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**Japan Information Processing Development Center**

## The Microcomputer Industry —Training Engineers, Creating Applications—

No. 73

# Japan Computer Quarterly

# 1988

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JIPDEC is a non-profit organization founded in 1967 with the support of the Ministry of International Trade and Industry, the Ministry of Posts and Telecommunications and related industry circles for the purpose of promoting information processing and the information processing industry in Japan.

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# No. 73

# FROM THE EDITOR

Demand in the steel and shipbuilding industries, those key industries that supported Japan's economic growth in the past, dropped considerably following the oil shocks. This factor, combined with the rise of the newly industrialized countries (NICs) and the increasingly stronger yen, have thrown Japan into a structural recession. International trade frictions and the rising yen have also taken their toll in durable consumer goods industries such as the automobile and household electric appliances industries, prompting companies in these industries to move their production operations overseas. This set of circumstances has had a devastating impact on Japanese industry, bringing about a drastic reduction in employment opportunities and hindering the development of production technology.

On the other side of the coin, however, the high economic growth enjoyed by Japan in the past supported this country's rapid industrialization, and raised the wages of Japanese workers to levels commensurate with those earned in the United States and Europe. As a result, Japanese citizens have been placing more emphasis on leisure activities. This trend has expanded the market for services industries such as the hotel, travel and restaurant businesses, the fashion industry and various businesses that cater to self-improvement. In the manufacturing industry as well, the improved standard of living has recently increased the need for information, technology, knowledge, design and software over that for tangible products, thus further advancing the trend toward a services-oriented economy. This has focused attention on a variety of new industries that are springing up as a result of this movement.

The information industry has played an important role in the advancement of industry overall. Supported by technological progress in the fields of information processing and communications, the information industry has gradually extended its activities to sectors of society outside the world of industry. That is, the information industry has penetrated deeply into the social fabric of Japan, establishing itself in our homes as well as our personal lifestyles, and is serving as the infrastructure upon which Japan is building an advanced information society.

By supplying other industries with semiconductors and LSIs, those devices that have become basic components in most manufactured products, the electronics industry has carved out a place for itself as a key new modern industry. And the microelectronics industry, which has its basis in microprocessors and microcomputers, is serving to further technological innovations and the advance of the information revolution in industry. As a result, microelectronics is expected to become Japan's leading industry in future.

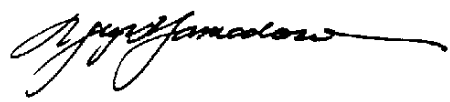
The world's first microcomputer was developed by America's Intel Corporation back in 1971 in response to an order from a Japanese calculator manufacturer. The technological innovations and widespread application of these devices which followed have resulted in their rapid growth and development. Based on the initial 4-bit devices, microprocessors and the microcomputers they form the cores of have rapidly evolved and grown technologically into first 8-bit, then 16-bit and recently 32-bit architectures. The applications to which these devices are being put have also grown, expanding into the fields of automobiles, household electrical appliances, inspection, measurement and control equipment and instruments, electronic data processing (EDP), traffic and transportation systems, as well as the fields of business and commerce. This widespread use of microcomputers has had a huge impact on the world of industry, and is also influencing the way we live our daily lives. This issue of the Japan Computer Quarterly (JCQ), therefore, describes some of the specific applications and products in which microcomputers are being used in Japan, plus provides some insights into systems architecture technology and future utilization trends.

The progress in the field of microcomputers has left in its wake a number of problems that will have to be solved in future. For example, advances in hardware technology generally result in shortages of appropriate software. New operating systems (OS) and utility programs, for instance, must be developed to meet the operational requirements of new hardware technology. Then there is the problem of software distribution and related copyright issues. Intellectual property rights have recently been recognized as a major problem in this regard. Other issues related to microcomputers include standardization and the education and training of human resources, both of which are necessary for promoting the efficient development of microcomputers.

The education and training of microcomputer engineers is an extremely vital task, especially in light of the broad knowledge and variety of knowhow required of these engineers, not only in the fields of hardware and software, but also in the various fields in which these devices are applied. Education and training programs aimed at cultivating microcomputer engineers are already in place at universities, technical schools and within corporations. However, these programs are not really systematic, and, as they stand now will not be sufficient to meet future demands. For these reasons, JIPDEC is in the process of putting together a standard curriculum for microcomputer engineers. This curriculum is divided into three categories or levels — basic, senior and advanced grade engineers — and sets forth the knowledge and skills deemed necessary at each level. This issue of JCQ provides an overview of the curriculum currently under consideration.

As pointed out above, microcomputer engineers must be knowledgeable in a broad range of fields. This, in turn, makes the evaluation of microcomputer engineers, i.e. their knowledge and skills, at each level of proficiency extremely important. Microcomputer engineers must also constantly acquire new knowledge and skills in order to advance to the next highest level. In response to these requirements, JIPDEC began administering in 1985 the Microcomputer Engineer Examination. This examination is divided into three levels, corresponding to basic, senior and advanced grade engineers. At present, however, only basic and senior exams are available; advanced level exams will be offered in the very near future. An overview of this examination system, plus specific examples of the types of problems covered therein, are also presented in this issue of JCQ.

We sincerely hope that JCQ's coverage of those aspects of the microcomputer industry in Japan mentioned above proves both informative and useful to all our readers.



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# THE MICROCOMPUTER INDUSTRY

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## THE DEVELOPMENT AND GROWTH OF MICROCOMPUTERS

Seventeen years have come and gone since Intel announced the world's first microcomputer, the 4004, back in 1971. In that amazingly brief span of time, microcomputers have evolved to the point where nowadays they can be equipped with functions equivalent to those found in advanced, high-performance minicomputers.

The birth of the microcomputer coincided with the appearance of large-scale mainframe computers and minicomputers, the paternal side of the relationship that brought these devices into the world. Today, compared to the widespread popularity of personal computers, only a handful of advanced users employ mainframes and minicomputers. The maternal half of the relationship that produced the microcomputer was integrated circuit technology, more specifically, the dedicated large-scale integration (LSI) chips used in calculators. The first microprocessor was actually a by-product of a project aimed at converting this dedicated calculator chip, which featured decimal arithmetic functions, into a general-purpose LSI. The microcomputer took after its mother in size, and was therefore much smaller than its father figure, the minicomputer. Thus its name, the MICROcomputer.

Microcomputers were the first devices to make use of integrated circuit technology to concentrate the processing elements so vital to a computer onto a single chip, or, in some cases multiple chips, making them quite different from conventional computers of the day. The development of the microcomputer subsequently resulted in the birth of revolutionary computers that made the most of the special characteristics of integrated circuits, i.e. compact size, low cost, low power consumption and mass production capabilities. The microcomputer was thus a new information processing tool born of the union of computer and integrated circuit technologies, and featured revolutionary electronic capabilities not found in either computers or integrated circuit chips produced prior to its development. Microcomputers have made possible the incorporation of computer functions into a variety of machines and equipment in the form of electronic components. This in turn has made it possible to incorporate heretofore unimaginably complex control functions into compact machines. In the world of computers as well, the early general-purpose microcomputers that were initially described as being slow, but inexpensive low-end minicomputers, have made their way into the domain of the super-minicomputer.

Japanese manufacturers have contributed greatly toward the development and growth of the microcomputer. For example, Intel's 4004 microprocessor announced in 1971 was the result of an order placed with Intel by a Japanese calculator manufacturer, Business Computer Co., Ltd., which also participated in the development of that device. Prior to the 4004, dedicated LSIs had to be specially developed for each make and model of calculator. This raised a number of problems, including increased development costs and turn-around times, as well as difficulty in estimating the number of LSIs that should be manufactured each time. Business Computer drew up plans for a project designed to develop the smallest chip set capable of overcoming these problems. However, Japanese chip manufacturers at that time were concentrating primarily on bipolar devices, and as a result, no firms in Japan were taking orders for metal-oxide semiconductor (MOS) LSI, considered the most appropriate for calculator use. Business Computer therefore placed an order with Intel for the desired general-purpose calculator chip. In 1969, Business Computer sent Masatoshi Shima and two other engineers to Intel to commence development of the new chip with Dr. Hoff and his staff. It was Dr. Hoff who suggested that the calculator chip be a 4-bit computer chip, which would then be programmed to meet different specifications. Shima was responsible for designing the central processing unit (CPU) for this microcomputer. Once completed, this microcomputer (Intel 4004) was incorporated into the Business Computer 141P calculator, which was marketed in 1971.

Intel followed up the 4004 with an 8-bit processor labelled the 8008. The 8008 LSI chip employed P-channel MOS (PMOS), a type of semiconductor especially well suited to large-scale integration, and was called a first generation microcomputer. By making some major improvements to the 8008, Intel was able to develop the 8080, another 8-bit LSI that used N-channel MOS (NMOS) as the substrate. The 8080 soon become a best seller, and is still widely used today.

One of Japan's major electric appliance manufacturers, Toshiba Corporation, although a bit slower getting off the mark than Intel, developed and began marketing in 1973 a 12-bit PMOS processor called the TLCS-12, which it developed in-house as an engine controller for the Ford Corporation of the U.S. This was the Business Computer-Intel case in reverse, with America's Ford Corporation coming to Toshiba to develop a custom-made chip. Also, it was Japan's Nippon Electric Corporation (NEC) that was the first to make the switch from PMOS (first generation) to NMOS (second generation) substrates in the field of 4-bit processors.

Numerous semiconductor manufac-

**Table 1. Japanese Second Sources of U.S.-made Microprocessors**

| Original Processor | Second Source in Japan |
|---|---|
| 8080A | Mitsubishi Electric, NEC, Oki Electric, Toshiba |
| Z80 | Hitachi, NEC, Sharp, Toshiba |
| 8085A | Mitsubishi Electric, NEC, Oki Electric, Toshiba |
| 6800 | Hitachi |
| 6802 | Fujitsu, Hitachi, Matsushita |
| 6809 | Fujitsu, Hitachi |

turers developed their own 8-bit processors after Intel announced its devices, but in the end, only Intel's 80 series and Motorola's 6800 series of microprocessors have remained as popular selling chips. In Japan, large numbers of semiconductor makers entered the market as second sources for the Intel and Motorola chips (See Table 1). After a time, microprocessors increased to 16- and then 32-bit architectures, and a variety of different kinds of processors were developed, to include signal processors, bit slice processors and single-chip microcomputers. Of these, the device that has contributed the most toward the growth of the microcomputer industry has been the single-chip microcomputer.

The single-chip microcomputer has its origins in the TMS 1000 series announced by America's Texas Instruments Corporation in 1975. This single-chip microcomputer integrated the three (3) essential elements of a computer – CPU, memory and input/output (I/O) interface – onto a single chip, thus making the most of the miniaturization, reduced weight and low power consumption associated with semiconductor chips. These features matched up perfectly with the consumer products orientation of Japanese industry. As a result, Japanese semiconductor manufacturers began developing their own versions of single-chip microcomputers, and these devices are now being incorporated in a wide range of electrical appliances and other consumer products in particular. The original 4-bit single-chip microcomputers have grown, and recently 16-bit versions of these devices are being employed, making possible truly advanced applications.

We are now heading toward the 32-bit single-chip microcomputer era, and Japanese firms are also in the process of developing original versions of these devices. For example, NEC has its V series of 32-bit chips, and Fujitsu Limited, Hitachi Limited, Mitsubishi Corporation and Toshiba have jointly developed The Real-time Operating System Nucleus (TRON) chip. These and other Japanese chip makers are also busy developing specialized microprocessors, such as those for use in image processing and artificial intelligence (AI) applications using Prolog and/or Lisp.

## MICROCOMPUTER APPLICATIONS

As pointed out above, microcomputers possess the special characteristics inherent in semiconductors and computers. The applications to which these devices are capable of being put can be broken down into the following three categories:

1) Replacements for conventional electric circuits (wired logic);
2) Computers, and
3) New applications.

When microcomputers are used in place of wired logic, control circuits which used to consist of wires are implemented via programming. In other words, hardware is replaced by software. As far as new applications are concerned, microcomputers are capable of complex control functions that were never possible before, thus creating applications specifically suited for microcomputers. The advent of the single-chip microcomputer also made possible the inexpensive mass production of the products used in these two types of applications. Examples of single-chip microcomputer applications in the field of computers* are the ubiquitous general-purpose personal computers (PCs), various types of workstations and wordprocessors.

Today, microcomputers are being put to a wide array of applications in a broad range of industrial fields. So many, in fact, that it is hard to keep up with them all. Table 2 provides some examples of the applications to which microcomputers are currently being put here in Japan. These examples demonstrate the diversity of microcomputer applications, but by no means cover all the products employing microcomputers today. Let's take a look at a few of these applications and trace their development.

### General-purpose Computers And Workstations

The advent of the microprocessor theoretically made it possible to construct compact, inexpensive computers by emulating conventional processors using microcomputers. And it was felt that these smaller, cheaper computers should still be able to make use of available software. However, the processing speeds of the initial microprocessors were slow, and they were designated low-end minicomputers. Bit slice processors offered another means of simulating conventional computers, as evidenced by Mitsubishi Electric Co., Ltd.'s MELCOM series of computers. In the U.S., the integration of minicomputer functions onto LSI chips progressed with the appearance of DEC's VAX computers and Data General's Eclipse, thus polarizing the minicomputer market into superminicomputers and low-end minicomputers on a chip.

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*NOTE: The term computer here is used in the broad sense of the word, and includes those systems comprised of keyboards (input devices consisting of ten or more alphabet keys) and displays. Wordprocessors and electronic notebooks are thus also included in this definition.

**Table 2. Japanese Products Incorporating Microcomputers Between 1976 and 1986.**

| | | | | 1976 | 1977 | 1978 | 1979 |
|---|---|---|---|---|---|---|---|
| 4-bit devices | Consumer goods | Radio/audio equipment | | Audio song selectors | Car radios, cassette decks | Clock car radios, audio timers, musical instrument tone generators | DD players, electronic stereo tuners |
| | | TV/VTR | | TV channel selector | TV remote control, VTR timers | Programmed TV, portable VTR | Bilingual TV, videotex, CATV, VTR mechanical control, VTR timer display |
| | | Household electric appliances | | | Timers, washing machines, gas ovens, FF stoves, micro-wave ovens | Air conditioners, rice cookers | Refrigerators |
| | | Others | (Tele-phones) (Commu-cations equip-ment) (Health equip-ment) (Games) (Hobbies) | | Telephone answering machines, push button phones, 8mm cameras | Car telephones, home facsimile machines, pagers, sphymo-manometers, interphones, toys/games, calculators | |
| | Industrial use | (Automobiles) (Information/communica-tion equip-ment) (Office Automation) | | | Facsimile ma-chines, radios, electronic cash registers (ECR), industrial sew-ing machines | Disaster preven-tion systems, marine radios, CB radios, copying ma-chines, thermal printers, ECR, data collectors, delivery control systems, optical measuring instruments | Automobile panels, print developers, power line carrier wave controller, agricultural dryers, rice cleaning ma-chine, vending machines |
| 8-bit devices | Consumer goods | (Audio) (TV/VTR) (Household Electrical Appliances) | | | | | |
| | Industrial use | (Automobiles) (Information/Communica-tion equip-ment) (Office Automation) | | 12-bit car engine control-lers (1975) | | | |
| 16-bit devices | | | | Workstations, microcomputer systems | Wire-bonders, educational kits | PCs, counter terminals | |

| 1980 | 1981 | 1982 | 1983 | 1984 | 1985 | 1986 |
|---|---|---|---|---|---|---|
| Car stereos, remote control stereos, fully-automatic tape players | HiFi stereos, audio equalizers, guitar tuners | DAD players, electronic organs, electronic pianos | Karaoke systems, CD players | | Portable component stereo systems | CD radio cassettes |
| VTR slow motion, VTR automatic search | Large screen TV, VTR system control, VTR head out, video cameras, video disks | Liquid crystal TV, video camera autofocus | Digital TV with built-in VTR | 8mm video camera | DBS (satellite broadcasting) | VTR field memory control, automatic color gradation control for video cameras |
| Electric fans, talking clocks, car air conditioners | Fully-automatic washing machines, compact pumps, kerosene heaters | Inverter air conditioners, electromagnetic cookers | Dishwashers, clothes dryers, water coolers, gas tubs | Gas water heaters, electronic carpets, electric kotatsu | Knitting machines | Home bakery units, hot plates, humidifiers |
| Health equipment (exercycles), pulsometers, scales | LL equipment, electronic "Go" games, electronic locks, pendulum clocks, toy watches, travel clocks, hand-held games | Multi-function telephones, system telephones, scales, PCs, disk cameras, TV cameras, massage machines, cameras, moisture measuring instruments for rice and other grains | Educational machines, gas alarms, remote controlled light apparatus, voice recognition calculators, pedometers, calculator watches | Air cleaners, mailboxes, calendar watches, sprinklers | Digital telephones, front door monitors, photoelectric equipment, MSX PCs, electrocardiograph, radio controlled toys, chess clocks, heightometers | Inch-millimeter conversion devices, talking games, tennis recorders |
| Automobile trip computers, automatic warning devices for cars, automatic doors, production control systems, coin changers | Car clocks, car engine controllers, traffic signal controllers, game machines, time recorders, show cases, gas meters | Automobile energy saving systems, voice synthesis controllers, voice recognition controllers, electronic swtiching equipment, AVM mobile station operation controllers, hotel CATV systems, FDD controllers, keyboards, typewriters/printers, automatic thermometers, robots | Automobile backup sensors, engine knock controllers, car speed monitors, tacometer graphics, cordless telephones, personal radios, emergency broadcasting systems, home environment controllers, security systems, word processors, electronic calipers | Car displays, automobile speed controllers, four-wheel drive CPN, antenna controllers, wiper controllers, taxi meters, HALS, digital mega | Automobile obstruction detection devices, diesel engines, emergency broadcast receivers, CD-ROM, IC cards, scanners, parking meters, fish detectors, gas cut-off controllers | Power steering, warehouse management system, card readers |
| Radio cassette players, CATV, calculators, hot water heaters | Receivers, word processors, games, sphygmomanometers, IC cards | Electronic musical instruments, CATV, VTR, car telephones, air conditioners, microwave ovens | Audio timers, DAD, video disks, heating controllers, cameras, PCs, educational machines, radio controlled toys | Electronic ovens | Karaoke grading systems, AF cameras, inverter air conditioners, game machines | CD players, VTR, video camcorders, electronic still cameras |
| Car engines, telephones, ECR, typewriters, printers, PPC | Taxi meters, radios, FDD, HDD, POS, disaster prevention equipment | Automobile panels, measuring instruments, IC cards, robots | Automobile sequential controllers, personal radios, navigators, keyboard encoders, modems, PCs, security systems, boiler controllers (kerosene), NC machine tools | Tachometers, telephone dialers, multifunction telephones, cordless telephones, communication equipment, PBX, hand-held PCs, HD controllers, industrial sewing machines, general-purpose inverters | Igniters, autocruise, push button phones, transceivers, bar code readers, charging timers, press safety devices | Car engine controllers, car radios, telephone answering machines, mouse controllers, POS terminals, vending machines, valve controllers |
| | NC machines, robots | Industrial robots | | | | |

However, advances in LSI technology gave rise to a phenomenon whereby LSI versions of 16-bit minicomputers surpassed their conventional counterparts. This phenomenon could be seen in the TLCS40 chip that simulated Toshiba's TOSBAC minicomputer, as well as in the J11 chip which simulated DEC's PDP11. The advent of high-performance 32-bit microcomputers has also resulted in the appearance of machines that surpass conventional super-minicomputers like the SUN-4. And in the fields of general-purpose computers and workstations, LSI versions of these machines are becoming popular.

## Japanese-language Wordprocessors

In the past, numerous difficulties and problems were experienced in getting computers to handle the Japanese language. Everyday Japanese makes use of several thousand Japanized Chinese characters called kanji. For this reason, the first problem faced in trying to make computers fluent in Japanese revolved around input methods. A number of input methods were considered, including arranging several hundred simple kanji on a tablet and then selecting from among these and/or combining them to make the more complex kanji, similar to the approach used with kanji typewriters. A multi-stroke input method was also tried whereby the first keystroke is used to select a kanji group, and the second to choose a specific character from among that group. However, these methods required considerable skill, and were therefore not well suited for popular use.

The second biggest problem to equipping computers with Japanese-language capabilities had to do with output functions. In order to output kanji to a VDT or printer, a dot matrix of at least 16 X 16 dots is required, and to make that kanji character easy to read, you need a minimum of 24 X 24 dots. However, incorporating these kanji character fonts into display devices or printers raised the prices of these equipment considerably. Finding a dot printer which could create precise fonts was also a problem. For these reasons, for a long time only those industries which absolutely had to do business in Japanese made use of large-scale mainframe computers equipped with Japanese-language capabilities.

It was under these circumstances that Toshiba began marketing the predecessor of today's Japanese-language wordprocessor which first employed the kana-kanji conversion method for inputting Japanese characters (kana refers to a dual syllabary system used in Japanese writing). This machine sold for about the same price as a low-end minicomputer, but was considered an amazing bargain at the time. Since that time, however, the cost of producing microcomputers, memory devices and peripheral equipment has been lowered considerably, and today's Japanese-language wordprocessors come equipped with liquid crystal displays, floppy disk drives and Japanese kanji printers, and sell for between 100—200 thousand yen (between US$770 – US$1,540 at US$1=130 yen).

## Personal Computers

The PET put out by America's Commodore Co., Ltd. can be considered the forerunner of modern personal computers (PCs). However, Japanese firms like NEC were marketing one-board computers such as the TK-80 even before the appearance of the PET. These one-board computers were equipped with micro-BASIC and TV interfaces, and, when all hooked up looked like real computers. Japan's Sord Computer Corporation was also among those companies that first marketed 4-bit microcomputer systems complete with floppy disk drives, keyboards and displays. The price tag on these early PCs was several million yen for single drive systems, which nevertheless was still considerably cheaper than minicomputers then.

These early 4-bit machines were followed by 8-bit PCs, and today we are entering the age of the 16-bit PC. Popular 8-bit machines in Japan include NEC's PC-8000 series, Fujitsu's FM series and Sharp's MZ series. In the beginning, these PCs were used primarily by computer buffs interested in playing electronic games. However, with the spread of floppy disk drives and other peripheral equipment, PCs could be used in business applications as well, and soon were playing a major role in the office environment.

The 16-bit PCs now being marketed boast a variety of very useful software such as spreadsheet programs, wordprocessors and database programs, which are helping these machines rapidly gain popularity. PIPS, easy-to-use business software featuring spreadsheets and other business-oriented programs on a card-like media was developed independently in Japan by Hiroshi Mochizuki, then with the Bank of Japan. Just as IBM's 16-bit microcomputer called PC is enjoying widespread popularity in the U.S., NEC's PC-9800 series of 16-bit machines is being widely used in Japan. PC-9800 series machines are equipped with the same Intel 16-bit processors as the IBM PC, and operate under a Japanese-language version of MS-DOS. Numerous Japanese software houses are developing wordprocessors, integrated software packages and other software for the NEC PC-9800 series and other makes of 16-bit Japanese PCs. Figure 1 shows the market forecast for PCs in Japan by year and application, and indicates the number of types of machines used for each kind of application.

In an attempt to open up the home market for PCs, America's Microsoft Corporation developed a PC configuration which it proposed be accepted as the standard. This home-use PC configuration is called MSX, and numerous Japanese home appliance manufacturers have developed MSX machines and are marketing them in Japan and overseas. Second generation MSX machines are equipped with 3.5-inch floppy disk drives and are selling for a low 50–60 thousand yen apiece. These home-use PCs can be hooked up to the family TV to play games and/or do word processing.

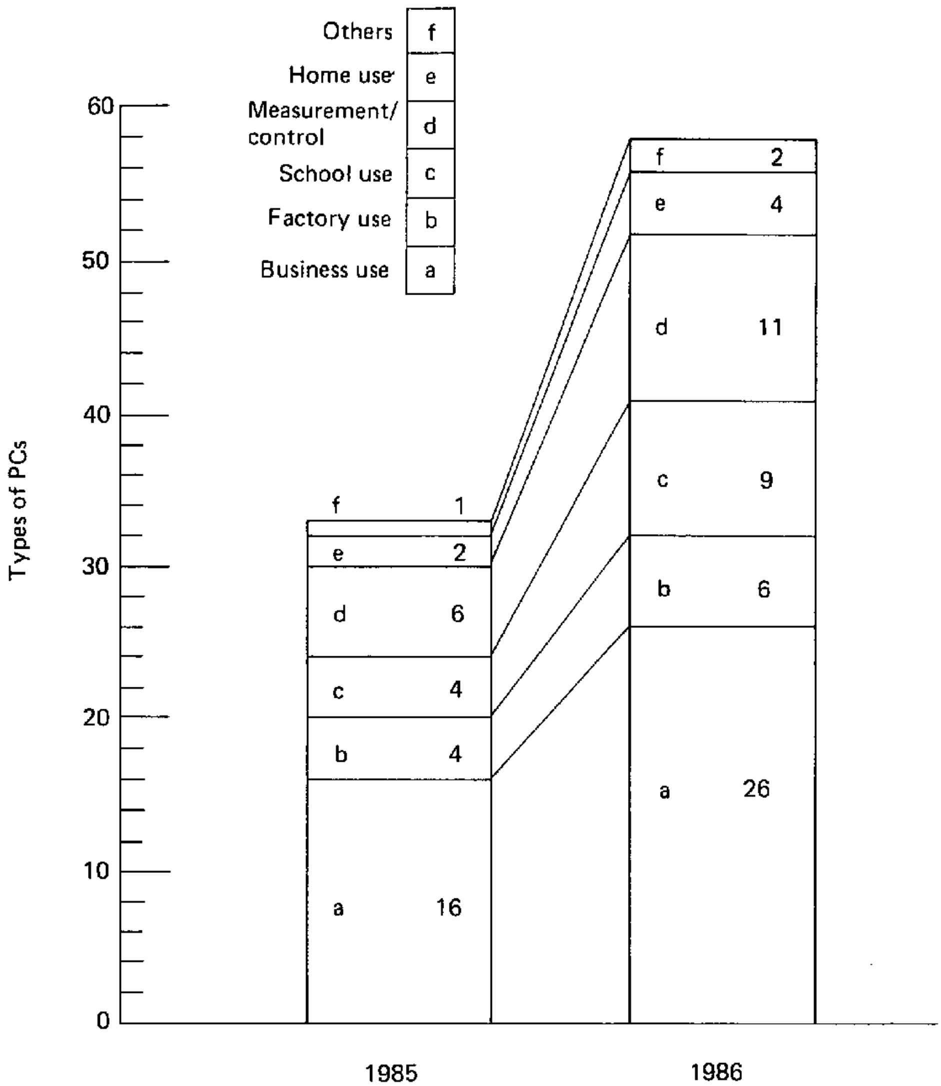


**Figure 1. Breakdown of Personal Computer Utilization by Application (Comparison of PCs Sold in 1985–86)**

## Home and personal use

The PCs, MSX machines and Japanese-language wordprocessors discussed above are steadily finding their way into the Japanese home. This holds especially true for the Japanese-language wordprocessors, which are being sold at ordinary home electric appliance shops and counters. And sales are increasing as the price tag on these wordprocessors continues to drop.

Considerable attention is also being focused on hand-held information instruments that can be used similarly to pocket calculators. Two examples of these kinds of microcomputer-based products are electronic dictionaries and electronic notebooks. Electronic dictionaries are programmed to display specified Japanese kanji, and give their correct reading and meaning. There are also more advanced models of these instruments which are equipped with Japanese-English and English-Japanese dictionaries and can perform simple, conversational translation. Electronic notebooks serve the same purpose as ordinary notebooks, that is, they possess functions that enable the user to create, maintain and retrieve needed addresses and telephone numbers, as well as memos and schedules. These machines are being manufactured by Sharp Corporation and Casio Computer Co., Ltd., and are gaining popularity among Japanese businessmen. In the future, we can look forward to a variety of electronic publishing equipment that make use of CD-ROM technology.

The electronic game market, by its very size, is also having a powerful influence on the semiconductor industry. At one time, game arcade-oriented microcomputer-based electronic game machines such as "Space Invaders" were so popular in Japan that semiconductors came into short supply. Today, the Family Computer marketed by Japan's Nintendo Corporation is extremely popular among children in the elementary and middle school age brackets. This is a dedicated game machine that employs ROM software and has to be hooked up to a TV set to be used. Third-party software makers are also churning out games for use on this machine, among which a number of bestsellers appear each year. The penetration of the Family Computer into the home market is being closely watched, and it is even being considered as a potential terminal device for a value-added network (VAN) project.

## FUTURE OUTLOOK FOR THE MICROCOMPUTER INDUSTRY

There is no doubt that the microcomputer industry will play an increasingly central role in the development of an information society in Japan between now and the start of the 20th Century. But there are a number of points that must be taken into consideration if that development is to take place in a sound manner. This section briefly discusses certain activities that are being undertaken to pinpoint and solve these problems.

### The Education And Training Of Engineers

The education and training of microcomputer hardware and software engineers is vital to the development of advanced devices in future. This is especially true in the field of microcomputer applications, where a broad range of knowledge and knowhow covering the fields of microcomputer hardware, software and applications technology are required. In Japan, the education and training of microcomputer engineers is

**Table 3. Actual and Projected Markets for PCs by Application, Bit Size and Value from 1983 to 1990**

(Domestic figures only)

3-1. Number of Units (%)

(Actual) (Projected)

| | 1983 ratio | 1984 ratio | 1985 ratio | 1986 ratio | 1987 ratio | 1988 ratio | 1989 ratio | 1990 ratio |
|---|---|---|---|---|---|---|---|---|
| Business Use | | | 38 | 39.3 | 40.5 | 41.3 | 42.3 | 42.9 |
| S&T/Measurement Control Uses | | | 13 | 13.0 | 13.0 | 13.0 | 12.9 | 12.9 |
| Education/Hobby/Home Uses | | | 49 | 47.7 | 46.5 | 45.7 | 44.8 | 44.2 |
| Total (Domestic) | | | 100% | 100.0% | 100.0% | 100.0% | 100.0% | 100.0% |

3-2. Shipping Values (%)

| | 1983 ratio | 1984 ratio | 1985 ratio | 1986 ratio | 1987 ratio | 1988 ratio | 1989 ratio | 1990 ratio |
|---|---|---|---|---|---|---|---|---|
| Business Use | | | 52 | 53.2 | 54.2 | 54.9 | 55.5 | 56.4 |
| S&T/Measurement Control Uses | | | 20 | 20.3 | 20.4 | 20.2 | 19.9 | 19.8 |
| Education/Hobby/Home Uses | | | 28 | 26.5 | 25.4 | 24.9 | 24.6 | 23.8 |
| Total (Domestic) | | | 100% | 100.0% | 100.0% | 100.0% | 100.0% | 100.0% |

3-3. Units by Bit Size (In thousands of units)

| | Fiscal 1983 | Fiscal 1984 | Fiscal 1985 | Fiscal 1986 | | Fiscal 1987 | | Fiscal 1988 | | Fiscal 1989 | | Fiscal 1990 | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 8-bit | 719 | 917 | 789 | 685 | 55 | 630 | 48 | 570 | 39 | 510 | 31 | 460 | 24 |
| 16-bit | 166 | 279 | 398 | 551 | 45 | 620 | 48 | 780 | 54 | 990 | 60 | 1,240 | 65 |
| 32-bit | | | | – | | 50 | 4 | 100 | 7 | 150 | 9 | 200 | 11 |
| Total (Domestic) | 885 | 1,196 | 1,187 | 1,236 | 100% | 1,300 | 100% | 1,450 | 100% | 1,650 | 100% | 1,900 | 100% |

3-4. Number of Units by Value (In thousands of units)

| | Fiscal 1983 | Fiscal 1984 | Fiscal 1985 | Fiscal 1986 | Fiscal 1987 | Fiscal 1988 | Fiscal 1989 | Fiscal 1990 |
|---|---|---|---|---|---|---|---|---|
| Less than 100,000 yen | 254 | 581 | 457 | 381 | 400 | 420 | 455 | 485 |
| 100,000–200,000 yen | 531 | 165 | 227 | 251 | 260 | 290 | 340 | 400 |
| 200,000–500,000 yen | | 331 | 365 | 433 | 455 | 515 | 595 | 700 |
| 500,000–1,000,000 yen | 62 | 76 | 90 | 131 | 130 | 155 | 185 | 220 |
| 1,000,000–3,000,000 yen | 38 | 42 | 478 | 40 | 55 | 70 | 85 | 95 |
| Total (Domestic) | 885 | 1,196 | 1,187 | 1,236 | 1,300 | 1,450 | 1,650 | 1,900 |

carried out primarily at universities, technical schools and via in-house training programs at companies and corporations. However, with the rapid advances being made in technology development, agencies and/or organizations capable of providing appropriate guidance and guidelines for the education of microcomputer engineers are extremely important. As is explained in other articles appearing in this issue of JCQ, the Japan Information Processing Development Center (JIPDEC) has drawn up guidelines for microcomputer education programs, and is directly involved in this education process as a result of its administration of the microcomputer engineer examinations.

## Standardization

When it comes to standards for microcomputers, numerous areas come to mind, including system buses and mnemonics, but those two areas where standardization is felt to be the most needed are operating systems (OS) and man-machine interfaces. Japan is contributing toward the standardization of system buses and mnemonics by heading up Subcommittee 47B of the International Electrotechnical Commission (IEC), and is pushing ahead with a national project called TRON, which is aimed at developing a new, standardized OS and man-machine interface environment. As stated above, TRON stands for The Real-time Operating System Nucleus, and is conceived of as being a series of interconnected real-time OS, complete with microcomputer man-machine interfaces. The TRON OS currently under development include ITRON for industrial applications, BTRON for business applications and CTRON, an OS designed specifically for large-scale computers with communications capabilities. A 32-bit TRON chip is being jointly developed by Mitsubishi, Fujitsu, Hitachi and Toshiba as a proprietary microprocessor unit for running TRON software.

## ASIC Microcomputers

The importance of application specific integrated circuits (ASIC) for use in microelectronic devices in future is becoming widely recognized, and when the "system-on-a-chip" is realized, we can expect more compact, higher performance microelectronic devices. However, microelectronic devices are substantially different from conventional products developed using independent devices. Due to problems arising from intellectual rights, it isn't possible to incorporate processors or circuits into chips as one pleases. Other problem areas related to ASIC microcomputer systems include the high costs of design work, the need to divide development work up between ASIC manufacturers and the firms producing the equipment the chips are to be used in, and the lack of standardized circuit libraries and distribution systems. All these problems will have to be dealt with before ASIC technology can be widely utilized.

## Software Distribution System

In order to insure the sound development of the software industry, a system will have to be established that will guarantee that copyrights on truly exceptional software programs be protected and the creators of those programs be fairly compensated for their efforts. For this reason, we are going to have to take another look at the software distribution system. Professor Ryoichi Mori of Tsukuba University has devised a revolutionary software distribution system which he calls the Software Service System (SSS). Right now, Professor Mori is cooperating with software producers to determine ways of commercializing this system. The SSS basically calls for software users to pay a utilization fee to software producers based on how frequently they utilize a software program. Users can freely copy software programs they need or want. Therefore, with the SSS, CD-ROMs loaded with software programs are distributed to users at extremely lost cost. The users then select only those programs they really want to use from among the software stored on the CD-ROM, and copy those programs to their own file systems or recorded them on a network server for their use. The user can then pay a fee to the producer of the software for the number of times he actually uses those programs.

This report has attempted to describe just one facet of microcomputers and their current applications. But microcomputers are multifaceted, which makes it almost impossible to discuss them in any depth in a short report such as this. Nevertheless, I hope this report helps those who read it gain some insight into the microcomputer industry in Japan.

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# MICROCOMPUTER APPLICATIONS

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## INTRODUCTION

Following the appearance of microprocessors in 1971, these devices and the microcomputer systems they form the cores of have been employed in a wide range of fields, in everything from commercial products to industrial machines and equipment, and have had an incalculable impact on our daily lifestyles. In fact, many of the benefits derived from today's microprocessors and microcomputers remain unknown to most people.

This report is designed to introduce just a few of the ways in which microcomputers are being put to use in the fast-growing microcomputer industry in Japan.

## MICROCOMPUTER APPLICATION SYSTEMS

As shown in Figure 1, microcomputer hardware and software must be technologically merged together to produce a microcomputer application system.

During the era of 8-bit microprocessors, CP/M was the operating system (OS) most often used as the basic software in microcomputer systems. But following the advent of the 16-bit microprocessor, MS-DOS has predominated the market. UNIX and OS-9 have also earned places for themselves as basic software for use in 16-bit microcomputer systems. Most off-the-shelf software packages and database software are now relatively inexpensive to purchase. The level of software expertise exhibited by the average user today has improved significantly, and numerous users are quite capable of putting together their own dedicated software programs. Increasingly large numbers of users are even trying their hands at producing their own communications software and constructing their own local area networks (LAN). MS-DOS, UNIX, OS-9 and other basic software programs play major roles in enabling users to develop their own applications software in this way.

Microprocessors comprise the physical cores of microcomputer systems. Two types of microprocessors have gained widespread utilization: bit-slice microprocessors and the so-called one-chip microcomputers. General-purpose microprocessors are steadily moving from 8- to 16-bit architectures, and 32-bit microprocessors are already gaining popularity.

As indicated in Figure 2, general-pur-

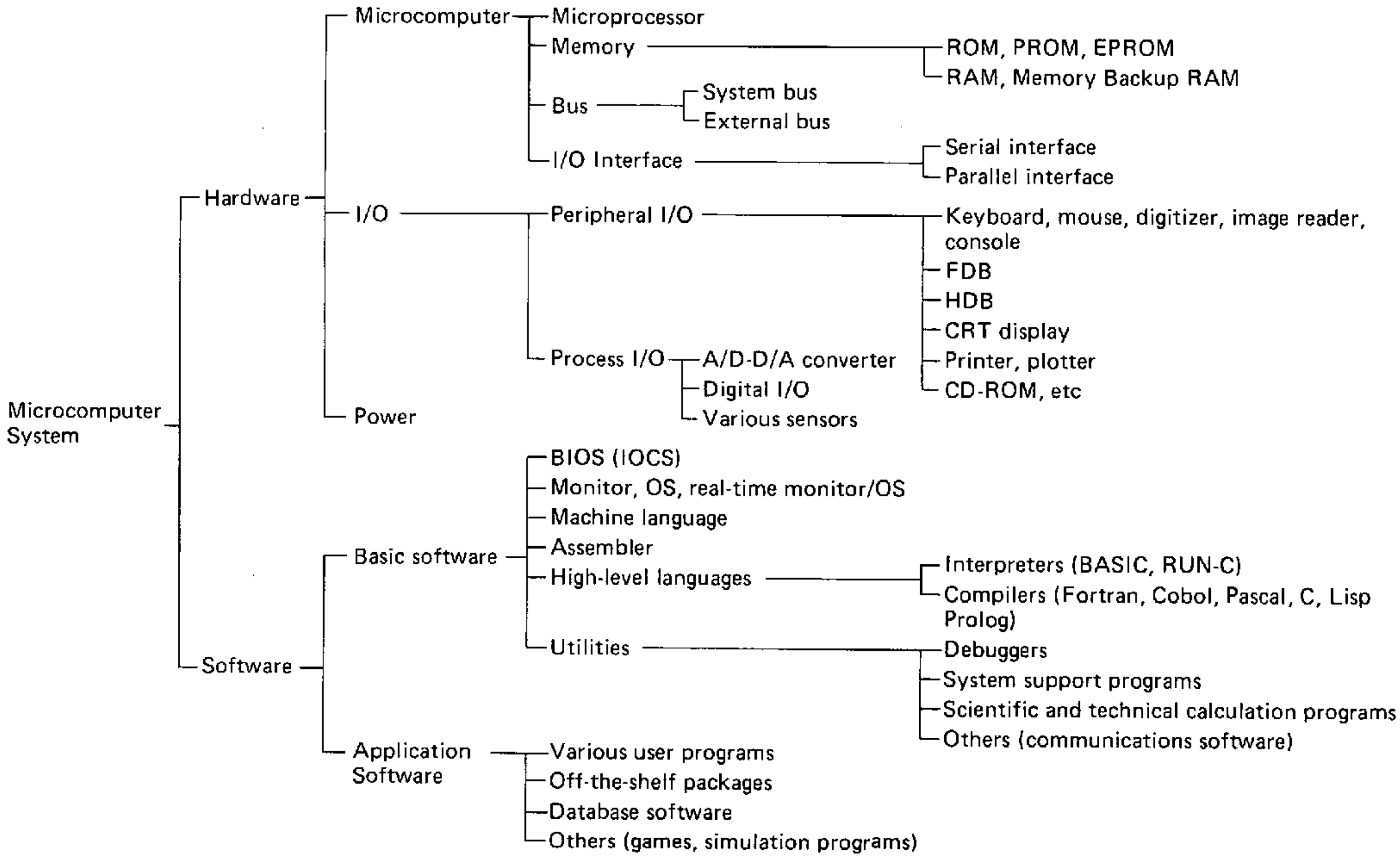
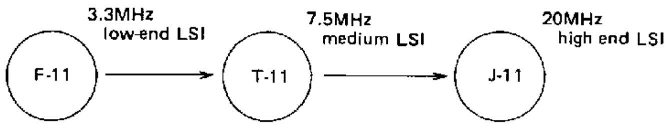
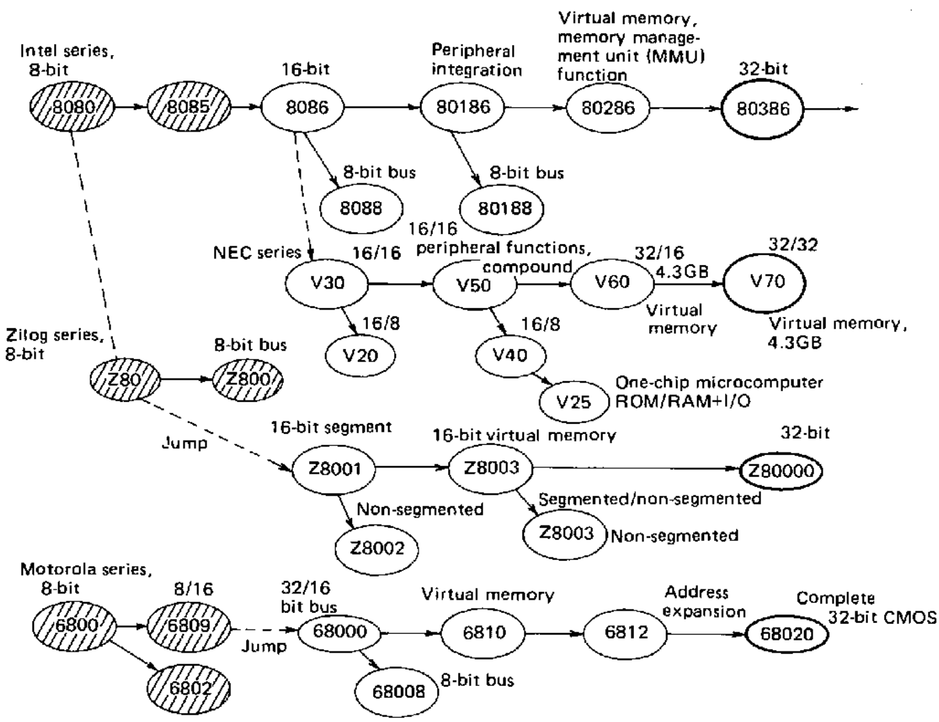


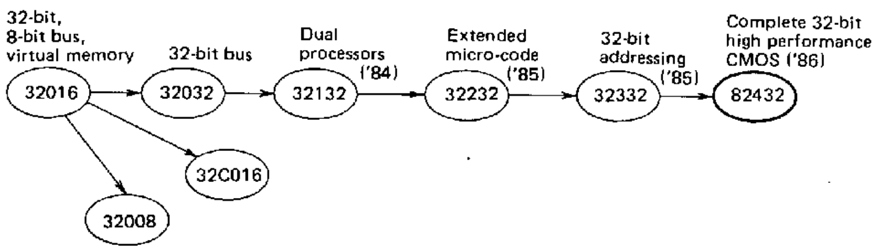

**Figure 1. Microcomputer System Configuration**




(a) Flow of Technology Inherited from Past Minicomputers (PDP-11)




(b) Flow of Technology Inherited from Microcomputers




(c) New Technology Flow (NS 32000 series)

**Figure 2. Three Microprocessor Technology Flows**

pose microprocessors can be broadly divided into three generally accepted categories: minicomputer-oriented, microcomputer-oriented and new 32-bit architectures.

Minicomputer-oriented microprocessors, such as the LSI-11, microNOVA and TI9900, inherit their characteristics from existing minicomputers. These microprocessors are actually minicomputers on a chip, so to speak, and were developed as large-scale integration (LSI) versions of existing minicomputers for the purpose of lowering system costs.

Microcomputer-oriented microprocessors, such as those produced by Intel, Zilog and Motorola, all inherit their characteristics and functions from past microcomputers.

The third category comprises 32-bit microprocessors with new architectures, as well as high-performance microprocessors based on reduced instruction set computer (RISC) technology.

In Japan, microcomputer-oriented microprocessors, especially Intel and Zilog microprocessors (the latter being primarily 8-bit processors), are the most widely employed. Figure 3 shows the evolution of Nippon Electric Corporation's (NEC) V series of microprocessors, which is representative of microprocessor development in Japan. The V20 and V30 microprocessors shown in the figure incorporate the conventional 8088/86 instruction set, and feature software resource succession. In addition, they also feature bit processing instructions, bit

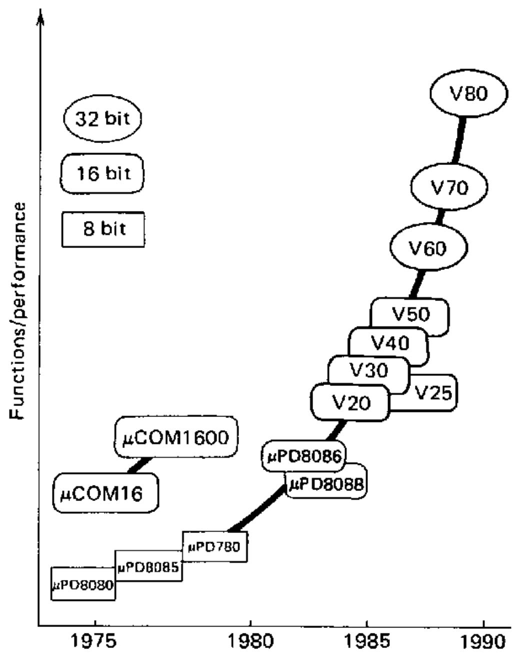



Figure 3. NEC's V Series

field operation instructions and decimal arithmetic instructions. In other words, architecture-wise the V20 and V30 microprocessors are compatible extensions of 8-bit microprocessors from the Zilog family. They are also equipped with an 8080 emulation mode to enable software resource succession from the 8-bit generation.

In 1986, NEC developed the V40 and V50 microprocessors with built-in peripheral functions, and commercialized the V60, its first 32-bit microprocessor in the V series. The V70 was developed the following year in 1987. The V60 and V70 32-bit microprocessors support both UNIX (System V) and ITRON. ITRON (industrial TRON), which goes by the product name of RX616, is an external specification of The Real-time Operating system Nucleus (TRON) developed as a part of the TRON Project headed by Assistant Professor Ken Sakamura of Tokyo University. A number of products have already been turned out based on ITRON. These include NEC's RX116 (1984) employing the V20 and V30 microprocessors; Hitachi Limited's H168K (1986) based on that company's 68000 microprocessor; and Fujitsu Limited's REALOS/286 (1986), which uses the 80286 microprocessor. NEC is striving to develop a 10-MIPS V80 microprocessor based on the 32-bit bus V70.

## SPECIFIC MICROCOMPUTER APPLICATIONS AND PRODUCTS

Figure 4 provides some specific examples of how microcomputers are being used. As the figure indicates, microcomputers are being applied to an extremely wide range of different fields. In fact, it probably would not be overstating a fact if we said that microcomputers are being put to use in thousands of different applications.

The examples given in Figure 4 are fairly specific, and include applications in consumer products and household appliances (these involve mostly 4- and 8-bit microcomputer systems); measuring, testing and monitoring equipment; industrial and control equipment; data processing devices; business and commercial equipment; data communications equipment; and traffic, transportation and other equipment and machines. Microcomputer systems are also being put to use in research and military applications as well.

In future, the fusion of microcomputer applications and telecommunications technologies can be expected to produce a variety of new systems for use in all sorts of different fields.

## MICROCOMPUTER APPLICATION TRENDS

The current trend in microcomputer applications in Japan is away from microcomputer systems comprised of single microprocessors and toward multiprocessing systems consisting of several microprocessors working together. There are a number of reasons for this. These include the rapidly rising costs of software development and the spread of ap-

Specific Microcomputer Applications and Application Fields

| | | |
|---|---|---|
| Consumer Goods/Home Appliances | 1. Automobiles | Automotive computers |
| | 2. Household appliances | TVs, microwave ovens, tape recorders, washing machines, gas appliances, timers, home automation computers, home computers, audio equipment, digital clocks, VTRs and DATs. |
| | 3. Calculators | High level calculators |
| | 4. Toys | TV games, Othello games |
| | 5. Educational instruments | Educational equipment, CAI, electronic ledgers |
| | 6. Others | 8mm movie cameras, ticket vending machines, state-of-the-art cameras |
| Measuring, Testing and Monitoring | 1. Measuring instruments | Image analyzer, dimension and shape measuring instruments, capacitance bridge, laser doppler current meter, meteorological data recording devices, multi-point temperature recording devices, digital integrators, coordinate analysis systems, proton accelerator monitoring systems, light wave intervention measurement device, laser wave length rectifier, self-registering spectro-photometer, automatic fluid measuring device and engine monitors |
| | 2. Analyzers | Blood analysis data processor, chemical reaction test measuring and control devices, vibration analyzers, infrared spectrum analyzers, noise analysis systems, petroleum gas analysis devices and gas chromatography instruments. |
| | 3. Test and Inspection Equipment | Logic card self-testing machines, clock component inspection system, electronic circuit inspection system, electronic circuit tester, pneumatic motor test system, transistor measuring system, generator test system, IC mask flaw inspection device, memory tester, gas equipment function inspection device, automatic inspection systems and automatic semiconductor inspection equipment. |
| | 4. Monitors | Sleep monitoring systems, warning monitor systems, disaster prevention monitoring systems, gas detection systems, dam data logger, radiation monitoring equipment, train schedule recording devices, power company remote monitoring equipment, production monitoring systems, electronic furnace monitoring devices, signal monitoring devices and water and sewage monitoring equipment. |
| | 5. Electronic Medical Equipment | Artificial kidney systems, physical strength diagnostic systems, medical analysis equipment, X-ray equipment, automatic lung examination equipment, X-ray analysis equipment and medical treatment systems. |
| | 6. Others | Protective relays, magnetic bubble memory controllers, microcomputer hardware monitors, automatic driving devices and electromagnetic wave polarizers. |
| Industry and Control | 1. Production Machinery and Equipment | Numeric controllers, programmable machining center welding equipment, assembly machines, automatic programming equipment for production machinery and automated machine tools. |
| | 2. Machine Controllers | Automatic insertion equipment, coin insertion equipment, pachinko controllers, sequence-controlled automatic measuring and packaging equipment, automatic assortment and conveyance systems, automatic packaging controllers, application controllers, clock production equipment, agricultural equipment, robots, air conditioner controllers, wire bonders, photographic equipment, crane controllers, PDC, industrial sewing machine conveyance devices and painting equipment. |
| | 3. Process Control | Process controllers, ingredient mixing systems, chemical plant controllers, filtering pond controllers, smeltering furnace controllers, electric furnace heat processors, hydroponic cultivation equipment, gas flow controllers, PID controllers and power plant control systems. |
| | 4. Dataloggers | Dataloggers, high-speed multi-channel digital recorders, power dataloggers, multi-channel data multiplexers and test data management devices. |
| | 5. Production Management Equipment | Operation monitors, production management equipment, voucher processing equipment and process automation equipment. |
| | 6. Others | Emergency power systems, industrial refrigeration equipment and agricultural machinery controllers |
| Data Processing | 1. General-purpose Computers | Personal computers, program development systems, data processing equipment, multi-microprocessors, microcomputer development systems for low-end general-purpose minicomputers, workstations, expert systems and AI systems. |
| | 2. Peripheral/terminal Equipment | Intelligent input terminals, modem interfaces, I/O controllers, coordinate input devices, floppy disk controllers, printer controllers, formatters, cartridge tape controllers, OCR processors, concentrators, data terminals, kanji data stations and high-precision video systems. |
| | 3. Scientific & Technical Computers | Scientific and technical computers and IBM 1070 replacements. |
| | 4. Others | Digital filter test equipment and machine translation systems |
| Business and Commerce | 1. Business Computing | Business processing machines, data collection machines, voucher processing equipment and accounting machines. |
| | 2. Sales and Inventory Control | Inventory control equipment |
| | 3. Word Processing | Typewriters, word processors |
| | 4. Retail Accounting | POS, ECR. |
| | 5. Financial Terminals | Terminals, intelligent CRT display terminals for financial use and hotel check-in terminals. |
| | 6. Business Machines and Others | Reproduction machines, SBCs, data entry machines and microfilm information retrieval (IR). |
| Data Communications | 1. Wired Communications | Electronic switching equipment, charge calculation machines, electronic PBX. |
| | 2. Data Communications | Digital telephones, terminal communication control equipment, telemetering equipment, bank online terminals, traffic and weather information collection equipment and message transmission equipment. |
| | 3. Image Communications | Kanji display terminals, graphics display terminals, stock price display terminals, facsimile machines, image communication equipment. |
| | 4. Wireless Communications | Guidance communications control equipment, remote monitoring control devices, ship telephones, mobile satellite communications stations and tuners. |
| | 5. Broadcasting | Studio transmission systems, automatic setup systems for TV cameras, VTR editing systems, echo cancellers, automatic address change equipment for VTRs and automatic program sending equipment. |
| | 6. Others | Map indexing equipment, communication controllers, wind power generator controllers, voice coding machines and decoding machines. |
| Traffic and Transportation | 1. Signal Control | Signal controllers, centralized signal control equipment. |
| | 2. Movement Control | Movement control equipment, traffic monitoring systems, traffic information systems, centralized automatic movement monitoring systems and train monitoring systems. |
| | 3. Station Automation | Fare collection equipment, automatic ticket machines and receipt issuing machines. |
| | 4. Sea and Air Transportation | Navigational equipment, satellite navigational equipment for ships and Omega navigation systems. |
| | 5. Others | Automobile malfunction information processing equipment, crane controllers, automatic driving devices and traffic simulation equipment. |
| Others | 1. Building Management | Building management systems and smart buildings. |
| | 2. Hotel Systems | Hotel systems. |
| | 3. Systems Control | General disaster prevention monitoring and control systems, education systems, power consumption monitoring systems and crime prevention systems. |
| | 4. Others | Laser tracking devices, elevator control systems and weather information processing equipment. |

**Figure 4. Specific Microcomputer Applications and Application Fields (partially revised JEIDA information)**

plication specific IC (ASIC) technologies, plus the need to meet demand for distributed processing and utilization as a means of enhancing performance and reliability.

To date, microcomputers have developed along the following lines:

1) smaller, less expensive to produce;
2) higher speed (higher operating frequencies and high speed memory elements);
3) higher performance (more powerful peripheral LSIs and the progression from 8- to 16- to 32-bit CPUs);
4) lower consumption (CMOS technology); and
5) multiprocessing capabilities (multiprocessors, ASIC technology and networking).

It can not be denied that microprocessors first made their debut in the form of hand-held calculators. However, in just a little over ten years microprocessors have changed radically, growing into computers in their own right. The impact these devices have had on the world at large has not been limited to the realm of technology alone — it has created a wave of new applications in almost all fields. This has given rise recently to increasingly strong demands for compatibility and standardization in the realms of both hardware and software. The trends apparent in the TRON project are good examples of this.

Some representative examples of how microcomputers are being applied in Japan include high-performance laptop personal computers (PCs); TRON machines; personal teleworkstations; LINKS-I/II; and the Dialog System.

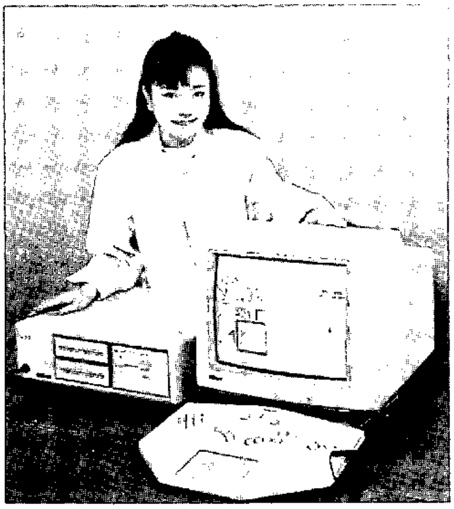


**Photo 1. BTRON Prototype Machine Built by Matsushita Electric Industries Co., Ltd.**

A good example of a Japanese-made high-performance laptop PC is Toshiba Corporation's T5100. This machine employs the 80386 microprocessor.

Photo 1 shows a prototype TRON machine produced by Matsushita Electric Industries Co., Ltd. This is a BTRON (business TRON) PC based on the 80286 microprocessor. This machine is expected to form the basis for educational PCs built to specifications set forth by the Center for Educational Computing (CEC).

Microcomputers are also finding application in system-oriented personal teleworkstations like the Mighty Mate/if COM7E shown in Photo 2. This device combines 16-bit (MSM80C86) PC functions with word processing, data communications and multi-purpose telephone functions, and packs all this into a com-

**Photo 2. System-oriented Teleworkstation Mighty Mate/ifCOM7E**

pact body together with a variety of expandable I/O functions for superb man-machine interface capabilities. Mighty Mate is the name given this machine by Nippon Telegraph and Telephone Corporation (NTT), and ifCOM7E is the product name given it by the original manufacturer, Oki Electric Industries Co., Ltd.

LINKS-I is a large-scale multiprocessor system developed by Osaka University and recently commercialized for use as a three-dimensional video generator. As shown in Figure 5, the LINKS-I consists of 65 node controllers (NCs). The route computer (RC) simultaneously transmits data required for diagram generation to all NCs via the bus switch (BS). The RC employs a centralized control system that provides the NCs with one scanning spot at a time for processing. Only when processing of one scanning spot is complete does the RC provide the NCs with the next scanning spot. LINKS-II is currently

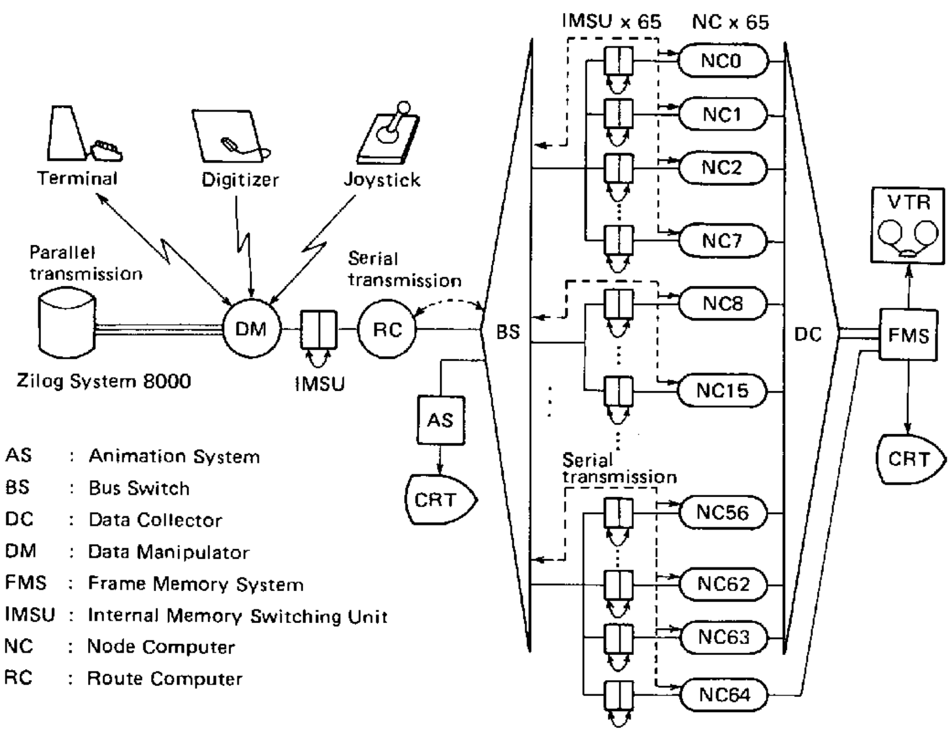



**Figure 5. LINKS-I Developed by Osaka University**

under development.

The Dialog System, which is presently under development by the Electrotechnical Laboratory, is a multiple instruction multiple data (MIMD) system designed to increase the transmission speed of a shared bus using spatial optical propagation. As shown in Figure 6, the Dialog system makes use of properties that determine the radius of a cylindrical mirror, the range of existence of a transceiver device (a) and the angle of radiation (c) so that the locus can be fixed to allow the light reflected from the cylindrical mirror to spread just to the space between b and c.

## MICROCOMPUTER APPLICATION SYSTEM ARCHITECTURES

Microcomputer systems are coming of age, and with the rapid progress being made in microprocessor technology, should reach the mature phase in their development before much longer. Microcomputer system architectures are also growing more sophisticated, and noteworthy new technologies and knowhow are being accumulated in vast amounts. For instance, new microcomputer system architectures will probably all incorporate basic technological elements comprised of next generation technical knowhow.

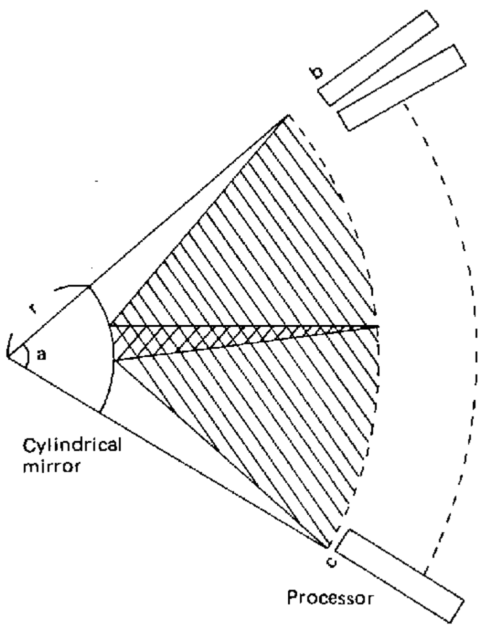



**Figure 6. DIALOG System Under Development by the Electrotechnical Laboratory**

## Easy-to-use Architectures

Among the new architectures for microcomputer systems will be easy-to-use architectures. These will include architectures oriented toward new programming languages like Ada, as well as new computing models. Easy-to-use architectures will also include high-level architectures.

## High-performance Architectures

There will also be high-performance architectures that go beyond anything capable under the old von Neumann machine concept. Some architectures that might fall under this category are parallel processing architectures, modular architectures and flexible architectures.

## New Application-oriented Architectures

PCs and other widely used advanced architectures, plus the artificial intelligence-type architectures that are now coming more and more into the spotlight are steadily carving out places for themselves as new applications-oriented architectures. These architectures will become the driving forces behind future office, factory and home automation schemes.

## High-Reliability Architectures

High-reliability architectures will require new technologies. Among these will be redundancy structured architectures, protection mechanism architectures, auto-diagnostic architectures, fail-soft architectures and fuzzy architectures.

## Network Architectures

Network architectures will consist of multiprocessor system architectures and LAN architectures among others.

By making the most of the new architectures cited above, microcomputer application fields in Japan will continue to grow and expand, enabling this country to deal with a wide variety of advanced problems using numerous and diverse microcomputer-based systems.

# CONCLUSION

Today, microcomputers can no longer be viewed simply as device technologies, but rather must be looked at as a form of computer technology. Thirty-two-bit microprocessors are being readied for commercialization, and the architectures used in the construction of these devices are comparable to those found in large-scale computers.

Rapid advances in integration technologies are expected to continue for some time to come. And as they do, ever larger scale integration and faster operating speeds will bring us closer to realizing microcomputer systems capable of tens of MIPS, speeds heretofore only possible with mainframe computers.

We can also expect to see the advent of new types of microcomputer systems, such as those which employ multiprocessor chips that combine a number of microprocessors on a single chip, and

ASIC-based user-designed microcomputer systems on a chip.

A lot of work is being put into the development of dedicated processors for use in AI, image processing, signal processing and LANs as well.

Microprocessor technology is merging with communications and multi-media technologies, a factor which will further advance the level of microcomputer system applications technologies in Japan. Microcomputer systems are expected to play a central role in fulfilling a variety of information processing needs in future.

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# EDUCATION CURRICULUM FOR MICROCOMPUTER ENGINEERS

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## MICROCOMPUTER APPLICATIONS AND ENGINEERS

### Overview

The importance of computer technology was recognized early on in Japan, and the world of industry was the first to set about devising measures to deal with this technology and the software so vital to its operation. However, new problems and issues kept cropping up and before we could really get a handle on it, computer technology had already become an essential part of our society. But our past experiences in this field will enable us to select the most appropriate new computer technologies to introduce into industry and society in future.

Radical advances were made in semiconductor technology starting in the 1970's. The subsequent appearance of high-performance, low-cost devices as a result of these advances prompted the rapid spread of microelectronics throughout industry, forcing industry to once again try to come to grips with a computer-related technology.

The goal then is to seek applications for microelectronics that allow the hardware and software aspects of this technology to mutually complement and unite with one another.

### Spread Of Microcomputer Systems

Today, microelectronics technology is finding applications in a wide range of different fields, and microelectronics devices are being incorporated into large numbers of products. Applications for microcomputer systems are steadily growing, both quantitatively as well as qualitatively.

### Cost effectiveness

As the term mechatronics implies, electronics technologies are rapidly replacing conventional technologies, and products incorporating microcomputers are fast becoming the norm. This is resulting in considerable cost effectiveness in product manufacturing processes. This goes for development costs as well as product costs, cost effectiveness being achieved in the materials and number of processes required to manufacture a product. In other words, microcomputer technology has become a requisite for companies striving to remain competitive.

### Improved product performance

Microcomputer technology makes it relatively easy to realize high level functions (computing, control, classification and inquiry functions) that were difficult to achieve in the past. This is stimulating the spread of "intelligent" products into a wide range of applications and fields. For companies, microcomputer technology has become an essential factor in achieving value added.

### System optimization

Office automation (OA) and factory automation (FA) represent the direction of computerization in the world of industry, and underlying these movements is the demand for total system performance. This trend is quite evident even at the individual product level, where products are being sought more and more as system components.

Functions suitable for use in distributed processing and network intermeshing are being sought, and microcomputer systems are essential to achieving these functions.

### Enhanced quality

Microcomputers enable larger scale integration and thus allow the number of component parts used to manufacture a product to be drastically reduced. This in turn enhances product reliability and improves quality. Microcomputers also facilitate the use of a variety of diagnostic tools, thereby enhancing efficiency by shortening the time it takes to locate and repair malfunctions.

## The Role Of Microcomputer Systems Engineers

The above cited spread of microcomputers is creating the following roles for microcomputer systems technology and the engineers that specialize in this technology.

### Product planning

Product planning requires timely decisions concerning market demand levels and the suitability of product planning schemes vis-a-vis those markets.

In making these decisions, provisions must be made for product competiveness as well, i.e. product planning has to take costs, functions, performance and quality into consideration. It is also necessary to formulate clear policies regarding product assessments/evaluations prior to marketing and post-marketing development work (See Figure 1).

These kinds of decisions and plans require considerable and varied inputs of knowledge from a wide range of technical fields, and especially from the field of microelectronics. First-class microcomputer systems engineers are therefore indispensable to the product planning process.

### Product development

Once a product plan reaches the development stage, work is generally

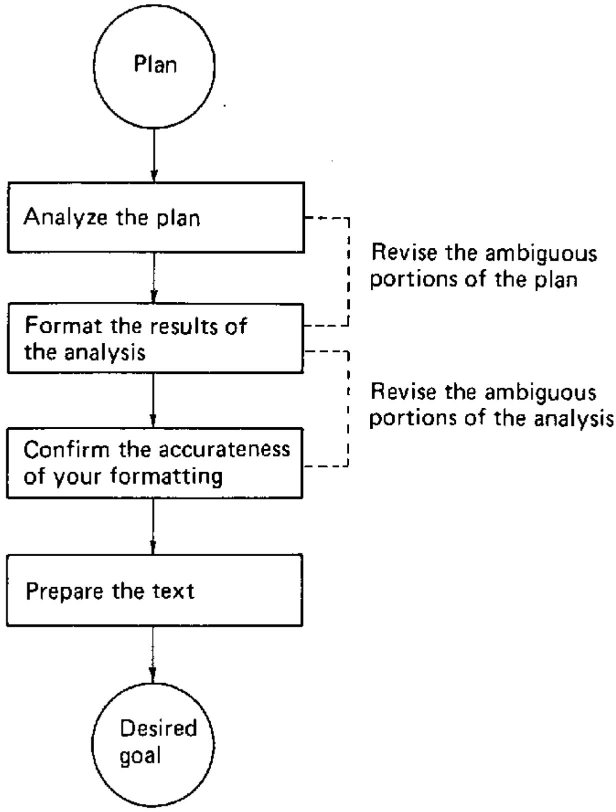


**Figure 1. Defining Requirements**

carried out by a project team comprising a project leader, who is charged with overall coordination of the project, and a number of designers from different fields.

The project leader oversees the design of the total system, which includes both hardware and software, and does so keeping the various trade offs between these two fields in mind.

The designers generally work either in hardware or software. No matter which field they are assigned to, they must bring with them specialized knowledge of their own chosen fields, plus skills and know-how in either hardware or software development. In some cases, designers are asked to undertake both hardware and software design at the same time.

As microcomputer-equipped products continue to increase and spread, microcomputer hardware is evolving and changing, resulting in new, original hardware configurations. And since it is software that controls this increasingly specialized hardware, the two technologies are becoming more inseparable all the time. Individual systems designers are thus being required to work in both realms simultaneously.

### Production design

People in charge of setting up production processes (installing production lines, putting together operation manuals and providing employees with education and training in the performance of those processes) and/or promoting their improvement, enhancement and value analysis do not necessarily do so in a uniform manner. In many cases, therefore, the skills and knowhow of systems engineers are needed at important steps in coordination and inspection processes in particular.

### Quality assurance and service

A wide range of microcomputer-related skills and knowhow are also required in the areas of quality assurance and afterservice for microcomputer-equipped products. In addition to establishing the kind of system mentioned above (manuals and training), microcomputer systems engineers are also needed to troubleshoot the various malfunctions that can occur in these products.

Figure 2 shows the process used to develop microcomputer systems. This flowchart also serves to illustrate the "flow" of responsibilities shouldered by microcomputer systems engineers.

## Training Microcomputer Systems Engineers

As pointed out above, the role of the microcomputer systems engineer is becoming increasingly important in a growing number of different fields. Nevertheless, the training programs currently in place for microcomputer systems engineers are still not satisfactory.

The current state of in-house education and training programs aimed at microcomputer systems engineers in Japan, as well as some of the more blatant problems that must be dealt with in this regard, can be summarized as follows:

1) Microcomputer systems engineers are not limited to working in the technical departments of companies alone, but rather must be assigned to a number of different departments and sections, to include the business and manufacturing departments. This situation is giving rise to a real shortage of qualified personnel to fill these positions;
2) As a rule, companies divide microcomputer systems development into two separate operations, one for hardware and another for software. However, it is now rather widely recognized that merging the two realms of hardware and software development into a single operation produces the best results. Nevertheless, those firms that have taken steps to reorganize their operations to achieve this have yet to proceed

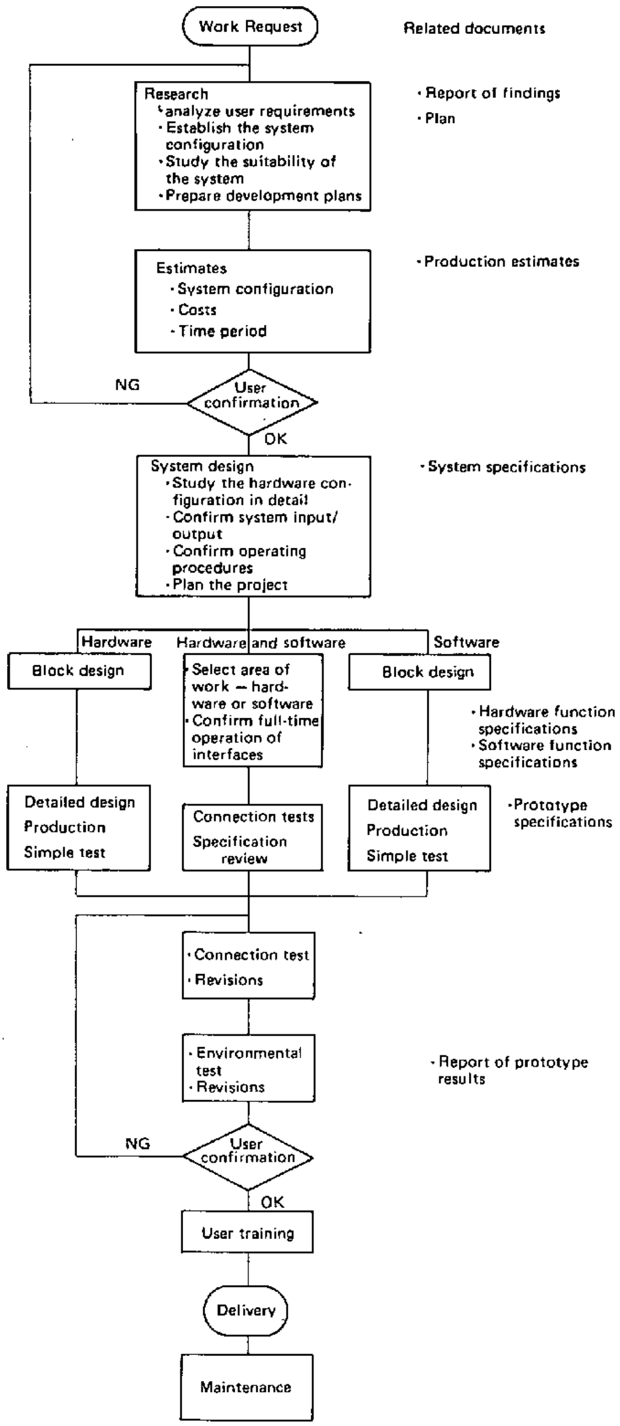


**Figure 2. Microcomputer System Development Process**

beyond the trial-and-error stage;

3) Historically speaking, microcomputer technology is quite new. At the same time, however, it has undergone tremendous changes in its brief existence. For these reasons, existing hierarchical structures are no longer adequate to the task, and new hierarchical structures are needed;
4) Microcomputer systems development sections often need to contact and cooperate with other divisions and sections within the same company, as well as with outside organizations. However, the means for coordinating these contacts and supporting systems engineers are still far from adequate; and
5) There is still no firmly established system for recognizing and evaluating the qualifications of microcomputer systems engineers, which in turn makes it difficult to set up educational and training goals and targets, and to devise effective plans for facilitating education/training programs. This also accounts to some degree for why so many companies are having such a hard time finding the qualified microcomputer systems engineers they so sorely need.

In 1987, the Japan Information Processing Development Center (JIPDEC) conducted a survey aimed at determining how well the supply of microcomputer-related engineers was meeting the demand for said at Japanese companies. The results of that survey are presented in Figure 3.

Figure 4 provides information on the types of work in which these same microcomputer-related engineers were actually engaged.

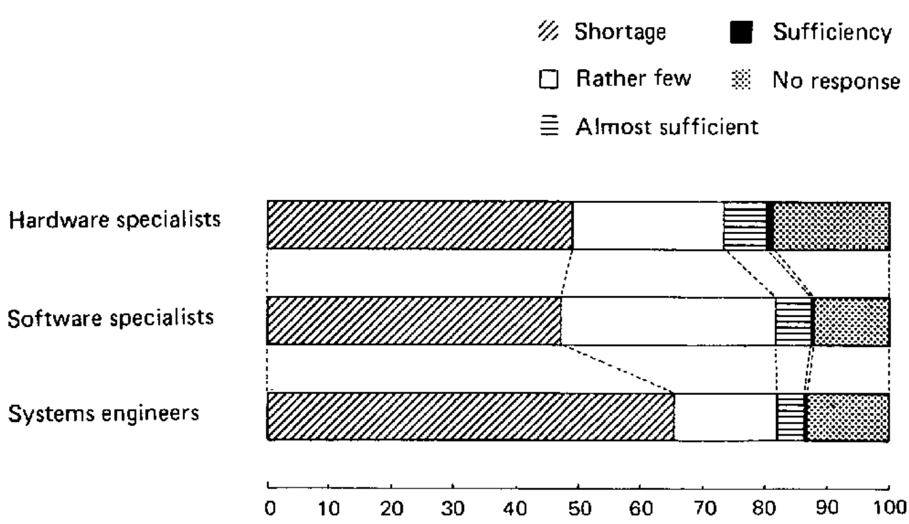


**Figure 3. Supply of Microcomputer-related Personnel by Technological Specialization**

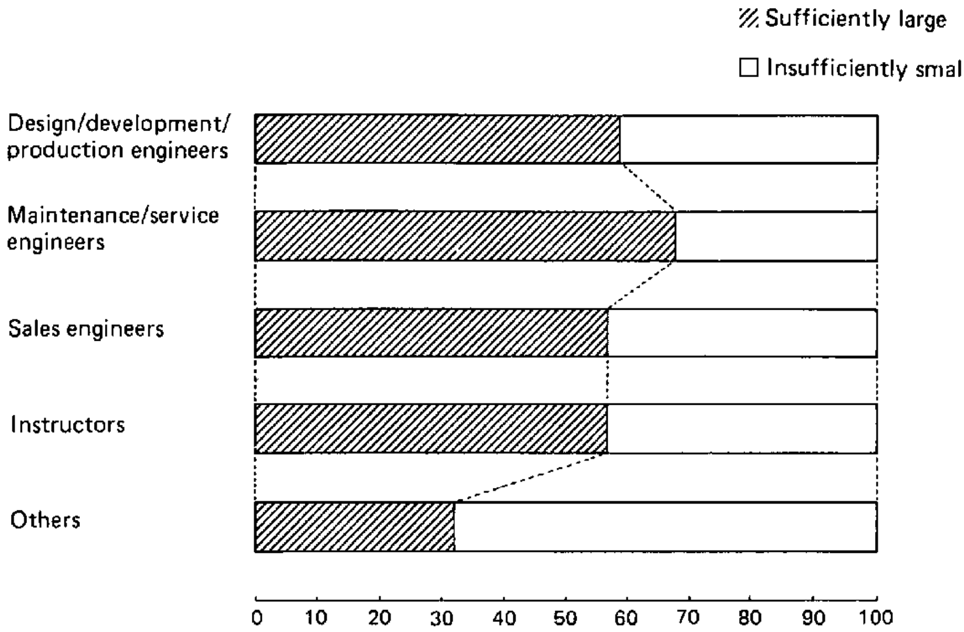


**Figure 4. Ratio of Personnel Possessing Required Microcomputer-related Knowledge**

Both sets of data indicate that the shortage of microcomputer engineers at Japanese firms is a serious problem. What this information does not indicate is the fact that the situation is becoming chronic. In order for Japanese companies to deal smoothly with the phenomenon of expanding microcomputer applications combined with ever more sophisticated technology, they are going to have to solve their personnel problems, and fast.

When it comes to in-house training programs for microcomputer engineers, most companies are relying on OJT schemes. However, in order to satisfy the need for more, higher quality engineers, these OJT schemes are going to have to be supplemented with systematic learning and/or complete education programs in the very near future. These systematic education programs will have to focus on in-house education and training schemes for the most part, and, with the exception of the major manufacturers, this means there are bound to be big gaps between what is ideal and what is possible from a practical standpoint. At present, the majority of Japanese firms have no recourse but to keep relying quite heavily on OJT. If this situation isn't overcome in the near future, then we can expect the dearth of qualified microcomputer engineers to continue to worsen.

What is urgently needed now to effectively manage the education and training of microcomputer engineers are some appropriate goals for these engineers to aim for, plus a system for objectively evaluating their qualifications and abilities.

## STANDARD EDUCATION CURRICULUM FOR MICROCOMPUTER SYSTEMS ENGINEERS

As should be evident from the previous sections, Japan is sorely in need of a policy for educating its microcomputer-related engineers. JIPDEC is therefore working to come up with a standard curriculum for use in the education of microcomputer systems engineers. The concepts and contents of such a curriculum are set forth below.

### Overall Curriculum Organization

Microcomputer systems engineers belong to a rather different world than information processing engineers. The difference between these two groups of engineers lies in the greater degree to which microcomputer systems engineers get involved in hardware-related development. More specifically, microcomputer systems engineers are concerned primarily with making the most of both hardware and software to develop systems that closely approach the goals they have in mind. This means that before an education program for microcomputer systems engineers can be developed, the various levels of skills and knowhow required by these engineers must first be established. Table 1 shows the three levels of skills and knowhow determined necessary for microcomputer systems engineers. Based on this overall image, JIPDEC formulated specific educational goals for each of the three levels, basic, senior and advanced engineers. Figure 5 attempts to express these goals in systematic terms.

### Overview Of Standard Curriculum For Basic Engineers

JIPDEC has already prepared a concrete curriculum for the education of basic grade microcomputer systems engineers, and is currently pushing forward with the preparation of guidelines for the education of these basic grade engineers (a manual for junior engineer instructors) and a standard curriculum for use in the education of senior grade engineers. JIPDEC intends to prepare a curriculum for advanced grade microcomputer systems engineers in future as well.

The standard curriculum for basic grade engineers is basically aimed at microcomputer engineers with at least one year actual working experience (hands-on experience with microcomputer technology), and is designed to raise the level of skills and knowhow possessed by individuals in this class.

### Curriculum organization

#### I. Introductory Training

Training aimed at providing basic grade microcomputer systems engineers with the minimum education required concerning both the hardware and software aspects of microcomputer systems.

## Table 1. Breakdown of Microcomputer Systems Engineers by Class and Skills/knowhow Required:

| Item / Class | Hardware Skills | Software Skills | Overall Position |
|---|---|---|---|
| Advanced Grade Engineers | 1. Should technically<br>1) be capable of working with formula designs for basic application fields (communications or control) and determining the optimum formulas (cost-performance-delivery period).<br>2) Be able to design systems with highspeed input/output, as well as real-time monitors.<br>3) Possess specialized knowhow in a variety of fields. | | 2. For projects, should be able to<br>1) work with formula designs, assign subordinates to positions commensurate with their abilities, and estimate development times accurately.<br>3. Should have worked as a senior grade engineer for at least two (2) years, and should be able to design an innovative system that is operationally sound.<br>[Should be capable of determining the best formulas.] |
| Senior Grade Engineers | 1) Should be capable of processing data by converting it from analog to digital, and of outputting data by converting it from digital to analog.<br>2) Should be capable of working with a variety of standard interfaces (should be able to design peripheral circuits that meet with the designated goals.).<br>3) Should be able to design the circuits needed for the above (should be knowledgable of analog circuits, noise reduction measures and power sources as well.). | 4) Should understand existing OSs and be able to design such systems as necessary.<br>5) Should be able to perform rather difficult processing work using Intel and Motorola assembler languages; should be able to modularize fairly large systems using compilers; and should be able to write a detailed flowchart.<br>(I/O doesn't require very high speeds.)<br>(Should be able to write re-entrant programs — should be capable of handling a number of targets in parallel.)<br>(Should be able to utilize lists — should be capable of efficient retrieval and recognition.)<br>(Should be able to write file management programs.) | 6) Should be capable of quickly utilizing new technologies (16/32 bit architectures, PLA and new OSs).<br>7) Should be able to function as a sub-leader on projects, and to assume responsibility for a good portion of those projects.<br>8) Should have between 2–3 years of experience as a basic grade engineer, and/or have designed an operable system.<br>9) Should be capable of viewing microcomputer systems as a whole.<br>[Should be capable of designing a system given the desired goals.] |
| Basic Grade Engineers | 1) Should be capable of inputting information via a keyboard, of performing simple processing operations, and of outputting information to printers, LEDs and other display devices.<br>2) Should be familiar with the RS-232C and Centronics interfaces.<br>3) Should be able to use (hardware) timers and interrupt keys to perform interrupt operations.<br>4) Should be able to read and produce diagrams for the off-the-shelf circuits required for systems with the above functions (including the necessary peripheral LSI diagrams). | 5) Should possess general knowledge of development and implementation environments.<br>6) Should be capable of performing simple processing operations using either Intel or Motorola assemblers (For instance, should be able to use I/O macros such as BIOS), and of performing fairly complex processing operations using BASIC and C (such as code conversion, aggregate and criteria operations).<br>7) Should be capable of producing accurate subroutines when provided with clear specifications (Should be able to do coding from flowcharts). | 8) Should be capable of performing auxiliary design work, and of producing a system in accordance with a design.<br>9) Should have one year of actual experience, or the equivalent of said in training (i.e. should be on the same level as a technical school graduate).<br>10) Should know technical terminology and be able to converse using those terms.<br>[• Should be capable of performing auxiliary design work, and of producing systems in accordance with those designs.<br>• Should be capable of using technical terminology.] |

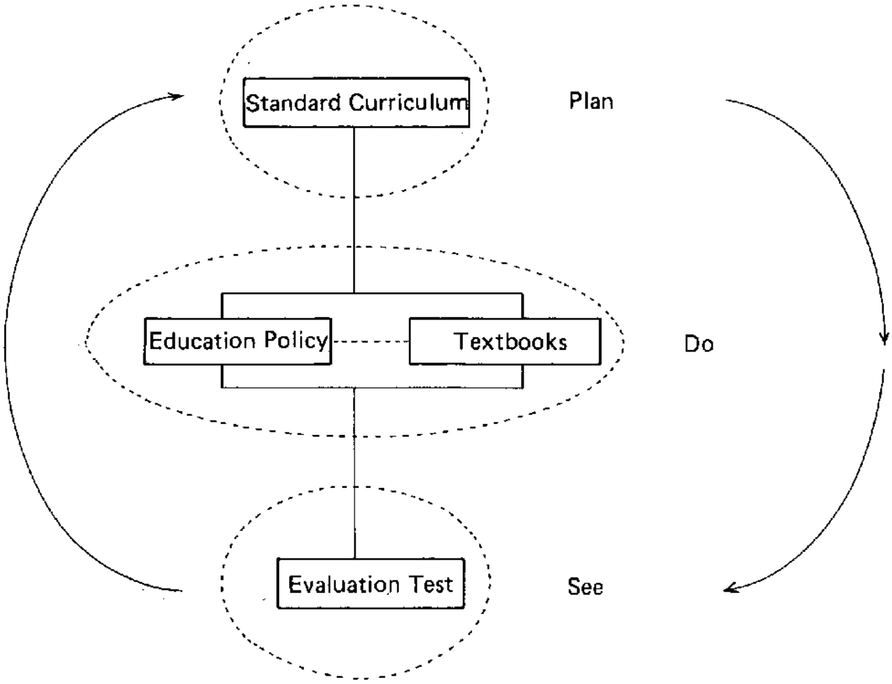


**Figure 5. Education System for Microcomputer Engineers**

## II. Hardware Training

Training aimed at orienting basic grade engineers toward the hardware aspects of microcomputer systems, while at the same time drawing on pertinent software knowhow.

## III. Software Training

Training aimed at orienting basic grade engineers toward the software aspects of microcomputer systems, while at the same time drawing on pertinent hardware knowhow.

## Levels of technology/knowhow

## I. Knowhow

Basic grade engineers must have a general knowledge of the technical terms used in the field. Problems corresponding to technical terminology are marked with an asterisk (*).

## II. Technology

Basic grade engineers should possess the technical skills necessary to apply knowledge and rules related to formula-based operations, circuit analysis and design and programming to develop a microcomputer system that approximates the type of systems desired.

## Curriculum-based training methods

The fundamental approach used to train basic grade engineers in accordance with the curriculum just outlined is as follows:

1) Introductory (joint hardware/software) training is mandatory;
2) Hardware and software training are electives; and
3) The suggested number of training hours per year is 180 hours (which works out to an average of 60 hours per category, i.e. joint hardware/software, specialized hardware and specialized software).

## Contents Of Standard Curriculum For Basic Grade Engineers

This section presents a detailed description of the contents of the standard basic grade engineer curriculum by category.

## I. Introduction (Basic Skills and Concepts)

### Educational Objectives

This part of the curriculum is designed to provide basic grade engineers with an understanding of microcomputer system configurations and operations, and the knowledge necessary to develop such systems. This category serves as a general introduction to the rest of the curriculum.

**Curriculum Outline**

| Contents | Hours |
|---|---|
| Part 1. Fundamentals<br>1. Numeric systems<br>2. Coding systems<br>3. Logic circuits<br>4. Sequential circuit operations | 20 hours |
| Part 2. Systems<br>1. Basic description of micro-computer systems<br>2. Microcomputer system design and development<br>3. Communications techniques | 8 hours |
| Part 3. Hardware<br>1. Microcomputer structures and functions<br>2. Peripheral devices<br>3. I/O interface functions<br>4. Electronic and mechanical components<br>5. Microcomputer systems<br>6. Hardware development/maintenance | 16 hours |
| Part 4. Software<br>1. Role of software<br>2. Program representation techniques<br>3. Programming languages<br>4. Interrupt processing | 16 hours |
| Total | 60 hours |

## Part 1. Fundamentals

### Objectives

The objectives of this part of the curriculum are to provide basic grade engineers with an overall understanding of microcomputer systems, and to teach them the basic mathematical and logic circuit knowhow necessary to work with these systems.

## Section 1. Numeric Systems

### Objectives

To provide basic grade engineers with an understanding of the numeric systems used to represent data and machine language in microcomputer systems. Special emphasis is placed on the concept of complements and how they are used, as well as on floating point operations.

### Contents

1.1 Number representation
   r numbers (binary, octal, decimal and hexidecimal numbers), bit, nibble, byte
1.2 r numbers and operation methods
   Four rules of mathematics (addition, subtraction, multiplication and division).
1.3 Complements
   r complements
   One's complement, two's complement
1.4 Code utilization
   Unsigned binary
   Signed binary
   Overflow
1.5 Other number representations and operations
   Binary coded decimal (BCD)
   Pack formats
   Various representation format operations
1.6 Floating points
   Radix
   Normalization
   Floating point numbers and operations
   Overflow and underflow
   Errors and approximations

## II. Hardware

### Educational Objectives

This part of the curriculum is designed to teach basic grade engineers about fundamental hardware theories and circuits, and to provide them with an understanding of microcomputer system devel-

### Curriculum Outline

| Contents | Hours |
|---|---|
| Part 1. Basic Circuits and Their Applications<br>1. Electric circuits and magnetism<br>2. Electronic circuits<br>3. Op amp<br>4. Power circuits<br>5. Logic circuits | 15 hours |
| Part 2. Microprocessors and peripherals<br>1. Overview of microprocessors<br>2. Microprocessor configurations and operations<br>3. Memory<br>4. I/O interfaces<br>5. Peripheral devices<br>6. Communications technology | 40 hours |
| Part 3. Interfaces<br>1. Interfaces<br>2. A-D/D-A converters<br>3. Sensors<br>4. Actuators | 15 hours |
| Part 4. Development Procedures and Tools<br>1. System development and design procedures<br>2. System development support tools<br>3. Electronic instrumentation | 10 hours |
| Part 5. Components and Packaging<br>1. Electronic components<br>2. Display devices<br>3. Packaging technology | 10 hours |
| Total Hours | 90 hours |

opment, design, production and inspection, evaluation testing and maintenance, as these relate to the software aspects of such systems.
An additional 30 hours of practical training and exercises are required.

## Part 1. Basic Circuits and Their Applications

### Objectives

This part of the curriculum is designed to provide basic grade engineers with an understanding of the fundamental circuits that comprise microcomputer systems, and their respective functions.

## Section 1. Electric Circuits and Magnetism

### Objectives

This section of the curriculum is designed to familiarize basic grade engineers with the fundamental rules and theories related to electricity, electric circuits and magnetism, and to teach them how to use actual circuits.

### Contents

1.1 Direct current circuits
1) Resistors linked in series and in parallel
2) Laws governing ohms
3) Kirchhoff's law
4) Power calculations

*1.2 Alternating current circuits
1) AC expressions
2) Resistance circuits
3) Inductance circuits
4) Capacitor circuits
5) Serial resonance

*1.3 Magnetism
1) Magnetic induction
2) Current induced magnetic fields (Percival's law)
3) Fleming's law
4) Lentz' law
5) Magnetic screens

# III. Software

**Educational Objectives**

This part of the curriculum is designed to provide basic grade engineers with basic knowledge regarding software by teaching them about the role of software as it relates to hardware, software development techniques, operating systems,

**Curriculum Contents**

| Contents | Hours |
|---|---|
| Part 1. Programming<br>1. Role of software<br>2. Programming languages<br>3. Basic programming<br>4. Structured programming and program writing rules | 30 hours |
| Part 2. Operating Systems<br>1. Operating systems<br>2. Language processors | 10 hours |
| Part 3. Software Applications<br>1. Software development procedures<br>2. Applied programming | 20 hours |
| Total hours | 60 hours |

programming languages and language processors. It is also designed to provide basic grade engineers with solid programming skills in the areas of basic, applied and structured programming and program writing rules.

An additional 60 hours of practical exercises and training are required.

## Part 1. Programming

### Objectives

This part of the curriculum is designed to provide basic grade engineers with an understanding of the role of software, plus programming languages and techniques. It is also designed to familiarize them with programs and data structures, and to teach them programming techniques that will allow them to prepare easy-to-read programs.

## Section 1. Role of Software

### Objectives

This section is designed to teach basic grade engineers about the role of software in microcomputer systems development, especially the many software problems related to hardware.

### Contents

*1.1 Software can best be described by:

1) Defining the term software
2) Explaining the special characteristics of software vis-a-vis hardware
3) Relating the problems encountered on the borderline between hardware and software

*1.2 The role of software in system control is:

1) PI control
2) Sequential control
3) Others

*1.3 The role of software in data processing is:

1) Sampling
2) Filtering
3) Physical data and its structure
4) Others

# Examination for Microcomputer-based Systems Engineers

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JIPDEC

## THE MICROCOMPUTER ENGINEER EXAMINATION

### Background

The trend in recent years toward higher performance, lower cost microcomputers has resulted in their becoming vastly popular in just a very short time. The world of industry has quite naturally taken advantage of this phenomenon to introduce this technology into our daily lifestyles. All we have to do is look around us and the truth of this statement becomes obvious. Microcomputers are used in all sorts of electric household appliances, as well as in automobiles, telephones, cameras, sewing machines and even toys. The widespread use of microcomputers is contributing greatly toward improving the way we live.

However, despite the ubiquitous nature of microcomputers, we seldom get to see these devices themselves since they make up the core around which products incorporating them are built.

Microcomputers are really just small semiconductor devices, but they are fast becoming indispensable to society. In future, ever higher performance microcomputers are expected to be incorporated in an increasingly larger and more diverse array of products. These devices could well give birth to products the likes of which we have never even dreamed of before. Come to think of it, they already have.

The rapid spread of microcomputers and microcomputer applications requires increasingly larger numbers of microcomputer systems engineers, and these engineers have to possess increasingly higher levels of skills and knowhow to keep pace with the advance of microcomputer systems and applications technologies. However, we are currently faced with a dire shortage of microcomputer engineers, in the corporate realm as well as other fields.

Educational institutes and corporations have recently begun to recognize the seriousness of the problem, and have started concentrating on the education and training of microcomputer engineers. However, since there is no standard curriculum in Japan for teaching the basic skills and knowhow required of microcomputer engineers, they are running into a number of snags in this regard. For this reason, most corporations have had to rely on relatively ineffective OJT (on-the-job training) schemes to train their microcomputer specialists.

## Introduction of an Examination System

As is evident from the above, the education and training of microcomputer-related engineers is an urgent issue in Japan. According to the results of a survey conducted by the Japan Information Processing Development Center (JIPDEC) in 1987, the amount of money and time spent on the training of microcomputer specialists and engineers in Japan considerably exceeds that for engineers from other fields (See Figure 1). Despite this, however, things are not going as well as people would like them to. To help alleviate the situation, JIPDEC developed a standard curriculum for educating microcomputer systems engineers, and has come up with a concise education policy. This, combined with the introduction in 1985 of an examination system for microcomputer systems engineers, has helped point the way and given impetus to the education of these engineers here.

# EXAMINATION MAKE-UP AND CONTENTS

## Composition of Examination

The Examination for Microcomputer-based Systems Engineers is divided into three levels: basic grade, senior grade and advanced grade. Each level of the examination assumes that the testees already possess certain skills and knowledge. For instance, the exam for basic grade engineers is designed for individuals who already have enough basic knowledge to benifit from OJT (a basic understanding of microcomputers and their applications systems.).

The senior grade exam is aimed at individuals capable of working on their own as microcomputer engineers (People with a solid grounding in microcomputer hardware, software and related technologies, who possess specialized know-

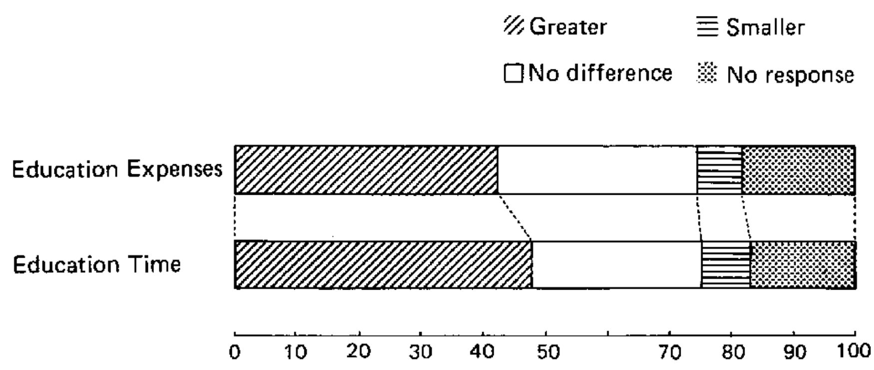



**Figure 1. Time and Expense Devoted to Education — A Comparison and Contrast of Engineers Working in Microcomputer-related Jobs and Those Working in Other Fields**

ledge and skills in the design and development of one or more of these areas, and who, when provided with the necessary specifications, are capable of constructing microcomputer systems.).

The advanced portion of the examination is for engineers with specialized technical knowledge and skills in the areas of microcomputer hardware and software design and development, plus the additional management skills and knowhow to function as project leaders (Engineers with the same technical skills as senior grade engineers, but with long years of practical experience which has prepared them for the development of high-level microcomputer systems and the management of project teams put together to carry out such project.).

The Examination for Microcomputer-based Systems Engineers was first given in 1985, and for the first two years (1985—86) consisted of only the basic grade portion of the test. In 1987, a senior grade exam was also included, and preparations are being made now to offer an advanced grade exam in the near future. The scope of the problems posed in the basic and senior grade exams are presented in Tables 1 and 2.

**Table 1. Scope of Problems Presented in the Basic Grade Exam**

| | |
|---|---|
| Scope of Software-related Problems | The microcomputer system used during the exam is a fundamental systems with a simple input/output device and one level interrupt capabilities. The microprocessor for this system is one of three types of general-purpose 8-bit devices, Intel's 8085, Zilog's Z80 or Motorola's 6800, anyone of which can be selected as necessary.<br><br>o **System Development Process**<br>Examinees are tested on their understanding of general system development processes and the specialized terminology used in said. They are also tested on their knowledge of the names and uses of required development tools, such as editors, debuggers and emulators.<br><br>o **Support Software and Languages**<br>Examinees are tested on their understanding of software development devices, operating systems, conversion programs and programming languages.<br><br>o **Software Development**<br>Examinees are tested on their ability to produce a module based on designs provided. They can choose from among the Z80, 8085 or 6800 microprocessors, and their respective command sets and programming techniques. |
| Scope of Hardware-related Problems | Examinees are evaluated as to their knowledge and ability to comprehend substrate-level designs using Intel, Zilog and Motorola general-purpose 8-bit microcomputers. They are tested in particular on their ability to construct simple logic diagrams used in designing microcomputer systems.<br><br>o **System Hardware and Components**<br>Examinees are tested on their knowledge of and ability to comprehend manufacturer specifications for passive components (resistors, condensors), active components (diodes, transistors), TTL and CMOS. Their basic knowledge of microprocessors, memory and other LSIs, system power sources and grounds, and I/O devices and substrates is also tested.<br><br>o **System Circuit Design**<br>Examinees are tested on their understanding of basic pulse circuits and the operation of logic circuits, and on the degree to which they are capable of constructing simple logic diagrams. Their basic knowledge of microcomputer system construction and the meaning and operation of interfaces is also tested.<br><br>o **System Packaging Technology, Installation Environments and Instrumentation**<br>Examinees are tested on their fundamental knowledge of the effects of heat and noise on microcomputer system installation, as well as their understanding of the fundamental handling procedures for microcomputer system instrumentation. |

**Table 2. Scope of Problems Presented in the Senior Grade Exam**

The senior grade examination is designed to test examinees' abilities to develop standard microcomputer systems hardware and software in accordance with set specifications. Examinees are also tested on their knowledge and ability to understand and analyze the various technologies related to microcomputer systems and their development.

Senior grade are also tested on their ability to make full use of general-purpose 8-bit microprocessors (8085, Z80 and 6800), as well as their understanding of the characteristics and concepts behind general-purpose 16-bit microprocessors, such as the 8086 and 68000.

- **Microcomputer Basics**
  Electronic circuits, multiple interrupt and stack operations.
- **Microprocessors**
  Details of general-purpose 8-bit processors (Selection of the 8085, Z80 and/or 6800 as necessary.).
  Characteristics and concepts of general-purpose 16-bit processors (Selection of the 8086 or 68000 as necessary).
- **Memory**
  Comparison of different types of memory, drive circuits, etc.
- **I/O devices**
  Detailed questions concerning peripheral devices (Displays, FDDs) and I/O devices (sensors, actuators).
- **Interface Circuits**
  Various interface circuits, representative interface chips and system buses.
- **I/O Control**
  Small- and medium-scale system I/O control (Reading of circuit diagrams for small- and medium-scale systems comprised of a number of printed circuit boards, and ability to write programs with system functions in mind.).
- **High-level Programming Languages**
  Programming in C and/or Pascal (Selection of languages as necessary) and structured programming.
- **Operating Systems**
  General descriptions of operating systems and real-time monitoring programs.
- **System Development and Evaluation**
  System development procedures, environments and tools, reliability, testing, maintenance and system evaluation.
- **Neworks**
  Networking, network control and computer-to-computer communication.
- **Packaging Technology**
  Fundamental packaging technologies.
- **Others**
  Power sources, grounds and heat designs.

## Contents Of Examination

Generally speaking, when taking examinations in Japan, we are often tested on matters that are not directly related to the subject at hand. It is something like being made to perform a number of unrelated tasks while striving to get your real work done — you wind up expending a lot of time and effort without really accomplishing anything.

As far as the general examination system in Japan is concerned, this trend simply can't be helped in many cases. However, when it comes to certifying the actual skills and knowhow possessed by engineers, this practice is totally unacceptable.

For this reason, the Examination for Microcomputer-based Systems Engineers is designed first and foremost as a means of testing the microcomputer-related skills and knowhow possessed by examinees. Questions and problems commensurate with each of the three skill levels tested (basic, senior and advanced) make up the brunt of the examination contents. In other words, engineers actually working in the field of microcomputer systems development do not have to spend a lot of time studying for the test in order to pass it. This doesn't mean they do not have to study for the test at all, it simply means that the time required in outside study is considerably less than for most other examinations they have taken.

To make this point clearer, let's take a closer look at the objectives and scope of problems set forth in the senior grade exam. For example, engineers sitting for the senior grade exam should have between 3–5 years of practical experience in the field, and should be well-versed in microcomputer systems development techniques if they wish to pass the test. They are therefore tested on their ability to develop standard microcomputer systems hardware; on their ability to develop the software required by these hardware systems; and on their knowledge of related technologies and their abilities to analyze and comprehend these.

The scope of the senior grade examination includes both 8- and 16-bit microcomputers. The 8085, Z80 and 6800 8-bit CPU/MPUs form the core of the applications-oriented portions of the test, and the 8086 and 68000 are used to test examinees understanding of the concepts and characteristics of 16-bit CPU/MPUs. senior grade examinees must demonstrate their understanding of the hardware and software that goes into making up total microcomputer systems, not just parts of those systems. They must also demonstrate their abilities to analyze these systems; simply possessing the knowhow alone isn't enough.

Specific problems presented in the senior grade exam cover the circuitry and programs used in systems employing the CPU/MPUs cited above and are designed to conform to actual working situations.

Examples of actual problems presented in the basic and senior grade exams for 1987 are given below.

## 1987 Basic Grade Examination I

Problem 8. In microcomputer systems, "1" is reflected in a number of different forms. Select the appropriate numbers or terms from among those given at the botoom of the page and write them in the squares provided in the following problems. The same answers can be used more than once.

[1] Output the ASCII code "1" to the I/O port address.

| 8085 CPU | Z80 CPU | 6800 MPU |
|---|---|---|
| MVI A, □ H | LD A, □ H | LDAA #$ □ |
| OUT PORT | OUT (PORT), A | STAA PORT |

[2] Change bit 1 to "1" without changing the other bits in the A register (accumulator). The MSB is bit 7 and the LSB is bit 0.

| 8085 CPU | Z80 CPU | 6800 MPU |
|---|---|---|
| ORI □ H | OR □ H | ORAA #$ □ |

[3] Put the 16-bit "-1" (complementary expression of 2) in the register.

| 8085 CPU | Z80 CPU | 6800 MPU |
|---|---|---|
| MVI H, □ H | LD H, □ H | LDAA #$ □ |
| MVI L, □ H | LD L, □ H | LDAB #$ □ |

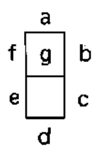
[4] When you want to express the binary numbers in the A register (accumulator) as decimals, implement the following commands when "1" is in the hundreds place, and when it is not, jump to the NEXT label.

| 8085 CPU | Z80 CPU | 6800 MPU |
|---|---|---|
| CPI □ H | CP □ H | CMPA #$ □ |
| JC NEXT | JR C, NEXT | BCS NEXT |
| CPI 0C8H | CP 0C8H | CMPA #$C8 |
| JNC NEXT | JR NC, NEXT | BCC NEXT |
| (Next command) | (Next command) | (Next command) |

[5] Display "1" in the seven segment display accessed via the I/O PORT address. The contents of the PORT address should conform to the following coordinate list.

Cordinate list for the PORT address and 7 segment display

PORT address




7 6 5 4 3 2 1 0

(MSB) (LSB)

| x | g | f | e | d | c | b | a |
|---|---|---|---|---|---|---|---|

The display will blink when you make the equivalent bit 1.

| 8085 CPU | Z80 CPU | 6800 MPU |
|---|---|---|
| MVI A, □ H | LD A, □ H | LDAA #$ □ |
| OUT PORT | OUT (PORT), A | STAA PORT |

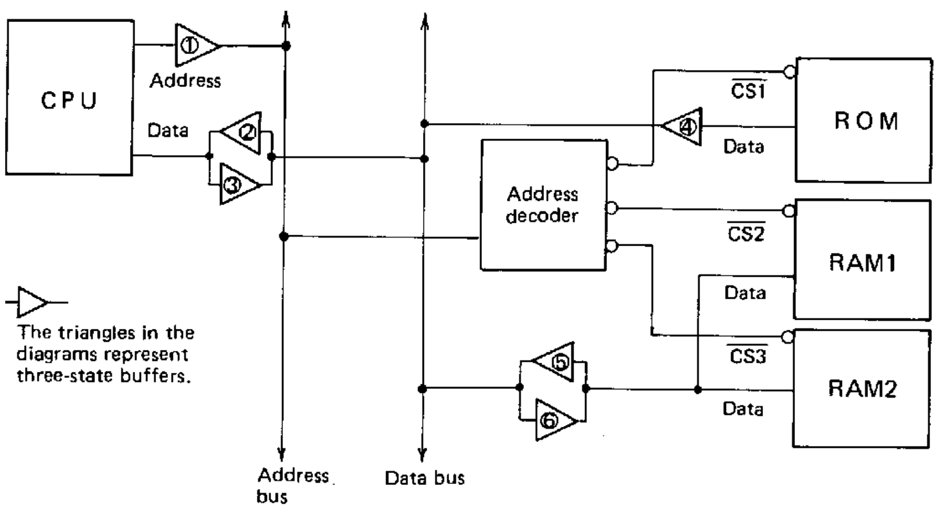
Answers

a. 00 b. 01 c. 02 d. 04 e. 06 f. 31
g. 63 h. 64 i. OFF j. 10

**1987 Basic Grade Examination II**

Problem 15. Select from among the following the three (3) statements which most accurately describe the microcomputer bus buffer control shown in the diagram below.

a. Normally, only one of the buffer gates connected to the data bus can handle output in a high impedance state.
b. If the CPU only is outputting to the address bus, it is not necessary for buffer gate [1] to be in a high impedance state.
c. Buffer gate [2] must be in a high impedance state between CPU lead cycles.
d. When the CPU accesses RAM, buffer gates [5] and [6] must both be in a high impedance state.
e. It doesn't matter whether buffer gate [4] is in a high impedance state or not when the CPU reads data from RAM since this gate plays no part in that operation.
f. Buffer gates [2], [4] and [5] must be in high impedance states when the CPU writes data into RAM.
g. Since the data I/O terminals of ordinary RAM chips are in a high impedance state when there is high level CS, these data I/O terminals can be linked in parallel when multiple RAM chips are used.




**Microcomputer Bus Configuration**

Problem 2. Select the appropriate term from the list of possible answers given at the bottom of the page and write it into the square provided in the following paragraph about branch instructions.

Table 1 shows the results of an investigation into all the branch instructions of a certain program and the scope of branch destinations therein. When this program is transferred to a processor with relative branch instruction sets like those in processors A, B and C shown in Table 2, then [ ] is capable of the smallest possible branch instruction program size (byte size).

**Table 1. Branch Destinations and Number of Instructions**

| Number of bits required to express the relative offset to the branch destinations | Number of Branch Instructions |
|---|---|
| 4 bits or less | 160 |
| 5 bits | 80 |
| Between 6 and 8 bits | 40 |
| Between 9 and 10 bits | 20 |
| Between 11 and 16 bits | 10 |

**Table 2. Branch Instruction Sets**

| | Processor A | Processor B | Processor C |
|---|---|---|---|
| 1-byte branch instruction | 7 6 5 4 3 2 1 0<br>OP \| AD | OP \| AD | None |
| 2-byte branch instruction | OP<br>AD | None | OP \| AD<br>AD |
| 3-byte branch instruction | OP<br>AD<br>AD | OP<br>AD<br>AD | OP<br>AD<br>AD |

OP stands for operation code and AD expresses the branch destination offset address.

**Answers** a. Processor A b. Processor B c. Processor C
d. Processors A and B e. Processors B and C f. Processors A and C

1987 Senior Grade Examination II

Problem 13. Figure 13.1 presents a diagram of the circuitry of a small-scale Z80 CPU-based system with an RS-232C serial interface and a floppy disk (flexible disk) interface. The program shown below is the one used to initialize this system. Study the circuit diagram and program and then answer questions 1 through 5.

For more information on the operations of the peripheral LSIs and logic devices shown in the circuit diagram, refer to the descriptions provided at the end of the test booklet.

[Question 1] Write the appropriate term or numeral in the squares provided in the following descriptions of this system.

[1] In the DMA controller (8237A-5), channel 0 controls the transmission of data between [ ] and menory.

[2] The serial transmission rate is set at [ ] bits per second.

[3] There are four (4) factors involved in interrupt processing. Of these, the [ ] has the highest degree of priority for interruptions that are input from the timer/counter (8253-2) to the interrupt controller (8259A).

[Program]

```
INIT:                           ; Initialize 8237A-5
        OUT     (0DH), A        ; MASTER CLEAR
        XOR     A
        OUT     (08H), A        ; SET COMMAND REG.
        OUT     (00H, A
        LD      A, 0F8H
        OUT     (00H), A        ; SET CH0 ADDRESS(F800H)
        LD      A, 0FFH
        OUT     (01H), A
        INC     A
        OUT     (01H), A        ; SET CH0 COUNT(00FFH)
        LD      A, 58H
        OUT     (08H), A        ; SET CH0 MODE
                                ; Initialize 8259A
        LD      A, 52H
        OUT     (10H), A        ; SET ICW1(Not ICW4, Single, 8Byte, Edge)
        XOR     A
        OUT     (11H), A        ; SET ICW2
                                ; Initialize 8253-2
        LD      A, 25H
        OUT     (23H), A        ; SET CH0 CONTROL WORD(BCD, Mode2, MSB)
        LD      A, 10H
        OUT     (20H), A        ; SET CH0 COUNT(1000)
        LD      A, 97H
        OUT     (23H), A        ; SET CH2 CONTROL WORD(BCD, Mode3, LSB)
        LD      A, 48H
        OUT (22H), A            ; SET CH2 COUNT(0048)
                                ; Initialize 8251A
        XOR     A
        OUT     (31H), A
        OUT     (31H), A
        OUT     (31H), A        ; DUMMY
        LD      A, 40H
        OUT     (31H), A        ; INTERNAL RESET
        LD      A, 4EH
        OUT     (31H), A        ; SET MODE INSTRUCTION
        LD      A, 15H
        OUT     (31H), A        ; SET COMMAND INSTRUCTION(Enable Tx/Rx)
                :
                :               ; Initialize 765A
                :
        LD      A, 0EH          ; 8237A-5 mask removal
        OUT     (0FH), A        ; SET MASK REG. (Enable CH0)
        EI
```

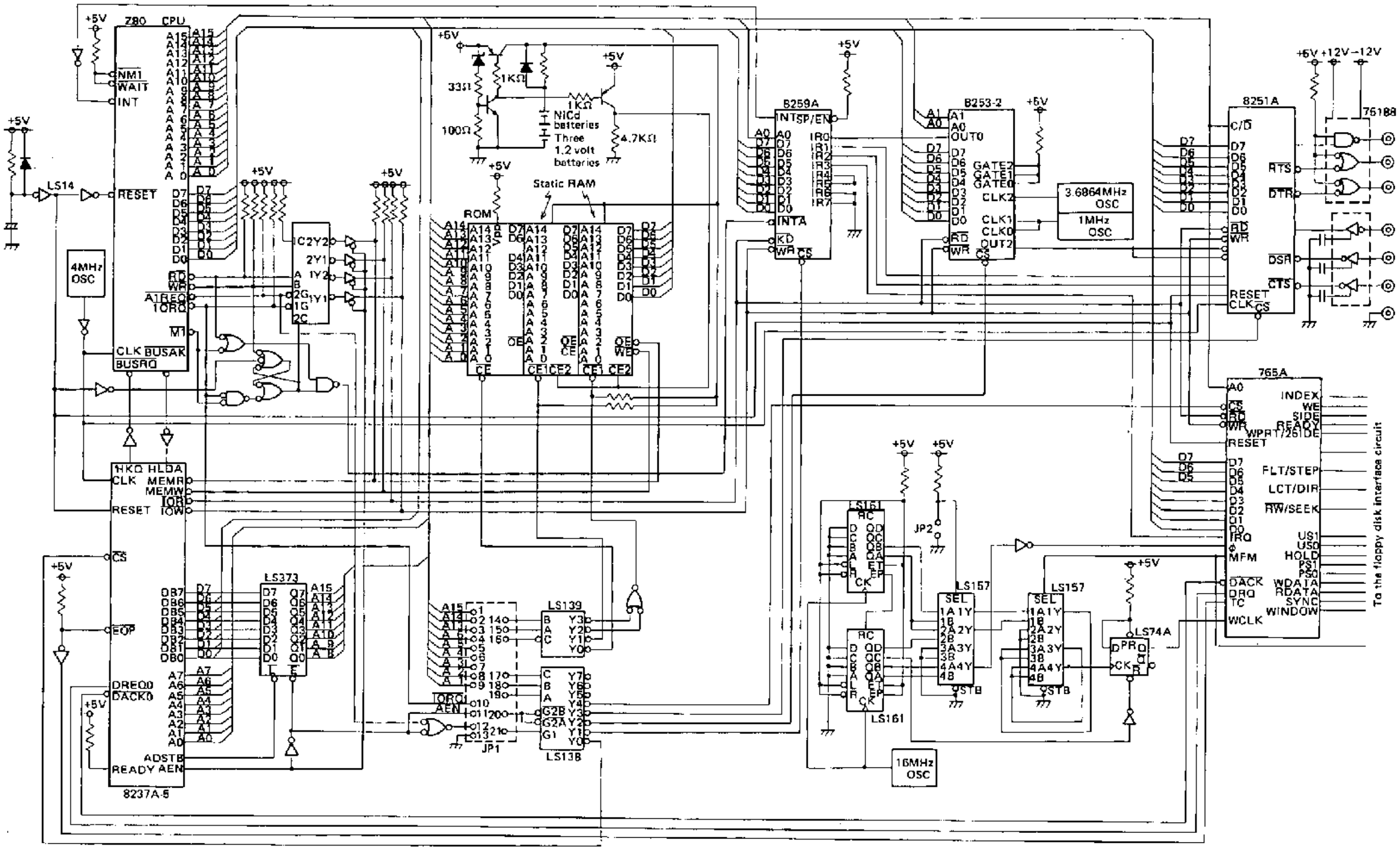



Figure 13.1 Circuit Diagram of the Z80 CPU

## Examination Results

As mentioned above, the Examination for Microcomputer-based Systems Engineers was first given in 1985. At that time, only the basic grade examination was given. Starting in 1987, the third year the examination was administered, senior grade examinations were also offered. Advanced grade exams will be offered in the near future.

The number of applicants for the 1987 exams exceeded 10,000, or roughly 2.3 times as many people as had applied for the initial examinations given in 1985.

The results of the 1987 examinations are shown in Table 3. As the figures indicate, the pass ratios for both basic and senior grade examinees were low. Apparently, the people who sat for the exams found them to be fairly difficult.

Looking at these results, three major points can be discerned: 1) the average age of the applicants and passees for both the basic and senior grade exams was rather high (See Table 4); 2) the ratio of passees engaged in research and development work was extremely high (See Figure 2); and 3) the ratio of females who passed the examinations was exceedingly small (See Figure 3).

In recent years, more and more women have entered fields related to information processing (software-related fields), and are performing a variety of different jobs. Women have been especially active in high level research work in particular.

However, as is indicated by the results of the 1987 exams, there are very few women working in microcomputer-related fields in Japan, a situation which is reminescent of the information processing field a generation ago.

Therefore, it would seem that one way of helping to relieve the shortage of personnel working in microcomputer-related fields would be to devise plans for promoting the entry of women into these fields.

Microcomputer systems engineers are expected to acquire skills and knowhow related to both the hardware and software aspects of microcomputer systems, which means that the amount of knowledge required of individual engineers is huge. We must therefore introduce efficient development tools and modularize systems development processes to interject greater efficiency and productivity into microcomputer systems development.

**Table 3. Applicants, Testees, Passees and Pass Ratios for 1987 Exams**

| | Applicants | Testees | Passees | Pass Ratio |
|---|---|---|---|---|
| Basic Grade | 7,883 | 6,041 | 1,194 | 19.8 |
| Senior Grade | 2,594 | 2,012 | 245 | 12.2 |

**Table 4. Breakdown of 1987 Applicants and Passees by Age**

| | Basic Grade Exam | | Senior Grade Exam | |
|---|---|---|---|---|
| | Applicants | Passees | Applicants | Passees |
| Average Age | 25.7 | 28.5 | 28.9 | 30 |
| Youngest | 16 | 17 | 16 | 16 |
| Oldest | 69 | 57 | 62 | 46 |

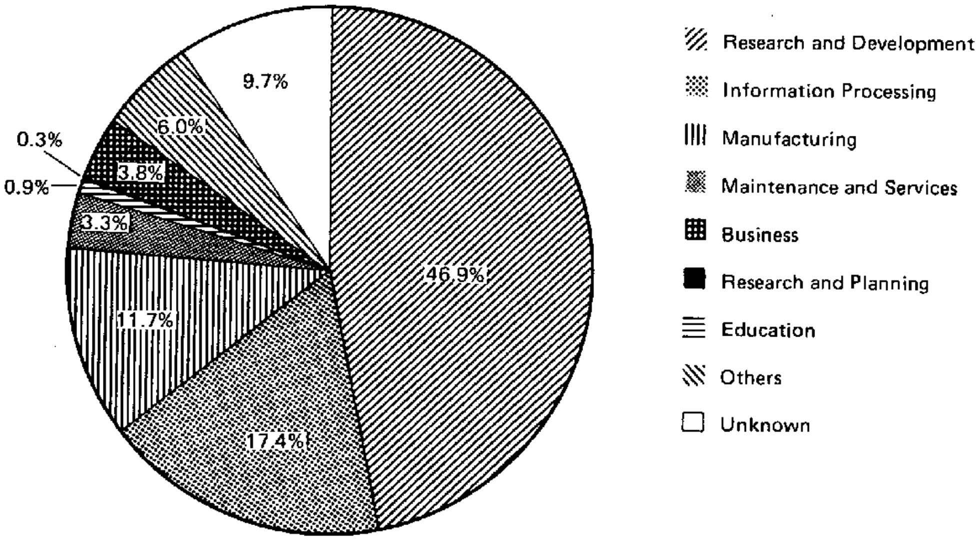



**Figure 2. Percentage of Total Passees of the Basic and Senior Grade Exams for 1987 by Occupation**

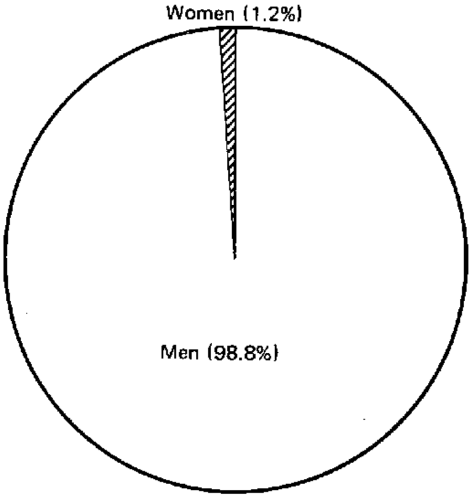



**Figure 3. Percentage of Male and Female Passees of the 1987 Basic and Senior Grade Examinations**

# CURRENT NEWS

## SYSTEM FOR DIAGNOSING NERVOUS DISORDERS IN INFANTS

Approximately 3% of all infants born each year, or roughly 50,000 babies, are victims of nervous disorders such as cerebral palsy or congenital metabolic abnormalities. The Agency of Industrial Science and Technology (AIST) of the Ministry of International Trade and Industry (MITI) has recently developed a computer-based "Nervous Disorder Diagnosis and Treatment Support System" to aid physicians in diagnosing and treating nervous disorders in newly born infants.

Electrodes are attached to a newborn infants body, and the diagnostic support system continuously measures six (6) of the baby's vital functions, to include brain wave activity and eye movement during sleep, over a 10-hour period. This data is processed by the computer and output in the form of graphs and tables for use by the physician in his diagnosis of the child.

The treatment support system is used to determine the optimum amount of medicine to be administered to a baby diagnosed as having a nervous disorder. This is done by administering medicine to the infant and then having the system analyze the very small quantities of that medicine in the child's blood in relation to the thickness of the blood.

This system is to be commercialized during 1988 and is expected to sell for around 50 million yen.

## NTT JOINS NINE OTHER FIRMS TO ESTABLISH NEW ISDN-ORIENTED COMPANY

Nippon Telegraph and Telephone Corporation (NTT), Toyota Motor Corporation, the data communications firm Logic Systems International (LSI) and six (6) other firms joined together to establish in March 1988 a new company called Infonex, which will specialize in the construction of ISDN-oriented data communications systems. The new firm is capitalized at 700 million yen, of which LSI invested 21.4%, NTT put in 17.1%, Toyota contributed 15.7% and Ushio Electric Corporation and Nihon Shimpan invested 14.3% each.

The fact that two major corporations such as NTT and Toyota have joined forces to set up this new company will probably cause quite a ripple throughout the business world, both inside and outside of Japan.

## NEC DEVELOPS THE WORLD'S FASTEST 16-BIT MPU

Nippon Electric Corporation (NEC) has developed the world's fastest 16-bit microprocessor unit (MPU). This device is an upgraded version of the company's V30 MPU, which is currently on the market. The new MPU is capable of processing data at 16 megahertz, or roughly twice as fast as any MPU developed to date. It can also run programs in excess of 640 kilobytes, the largest programs capable of being handled by 16-bit MPUs up until now, thus putting it on a par with 32-bit MPUs. However, since 16-bit peripheral circuits can be used with this new MPU, the cost of the overall system can be kept quite low, making it a "super" 16-bit device.

NEC is going all out in its efforts to develop bigger and better MPUs, and plans to develop during 1988 the top-of-the-line model of a 32-bit MPU it has already commercialized.

## FUJI XEROX HAS NEW ONLINE DIAGNOSTIC SYSTEM FOR ITS NATIONWIDE AI WORKSTATION NETWORK

Fuji Xerox Corporation has developed an online diagnostic system for workstations that use artificial intelligence (AI). The company has 1,500 AI workstations installed at its various offices throughout Japan, all of which are linked together via its own local area network (LAN). When a breakdown or malfunction occurs at one of these workstation sites, the operator is queried as to the nature of the breakdown and then told how to take care of the problem via electronic mail. These "prescriptions" come from a knowledge base comprised of 500 data items, which is enough to allow the ordinary user to "heal" his workstation on his own about 45% of the time. This AI diagnostic system runs on Fuji Xerox's J-Star model of workstation.

## DAI-ICHI KANGYO LINKS UP ONLINE WITH CITIBANK

In January of this year, CitiBank, America's largest banking institution, linked its cash dispensors (CDs) and automatic teller machines (ATMs) installed in Japan online with those of Japan's Dai-Ichi Kangyo Bank. Now account holders from both banks can withdraw cash and/or check their balances using the machines of either bank. This is the first time a Japanese bank and a foreign bank have linked up online like this in Japan. Dai-Ichi Kangyo and CitiBank reached a fundamental agreement for the link up in May 1987.

## TOYOTA USING LEASED LINES TO COMMUNICATE WITH U.S. SUBSIDIARIES

Toyota Motor Corporation recently announced that it is using digital leased lines as the primary communication link between the headquarters and its subsidiaries in the U.S. and manufacturing plant in Kentucky. This is the first step toward achieving a global network employing communications satellites. This is the first time a Japanese firm has made use of a large-capacity 256 K-bit digital leased line. For the time being, this communication link is being used for international telephone calls and facsimile transmissions, but in future Toyota plans to add data and image communications capabilities to its menu, and to expand the network to include its subsidiaries in Canada as well. The ultimate goal is to use this international network to enable the company to manage all international production, distribution, sales and inventory information from its headquarters here in Japan.

## NEC-HONEYWELL-BULL BUILD INTERNATIONAL FINANCIAL NETWORK

Nippon Electric Corporation (NEC), America's Honeywell Corporation and France's Bull Corporation have agreed to develop, market and service an international financial network. They are going to establish a system that enables them to utilize their respective makes of computers as if they were all compatible. Up until now, International Business Machines Corporation (IBM) has had an overwhelmingly large share of the financial network market, but with this agreement, NEC and its partners will be challenging the Big Blue on its own turf. NEC et al are scheduled to cosponsor a seminar designed to explain this proposed network system to a gathering of representatives of some 300 of the world's leading financial houses and securities firms in Lisbon, Portugal in June of this year. Through this tie-up, NEC will be able to provide its Japanese users with access to an international financial system without the need for overseas bases of its own.

## DAIEI TO ENTER INTO CREDIT CARD TIE-UPS WITH BOTH VISA AND MASTERCARD

The Daiei and Seibu Saison groups intend to internationalize their credit card operations by entering into tie-ups with Visa International and MasterCard International, two U.S.-based credit card firms that are vieing with one another for top position in the global credit card industry. This will be the first time that Visa and MasterCard, both of which rely on financial institutions for the brunt of their members, have linked up directly with non-banking capital represented by major distribution firms. If the credit cards currently being issued by both of these groups attain international status, it could lead to considerable changes in the domestic card market presently lead by the credit unions and banking houses.

## Back Issues of Japan Computer Quarterly are as follows:

No. 72: Informatization – Handling Tomorrow's Problems Today –
71: Systems Security – The Fight Against Computer Crime –
70: The Informatization of Small and Medium Businesses
69: Expert Systems in Japan
68: Large-scale Projects in Japan
67: Information Services in Japan
66: IC Cards – Cards with Brains –
65: Database Services in Japan
64: Machine Translation – Threat or Tool –
63: EDP Certification – ExamLand, Japan –
62: Liberalizing Telecommunications
61: VIDEOTEX: A Glimpse of The 21 Century
60: The Day of the Robot

No. 59: Financial Revolution – Electronic or Plastic –
58: The Advanced Information Society – ISC Interim Report –
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