%)	(11.3)	23.0	(8.0)	1.8	15.6

Operating Performance (Fiscal Year Ending December 31)

	1983	1984	1985	1986	1987
Revenue	$4,580	$ 5,742	$ 4,925	$ 4,974	$ 5,595
U.S. Revenue	$3,295	$ 4,087	$ 3,506	$ 3,488	$ 3,829
Non-U.S. Revenue	$1,285	$ 1,655	$ 1,419	$ 1,486	$ 1,766
Cost of Revenue	$3,607	$ 3,823	$ 3,710	$ 3,629	$ 3,955
R&D Expense	$ 301	$ 367	$ 402	$ 406	$ 428
SG&A Expense	$ 901	$ 858	$ 840	$ 827	$ 909
Pretax Income	($ 323)	$ 487	($ 115)	$ 99	$ 415
Pretax Margin (%)	N/A	8.5	N/A	2.0	7.4
Effective Tax Rate (%)	N/A	35.1	N/A	59.6	38.1
Net Income	($ 145)	$ 316	($ 119)	$ 29	$ 309
Average Shares Outstanding (Millions)	71.59	72.63	74.84	75.94	82.02
Per Share					
Earnings	$ 2.03	$ 4.35	($ 1.59)	$ 0.24	$ 3.59
Dividends	$ 0.67	$ 0.67	$ 0.67	$ 0.67	$ 0.71
Book Value	$16.80	$ 21.22	$ 19.08	$ 22.74	$ 27.39
Price Range	$33.67- 58.67	$ 37.25- 49.83	$ 28.75- 43.92	$ 34.25- 49.42	$ 36.25- 80.25
Total Employees	80,696	86,563	77,872	77,270	77,984
Capital Expenditures	$478.0	$ 722.0	$ 515.0	$ 447.0	$ 459.0

N/A = Not Applicable
*Per share amounts and average shares have been retroactively adjusted for the three-for-one stock split in 1987.

Source: Texas Instruments, Incorporated
Annual Reports
Dataquest
June 1988

Texas Instruments, Incorporated

EXECUTIVE SUMMARY

Background

Texas Instruments, Incorporated (TI), was formed in 1951 by Erik Jonsson, Cecil Green, and Patrick Haggerty, having begun as a manufacturing division of Geophysical Service, Inc. TI's involvement in the semiconductor business began in 1952 with the purchase of licenses to manufacture the transistor, invented at Bell Laboratories in 1949. By 1953, TI had become a volume producer of transistors. In only one year, the delivery cost of these devices made inexpensive transistor radios a reality and ushered in the consumer electronics boom. The Company has an impressive record of industry firsts, ranging from invention of the first integrated circuit (IC) to the first hand-held electronic calculator. In addition, TI has been a pioneer in speech synthesis.

In 1985, TI's management underwent a significant restructuring with Jerry Junkins replacing Fred Bucy as president and CEO. Mr. Junkins faced a great challenge: TI suffered a loss of $119 million on sales of nearly $5 billion in 1985. Cost-cutting measures began with the paring of 7,000 employees, the indefinite freezing of wages, capacity consolidations, and the reduction of expenses across the company. Within the semiconductor group, a wafer-processing facility in Houston, Texas, was closed, along with an assembly and test site in El Salvador. TI began reorganizing and reevaluating its position in all of its businesses.

After more than two years under new management, TI has made demonstrable progress. Like many other semiconductor manufacturers, TI did not experience its best year in 1986; however, the company was profitable and began to pull out of the industry slump. Net income for TI's total operation was $29.1 million on sales of $4.974 billion in 1986.

On January 24, 1986, TI filed patent-infringement lawsuits in the Federal District Court in Dallas, Texas, against one Korean and eight Japanese semiconductor firms. TI believed that the dynamic random access memory (DRAM) chips sold in the United States by these companies violated its patents and should have been under a licensing agreement. As a result of out-of-court settlements with the companies named in the lawsuits, TI received royalty payments of $191 million in 1987.

Company Organization

TI, which employs approximately 77,984 people, is composed of four main groups: Semiconductors, Defense Systems and Electronics, Materials and Controls, and Data Systems. The semiconductor group is the largest and most important in the Company. It is jointly headed by William Weber, president of the Semiconductor Group, and Wally Rhines, executive vice president of the Semiconductor Group, in charge of Systems Products. The group is estimated to account for at least one-third of the total work force. TI has leveraged its strength in semiconductors to enter such product markets as calculators, computers, learning aids, terminals, peripherals, and programmable controllers. Areas of emerging importance for TI are artificial intelligence and industrial automation.

FINANCIAL INFORMATION

Texas Instruments' 1987 sales of $5.595 billion represented an increase of 12 percent over 1986 revenue of $4.974 billion. Net income for 1987 jumped from $29 million in 1986 to $309 million. Major factors contributing to improved performance in 1987 include significantly improved profitability in the semiconductor segment, reduced losses in the services segment, and lower depreciation costs. The 1987 results also include royalty income from settlement of DRAM patent litigation.

OPERATIONS

The four organizational groups reflect management structure rather than the operating lines of business shown in Table 1. The Components Segment represents financial grouping and includes semiconductors and other components. Much of the improved profit from operations is attributed to increased profitability in the Components Segment. Although TI's defense electronics segment achieved record net sales billed, profitability remained largely unchanged from 1986. The Semiconductor Segment, or Components Segment, is the largest revenue-generating group in the Company, followed closely by the Defense Electronics Segment, as can be seen from Table 1. Semiconductor revenue grew to $2.125 billion in 1987, an increase of 19.3 percent over 1986.

Table 1

Texas Instruments, Incorporated
Estimated Revenue by Operating Group
(Millions of Dollars)

	Fiscal Year Ending December 31				
	1983	1984	1985	1986	1987
Semiconductor Group	$1,638	$2,484	$1,742	$1,781	$2,125
Digital Products Group	1,109	1,147	1,000	931	891
Defense Electronics Group	1,236	1,417	1,480	1,717	1,979
Materials and Electrical Products Group	460	483	486	464	481
Services Group	440	431	407	259	240
Intracompany Sales	(303)	(220)	(191)	(178)	(121)
Total Revenue	$4,580	$5,742	$4,924	$4,974	$5,595

Source: Texas Instruments, Incorporated
Annual Reports
Dataquest
June 1988

Manufacturing Facilities

Table 2 describes Texas Instruments' manufacturing facilities according to the classification scheme followed by Dataquest's Semiconductor Equipment and Materials Service (SEMS).

Table 2

Texas Instruments, Incorporated
Semiconductor Manufacturing Facilities

Location	Type	Clean Room (Sq. Ft.)	Products	Technology
Dallas	R	18,000	4Mb DRAM	CMOS MOS
Dallas	F	5,000	Internal Opto	Focal Plane Array
Dallas	F	30,000	Logic, ASIC	Bipolar, MOS
Dallas	F	25,000	Linear	CMOS
Dallas	F	30,000	MIL STD, MPUs, AI	Bipolar
Dallas	F	5,000	Logic, 4K Arrays Linear	GaAs, CMOS
Dallas	F	30,000	256K 1Mb DRAM	CMOS
Dallas	F	13,000	1Mb DRAM	CMOS
Dallas	F	10,000	MIL STD	Bipolar
Dallas	F	5,000	Opto	HgCdTe*
Houston	F	20,000	ADV Bipolar	Bipolar
Houston	F	15,000	16K SRAM	Bipolar, BICMOS
Lubbock	F	30,000	EEPROM, 1Mb EPROM, Logic	MOS
Sherman	F	20,000	Logic, MPR	Bipolar TTL
Sherman	F	20,000	ADV Schottky	Bipolar
Bedford, England	F		Discrete, LSI	Discrete, MOS, Opto
Villeneuve-Loubet, France		66,000	Custom LSI	MOS
Freising, West Germany		N/A	Digital Linear	Bipolar Linear
Hatogaya, Japan	F	N/A	32-bit MPU, Logic	MOS
Hatogaya, Japan	F	N/A	Memory	MOS
Hiji, Japan	F	N/A	Bipolar, Logic, Linear, 32-bit Lisp Processor	Bipolar, CMOS
Miho, Japan	F	N/A	256K 1Mb DRAM	MOS
	F	N/A	Dev. 4Mb DRAM	
Miho, Japan	F	N/A	256K DRAM	MOS

R = Semiconductor Research Facility
F = Fab (Front-End Processing)
N/A = Not Available
*Mercuric cadmium telluride

Source: Dataquest
June 1988

Capital Expenditures and R&D Spending

In terms of capital spending, the company's main focus has been on the support of new semiconductor products, specifically new memory and logic products and manufacturing productivity improvement. Capacity additions in 1985 permitted the reduction of capital spending for semiconductors in 1986. Capital spending increased again in 1987. Table 3 provides details of TI's capital spending and R&D spending in semiconductors.

Table 3

Texas Instruments, Incorporated
Semiconductor Spending by Calendar Year
(Millions of Dollars)

	1983	1984	1985	1986	1987
Semiconductor Revenue	$1,638	$2,484	$1,742	$1,781	$2,125
Semiconductor Capital Spending	$ 232	$ 472	$ 281	$ 213	$ 240
Percent of Semiconductor Revenue	14.2%	19.0%	16.1%	12.0%	11.3%
Percent Change in Capital Spending	65.7%	103.4%	(40.5%)	(24.2%)	12.7%
Semiconductor R&D Spending	$ 163	$ 195	$ 214	$ 256	$ 270
Percent of Semiconductor Revenue	10.0%	7.0%	12.3%	14.4%	12.7%
Percent Change in R&D Spending	27.3%	19.6%	9.7%	19.6%	5.5%

Source: Dataquest
June 1988

Texas Instruments, Incorporated

MARKET ANALYSIS

Products and Markets

Texas Instruments participates in all major semiconductor product areas: logic devices, memories, microcomponents, linear circuits, discrete devices, and optoelectronics. TI maintained its number five ranking in the worldwide semiconductor market from 1986 to 1987. Table 4 shows a history of the Company's semiconductor revenue by major product area, and Table 5 describes its market share by product categories and changes in revenue between 1986 and 1987.

Table 4

Texas Instruments, Incorporated
Estimated Worldwide Semiconductor Revenue by Product
1983–1987
(Millions of Dollars)

	1983	1984	1985	1986	1987*
Total Semiconductor	1,638	2,484	1,742	1,781	2,125
Total Integrated Circuit	1,535	2,375	1,653	1,689	2,022
Bipolar Digital (Technology)	667	1,077	796	826	908
TTL	650	1,056	786	814	897
ECL					
Other Bipolar Digital	17	21	10	12	11
Bipolar Digital (Function)	667	1,077	796	826	908
Bipolar Digital Memory	50	70	44	48	54
Bipolar Digital Logic	617	1,007	752	778	854
MOS (Technology)	572	889	522	511	728
NMOS	461	752	428	418	552
PMOS	91	97	46	24	29
CMOS	20	40	48	69	147
MOS (Function)	572	889	522	511	728
MOS Memory	371	670	349	286	405
MOS Micro Devices	135	117	88	92	139
MOS Logic	66	102	85	133	184
Linear	296	409	335	352	386
Total Discrete	48	59	56	58	64
Transistor	45	57	54	58	64
Total Optoelectronic	55	50	33	34	39

*1987 Preliminary

Source: Dataquest
June 1988

Table 5

Texas Instruments, Incorporated
Worldwide Ranking—Semiconductor Markets
(Millions of Dollars)

	1986 Rank	1987 Rank	Revenue % Change 1986-1987	Industry % Change 1986-1987
Total Semiconductor	5	5	19.3%	24.3%
Integrated Circuit	3	4	19.7%	26.8%
Bipolar Digital	1	1	9.9%	9.7%
MOS Digital	8	8	42.5%	36.3%
Linear	5	6	9.7%	18.7%
Discrete	24	24	10.3%	15.9%
Optoelectronic	16	15	14.7%	16.6%

Source: Dataquest
June 1988

International Activities

TI has been a leader in developing international markets. Early on, the Company took steps to penetrate markets outside the United States by establishing factories in regional markets. The fact that more than half of TI's business is outside the United States attests to its success. Table 6 details 1987 semiconductor revenue by geographic region.

Table 6

Texas Instruments, Incorporated
Estimated 1987 Semiconductor Revenues by Geographic Region
(Millions of Dollars)

	United States	Japan	Europe	Rest of World	Total
Total Semiconductor	980	396	525	224	2,125
Integrated Circuit	931	395	480	216	2,022
Bipolar Digital	443	217	180	68	908
MOS	332	92	184	120	728
Linear	156	86	116	28	386
Discrete	28	1	30	5	64
Optoelectronic	21		15	3	39

Source: Dataquest
June 1988

Texas Instruments, Incorporated

Market Positioning

Memories

Texas Instruments has been an industry leader in the memory market for many years. The Company offers memories in TTL, NMOS, and CMOS process technologies. Dataquest estimates that TI sold approximately $405 million in memory products in 1987. TI's biggest portion of market share stems from DRAM products, which are offered in 64K, 256K, and 1-Mbit densities. TI's strategy in the DRAM market is to stay a major manufacturer but not to dominate the market. More important to TI, DRAM products and processes are used as technology drivers for much of the Company's manufacturing and could be considered the backbone of TI's semiconductor products. TI has experienced major difficulties in the DRAM market during the past couple of years as a result of Japanese competition. Nevertheless, although the Company lost market share, it did not choose to leave the market, as did many other U.S. DRAM manufacturers. In fact, with approximately $290 million of the $2.6 billion market, TI ranks as the fourth-largest DRAM producer in the world. Most of this revenue is generated by sales of 256K DRAMs. TI's major competitors in this market segment are Toshiba, NEC, and Hitachi. In order to contend with what TI terms the 1-micron barrier, the Company moved to a CMOS process technology and opted to employ a trench capacitor approach for production of the 1-Mbit DRAM. Currently, the 1-Mbit DRAM is in volume production in Miho, Japan, and in low-volume production in Dallas, Texas.

TI entered the EPROM market in 1976 with a 16K EPROM. The Company currently produces 16K, 32K, 64K, 128K, 256K, and 512K EPROMS, emphasizing both standard and high-performance, high-speed parts. TI's 1987 EPROM sales, estimated at almost $82 million of the $1.2 billion market, made it the seventh-largest EPROM producer last year. EPROMs represent the Company's CMOS process driving force. TI plans to expand this family by adding new devices, including a 1-Mbit part.

Among TI's bipolar products are programmable read-only memories (PROMs), random access memories (RAMs), and first-in first-out memories (FIFOs). TI produces these products mainly for the military in high-performance ECL technology. Earning approximately $54 million in bipolar memory sales in 1987, Texas Instruments was the world's fifth-largest bipolar memory producer in the $640 million market, which is led by Fujitsu and AMD.

TI also has recently reentered the SRAM market with an emphasis on military applications. The Company is in the process of introducing a full line of fast SRAMs with densities ranging from 16K to 256K, with access times varying from 45ns to 25ns. This will put it in competition with other military SRAM suppliers such as Integrated Device Technology and Cypress Semiconductor. Still questionable, however, is when, or even if, TI will enter the fast SRAM commercial market.

Texas Instruments also produces memory modules. The Company was among the first to participate in the SIMM (Single-in-line memory module) market. TI offers 64x4, x5, x8, and x9 SIMMs, as well as 256x4, x8, and x9 SIMMs.

Memories represent a key part of the Company's semiconductor strategy not only as TI's process technology driver but also because they drive excellence in manufacturing. In the last two years, TI has completed two advanced wafer fabrication facilities in Miho, Japan, and Dallas, Texas. From the yield improvement in its Dallas facility, TI's manufacturing yields have brought high-density MOS memory products on a par with the best semiconductor companies in Japan. While DRAMs remain TI's strongest memory interest, new memory products are gaining support. Growing ASIC activity has enabled Texas Instruments to reap the proceeds from a color palette graphics chip, special cache memory chips, and video RAMs. Special-application products such as these represent growth opportunities for the Company.

Microcomponents

For the microcomponent market, TI produces a selection of microprocessors (MPUs), microcontrollers (MCUs), and microperipherals (MPRs), including communications chips and digital signal processors (DSP). Based on projected 1987 Dataquest market share estimates, Texas Instruments garnered $139 million of the approximately $5.0 billion microcomponent market. TI is not considered to be a major participant in the general-purpose microcoprocessor market, and that is by design. TI is targeting application-specific processors so that although the Company has a low profile in MPUs and MCUs, it is the world's largest supplier of digital signal processors.

The first microcontroller introduction for TI was the TMS1000 4-bit MCU, which made TI a dominant supplier. The popular TMS1000 was used in calculators, watches, and other consumer products. The Company was late in introducing its TMS7000 8-bit MCU, however. Because Intel and Motorola already had well established their 8-bit MCU product offerings, TI's 8-bit MCU did not become a dominant factor in the market. Recently, however, TI announced a new product family, the TMS 370 that will target the MCU market with renewed vigor. The family of performance-oriented 8-bit MCUs will offer on-chip options such as EEPROM and an A/D converter. The product family is designated configurable because the modular design methodology used to develop the product permits the customer to configure devices comprising different function modules to address specific application requirements. Although TI is a second source for National Semiconductor's 32000 series of 32-bit microprocessors, it is not considered a major supplier.

In order to become a larger player in the microcomponent area, TI's strategy was to focus on the application-specific processor market, where it has achieved some notable successes. These successes include the following:

- TMS320 product family—Digital signal processors (DSPs)
- TMS340 product family—Graphics processors
- TMS380 product family—Local area networks (LANs)
- TI888 product family—Bit-slice processors

TI's TMS320 DSP family is designed to support a wide range of high-speed or numeric-intensive DSP applications. As stated previously, TI is the world's largest supplier of single-chip digital signal processors, and the Company already has introduced a third generation of compatible DSP devices. TI's DSP revenue is estimated by Dataquest to be approximately $45 million for 1987. In the graphics processing area, a major product is the advanced high-performance CMOS 32-bit coprocessor, the TMS34010. This device has gained market acceptance because of its high level of performance and its general-purpose nature, which allows flexibility. The Company also recognized the importance of providing extensive development support. Several new products will be added this year to extend TI's capability in graphics processing. The LAN adapter chip set, developed jointly with IBM, provides computer, peripherals, and telecommunications equipment manufacturers with a verified chip set for connecting to the IBM Token-Ring LAN. TI's first bit-slice processor was the ECL-TIE100888 8-bit bit-slice; it received popular market acceptance early in 1986, but design-ins tapered off later in the year. TI also offers the 74AS8832, a bipolar 32-bit processor.

Linear

The linear segment is one of the major components of TI's semiconductor product line. TI's linear group started in the early 1970s and has grown to be one of the world's leading suppliers of linear integrated circuits. This product line is one of the broadest in the marketplace, including interface circuits, op amps, regulators, comparators, data converters, and high-voltage power integrated circuits. TI is the fifth-largest linear producer in the world, with estimated sales of $386 million in the almost $6.9 billion market. Of U.S. producers, only National Semiconductor sold more linear products in 1987.

Texas Instruments has seen significant changes occur in the linear marketplace, such as increased analog performance, the growth of digital signal processing, total system solution requirements, the merging of analog and digital on a single chip, and reduced design cycles. The Company's LinASIC library presently contains approximately 30 analog cells in CMOS and 300 digital cells. TI's strategy in this market is to emphasize the development of analog CAD/CAM tools. The advanced linear strategy is focused on addressing the demands of its customers in this rapidly changing market. The data conversion area addresses three primary categories:

- High-precision converters with resolutions of 12 bits and beyond to support DSP requirements
- High-speed flash analog to digital (A/D) converters
- Video digital-to-analog converters (DACs) to support video and graphics solutions

Logic

With an estimated $854 million in bipolar logic revenue in 1987, TI was the leading supplier worldwide, with a market share almost twice the size of its nearest competitor, National Semiconductor. In MOS logic, TI's revenue amounts to approximately $184 million, placing the Company just short of the top 10.

Application-Specific Integrated Circuits

As computer-aided design technology and manufacturing techniques have advanced, standard logic products have increasingly been replaced by application-specific integrated circuits (ASICs) manufactured to meet individual customer specifications. In 1987, ASICs represented a $6.0 billion total available market. TI's revenue of approximately $230 million in ASICs placed it among the top 10 ASIC suppliers worldwide. Presently, TI offers two families of CMOS standard cells. The first family, introduced in 1984, is the 3-micron CircuitCell library featuring approximately 278 cells. The newer cell library is the SystemCell series, which initially comprised about 320 cells. TI is increasing density and performance in VLSI logic, while extending its position in standard logic with the introduction in 1986 of a new family of 1-micron CMOS logic circuits in which the Company has begun implementing customers' designs for gate arrays.

In 1987, TI's combined bipolar and MOS gate array shipments totaled almost $20.0 million, essentially remaining flat over 1986 in a market that grew approximately 28 percent to total $2.2 billion in 1987. Of TI's 1987 revenue, 65 percent was generated from CMOS gate arrays, reflecting a decline in the Company's bipolar revenue for the year due to phasing out of TTL products while ECL is still ramping up. TI uses double-level metal, silicon-gate CMOS technology, a 2.8-micron H series, and a 2.3-micron VH series utilizing automated layout capability with three programming layers.

Texas Instruments is a significant force in the programmable logic device (PLD) market, ranking second only to the formidable combination of AMD/MMI. TI's 1987 revenue was approximately $50.0 million in a total market of $440.0 million. The Company offers bipolar TTL PLDs, CMOS PLDs, ECL PLDS, and advanced architecture arrays.

TI made an important addition to its ASIC capability in July 1987 through a joint venture agreement with Intel. The two companies plan to build a common cell library and common gate array macro library to take advantage of TI's advanced logic and specific-application processor capabilities and of Intel's microcontroller, microprocessor, and peripherals designs. The agreement further stipulates that joint testing, packaging, and design rules will be developed. A compatible 1.0-micron CMOS process will be used to produce ASIC products developed through the agreement.

Business Strategies

Over the past eight years, TI has lost market share in several product areas where it competes, as compared with industry growth rates. This was partly due to some product strategies being tied to in-house systems products and partly due to expensive forays into consumer electronics, that were not always well accepted. However, as considerable restructuring has occurred at TI, the company expects to be better positioned for the future. In its semiconductor operations, TI will address two challenges:

- To compete with well-financed vertically integrated Far East manufacturers in an increasingly global market
- To effectively deal with the boom-and-bust characteristics of the semiconductor market

TI's strategies to meet these challenges are:

- Increase design automation to shorten time to market and to lower costs
- Maintain manufacturing process leadership through focused R&D efforts and aggressive moves into new technologies
- Develop closer relationships with customers
- Penetrate the market in the following five product areas where TI can provide system-level solutions:
  - Application-specific integrated circuits (ASICs)
  - Application processors
  - Advanced linear devices
  - Military semiconductors
  - Very large scale integration (VLSI) logic

The Company predicts that the above five product areas will make up 50 percent of its semiconductor revenue by 1990.

TI has established a new business objective that builds on the synergy between its semiconductor and defense electronics business and expands its military components product offering to include gallium arsenide circuits, very high speed integrated circuits (VHSIC), and high-density power supplies. Research and development capital is also being invested toward a higher level of systems capability in some specific target businesses. The major investments will be in VLSI (very large scale integration), defense electronics, artificial intelligence, and industrial automation technology. TI believes that artificial intelligence and industrial automation can support a much larger business and strengthen the systems capability across the Company. TI has developed an AI-based system that brings advanced technology to training and maintenance and boosts productivity in a wide variety of applications. In early 1987, Texas Instruments announced the development of the first artificial intelligence (AI) microprocessor, which lies at the heart of TI's Compact Lisp Machine, a set of four module boards being developed by the Company under government contract. TI expects the Lisp chip to greatly expand the range of AI applications in both commercial and defense systems.

TECHNOLOGY TRENDS/EMERGING AREAS

One of TI's driving forces for the future is what is termed MegaChip Technologies. Not one chip, process, or service, MegaChip Technologies is rather the culmination of a number of new requirements for creating, manufacturing, and supporting highly sophisticated ICs. Manufacturing MegaChip-class products begins with the latest 1-micron and submicron processing capabilities.

The following are examples of MegaChip-class processes developed and in use at TI:

- EPIC (Enhanced performance implanted CMOS) is an outgrowth of the 1-micron CMOS process developed at TI to support its 1-Mbit dynamic random access memory (DRAM).
- IMPACT-X (Implanted Advanced Composed Technology) is an extension of TI's 2-micron bipolar IMPACT process technology. This process is capable of delivering 10,000+ gates per chip and a speed/power product of less than 0.1 picojoule per gate.
- ExCL is a new advanced ECL (emitter-coupled logic) bipolar process. ExCL reduces the RB parameter through the use of a silicided polysilicon base-contracting layer and shortens the distance between emitter and base to boost switching speed. ExCL is currently used in TI's TGE8000 ECL gate array and will be used for high-density ECL static RAMs in the future. Also in development is a higher-breakdown version intended for the Company's line of programmable logic devices.

TI's AS88XX chipset utilizes both the EPIC and IMPACT-X processes, permitting the optimum technology to be used for each member of the family. Greater focus will be placed on the BICMOS process for such devices as SRAMs, gate arrays, MPUs, and logic in the 1990s. MegaChip-class products utilizing EPIC include TI's high-density memories, application-specific processors for graphics and digital signal processing, and the Explorer Lisp microprocessor. IMPACT-X is also being used in TI's new Advanced CMOS logic (ACL) family.

Texas Instruments continues to invest heavily in automation. To stay at the leading edge of process technology, the Company emphasizes the manufacturing of DRAMs and EPROMs.

ALLIANCES

Nowhere is the change in philosophy at Texas Instruments more in evidence than in the realm of alliances, where previously the Company has not been very active. In order to broaden its product base and increase market share, TI has come to the realization that it cannot go it alone. Consequently, the Company has entered into a number of agreements with other semiconductor vendors and with customers. Table 7 provides a summary of the companies involved, the types of activity, and the products. The first company designation represents either TI or, where applicable, the company providing the product in the agreement. Following the summary table is a short abstract containing more detail about each agreement.

Table 7

Texas Instruments, Incorporated
Summary of Alliances

	Providing* Company	Receiving* Company	Type	Products	Date
1.	TI	Hyundai	C	256K DRAM	08/87
2.	TI	NMB Semiconductor	C	FRAMs	08/87
3.	TI	Intel	JD	ASICs	07/87
4.	TI	Linear Technology	SS	Linear ICs	03/87
5.	TI	Ericsson	JD	ISDN	02/87
6.	TI & Philips	European Silicon Structures.	PT	Cell-based ICs	02/87
7.	TI	Raytheon	JD	MIMIC	02/87
8.	Digital Equipment	TI	SS	MPR	11/86
9.	TI	Philips-Signetics	JD	CMOS Logic	01/86
10.	Signetics	TI	JD	CMOS Logic	02/85
11.	TI	NTT	JD	CMOS process	02/85
12.	TI	National Semiconductor	TE	PLD	01/85
13.	IBM	TI	JD	MPR	09/84
14.	Signetics	TI	JD	Std. cell	09/84
15.	Western Digital	TI	SS	MPRs	06/84
16.	TI	GI	TE	DSP, MCU	05/84
17.	National	TI	TE	MPUs, MPRs	05/84
18.	Fujitsu	TI	SS	Gate arrays	01/84
19.	TI	Mitsubishi	IV	64K EPROM	03/83

FA = Foundry Agreement
JD = Joint Development
MA = Marketing Agreement
PT = Prototyping
SS = Second Source
TE = Technology Exchange
IV = Purchase Resale
C = Contract Award

*Where applicable

(Continued)

Table 7 (Continued)

Texas Instruments, Incorporated
Summary of Alliances

1. TI and Hyundai
   Hyundai will supply TI with 256K DRAMs designed by TI. Under an OEM agreement, Hyundai is expected to supply more than $100 million in 1988.

2. TI and NMB Semiconductor
   NMB will supply TI with TI-designed 1Mb field RAMs (FRAMs). The chip is used in video equipment such as digital TVs and VCRs, as well as copiers, printers, and facsimiles. Initially, NMB is expected to supply 100,000 units per month. TI will manufacture 1Mb versions that use its advanced trench capacitor technology in Miho, Japan, while NMB produces the more conventional planar technology. TI will also add 1Mb production to the 256K production in Dallas.

3. TI and Intel
   TI and Intel announced an agreement to develop a common cell library and common gate array macro library. The agreement may also include provisions for common testing, packaging, and design rules. Both suppliers will develop specifications for compatible CMOS processes that will facilitate alternate sourcing.

4. TI and Linear Technology Corporation (LTC)
   In March 1987, TI and LTC signed a five-year agreement. TI can select six of LTC's circuits every six months for the duration of the agreement. TI will make semiannual $500,000 payments to LTC and also pay royalties on a descending scale for a 10-year period on any LTC circuits that TI produces. This represents part of TI's high-performance linear strategy. As for LTC, this establishes a strong second-source supplier in the high-performance segment of the linear IC market.

5. TI and Ericsson
   TI and Ericsson formed a joint alliance to develop and produce telecommunication components that meet Integrated Services Digital Network (ISDN) standards.

(Continued)

Table 7 (Continued)

Texas Instruments, Incorporated
Summary of Alliances

6. TI, Philips, and European Silicon Structures
Philips and TI concluded an agreement with European Silicon Structures to extend prototyping services for the SystemCell range of CMOS standard cell ASICs. Under the agreement, European Silicon Structures, using E-beam direct-write techniques, will supply European customers with fast, lower-cost prototypes and low-volume quantities in a SystemCell-compatible process.

7. TI and Raytheon
Raytheon and TI formed a joint venture to aid in developing and producing large quantities of microwave/millimeter wave monolithic integrated circuit (MIMIC) components for the U.S. Department of Defense. Total funding for this four-phase program, which will run from 1987 to 1992, is planned to be in excess of $135 million. The components will have applications in radar, communications, smart weapons, and electronic warfare systems. The joint venture allows both companies to share information and tap each other's specialized capabilities.

8. Digital Equipment Corporation and TI
TI was licensed by Digital Equipment as an alternate source for its 78808 octal universal asynchronous receiver transmitter (UART). TI will market the device as its part number TCM78808.

9. TI and Philips-Signetics
TI and Philips-Signetics announced in January 1986 the intention of jointly developing and manufacturing an advanced CMOS logic (ACL) family that is three times faster than high-speed CMOS ICs and provides 24mA of output drive current. Each company has the responsibility to design a specific function in the 1-micron logic family, and it is the intention of the companies to exchange design in order to quickly introduce a new, alternate-sourced product family.

10. Signetics and TI
Joint development of a 1-micron CMOS logic family.

11. TI and NTT
TI and NTT are involved in joint development of a buried-oxide technique for building CMOS devices.

(Continued)

Table 7 (Continued)

Texas Instruments, Incorporated
Summary of Alliances

12. TI and National Semiconductor
National Semiconductor agreed to produce TI's IIFPLA839/840 programmable logic array. In exchange, TI will produce National's ultrafast ECL PAL.

13. IBM and TI
TI and IBM pooled design-automation and verification methodologies to develop a five-chip set that is an adaptor for the token-passing local network devised by IBM.

14. Signetics and TI
TI and Signetics will develop an electronic design interchange format (EDIF). The companies signed an open-ended standard-cell agreement. No money will exchange hands, nor will any technology transfer occur.

15. Western Digital and TI
TI will second-source Western Digital's storage and communication controllers.

16. TI and GI
GI will second-source TI's TMS320 32-bit digital signal processor and TMS 7000 series. TI will transfer design information and product tooling to GI, and GI will develop a CMOS version of the TMS320.

17. National and TI
TI and NSC signed a long-term agreement covering advanced 32-bit MPUs and peripherals. TI acquired the right to manufacture National's high-end Series 32000 MPU family.

18. Fujitsu and TI
TI will second-source Fujitsu's gate arrays, which include B-240, B350, B-600, and B-110 bipolar Schottky TTL arrays in a nonexclusive alternate-source arrangement.

19. TI and Mitsubishi
Sometime prior to March 1983, Mitsubishi supplied both loose dice and packaged 64K EPROMs to Texas Instruments (TI) to be sold through TI's distribution channel and with TI markings. TI would continue to produce its own part at full capacity.

Source: Dataquest
June 1988

Texas Instruments, Incorporated

PRODUCTS

Semiconductor Products

Texas Instruments participates in all major semiconductor product areas, as explained in the "Products and Markets" section of this company profile.

Nonsemiconductor Products

As mentioned earlier in this profile, TI is involved in many businesses besides semiconductors. The following paragraphs present a brief summary of TI's other business activities.

Metallurgical Materials

Includes clad metals, precision-engineered parts, and electronic connectors for use in a variety of applications such as appliances, automobiles, electronic components, and industrial and telecommunications equipment. These metallurgical materials are primarily sold directly to original equipment manufacturers.

Services

Includes collection and processing of seismic data, including employment of three-dimensional seismic technology in connection with petroleum exploration. This data is primarily collected using equipment manufactured by TI. These services are provided to the petroleum industry, including national oil companies. During the fourth quarter of 1987, TI and Halliburton signed a letter of intent whereby Halliburton will purchase a 60 percent interest in Geophysical Service Inc. (GSI), with provisions for possible complete ownership within a few years. GSI had been making losses for the past four years.

Defense Systems and Electronics

Products from this group are widely diversified within the government electronics business segment. The complex defense systems and equipment designed, developed, and produced by this group include missile systems, tactical weapons, and electro-optics systems. TI's Defense Systems and Electronics group is also at the forefront of applying advanced technologies such as VHSIC, artificial intelligence, gallium arsenide, microprocessors, and sensors to meet the expanding needs of the defense community.

As a leader in radar systems, TI is developing and producing terrain-following/terrain-avoidance radar systems for the newest and most advanced aircraft in the military inventory. Also in development are ocean search and surveillance radars and magnetic anomoly detection systems for both carrier-based and land-based fixed-wing aircraft and helicopters. TI has been awarded contracts in the HARM, ASW radar, and LANTIRN projects, as well as in classified projects.

Texas Instruments, Incorporated

Data Systems

This category includes the manufacturing and making of extensive array and commercial computing products worldwide. The group's three product divisions are as follows:

- Advanced Systems Division
- Computer Systems Division
- Peripheral Products Division

The Advanced Systems Division (ADS) is focusing on the artificial intelligence technologies developed at TI. ASD is responsible for TI's widely acclaimed Explorer Lisp workstation, as well as software packages that allow personal computers to solve increasingly complex problems and emulate human reasoning. This division also has introduced speech and natural language products to make computers easier to use. Products of the Advanced Systems Division include:

- The Explorer
- Personal Consultant expert system development tool
- TI-Speech hardware and software
- Arborist and NaturalLink software

In a recent development, the Data Systems Group announced the new microExplorer computer system. Under an agreement with Apple Computer, TI will purchase Macintosh II PCs from Apple and incorporate a specially developed coprocessor board based on the Explorer Lisp microprocessor and its advanced software environment.

The Computer Systems Division offers a cohesive, expandable product line that provides business computing solutions for 1 to 128 users. Products of the Computer Systems Division include:

- TI Professional Computer
- Business-Pro Computer
- Business Systems 100, 300, 600, 800, and 1,000

Texas Instruments, Incorporated

The Peripheral Products Division offers a wide range of printers and terminals. TI's first patented thermal printing data terminal was introduced in 1969. Today, the silent 700 is a leader in the market pioneered by that technology. Products of the Peripheral Products Division include:

- PC Printers
- Systems Printers
- Portable Data Terminals

Toshiba Corporation

Toshiba Corporation
1-1 Shibaura 1-chome
Minato-Ku, Tokyo 105, Japan
Telephone: 03-457-4511 Telex: J22587
(Billions of Yen Except Per Share Data)

Balance Sheet (March 31)

	1983	1984	1985	1986	1987
Working Capital	¥ 132	¥ 116	¥ 186	¥ 102	¥ 135
Long-Term Debt	¥ 247	¥ 339	¥ 457	¥ 469	¥ 525
Shareholders' Equity	¥ 422	¥ 465	¥ 548	¥ 567	¥ 593
After-Tax Return on Average Equity (%)	9.2	13.3	17.0	10.6	5.9

Operating Performance (Fiscal Year Ending March 31)

	1983	1984	1985	1986	1987
Revenue	¥ 2,401	¥ 2,707	¥ 3,343	¥ 3,373	¥ 3,308
Japanese Revenue	¥ 1,787	¥ 1,968	¥ 2,297	¥ 2,319	¥ 2,287
Non-Japanese Revenue	¥ 614	¥ 739	¥ 1,046	¥ 1,054	¥ 1,021
Cost of Sales	¥ 1,715	¥ 1,931	¥ 2,389	¥ 2,444	¥ 2,429
R&D Expense	¥ 119	¥ 141	¥ 175	¥ 190	¥ 201
SG&A Expense	¥ 587	¥ 651	¥ 770	¥ 807	¥ 827
Pretax Income	¥ 107	¥ 135	¥ 186	¥ 131	¥ 78
Pretax Margin (%)	4.5	5.0	5.6	3.9	2.4
Effective Tax Rate (%)	58.3	56.3	53.8	54.1	57.6
Net Income	¥ 38	¥ 59	¥ 86	¥ 59	¥ 34
Average Shares Outstanding (Millions)	2,478	2,559	2,652	2,674	2,704
Per Share					
Earnings	¥ 14.8	¥ 22.5	¥ 29.6	¥ 19.2	¥ 11.9
Dividends	¥ 6.7	¥ 7.3	¥ 8.0	¥ 8.0	¥ 8.0
Book Value	¥170.30	¥181.71	¥206.64	¥211.88	¥219.28
Total Employees	103,000	105,000	114,000	120,000	121,000
Capital Expenditure	¥ 131	¥ 171	¥ 274	¥ 288	¥ 204
Exchange Rate (Yen per US$)	249	236	245	221	160

Source: Toshiba Annual Reports
Dataquest
October 1988

Toshiba Corporation

Toshiba Corporation
1-1 Shibaura 1-chome
Minato-Ku, Tokyo 105, Japan
Telephone: 03-457-4511 Telex: J22587
(Millions of Dollars Except Per Share Data)

Balance Sheet (March 31)

	1983	1984	1985	1986	1987
Working Capital	$ 530	$ 492	$ 759	$ 462	$ 844
Long-Term Debt	$ 992	$ 1,436	$ 1,865	$ 2,122	$ 3,281
Shareholders' Equity	$1,695	$ 1,970	$ 2,237	$ 2,566	$ 3,706
After-Tax Return on Average Equity (%)	9.2	12.7	15.7	10.5	5.9

Operating Performance (Fiscal Year Ending March 31)

	1983	1984	1985	1986	1987
Revenue	$9,643	$11,470	$13,645	$15,262	$20,675
Japanese Revenue	$7,177	$ 8,339	$ 9,376	$10,493	$14,294
Non-Japanese Revenue	$2,466	$ 3,131	$ 4,269	$ 4,769	$ 6,381
Cost of Sales	$6,888	$ 8,182	$ 9,751	$11,059	$15,181
R&D Expense	$ 478	$ 597	$ 714	$ 860	$ 1,256
SG&A Expense	$2,357	$ 2,758	$ 3,143	$ 3,652	$ 5,169
Pretax Income	$ 430	$ 572	$ 759	$ 593	$ 488
Pretax Margin (%)	4.0	4.8	5.4	3.7	2.4
Effective Tax Rate (%)	58.3	56.3	53.8	54.1	57.6
Net Income	$ 153	$ 250	$ 351	$ 267	$ 213
Average Shares Outstanding (Millions)	2,478	2,559	2,652	2,674	2,704
Per Share					
Earnings	$ 0.06	$ 0.10	$ 0.12	$ 0.09	$ 0.07
Dividends	$ 0.03	$ 0.03	$ 0.03	$ 0.04	$ 0.05
Book Value	$ 0.68	$ 0.77	$ 0.84	$ 0.96	$ 1.37
Total Employees	103,000	105,000	114,000	120,000	121,000
Capital Expenditures	$ 526	$ 725	$ 1,118	$ 1,303	$ 1,275
Exchange Rate (Yen per US$)	249	236	245	221	160

Source: Toshiba Annual Reports
Dataquest
October 1988

Toshiba Corporation

THE COMPANY

Background

Toshiba Corporation was founded as Tanaka Seizo-sho in 1875 and was renamed Shibaura Engineering Works in 1893. In 1939, the Company merged with Tokyo Electrical Company (founded in 1890 as Hakunetsu-sha) and became Tokyo Shibaura Electric Co., Ltd. In 1978, the Company's English name was changed to Toshiba Corporation.

Toshiba is one of two leaders of the Toshiba-IHI Group; the other is Ishikawajima-Harima Heavy Industries (IHI). These parent companies have close capital and business connections. Their subsidiaries are engaged in electrical and electronics products, construction, trading and finance, and shipbuilding.

Toshiba has developed the concept of Electronics and Energy (E&E) as its corporate hallmark. In addition to being a leader in the electronics field, the Company holds 40 percent of the Japanese thermal power plant market and 30 percent of Japan's hydroelectric plant market. Toshiba hopes to integrate E&E by adopting new technologies that are synergistic. Some examples are the increasing use of electronics in color televisions, VCRs, and refrigerators that will lead to more power-efficient products that also consume less energy. As a complement to E&E, the Company has implemented a company-wide program called "Project I"; the "I" stands for the three central concepts of Information, Integration, and Intelligence.

Toshiba is targeting AI technologies, next-generation computers, and software as areas of especially high growth.

Highlights

Company highlights include the following:

- Toshiba reported revenue of ¥3,308 billion for fiscal 1987, down 2 percent from 1986.
- Toshiba is the the third-largest electronics manufacturer in Japan (after Matsushita and Hitachi), and the tenth-largest worldwide.
- Toshiba remained the second-largest worldwide semiconductor supplier in 1987, with revenue of $3,002 million.
- Toshiba remained the second-largest semiconductor supplier in Japan, with revenue of $1,859 million.

Toshiba Corporation

- Toshiba continues to make substantial semiconductor capital investments, as well as research and development investment.

- Toshiba has had many firsts in its history including development of Japan's first radar system in 1942, production of Japan's first digital computer in 1954, manufacture of Japan's first transistor radio in 1957, the first transistorized television set in 1960, and first microwave oven also in 1960.

In 1978, Toshiba invented electron-beam lithography to produce LSI ICs. In the 1980s, Toshiba developed the world's first GaAs gate array LSI, the world's first commercial 1Mb DRAM, and the world's first prototype 4Mb DRAM.

Investment in the Company

Toshiba's major shareholders are listed in Table 1.

Table 1

Toshiba Corporation
Major Shareholders

Shareholders	Percent of Shares
Dai-ichi Mutual Life Insurance Company	4.8%
Nippon Life Insurance Company	3.7%
Mitsui Bank, Limited	3.4%
Mitsui Mutual Life Insurance Company	2.4%
Mitsui Trust & Banking Co., Ltd.	2.3%
Sumitomo Trust	2.1%
Nippon Fire & Marine Insurance Company, Limited	2.1%
Long-Term Credit Bank of Japan, Limited	2.0%

Source: Toshiba Corporation
Annual Reports

Toshiba is listed on three Japanese stock exchanges, as well as on the Amsterdam, Basel, Dusseldorf, Frankfurt, Geneva, London, Luxembourg, Paris, and Zurich exchanges. Major short- and long-term borrowings are from Mitsui Bank, Tokai Bank, and Sumitomo Bank. Total foreign stock ownership is 5.8 percent.

Toshiba Corporation

Operations

Toshiba reported revenue of ¥3,308 billion for the year ended March 31, 1987, a 2 percent decrease from the previous year. Earnings declined dramatically, down 42 percent from the previous year to ¥34 billion. The Company attributed the decreases to slow economic growth in the United States, the continuing rise in the value of the yen, and intensified trade friction.

Toshiba's business operations are divided into the following five product areas:

- Electronic components
- Consumer products
- Heavy electrical apparatus
- Industrial electronics
- Materials, machinery, and other products

Revenue by product area is shown in Table 2. (For purposes of public financial reporting, the Company combines the Industrial Electronics and Electronic Components groups.)

Table 2

Toshiba Corporation
Revenue By Product Area
(Billions of Yen)

	Fiscal Year Ending March 31				
	1983	1984	1985	1986	1987
Consumer Products	¥ 715	¥ 790	¥ 904	¥1,044	¥ 941
Heavy Electrical Apparatus	689	724	965	866	868
Industrial Electronics and Electronic Components	725	907	1,151	1,128	1,183
Material, Machinery, and Products	272	286	323	335	316
Total	¥2,401	¥2,707	¥3,343	¥3,373	¥3,308
Exchange Rate (Yen per US$)	249	236	245	221	160

Source: Toshiba Annual Reports
Dataquest
October 1988

Toshiba Corporation

INTERNATIONAL ACTIVITIES

Toshiba's overseas sales decreased about 3 percent during fiscal 1987 to ¥1,021 billion, representing 31 percent of the Company's revenue. Appreciation of the yen and the increasing trade friction presented international challenges for Toshiba in 1985, 1986, and 1987. Toshiba has taken the following measures for its long-term growth:

- Expanded offshore production
- Entered into joint ventures for overseas production
- Entered into international cooperative programs

In early 1987, Toshiba agreed to provide the People's Republic of China (PRC) with assembly technology for color television LSIs. It will supply the necessary equipment to the Jiangnan semiconductor device factory in Wuxi.

Distribution

Toshiba's major distributors in Japan are Toshiba Electron Device, Midoriya Electric, Tokyo Shuma, and Kenden Kogyo.

In the United States, Toshiba's products are sold by Toshiba America Ltd., headquartered in Tustin, California. Toshiba's products are also available through several U.S. distributors.

Toshiba has sales offices throughout Europe and also sells through European distributors.

Facilities

Toshiba's semiconductor facilities are listed in Table 3.

Table 3

Toshiba Corporation
Semiconductor Plant Locations

Location	Floor Space (square meters)	Functions/Products
Buzen Toshiba Electronics	N/A	Fab, Assembly, Test—Optoelectronics
Hamaoka Denshi Buhin	N/A	Assembly
Himeji Factory	242,413	Fab, Assembly, Test—Discretes
Iwate Toshiba Electronics	23,000	Assembly—Linear, Discretes
Iwate Toshiba Electronics Kitakami	40,000	Fab, Assembly, Test—MOS
Kitakyushu Factory	54,559	Fab, Assembly, Test—Linear
Kitsuki Factory	8,300	Assembly—Bipolar, MOS
Micro Technology Laboratory	N/A	Fab, Test—Bipolar, MOS
Micro-Electronics Center	68,334	Fab, Test—Bipolar, MOS
Nohgata Toshiba Electronics	5,000	Fab, Assembly, Test
Oita Factory	67,755	Fab, Assembly, Test
Toshiba Components	N/A	Assembly—Discretes
Kaga Toshiba Electronics	N/A	Assembly, Test—Discretes
Korea Electronics*	N/A	Assembly, Test—ICs, Discretes, Opto
Toshiba Electronics Malaysia	N/A	Assembly, Test—ICs, Discretes
Industria Mexicana Toshiba	N/A	Assembly, Test—ICs, Discretes
Toshiba Semiconductor (USA)	N/A	Assembly—MOS Memory
Toshiba Semiconductor GmbH	3,000	Assembly, Test—MOS

*Joint Venture
N/A = Not Available

Source: Dataquest
October 1988

Capital and R&D Spending

Capital investments, which totaled ¥204 billion for fiscal 1987, were down 21.0 percent from 1986 due to the severe downturn in the semiconductor industry. Research and development (R&D) expense increased slightly, to 6.1 percent of total sales.

Tables 4 and 5 show Toshiba's 1987 capital and R&D spending in yen and dollars.

Table 4

Toshiba Corporation
Capital and R&D Spending as a Percent of Revenue
(Billions of Yen)

Fiscal Year Ending March 31	1983	1984	1985	1986	1987
Revenue	¥2,401	¥2,707	¥3,343	¥3,373	¥3,308
Capital Spending	131	171	274	288	204
% of Revenue	5.5%	6.3%	8.2%	8.5%	6.2%
R&D Spending	119	141	175	190	201
% of Revenue	5.0%	5.2%	5.2%	5.6%	6.1%
Combined Capital and R&D Spending	250	312	449	478	405
% of Revenue	10.4%	11.5%	13.4%	14.1%	12.3%
% Increase	13.0%	25.0%	42.0%	0.6%	(15.3%)

Source: Toshiba Corporation
Annual Reports
Dataquest
October 1988

Table 5

Toshiba Corporation
Capital Spending and R&D Spending in Dollars
(Millions of Dollars)

	Fiscal Year Ending March 31				
	1983	1984	1985	1986	1987
Revenue	$9,643	$11,470	$13,645	$15,262	$20,675
Capital Expenditures	526	725	1,118	1,303	1,275
R&D Expenditures	478	597	714	860	1,256
Exchange Rate (Yen per US$)	249	236	245	221	160

Source: Toshiba Corporation
Dataquest
October 1988

Toshiba Corporation

Table 6 shows Toshiba's semiconductor capital spending.

Table 6

Toshiba Corporation
Semiconductor Capital Spending By Calendar Year
(Millions of Dollars)

	1983	1984	1985	1986	1987
Semiconductor Revenue	$983	$1,561	$1,468	$2,261	$3,002
Semiconductor Capital Spending	366	574	517	389	325
% of Semiconductor Revenue	37%	37%	35%	17%	11%

Source: Dataquest
October 1988

Toshiba believes that "technology is the driving force of corporate development," and thus the Company has been intensifying its R&D efforts. R&D emphasis is on semiconductors, factory automation, and new materials.

Semiconductor R&D is conducted in Kawasaki, Kanagawa Prefecture, in a Research and Development Center. Toshiba also has seven development laboratories—five in Kawasaki; one in Otawara, Tochigi Prefecture; and one in Yokohama, Kanagawa Prefecture.

Toshiba has developed a plan to promote basic research to create new business in the 21st century. As a first step, in April 1988 the Company established an Advanced Research Laboratory within its Research and Development Center in Kawasaki. At the same time, its VLSI Research Laboratory became independent of the Research and Development Center, upgrading and changing its name to ULSI Research Laboratory. The Company plans to invite foreign researchers to the new laboratory.

In January 1986, a Toshiba R&D scientist, Dr. Yoshio Nishi, undertook the direction of Hewlett-Packard's VLSI Research Laboratory in Palo Alto, California. This is part of a continuing program between the two companies, which have exchanged about six researchers over the past five years. Dataquest believes that this assignment will not only help Hewlett-Packard to design 1Mb DRAMs into its new computer products, but will also give Toshiba valuable computer technology and contacts with IC researchers at Stanford University and Hewlett-Packard.

Toshiba Corporation

PRODUCTS AND MARKETS

Semiconductor Product Markets

The Company remained the second-largest worldwide semiconductor supplier in 1987. The Company's calendar 1987 worldwide semiconductor revenue was $3,002 million, a 32 percent increase over 1986 revenue of $2,281 million. Toshiba is also the second-largest supplier to the Japanese semiconductor market with revenue of $1,859 million.

A few of Toshiba's highlights in the semiconductor market are as follows:

- Toshiba's 1987 total MOS revenue increased 41 percent to $1,566 million.
- CMOS revenue increased 45 percent in 1987 to reach $1,033 million.
- MOS logic sales were approximately $652 million, an increase of 36 percent.
- MOS microcomponent revenue was an estimated $283 million, an increase of 57 percent.
- MOS logic devices sales are estimated at $631 million, an increase of 39 percent.

Table 7 shows Toshiba's worldwide semiconductor revenue by product. Table 8 shows Toshiba's worldwide semiconductor ranking. In addition to MOS devices, Toshiba is a leader in linear, discrete, and optoelectronic devices.

Table 7

Toshiba Corporation
Estimated Calendar Worldwide Semiconductor Revenue
(Millions of Dollars)

	1983	1984	1985	1986	1987
Total Semiconductor	983	1,561	1,468	2,281	3,002
Total Integrated Circuit	613	1,035	1,004	1,616	2,167
Bipolar Digital (Technology)	21	37	33	129	125
TTL		30			
ECL		6			
Other Bipolar Digital		1	33	129	125
Bipolar Digital (Function)	21	37	33	129	125
Bipolar Digital Memory					
Bipolar Digital Logic	21	37	33	129	125
MOS (Technology)	458	770	736	1,114	1,566
NMOS	165	230	181	404	533
PMOS	21	2	1		
CMOS	272	538	554	710	1,033
MOS (Function)	458	770	736	1,114	1,566
MOS Memory	221	396	297	479	652
MOS Micro Devices	45	70	69	180	283
MOS Logic	192	304	370	455	631
Linear	134	228	235	373	476
Total Discrete	272	418	368	556	703
Transistor	133	200	173	325	418
Small-Signal Transistor		87	70		
Power Transistor		113	103		
Diode	106	163	142	179	211
Small-Signal Diode		90	50		
Power Diode		53	84		
Zener Diode		20	8		
Thyristor	19	30	51	50	65
Other Discrete	14	25	2	2	9
Total Optoelectronic	98	108	96	109	132
LED Lamps		25	18		
LED Displays		10	21		
Optical Couplers			35		
Other Optoelectronics		73	22		
Exchange Rate (Yen/US$)	235	237	238	167	144

Source: Dataquest
October 1988

Toshiba Corporation

Table 8

Toshiba Corporation
Worldwide Ranking by Semiconductor Markets
(Revenue in Millions of Dollars)

	1986 Rank	1987 Rank	1987 Revenue	Revenue % Change 1986-1987	Industry % Change 1986-1987
Total Semiconductor	2	2	$3,002	32%	23%
Total IC	4	2	2,167	35%	26%
Bipolar Digital	10	10	125	(3%)	8%
MOS Digital	3	2	1,566	41%	35%
MOS Logic	2	1	631	39%	31%
MOS Memory	4	3	652	36%	35%
MOS Micros	6	5	283	57%	40%
Linear	3	3	476	28%	19%
Total Discrete	2	1	703	26%	13%
Total Optoelectronics	5	5	132	21%	16%

Source: Dataquest
October 1988

Dataquest estimates that approximately 38 percent of Toshiba's semiconductor sales are overseas, an increase of 5 percent from 1985. Approximately 16 percent of sales are to the United States, 16 percent to ROW, and 6 percent to Europe. The remaining 62 percent originates in Japan as shown in Table 9. Table 10 shows Toshiba's regional growth from 1986 to 1987.

Toshiba Corporation

Table 9

Toshiba Corporation
Estimated Semiconductor Revenue by Geographic Region—1987
(Millions of Dollars)

	U.S.	Japan	Europe	ROW	World
Total Semiconductor	474	1,859	191	478	3,002
Total Integrated Circuit	395	1,297	145	330	2,167
Bipolar Digital	3	117	2	3	125
MOS	381	833	126	226	1,566
Linear	11	347	17	101	476
Total Discrete	68	487	33	115	703
Total Optoelectronic	11	75	13	33	132

Source: Dataquest
October 1988

Table 10

Toshiba Corporation
Regional Growth in the Semiconductor Market—1986 to 1987
(Millions of Dollars)

	1986	1987	Change
Total Semiconductor	$2,276	$3,002	32%
Japan	1,572	1,859	18%
Total Overseas	704	1,143	62%
United States	294	474	61%
Europe	110	191	74%
ROW	300	478	59%

Source: Dataquest
October 1988

Toshiba Corporation

Semiconductor Products and Technologies

Toshiba supplies a broad range of semiconductors, including bipolar digital, MOS, and linear ICs; discretes; and optoelectronics. The Company's predominant technology is MOS, particularly CMOS, an area in which it is the world leader.

The following are a few of Toshiba's highlights:

- In November 1987, National settled its copyright dispute with Toshiba. At issue was whether Toshiba copied National's UART chips. Under an agreement, National will not press its copyright claim. Toshiba will buy UARTs from National for internal use and will sell them in Japan to help National increase its market share in Japan. Toshiba will also supply National with some of its chip packaging technology.
- Toshiba is producing 2 million units of BICMOS chips at its Kyushu plant. Devices being produced are display-driving ICs, electronic camera-controlling ICs, and control circuits for office automation.
- In mid-1987, Toshiba completed a Semiconductor System Technology Center in the Technopia Bloc in Kawasaki, Kanagawa Prefecture. The center will become the nucleus of the Company's 10 LSI design centers at home and abroad.

ASICS

In November 1987, Toshiba, GE Solid State, and Siemens completed the first cell-based ICs designed with the ADVANCELL ASIC library, a library jointly developed by the companies. The library currently comprises 160 logic cells, 50 I/O cells, and 8 macrocells. All partners are providing additional support to customers in the form of existing libraries that are fully compatible with ADVANCELL ASICs.

In December 1987, Toshiba offered its Super Integration (SI) custom megacell circuits to the U.S. market. The megacell library includes all Z80-type family components, a range of 82CXX megacells, and system peripherals.

In May 1988, Toshiba announced the TC24SC series of cell-based ICs using 1.0-micron design rule technology. The new cells use the ADVANCELL developed by Toshiba, Siemens, and GE.

Toshiba Corporation

In March 1988, Toshiba introduced the TC210G series of gate arrays that use a 1.0-micron CMOS process. The series consists of five master arrays with gate complexities ranging from 37,392 to 129,042 raw gates.

Memory

In early 1988, Toshiba announced that it had developed a CMOS 16Mb DRAM with an access time of 70ns.

In January 1988, IBM Japan, Ltd. began purchasing 1Mb DRAMs from Toshiba. The DRAMs are used for IBM computers, including the 3090 and the PS/2 series.

In October 1987, Toshiba's VLSI Research Center introduced a 6,000-gate GaAs gate array. The array uses a conventional SCFL structure to implement 232 rows by 26 columns of cells. A test structure, with serial-parallel-serial registers occupying 80 percent of the die, consumes 952 mW when operated at an 850-MHz data rate.

In November 1987, Toshiba introduced the TC532000P, a 2Mb CMOS ROM with an access time of 200ns. The ROM, configured 256Kx8, dissipates operating current of 30 mA and standby current of 20 µA. Operating temperature range is –40 to +85 °C. Applications include application program storage for high-volume MPU-based products.

In December 1987, Toshiba offered the TMM24512P—a 512K OTP EPROM organized 64Kx8 that features access time of 250ns.

In May 1988, Toshiba introduced the TC551001, a high-density, low-power 1Mb SRAM organized 128Kx8. The device is available in either a 32-pin, 600-mil plastic dual in-line package or a 450-mil SOIC package. The SRAM can be used in main or buffer memory or can be used in battery-backup designs such as memory cards.

In April 1988, Toshiba introduced the TC55416P/J and TC55417P 64K CMOS SRAMs with access times as low as 20ns and surface-mount packaging for high density. Applications include superminicomputer memory and real-time processor cache memory.

In April 1988, Toshiba introduced the TMM2088P and TMM2989P NMOS SRAMs featuring access times as fast as 35ns, low power dissipation, and a byte or byte-plus-one organization. The TMM2088P is designed for use in cache memory, writeable control store, and high-speed buffers. The TMM2089P with its 9-bit organization is most suited for memory systems with a parity bit or cache memory with ECC.

Toshiba Corporation

In November 1987, Toshiba sampled a 4Mb DRAM. Engineering samples began in the first quarter of 1988, followed by customer sampling in the second quarter and full production in the third quarter. The initial device was a 0.9-micron prototype, followed by a 0.8-micron version in the first quarter of 1988 and a 0.7-micron version in early 1989.

In October 1987, Toshiba offered the TC524256 and TC524527 CMOS 1Mb video RAMs organized 256Kx4. Access time is 100ns or 120ns.

Optoelectronics

Toshiba announced plans to market a visible-light-emitting semiconductor laser designed for bar code readers in supermarkets. The TOLD 9200 uses 85 milliamperes for continuous-wave operation and has a light output of 3 mW. Its laser life is estimated at 10,000 hours.

Toshiba announced that it has manufactured, on an experimental basis, a CCD with 2 million picture elements. By using the most advanced submicron technology, it has successfully integrated 1,989,120 (1,920 x 1,036) picture elements on a single chip. The Company plans to use the CCD in high-density televisions. CCDs are one of the most important products in Toshiba's semiconductor business for fiscal 1988.

Process

In December 1987, Toshiba announced it has developed a 0.8-micron BICMOS design-rule process. The 0.8-micron design rule has typical propagation time of 0.3ns. Toshiba plans to use the process for its next-generation high-speed memories, ASICs, and MPUs.

Semiconductor Agreements

Toshiba has been involved in numerous licensing agreements and joint ventures, as discussed in the following paragraphs.

Aida Corporation

In June 1987, Toshiba agreed to license its TC17G gate array library models to Aida Corporation. Toshiba gains access to Aida's semicustom IC design equipment.

Toshiba Corporation

Brooktree

In 1985, Toshiba and Brooktree signed a royalty-bearing licensing agreement to use Brooktree technology for consumer digital audio applications.

General Electric

In August 1986, Toshiba, GE Solid State, and Siemens agreed to a five-year joint development project to develop a cell-based library based on 1.5-micron CMOS technology, later to be shrunk to 1.0-micron and beyond. It is said to be the first international agreement on cell-based ICs involving major semiconductor manufacturers.

Hewlett-Packard

In 1985, Toshiba assigned Dr. Yoshio Nishi, manager of its 1Mb DRAM team, to head Hewlett-Packard's VLSI Research Center for three years.

Intel

In March 1986, Intel contracted with Toshiba to produce and sell two types of Multibus II-compatible interface IC models.

KEC

In 1984, Toshiba signed a five-year technical assistance agreement with Korean Electronics Company (KEC). Toshiba supplied KEC with technical documents on linear IC design and production, provided consulting services to KEC, and helped to train KEC engineers.

LSI Logic

In 1981, Toshiba and LSI Logic jointly developed a family of 1,000- to 10,000-gate CMOS arrays. Toshiba supplied HCMOS wafers; LSI Logic provided gate array designs. The effort resulted in a 6,000-gate array with SRAM on-chip in December.

In 1983, Toshiba and LSI Logic jointly developed a channelless compacted array.

In 1985, LSI Logic and Toshiba agreed to a four-year joint venture to develop a 50,000-gate sea-of-gates array using 1.5-micron design rules, Toshiba's process, and LSI Logic's simulation and software.

Toshiba Corporation

Mitsui & Company

In November 1987, Toshiba and Mitsui formed a joint venture to develop the Bangkadi Industrial Park near Bangkok, Thailand. Toshiba's three Thai subsidiaries will have a 51 percent interest in the venture, with Mitsui holding the remainder. The 1.8 million-square-yard park is expected to be complete in 1989 with Toshiba's subsidiaries occupying one-third of the site. Mitsui is seeking Japanese and domestic tenants to fill the remainder.

Motorola

In 1984, Motorola licensed Toshiba to second-source a stereo recorder IC.

In 1985, Motorola agreed to package, assemble, and market DRAM die manufactured by Toshiba.

In June 1986, Toshiba agreed to produce semicustom ICs based on Motorola specifications and supply the chips to Motorola on an OEM basis.

In December 1986, Toshiba agreed to provide CMOS memory process technology in exchange for Motorola's 16-bit MPU technology. Motorola will import Toshiba die to be packaged by Motorola.

In December 1986, Motorola and Toshiba signed an extensive five-year agreement. The two companies agreed to invest equally in a joint venture to be called Tohoku Semiconductor Corporation. In May 1988, Tohoku Semiconductor completed construction of its factory in Miyagi Prefecture and began production. Capital investment of the 36,000-square-meter facility was about $2.8 billion. The Company is manufacturing 1Mb DRAMs and 8-bit and 16-bit MPUs. The Company plans to produce 4Mb DRAMs and 32-bit MPUs at the factory in the future.

In December 1987, Motorola installed Toshiba's CMOS process for submicron geometries at its MOS 6 wafer fab in Mesa, Arizona. Motorola is completely reconstructing the fab, and GCA is upgrading about 20 of MOS 6's existing steppers to be compatible with its submicron 8500 stepper line. The upgrade allows Motorola to produce 4Mb DRAMs, 1Mb SRAMs, or high-density microcomponents.

Olivetti

In 1985, Toshiba bought 20 percent of Olivetti Japan to become a strategic supplier to Olivetti.

Toshiba Corporation

SDA Systems

In May 1987, Toshiba and SDA Systems signed a five-year joint venture to cooperatively develop CAD software for IC design. The final product will sold by SDA Systems.

STM

In 1982, Toshiba and SGS-Thomson Microelectronics (STM) agreed to a technical cooperation agreement involving 16K CMOS SRAM technology.

In 1985, Toshiba and STM signed a technical assistance agreement for joint development of ultrahigh-speed CMOS logic. In return, Toshiba will use SGS-ATES' European semiconductor sales network.

In May 1987, Toshiba and STM signed a five-year agreement allowing Toshiba to use SGS-ATES' semiconductor sales network in Europe. SGS-ATES will receive LSI fab technology and technical training for its engineers from Toshiba.

In June 1988, SGS-Thomson and Toshiba extended the former six-year agreement that provided for wide-ranging, worldwide, nonexclusive, patent cross-licensing related to semiconductor technology.

Siemens

In 1984, Siemens provided CAD software for cell-based ICs. Toshiba provided information on its cell-based design technology and CMOS-processing knowledge for 1.5- and 1.2-micron devices.

In 1985, Toshiba signed a seven-year agreement with Siemens that includes technology sharing and joint development of new devices. Siemens is to second-source Toshiba's CMOS 1Mb DRAM.

In March 1986, Toshiba and Siemens agreed to cooperate on cell libraries.

Sun

In 1985, Sun Microsystems supplied $35 million in CAD Microsystems workstations to Toshiba.

Toshiba Corporation

Tangent Systems

In November 1987, Tangent Systems signed a one-year channelless CAD tool agreement with Motorola and Toshiba. Toshiba will use the CAD tools to place and route its TC110G family of 1.5-micron CMOS gate arrays with 5,330 to 129,042 gates. Motorola will use the CAD tools with its MAX family.

Tokuda Works

In 1986, Toshiba and Tokuda Works announced a jointly developed, fully automated reactive etching system (HIRRIE-500) that can handle ultranarrow geometries of less than 0.5 micron. The new etcher can process 8- to 10-inch wafers at a rate of 20 wafers per hour.

Viewlogic Systems

In November 1987, Toshiba named Viewlogic Systems as its principle worldwide supplier of CAE software. Toshiba supports its gate array family and cell library series on Workview and has integrated its CAD tools for designs developed by its customers. Toshiba and Viewlogic also jointly developed a new ASIC design kit.

VISA International

In 1985, Visa International and Toshiba agreed to a joint development of multipurpose IC cards—Super Smart Cards.

Zilog

In 1982, Zilog received Toshiba's CMOS process, while Toshiba acquired the right to produce the Z80 and Z8000 MPUs.

In 1985, Toshiba reached a sales contract agreement for the CP/M 8000 operating system for the Z80 MPU, and Toshiba agreed to market the OS with a C compiler.

In 1986, Toshiba signed a technology exchange with Zilog to design CMOS versions of the Z80 and Z8000 for Zilog.

Zoran

In January 1988, Toshiba and Zoran agreed to a technology and manufacturing alliance.

Toshiba Corporation

NONSEMICONDUCTOR PRODUCTS SUMMARY

Other Electronic Components

Other products in the electronic components sector include electron tubes, CRTs, magnetron tubes, and printed circuit boards.

Consumer Products

In fiscal 1987, revenue in the consumer products sector decreased 10 percent from fiscal 1986. This sector accounted for ¥941 billion or 28 percent of Toshiba's total revenue. Products in this sector include video equipment, audio equipment, household appliances, and lighting equipment.

Highlights in consumer products during fiscal 1987 include the following:

- Production of VCRs began at the Toshiba America television plant in Tennessee.
- Importation of overseas consumer products for resale began in Japan under the Toshiba label.

Heavy Electrical Apparatus

During fiscal 1987, revenue in the heavy electrical apparatus sector was flat. This sector accounts for 26 percent of Toshiba's total sales. Products in this sector include power-plant systems, industrial electric apparatus, transportation equipment, measuring instruments, and factory automation equipment.

Industrial Electronics

Revenue in the industrial electronics business sector is reported with the electronic components sector revenue. In fiscal 1987, these two sectors combined accounted for 36 percent of Toshiba's total sales. Fiscal 1987 sales represented a 5 percent increase over fiscal 1986 sales. Products in the industrial electronics sector include office automation equipment, medical equipment, telecommunications equipment, airport equipment, aerospace equipment, and labor-saving automation equipment.

Toshiba Corporation

Fiscal 1987 highlights for the industrial electronics sector include the following:

- Production of laptop computers began in the United States.

- A major order was received from Tokyo University for a local area network (LAN) system that will incorporate 600 computer terminals of 70 different types into a single network.

- Toshiba announced that it will produce large digital PBXs capable of connecting more than 1,000 extension lines in cooperation with NTT.

Materials, Machinery, and Other Products

Fiscal 1987 revenue in the materials, machinery, and other products sector decreased 6 percent from fiscal 1986. This sector accounts for only 10 percent of Toshiba's total sales. Products in the sector include steel tubing, alloys, ceramics, optical equipment, chemical materials, semiconductor manufacturing equipment, prefabricated housing, and insulating materials.

Fiscal 1987 highlights for materials, machinery, and other products include include a new joint venture company, Akashi Beam Technology Corporation, which was established with Akashi Seisakusho Ltd., a major manufacturer of electronic microscopes.

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United Microelectronics Corporation (UMC)

United Microelectronics Corporation
No. 3 Industrial East Third Road
Science-Based Industrial Park, Hsin Chu City
Telephone: 035-773131, Fax: 035-774767
(Millions of Dollars except Per Share Data)

Balance Sheet (December 31)

	1983	1984	1985	1986	1987
Financial Resources	$ 7.5	$ 9.4	$ 9.9	$13.7	$22.4
Long-Term Liabilities	$ 8.2	$11.0	$11.6	$ 7.0	$ 7.3
Shareholders' Equity	$21.4	$23.0	$25.9	$46.4	$77.8
After-Tax Return on Average Equity (%)	38.7	5.5	11.7	37.5	29.0

Operating Performance (September 31)

	1983	1984	1985	1986	1987
Revenue	$27.4	$26.4	$32.6	$69.1	$89.1
Cost of Revenue	$14.6	$19.4	$21.9	$36.0	$52.0
R&D Expense	-	$ 0.6	$ 0.8	$ 3.7	$ 4.4
SG&A Expense	$ 3.4	$ 3.8	$ 4.4	$ 7.4	$10.4
Pretax Income	$ 8.4	$ 1.3	$ 3.0	$16.4	$20.4
Net Income	$ 8.3	$ 1.3	$ 3.0	$16.4	$20.4
Average Shares (Million)	73.6	78.6	80.0	93.4	131.6
Per Share (Won)					
Earnings	$ 4.5	$ 0.6	$ 1.5	$ 6.6	$ 4.9
Dividends				$ 3.7	$ 3.8
Book Value	$11.7	$11.6	$12.9	$17.6	$16.9
Price Average	N/A	N/A	N/A	N/A	N/A
Total Employees	580	777	833	887	989
Exchange Rate (NT/US$)	40.3	39.5	39.9	35.50	28.55

N/A = Not Available

Source: United Microelectronics Corporation Annual Reports
Dataquest
November 1988

BACKGROUND

United Microelectronics Corporation was established in 1980 and started wafer fabrication in March 1982. UMC is the first Taiwanese electronic company invested in by both the government and by private enterprise. UMC received its technology from ERSO. UMC began construction in 1987 of a VLSI fab area to produce 1.5-micron devices on 6-inch silicon wafers. The following is a list of significant milestones in UMC's corporate history:

- May 1980—Company formally established
- January 1982—UMC began production
- March 1982—First export sales
- November 1982—UMC became profitable
- April 1983—Dailer ICs produced in cooperation with AMI
- December 1983—UMC ranked No. 1 in profitability in Taiwan's semiconductor industry
- August 1984—Began VLSI development in cooperation with MOSEL
- November 1984—Established U.S. design facility
- April 1985—21 Synertek products licensed
- October 1985—Successfully developed 1.25-micron 64K SRAM VLSI together with MOSEL
- April 1986—Successfully developed 1.25-micron VLSI together with TRW
- June 1986—Signed a contract with SMC of the U.S. for technical cooperation on computer IC development
- August 1986—Board of Directors approved US$170 million for five-year expansion plan
- January 1987—Dataquest listed UMC as 33rd in worldwide MOS sales
- March 1987—Dr. Morris Chang became Chairman of the Board
- December 1987—Started construction on US$170 million VLSI plant II, with a capacity of 30,000 6-inch wafers per month

United Microelectronics Corporation (UMC)

Manager: H.C. Tsao

Customer Contact: John Hsuan

Address: Hsin Chu City Plant, No. 3 Industrial E. Third Rd., Science-Based Industrial Park, Hsin Chu City, Taiwan

Date of first production: April 1982

Employees (January 1988): 989

Facilities: 92,000 square feet (32,000 square feet—wafer fabrication area)

MAIN PRODUCTS

- Microcomponents, memory, and telecommunication ICs

WORLDWIDE SEMICONDUCTOR SALES BY MAJOR PRODUCT LINE (Millions of U.S. Dollars)

	1983	1984	1985	1986	1987
Total Semiconductor	$25.7	$20.0	$27.7	$65.0	$88.2
MOS	$25.7	$20.0	$27.7	$65.0	$88.2
Memory	2.3	2.5	2.6	13.0	8.2
Micro	-	-	5.3	15.0	30.8
Logic	23.4	17.5	19.8	37.0	49.2

Source: United Microelectronics Corporation Annual Reports

CAPITAL SPENDING (Millions of U.S. Dollars)

	1983	1984	1985	1986	1987
Plant & Equipment	$5.0	$5.0	$5.0	$26.1	$14.5
Research & Development	-	-	-	2.7	1.6

United Microelectronics Corporation (UMC)

DESIGN CENTER

UMC set up a design center in Taipei in July 1986. This design center offers semicustom design service using the gate-array and standard modular library approach.

JOINT VENTURES/LICENSING

Partner	Country	Year	Technology
ERSO	Taiwan	1980	Technology transfer
AMI	United States	1983	Telephone dial IC
MOSEL	United States	1984	16K SRAM
Synertek	United States	1985	Computer ICs

CONTRACT MANUFACTURING

UMC produces wafers for 12 major customers, including 8 U.S., 2 European, and 2 Taiwanese companies.

U.S. Subsidiary

Unicorn Microelectronics Corporation is a design company.

President: Singi Yang

Address: 99 Tasman Drive, San Jose, CA 95134

Telephone: (408) 433-3388/3393

Fax: (408) 433-0705

Telex: 5106004303

Established: 1985

Employees: 20

Investment: US$2.7 million

Product: ASIC

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