ISSN 0388-0494

1982

Jipdec Report

Japan Information Processing Development Center

The Robots Are Coming

No. 50

Jipdec Report

1982

CONTENTS

No. 50

Japan Information Processing Development Center (JIPDEC) was established in 1967 with the support of the Government and related industrial circles. JIPDEC is a non-profit organization aimed at the promotion, research and development of information processing and information processing industries in Japan.

The Jipdec Report has been prepared with the assistance of the Japan Keirin Association through its Machine Industry Promotion Funds. These funds are part of the profits that the association earns via the sponsoring of bicycle races.

Publisher Yoshihito Shimada
Editor Yuji Yamadori

Jipdec Report is published quarterly by Japan Information Processing Development Center, Kikai Shinko Kaikan Bldg., 5-8, Shibakoen 3-Chome, Minato-ku, Tokyo,105, Japan. Annual subscription: ¥12,000 (Japan), US$85 (Other Countries) Subscription order must be submitted to:
Fuji Corporation
Busicen Bldg., 5F, 5-29-7, Jingu-mae, Shibuya-ku, Tokyo 150, JAPAN
PHONE: (03) 409-6291 TELEX: 0242 5496 FUJICO J.

Printed by
SEIBUNSHA CO., LTD.
Printed in Japan, July, 1982

The Present State of Industrial Robots in Japan and Their Prospects for the Future

Yasuhiro Komori
Japan Industrial Robot Association

Introduction

The industrial robot manufacturing industry in Japan got its start back in 1967 when playback robots were first introduced to this country from the United States. Today, after the passage of just ten some odd years, it is still a very young industry.

During this interval, each of the manufacturers in this industry has concentrated the bulk of its energies in the area of research and development in efforts to come up with new products and applications.

As a result of these efforts, the industry as a whole achieved production output equivalent to ¥78.4 billion in 1980. By 1981 the industry's yearly production by value had exceeded ¥100 billion, indicating that it had at last established a solid foundation for itself.

Industrial robots have been contributing to the various industries they serve by increasing the productivity of those industries, thus strengthening their international competitive power and the business foundations of the individual enterprises which comprise them.

Industrial robots have also been conducive to the prevention of work-related accidents and the outbreak of occupational diseases.

There are also those, however, who expect that robots will play an even bigger role in industry during the 1980's. For example, their ability to reduce the percentage of defects and raise product quality, as well as save resources and improve the efficiency of plant and equipment investments is expected to contribute greatly towards the creation of intellectually stimulating, genial work-places which correspond to the move toward white collar jobs that is accompanying resource and energy conservation policies and higher levels of formal education among workers. Over the next ten years the needs of society should increase tremendously and the robot industry is expected to develop into a ¥1 trillion industry under the banner of mecha-tronics.

What are Industrial Robots?

There is no one, standard, internationally-accepted definition for industrial robots, but they have been described as "Devices that possess functions enabling them to perform a variety of actions with a high degree of freedom in a three-dimensional space." In their most modern forms, they can be defined as "Mechanical systems capable of flexible movements similar to those of the human upper limbs (arms and hands) or which combine these functions with sensory and recognition capabilities to enable autonomous action (intelligent robots)."

As technology progresses in future, however, robots will not be limited to movements resembling those of human upper limbs alone, but will also be capable of imitating the movements of the lower limbs (legs) as well. There will even be those industrial robots that can move like snakes and crabs and other lower forms of animal life as the situation calls for it. Whatever the case may be, the fact that industrial robots are capable of flexible motion is in itself unique, and it is this unique ability to move that will enable the automation of a variety of limited production processes, something that has not been possible with conventional automatic machines.

In other words, the major difference between industrial robots and other specialized automatic machines is the fact that while the latter are an effective means of carrying out mass production operations, the former, industrial robots, are capable of handling changes in the type of product they work on, as well as model and design changes, without the necessity of retooling. This is due to their supple, flexible, nearly free movement capabilities both in terms of time and space. It is for this reason that industrial robots are expected to prove a potent means of automating a variety of limited production processes.

Tables 1 and 2 show how these industrial robots have been classified by input information, teaching method and type of motion. This classification is in accordance with the Japanese Industrial Standards' regulation JIS-13-0134-1979, established on February 1, 1979.

The above is how industrial robots are defined in Japan. However, since, as stated previously, there is still no internationally-accepted standard definition for these devices, it becomes rather confusing when we try to compare them on an international basis.

For example, robots (industrial robts?) are defined in the United States as follows: "A reprogrammable, multifunctional manipulator designed to move materials, parts, tools or specialized devices through variable programmed motions for the performance of a variety of tasks."

Thus, when we attempt to compare the number of robots being produced in Japan with those of other countries by type we are forced to eliminate manual manipulators and fixed sequence robots as classified in Table 1 from the comparison.

Table 3 indicates the total number of industrial robots produced in Japan by type as of the end of 1980. If we assume that most of these are currently in operation, then these figures can be considered to be the number of industrial robots presently maintained in Japan.

When these numbers are compared with the number of robots maintained

Table 1 Classification by Input Information and Teaching Method
(Japanese Industrial Standard JIS B 0134-1979)

Manual manipulator	A manipulator directly operated by a man.
Sequence robot	A manipulator, the working steps of which operate sequentially in compliance with preset procedures, conditions and positions.
Fixed sequence robot	A sequence robot as defined above, for which the preset information cannot be easily changed.
Variable sequence robot	A sequence robot as defined above, for which the preset information can be easily changed.
Playback robot	A manipulator that can repeat any operation, it is instructed to do by a man.
Numerically controlled robot	A manipulator capable of executing operations in compliance with numerically loaded working information on e.g. position, sequence and conditions.
Intelligent robot	A robot that can determine its own actions through its sensing and recognitive abilities.

Table 2 Classification by Motion
(Japanese Industrial Standard JIS B 0134-1979)

Cylindrical coordinate robot	A manipulator which moves primarily in the cylindrical coordinate system.
Polar coordinate robot	A manipulator which moves primarily in the polar coordinate system.
Cartesian coordinate robot	A manipulator which moves primarily in the cartesian coordinate system.
Articulated robot	A manipulator which consists primarily of an articulated arm, that is, revolute joints.
Note:	
Manipulator:	A device for handling objects as desired without touching them by hand and which has more than two motional capabilities such as revolutio, out-in, up-down, right-left travelling, swinging or bending, so that it can spatially transport an object by holding it, adhering to it, and so on.
Robot:	A robot is defined as a mechanical system which has flexible motion functions analogous to the motion functions of living organisms and which, in some cases, combines such motion functions with intelligent functions, and which acts in response to the human will. In this context, intelligent functions mean the ability to perform at least one of the following: judgement, recognition, adaptation or learning.

in other countries around the world, we must first eliminate the number of manual manipulators and fixed sequence robots from the comparison, leaving Japan with a total of better than 14,000 of what can pass internationally as robots. Even so, as Table 4 shows, Japan maintains 62.6% of the world's total robot 'population'. If we go one step further in our efforts to meet with the American definition of a robot, we might then also eliminate variable sequence robots from the comparison, dropping the total number of Japanese robots to less than 7,000 units. As can be seen from Table 4, Japan would still come out ahead of the other countries in terms of total numbers of industrial robots currently being maintained.

Table 3 Total Number of Industrial Robots Produced in Japan by Type as of the End of 1980 (Includes estimated figures)

A.	Manual Manipulators	9,226	(12%)
B.	Fixed Sequence Robots	53,189	(69%)
C.	Variable Sequence Robots	7,347	(10%)
D.	Playback Robots	4,305	(6%)
E.	NC Robots	1,124	(1%)
F.	Intelligent Robots	1,470	(2%)
	Total	76,661	(100%)

C–F: 14,246 (19%)
B–F: 67,454 (88%)
A–F: 76,661 (100%)

Table 4 World Industrial Robot Population (Excluding Manual Manipulators & Fixed Sequence Robots)

	Units
Japan	14,250[1] (62.6%) (76,700)
U.S.A.	4,100[2]
Canada	250[3]
Belgium	42[2]
Denmark	66[2]
Finland	116[2]
France	600[4]
W. Germany	1,420[2]
Italy	353[5]
Netherlands	51[2]
Norway	170[6]
Sweden	940[7]
Swiss	50[2]
U.K.	371[2]

America (U.S.A., Canada): 4,350 (19.1%)
Europe (Belgium – U.K.): 4,179 (18.3%)
Western Nations: 8,529 (37.4%)
Total: 22,779 (100%)

Remarks:
1) JIRA Survey (end of 1980), ( ) including Manual Manipulators and Fixed Sequence Robots
2) RIA Survey (1981)
3) National Research Council (end of 1981)
4) Jetro, Paris Survey (1981, 11)
5) Italian Industrial Robot Association (1981)
6) RIA Survey (1980)
7) Swidish Computors and Electronics Commission, Ministry of Industry (1981).

British Robot Association Survey (Dec. 1981);

U.S.A.	5,000	U.K.	713
Germany	2,300	France	600
Sweden	1,700	Italy	450

Supply and Demand Trends

(1) Production Trends

The importation and public display of the first playback robots from America in 1967 proved a very strong stimulus to Japan. This can be seen from the fact that the very next year, 1968, research and development into as well as utilization of industrial robots began in earnest in Japan. The 1960's was a decade of high economic growth for Japan with rises in the GNP averaging 12% per year. However, labor power during this same period was in exceedingly short supply (the shortage of skilled workers in 1968 was calculated at roughly 1.8 million).

For this reason, the industrial robot was welcomed as a kind of saviour. The business recession which followed this in 1971, combined with the crippling effects of the first oil crisis in October, 1973, put a damper on investments in plant and equipment in Japan, and this in turn dashed expectations for rapid growth in the industrial robot manufacturing industry.

The period of slow economic growth that followed the oil shock tended to hold down new investments, especially in plant and equipment. However, the rising cost of crude oil, a resource which Japan depends almost entirely on overseas supplies of, brought with it steep rises in the price of commodities and labor costs. In order to deal with this situation, the desire to invest in measures that would increase productivity, cut labor costs and automate the production process grew in intensity, leading to a steady growth in the production of industrial robots in and after 1976.

Annual production output by value for 1977 didn't exceed ¥21.6 billion, but by 1979 this figure had nearly doubled to ¥42.4 billion. Output of industrial robots by value for 1980 amounted to a respectable ¥78.4 billion, up 85 percent over the previous year's figures.

Industrial robot production is expected to rise even more rapidly in future in answer to the strong demand for increased productivity and worker's safety coming from the world of industry. Increased numbers of industrial robots would also be a means of dealing with the steadily increasing shortage of skilled labor brought about recently as a result of uniformly higher formal education. (This shortage was estimated at approximately 840 thousand as of June, 1980, according to a Japanese Ministry of Labor Study.).

According to a demand forecast made by the Japan Industrial Robot Association (JIRA) which takes into consideration robot utilization in both the manufacturing and non-manufacturing industries, robot requirements on a value basis are expected to reach nearly ¥300 billion by 1985 (¥290 billion for the manufacturing sector and ¥6.4 billion for the non-manufacturing sector) and almost ¥600 billion by 1990 (Manufacturing ¥525 billion; non-manufacturing ¥66.5 billion).

Furthermore, this growth in demand is seen as following the same course of development time-wise as NC machines

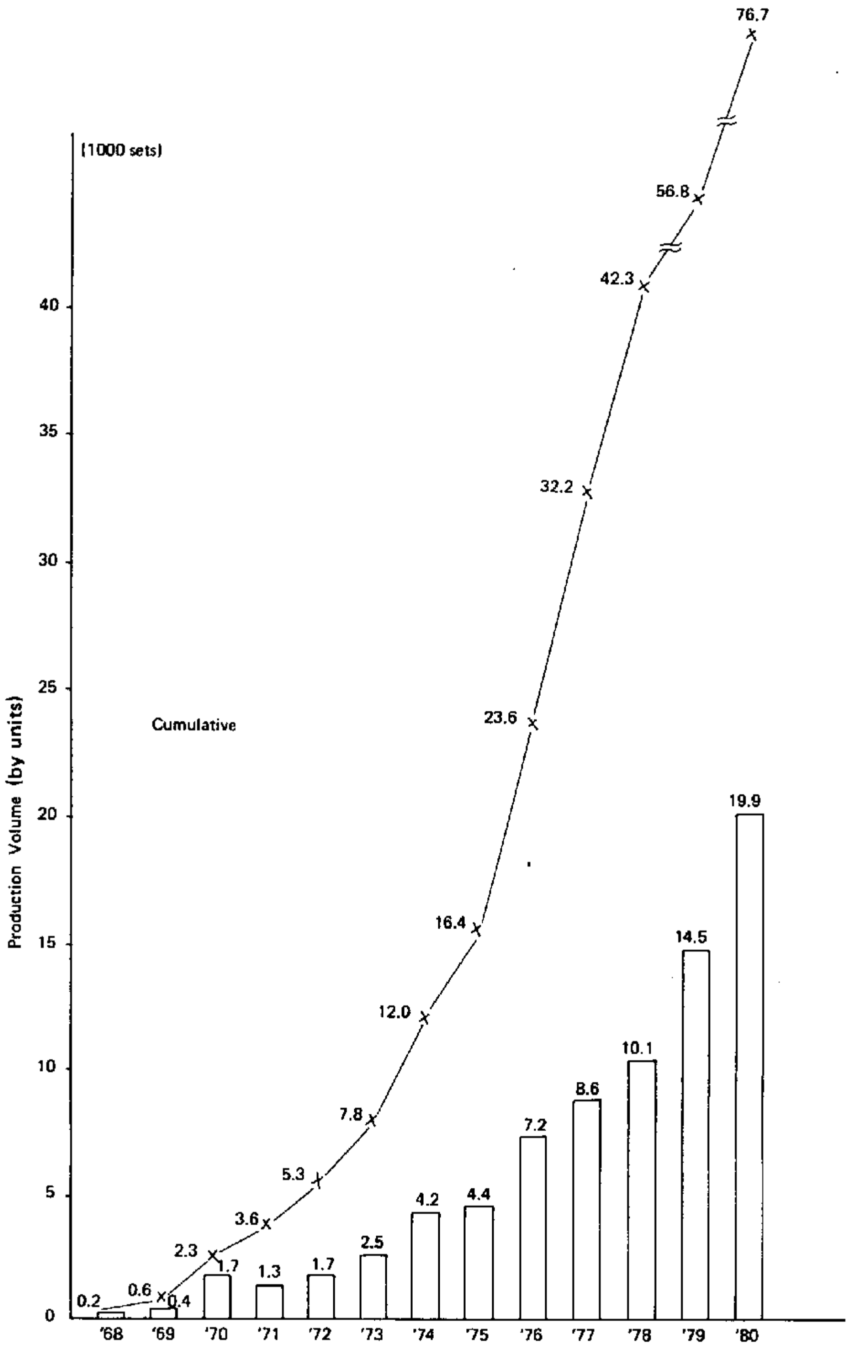


Fig. 1 Robot Production by Volume
(thousands of units)

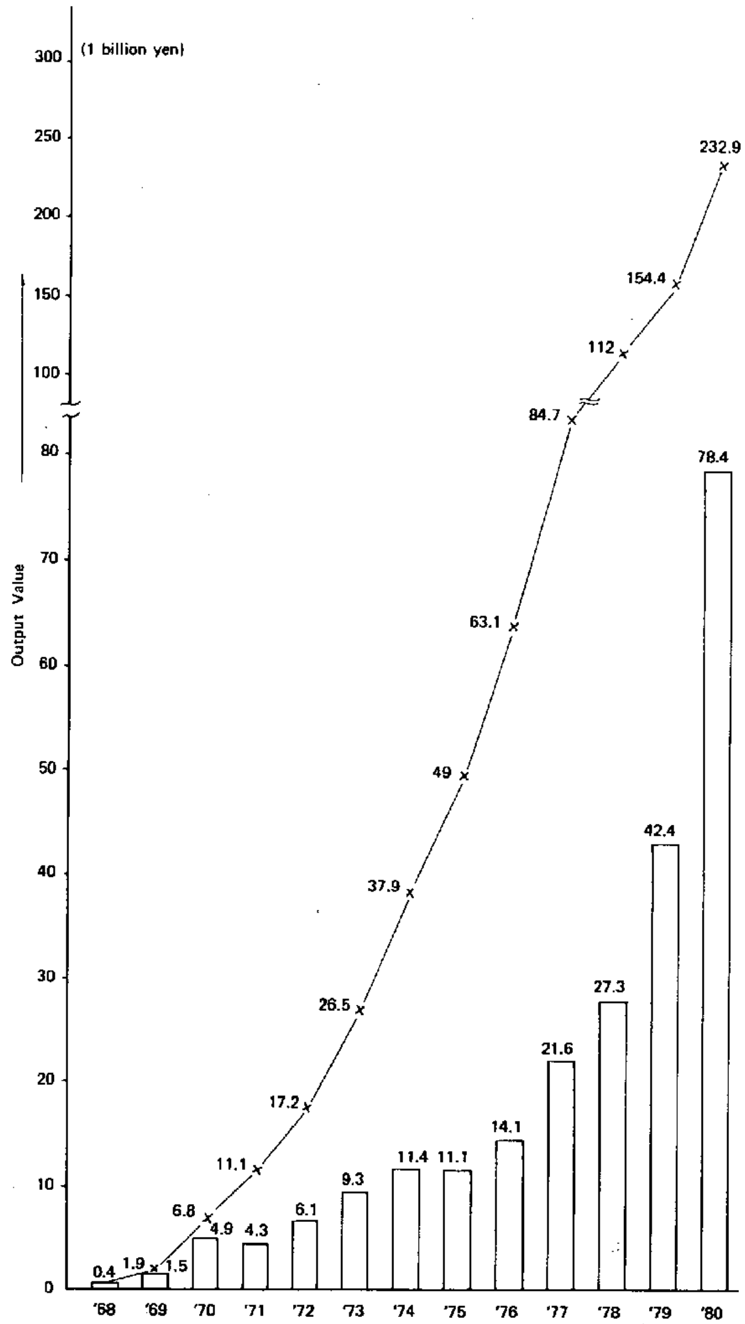


Fig. 2 Robot Production by Volue

and computers. (See figures 1, 2 and 3.).

Figure 4, on the other hand, shows changes in production trends for industrial robots as classfiied by input information and teaching method. Moreover, the share of overall production occupied by robots possessing advanced functions such as playback and intelligent robots is expected to increase quite rapidly from here on out in answer to rising demand for automation of assembling, inspection and measuring processes.

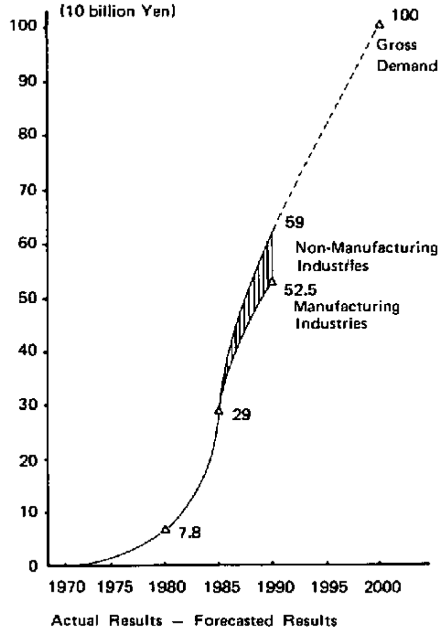


Fig. 3 Long-Range Demand Forecast for Industrial Robots

(2) Demand Trends

Demand for industrial robots is spreading throughout the secondary manufacturing industries. As Figure 5 indicates, the principal demand sectors are the automobile industry, electrical machinery industry, plastic processing industry, metal working industry and metal working machinery industry.

Next, if we view industrial robots in terms of the processes they are called upon to perform, we seee that their major applications are in assembly work, welding, cutting processes, press work, plastic molding, diecast operations and painting (See Figure 6).

In 1980 there was a sharp rise in demand for industrial robots in the electrical machinery manufacturing industry, especially for NC and assembly robots. This rise in demand was due to the need for robots to perform the task of inserting parts (condensors, resistors, etc.) into printed circuit boards.

In future, industrial robots are expected to be applied more and more to the carrying out of complicated assembly and/or inspection processes as their levels of artificial intelligence are increased thanks to the incorporation of sensors and computers into their operating systems.

The development of robots capable of this kind of assembly work is expected to increased demand for them in the electrical machinery and tools manufacuturing industry and other machine manufacturing industries in particular. In addition, it is felt that demand for industrial robots which can substitute for man in the performance of dangerous and grueling tasks and in the conduct of work that must be carried out under abnormally harsh or unfavorable conditions will rapidly expand throughout the industrial sector in general.

A: Manual manipulators
B: Fixed sequence control robots
C: Variable sequence control robots
D: Playback robts
E: NC robots
F: Intelligent robts

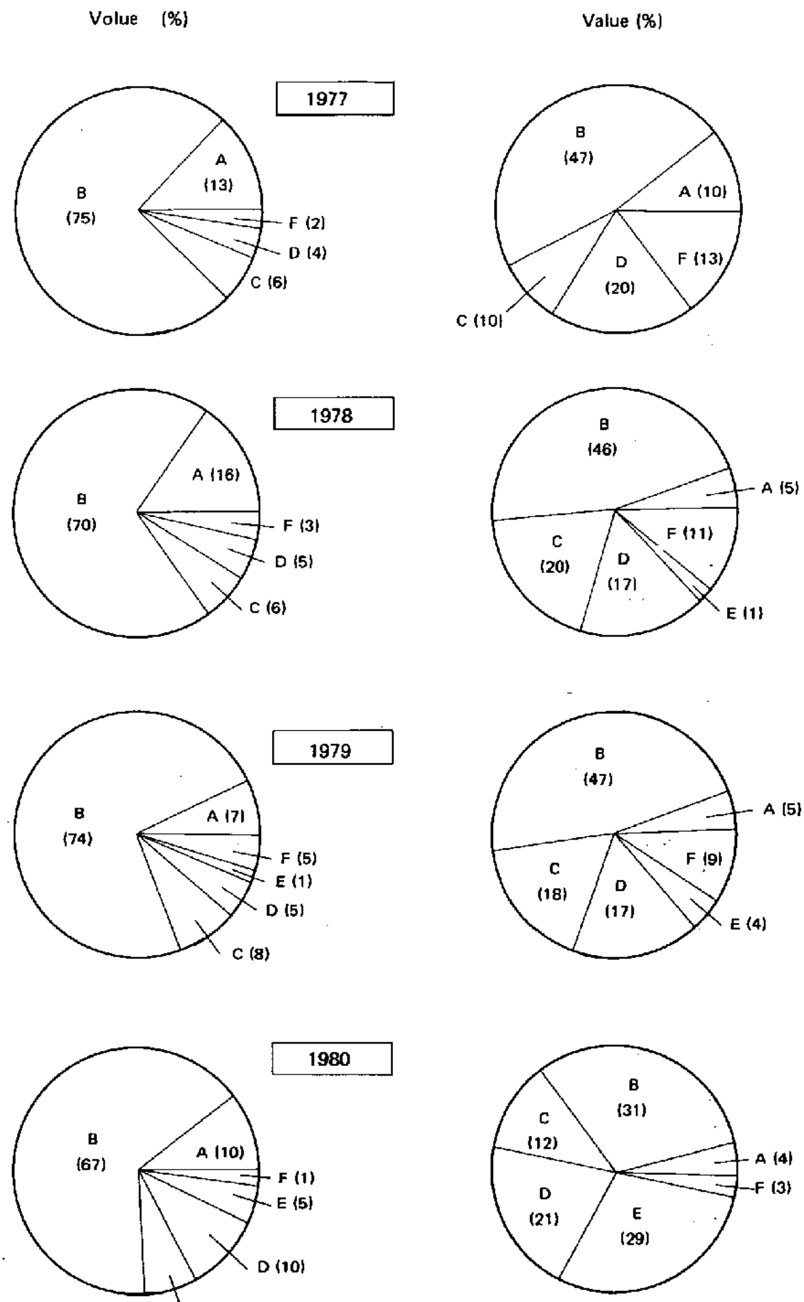


Fig. 4 Robot Production by Type

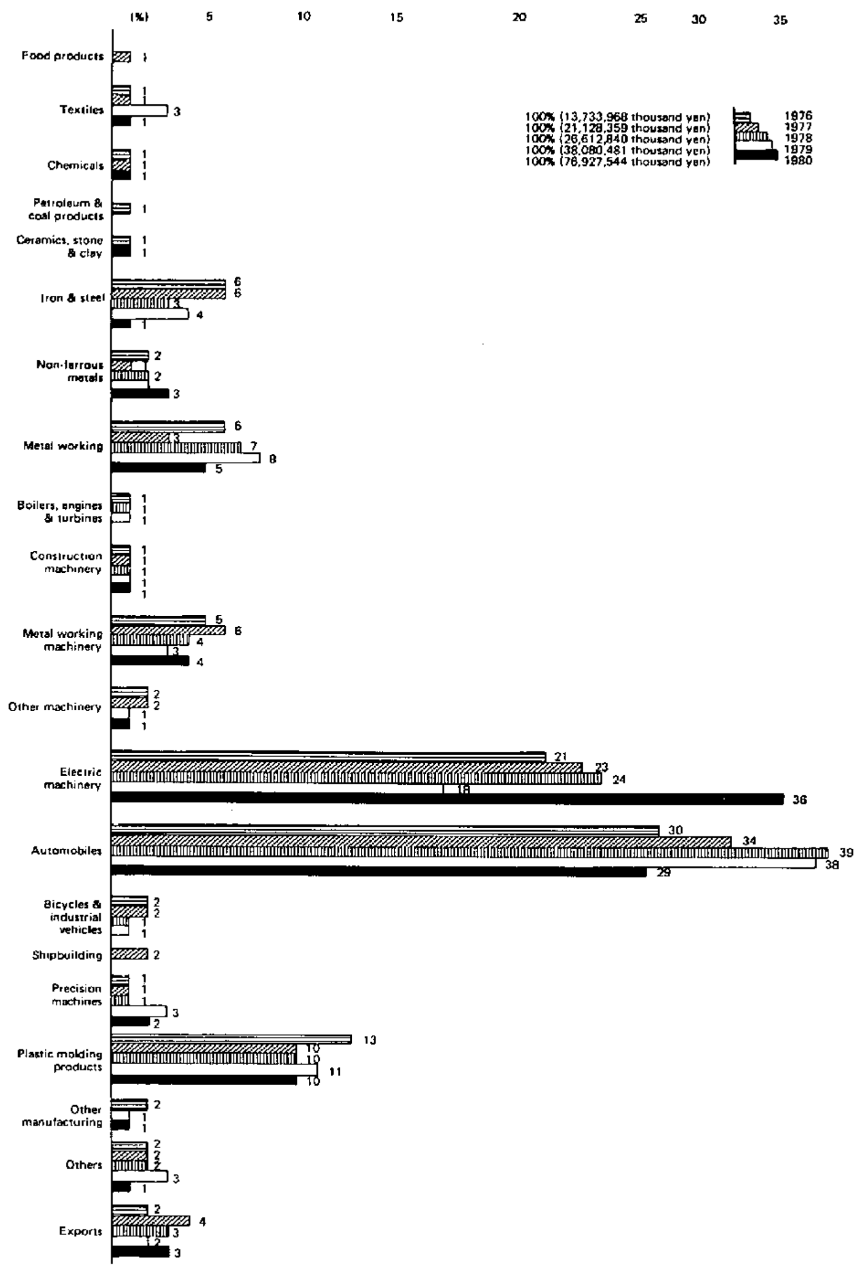


Fig. 5 Industrial Distribution of Robots Delivered in 1976, 1977, 1978, 1979, 1980 (Percentage in supply value)

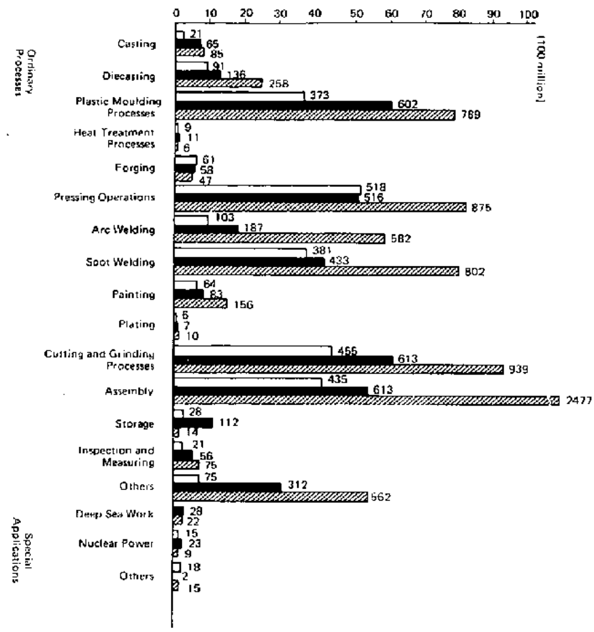


Fig. 6-1 Value of Industrial Robot Shipments for Fiscal Years '78, '79 and '80 by Application

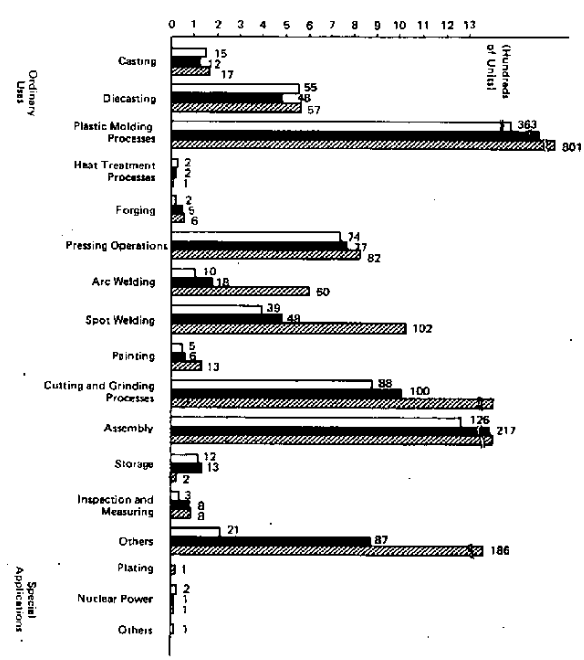


Fig. 6-2 Volume of Industrial Robot Shipments for Fiscal Years '78, '79, and '80 by Application

Furthermore, demand for industrial robots in future will not be limited simply to the manufacturing industries, but will also find its way increasingly into such diverse, non-manufacturing areas as marine industries, fields related to nuclear power, medical care and social welfare, as well as the agricultural, forestry and construction industries.

Also, as Figure 5 shows, the percentage of industrial robots exported by Japan is an extremely low 2 to 3 percent of total annual output each year.

The reasons for this are 1.) The robot industry is still a developing young industry and therefore finds itself in a situation where it is pressed to deal with large numbers of newcomers to its domain from other industries, fierce domestic competition and a domestic market where shares are not fixed, and 2.) in order to ensure the smooth introduction and operation of industrial robots at the workplace, it is necessary to first carry out thorough investigations as to their feasibility, and once this has been established, to perform appropriate engineering studies for their installation. Once the new robots have been installed it is also necessary to provide adequate maintenance and after service. Thus, it isn't simply a matter of providing the customer with a robot, but entails much, much more.

For these reasons, there is currently a trend among Japanese industrial robot manufacturers to enter into tie-ups with prominent overseas firms that possess manufacturing, engineering and maintenance technology related to industrial robots.

Therefore, the export of industrial robots in future as well is seen as progressing along the lines of international industrial cooperation aimed at making possible the mutual exchange of technology and creation of employment opportunities in partner countries via such enterprise-level tie-ups.

The following are some representative examples of how industrial robots are envisioned as being utilized in industries other than those dealing in manufacturing in future.

(1) Applications in Nuclear Power-Related Fields

Robots will be employed in a wide range of applications in nuclear power plants to include a variety of handling operations such as the disposal of radioactive waste materials, plant maintenance work and even inspections.

(2) Applications Related to the Fields of Medicine and Social Welfare

Helper robots will most likely appear which will aid the handicapped and bedridden elderly people in the conduct of their everyday lives, as well as act as assistants to nurses in the performance of their daily duties. Other types of helper robots will serve as the arms and legs of handicapped persons, enabling them to do the same days work as a normal, healthy person. Robots should also find application in such tasks as firefighting, rescue operations, disposal

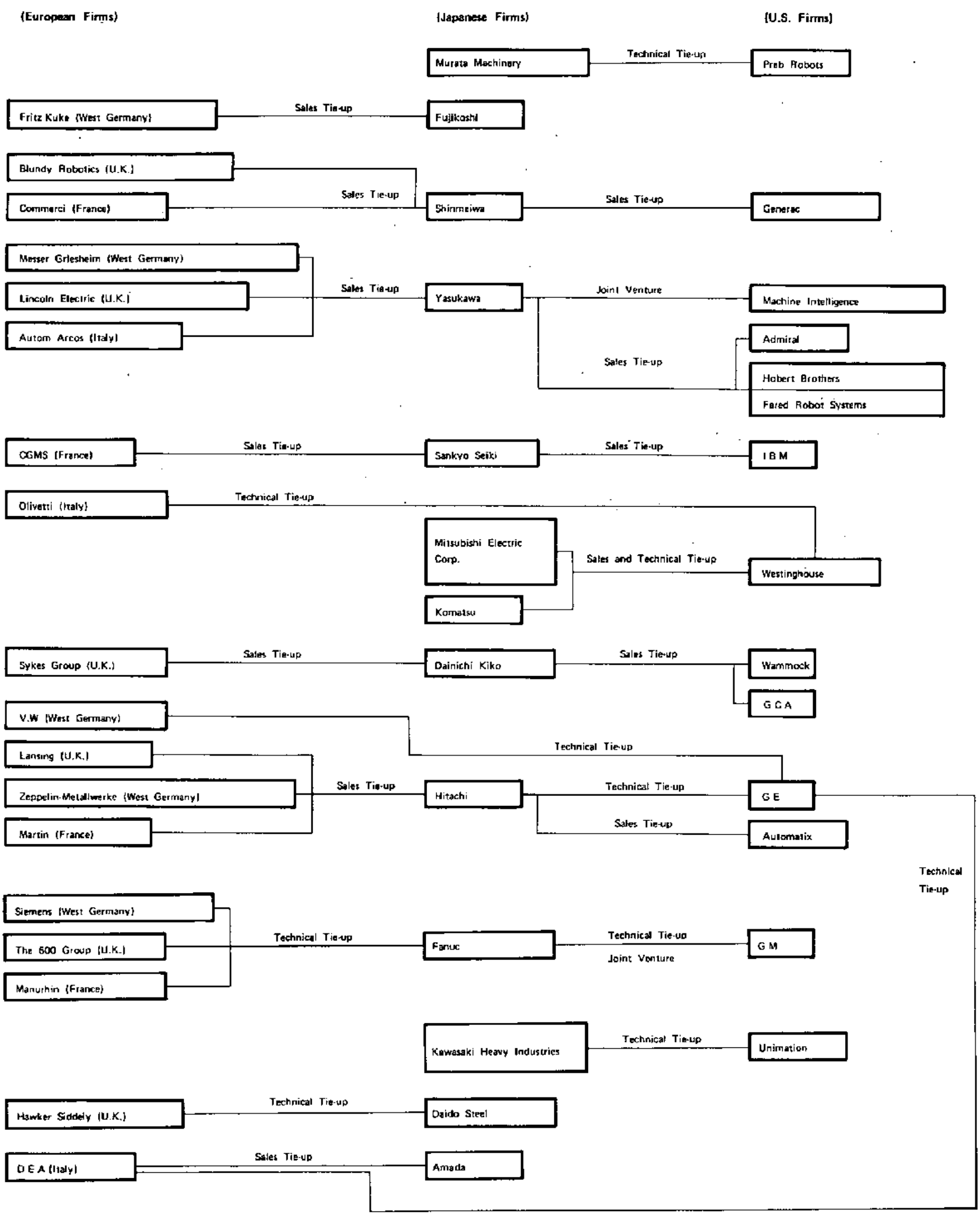


Fig. 7 Assembly of transistors

of dangerous materials and even sanitation work.

(3) Utilization in Fields Related to Ocean Development

Robots will be utilized to perform a variety of handling operations in the construction of underwater structures, and in the conduct of underwater machine processing and multipurpose surveys.

(4) Agricultural and Forestry Applications

Robot technology will be applied to the areas of agriculture and forestry in such endeavors as the harvesting of fruit, cropdusting, and a variety of logging operations.

(5) Applications in the Construction Industry

Robot technology will be applied in the placement of reinforcing rods, painting of bridges and in painting and assembly work both inside and outside of high rise buildings.

(6) Applications for Robot Technology in such Fields as Transportation and Other Service Industries

The advancement of robot technology holds forth great promise for the development of even more new areas of possible application in addition to those mentioned above.

List of JIRA Regular Members

(alphabetical order)

As of 1, Apr. 1982

Company	Postal Code	Address	Telephone
AIDA ENGINEERING, LTD.	229	2-10, Ohyamacho, Sagamihara City, Kanagawa Pref.	(0427)72-5231
DAIDO STEEL CO., LTD.	460	1-11-18, Nishiki, Naka-ku, Nagoya City, Aichi Pref.	(052)291-5111
DAIKIN KOGYO CO., LTD.	530	Shin-Hankyu Bldg., 1-12-39, Umeda, Kita-ku, Osaka City	(06) 346-1201
DAINICHI KIKO CO., LTD.	400-04	Kosai-Kogyo danchi, Kosai-cho, Nakakomagun Yamanashi Pref.	(0552)812-5581
ENGINEERING SYSTEM CO., LTD.	399-65	5652-83 Sasaga Matsumoto City, Nagano Pref.	(0263)26-1212
FUJI ELECTRIC CO., LTD.	100	Shin-Yurakucho Bldg., 1-12-1, Yurakucho Chiyoda-ku, Tokyo	(03) 211-711
FANUC LTD.	194	3-5-1, Asahigaoka, Hino City, Tokyo	(0425)84-1111
HITACHI, LTD.	100	Shin-Maru Bldg., 1-5-1, Marunouchi, Chiyoda-ku Tokyo.	(03) 212-1111
ICHIKOH ENGINEERING, CO., LTD.	379-21	1297-3, Ninomiyacho Maebashi City, Gunma Pref.	(0272)68-2131
ISHIKAWAJIMA-HARIMA HEAVY INDUSTRIES CO., LTD.	100	Shin-Ohtemachi Bldg., 2-2-1, Ohtemachi, Chiyoda-ku, Tokyo.	(03) 244-6105
KANTOH CO., LTD.	153	2-7-2 Shimo Meguro, Meguro-ku, Tokyo	(03) 491-5191
KAWASAKI HEAVY INDUSTRIES, LTD.	105	World Trade Center Bldg., 2-4-1, Hamamatsucho, Minato-ku, Tokyo.	(03) 435-2326
KAYABA INDUSTRY CO., LTD.	105	World Trade Center Bldg., 2-4-1, Hamamatsucho, Minato-ku, Tokyo	(03) 435-6451
KITAMURA MACHINERY CO., LTD.	939-11	1870 Toide-cho, Takaoka-shi, Toyama Pref.	(0766)63-1100
KOBE STEEL, LTD.	651	1-3-18, Wakihamacho, Fukiai-ku, Kobe City Hyogo Pref.	(078)251-1551
KOMATSU LTD.	107	2-3-6, Akasaka, Minato-ku, Tokyo	(03) 584-7111
KOYO AUTOMATION SYSTEMS	135	1-26-3, Toyo Kohto-ku, Tokyo.	(03) 615-2611
KUROGANE CRANE CO., LTD.	457	60 Shiba-cho, Minami-ku, Nagoya City.	(052)822-3211
KYORITSU ENGINEERING CO., LTD.	730	Miyado Bldg., 6-19, Hacyobori Nakaku, Hiroshima City, Hiroshima Pref.	(0822)28-9747
KYOSHIN ELECTRIC CO., LTD.	146	6-20, Ikegami Ohta-ku, Tokyo.	(03) 751-2131
MATSUSHITA INDUSTRIAL EQUIPMENT CO., LTD.	561	3-1-1, Inazumachi Toyonaka City, Osaka Pref.	(06) 862-1121
MEIDENSHA ELECTRIC MFG. CO., LTD.	141	21-17, Osaki, Shinagawa-ku, Tokyo	(03) 492-1111
MITSUI ENGINEERING & SHIPBUILDING, CO., LTD.	104	5-6-4, Tsukiji, Chuo-ku, Tokyo.	(03) 544-3455
MITSUBISHI ELECTRIC CORP.	100	2-2-3, Marunouchi, Chiyoda-ku, Tokyo	(03) 218-2164
MITSUBISHI HEAVY INDUSTRIES, LTD.	100	2-5-1, Marunouchi, Chiyoda-ku, Tokyo	(03) 212-3111
MOTODA ELECTRONICS CO., LTD.	156	4-32-9, Kamikitazawa, Setagaya-ku, Tokyo	(03) 303-8481
MURATA MACHINERY LTD.	601	3 Minamiochiai-cho Kisshoin Minami-ku, Kyoto-City	(075)681-9141
NACHI-FUJIKOSHI CORP.	105	World Trade Center Bldg., 2-4-1, Hamamatsucho, Minato-ku, Tokyo	(03) 435-5036
NIPPON ELECTRIC CO., LTD.	108	5-33-1, Shiba, Minato-ku, Tokyo	(03) 454-1111
NIPPON ROBOT MACHINE CO., LTD.	446	73 Yoge, Nihongi-cho, Anjo City, Aichi Pref.	(0566) 74-1101
NISAN DENKI CO., LTD.	144	3-35-2, Nishikoujiya Ohta-ku, Tokyo	(03) 743-0201
OKAMURA CORP.	210	1-4-1, Kitako, Nishi-ku, Yokohama City, Kanagawa	(045)319-3401
OKI ELECTRIC INDUSTRIES CO., LTD.	105	1-7-12, Toranomon, Minato-ku, Tokyo	(03) 501-3111
OMRON TATEISI ELECTRONICS CO.	617	Igadera Shimokaiinji Nagaokakyo City, Kyoto	(075)921-51111
ORII CORP.	259-11	6 Suzukawa, Isehara City, Kanagawa Pref.	(0463)93-0811
OSAKA TRANSFORMER CO., LTD.	532	2-1-11, Tagawa Yodogawa-ku, Osaka City	(06) 301-1212
PENTEL CO., LTD.	340	4-1-8 Yoshi-cho, Soka City, Saitama Pref.	(0489)22-1111
SANKI ENGINEERING CO., LTD.	100	Sanshin Bldg., 1-4-1, Yurakucho, Chiyoda-ku, Tokyo	(03)502-61111
SANKYO SEIKI MFG. CO., LTD.	105	1-17-2, Shinbashi, Minato-ku, Tokyo	(03) 508-1156
SHINKO ELECTRIC CO., LTD.	103	Asahi Bldg., 3-12-2, Nihonbashi, Chuo-ku, Tokyo	(03) 274-1111
SHINMEIWA INDUSTRY CO., LTD.	665	1-1, Shinmeiwacho, Takarazuka City, Hyogo Pref.	(0798)52-1234
SHOKU CORP.	103	3-14-1, Nihonbashi, Chuo-ku, Tokyo	(03) 281-1231
STAR SEIKI CO., LTD.	467	2-36, Sakamachi, Mizuho-ku, Nagoya City, Aichi Pref.	(052)881-2817
SUMITOMO HEAVY INDUSTRIES CO., LTD.	100	Shin-Ohtemachi Bldg., 2-2-1, Ohtemachi Chiyoda-ku, Tokyo.	(03) 243-0561
SUMITOMO ELECTRIC INDUSTRIES LTD.	554	1-1-3, Shimaya Konohana-ku, Osaka City	(06) 461-1031
TAIYO, LTD.	533	48 Kita-Eguchicho, Higashi-Yodogawa-ku, Osaka	(06) 340-1111
TEXAS INSTRUMENTS JAPAN LTD.	334	18-36, Minami 3-chome, Hatogaya City, Saitama Pref.	(0482)82-2211
TOEI ELECTRIC CO., LTD.	108	Kaikyo Bldg., 2-21-26, Takanawa Minato-ku, Tokyo	(03) 442-8300
TOKICO, LTD.	210	1-6-3, Fujimi, Kawasaki-ku, Kawasaki City Kanagawa Pref.	(044)244-31111
TOKYO KEIKI CO., LTD.	144	2-16, Minami-Kamata, Ohta-ku, Tokyo	(03)732-21111
TOKYO SHIBAURA ELECTRIC CO., LTD.	100	1-1-6, Uchi-Saiwaicho, Chiyoda-ku, Tokyo	(03) 454-7111
TOSHIBA SEIKI CO., LTD.	243	5-14-33, Higashi-Kashiwagaya, Ebina City, Kanagawa Pref.	(0462) 31-81111
TOYODA MACHINE WORKS, LTD.	448	1-1, Asahicho, Kariya City, Aichi Pref.	(0566)22-2211
TSUBAKIMOTO MACHINERY & ENGINEERING CO., LTD.	100	Kokusai Kanko Kaikan Bldg., 1-8-3, Marunouchi, Chiyoda-ku, Tokyo.	(03) 214-7571
YASUKAWA ELECTRIC MFG. CO., LTD.	100	Ohtemachi Bldg., 1-6-1, Ohtemachi, Chiyoda-ku, Tokyo.	(03) 217-4111

Trends in the Research and Development of Intelligent Robots

Yoshiaki Shirai
Electrotechnical Laboratory

1. The Gap between Research and Practical Applications

The recent spread of industrial robots has been quite remarkable and their performance is steadily improving. Moreover, devices for determining the position of objects as well as defects by means of visual sensors have been made practical. Has the spread of these kinds of robots been brought about by new developments in technology? The answer is NO. The manipulators and visual technology that have come into use lately were developed over ten years ago. The major reasons why they weren't put into practical use at that time can be summed up as follows:

a) The high cost of processors and memory devices;
b) Inefficient performance of motors and;
c) The high cost of the visual sensors themselves, as well as that involved in the inputting of visual information into the processors.

None of these factors are problems inherent in robots themselves, and have been at least partially solved with recent advances in hardware technology. Cases where the solving of a) in particular has led to successful control of complicated manipulators and to speedy, low cost detection of defects are numerous.

Thus, there exists these kinds of gaps between research into intelligent robots and their practical applications, and since the goals for research and practical application also differ, the two must be treated separately. The purpose here then, is to deal almost exclusively with research and development aspects, limiting examples of robots that are already in practical use to those which are of particular interest technologically.

2. The Direction of Research on Intelligent Robots

Research on intelligent robots in Japan didn't get started until the late 1960's, or roughly 5 years after similar research had already begun in America. In 1970, the Hitachi Central Research Laboratory together with the Electrotechnical Laboratory (ETL) came out with a robot that possessed both "hands" and "eyes".

As shown in Figure 1, Hitachi demonstrated that this robot was capable of recognizing drawings, i.e. distinguishing between three different drawings with one 'eye', and then assembling simple building blocks into the forms shown in those drawings using handling equipment and another 'eye' capable of recognizing objects.

ETL for its part contributed in the following areas:

(a) Control capabilities for an hydraulically-operated, multiple jointed manipulator;
(b) A visual system capable of inputting such visual information as light, color and distance (range);
(c) Object recognition capabilities utilizing the above visual information;
(d) Hand/eye coordination capabilities; and
(e) Object recognition capabilities based on a sense of touch, i.e. distinguishing objects by grasping them between the fingers.

With the exception of (d), all of the above capabilities can be separated into either hand or eye functions. As for (d), however, this capability enables assembly work to be done utilizing (1) visual classification of objects and their handling based thereon, and (2) visual feedback. The one capability where eye and hand functions can't possibly be considered separately is visual feedback. This is because this capability requires that the hand and eye of the robot work together in the accomplishment of a single task. For example, even the simple task of assembling wooden blocks demands considerable hand/eye coordination. First, the hand of the robot picks up the appropriate wooden block and manuevers it over the slot into which it is to be inserted. Having done so, the eye of the robot then examines the position of the block in relation to the slot and determines the displacement. This visual data is then fed back to the hand which adjusts the position of the block based on that information. This process is repeated until the eye is satisfied that the hand has the block perfectly line up with

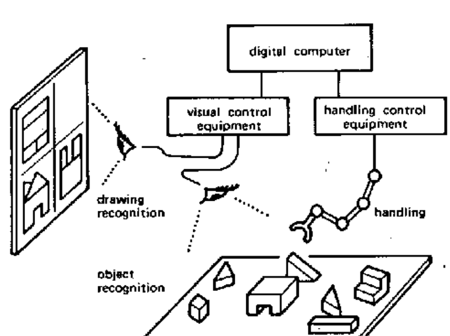


Fig. 1 Outline of Hitachi's demonstration

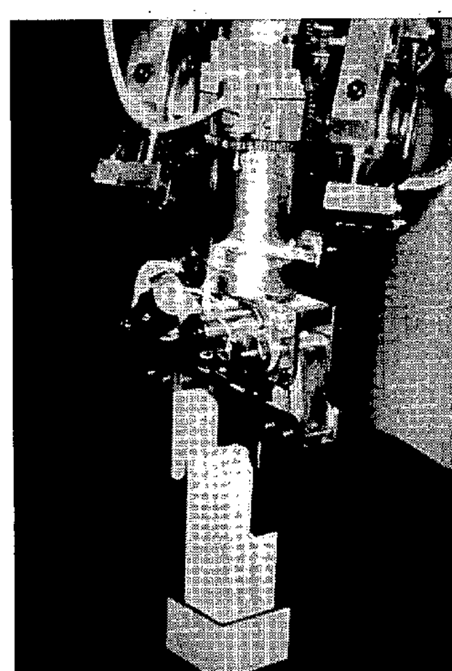


Fig. 2 Manipulation by visual feedback

the slot, at which time the block is inserted into the slot and the assembly process completed. Figure 2 shows the results of that process.

The 1970 demonstration was an epoch-making one for its time, but it was impossible to put the systems utilized therein to practical use at that time. Furthermore, both the hand and eye technologies introduced then were insufficient to build a more advanced intelligent robot. Thus, development of a comprehensive robot was suspended and research into hand and eye capabilities steadily promoted. Other types of research also had their origins in that for intelligent robots and were generalized as research into broader forms of artificial intelligence (i.e. problem solving). Also, the research divisions of robot manufacturers raised specific applications and then proceeded to develop practical systems capable of carrying out those applications.

Meanwhile, as industrial robots have spread and the automation of simple, repetitive work processess progressed, the demand for automation of more complex work processes has arisen. Currently, industrial robots are being equipped with sensors and tested in their ability to perform simple recognition tasks. These types of robots are also called intelligent robots in industrial circles. In this way, the specialized technology of the 1970's is becoming integrated once again in the 1980's. Also, the combination of CAD/CAM with database technology is expected to result in comprehensive systems applicable to flexible manufacturing plans. Figure 3 is a simple diagram of the direction or flow of research and development in Japan since its inception.

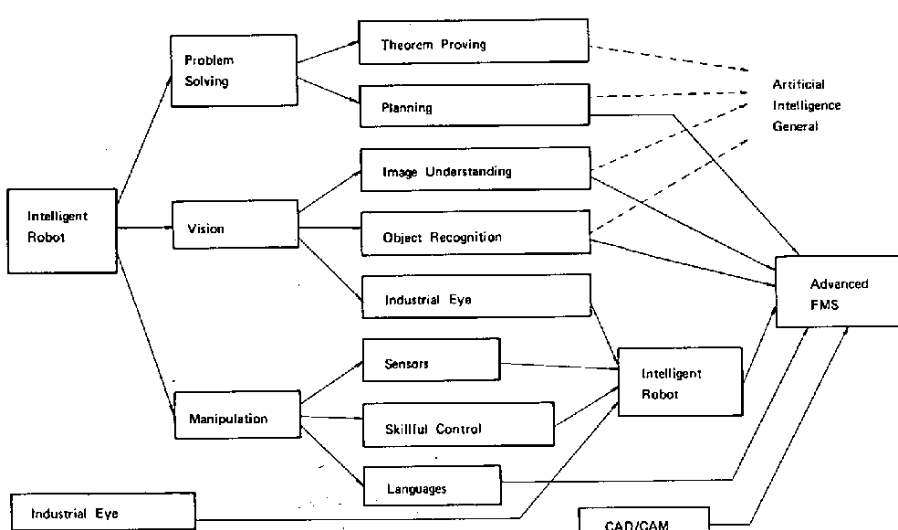


Fig. 3 Flow of research and development

3. Research and Development of Manipulators

3.1 Industrial Robot Manipulators

The principal function of a manipulator is to move the tip of its arm accurately and precisely to a designated spot. Since industrial robots just repeat work that they were previously taught to do by a human being, then it is simply a matter of their ability to achieve repetitive accuracy. This problem can be sufficiently handled with the aid of a step motor and position detecting encoder.

Another problem is the weight of the object being handled. Multiple jointed. manipulators which are widely used require a considerable amount of power just to move their empty weight (i.e. when they are not handling on object). For this reason, the weight of the object being handled must be less than the manipulator itself. In order to cope with this problem, torque or turning force that is proportional to and in the opposite direction of the empty weight of the manipulator and the object which it is holding must be provided to the principal joints of the manipulator. Robots are in practical use now that solve this problem by supplying a counter weight by means of an air cylinder and piston mechanism.

3.2 Force Sensing

Even though the human hand isn't capable of accurate positioning, it can insert a rod or shaft into a hole that has only about 10 μm clearance. To get a manipulator to do this same job, it isn't enough just to raise the positioning accuracy at the tip of its arm.

On the contrary, its better to use a flexible hand. Figure 4 gives an example of a shaft being inserted into a hole utilizing such a device. The grip that is holding the shaft is connected to the wrist by a spring. As Figure 4 (a) indicates, the on-off sensor in the wrist of the manipulator will remain 'on' as long as a uniform force is being applied in a downward direction. It is in this state that the manipulator searches for the center of the hole.

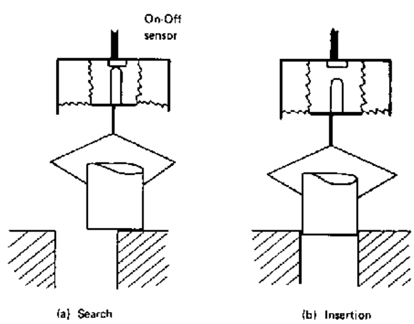


Fig. 4 Insertion by force sensing

When the shaft enters the hole, the grip moves downward and the on-off sensor switches 'off'. In other words, this sensor knows when the pressure or force pushing up against it has diminished and then moves the wrist downward. At this point, the wrist detects the lateral or side force and controls the remainder of the operation until the shaft is properly in place in the center of the hole.

This mechanism resembles the RCC (Remote Control Compliance) developed at MIT's Draper Laboratory but it was built earlier and put to practical use for a motor and compressor assembly.

3.3 Force Control

Research is also being carried out on how to get manipulators to perform skilled labor by means of controlling not only their positioning and speed but also their force.

Two manipulators developed by ETL have all of their joints controlled by wires, the tension of which is directly specified by computer. Since this makes it unnecessary to install motors at the movable parts of these manipulators, it was possible to hold their weight down to a low 5 kg each. These manipulators are called the robot carpenter and are capable of doing carpentry work using the same tools as men, that is, hammers, vises, saws, drills and so forth.

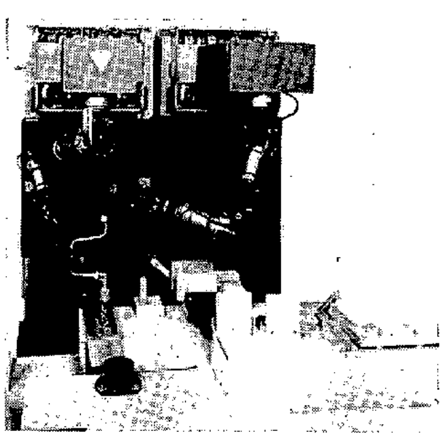


Fig. 5 Force control manipulators

Figure 5 shows these manipulators working together using a hand drill to drill holes in a piece of wood. First, the left manipulator positions the tip of the drill over the spot to be drilled. Next, the right manipulator maintains the drill in an upright position and applies a uniform downward force to the top of the drill. The manipulator on the left then applies force in such a way as to rotate the drill in a circular motion. Since the position of this manipulator is determined by the position of the drill, there is no need for it to have accurate positioning control. In this way, it is possible to produce movement that is restricted by another object. It is also possible to carry out a task that requires the coordinated efforts of two manipulators in this way.

3.4 Hands with Multiple Degree of Freedom

The hands of ordinary manipulators only possess two fingers capable of simply opening and closing. In order to have then perform complex tasks, special grips must be utilized. However, it is difficult to keep all the grips available that are necessary to carry out variable limited production operations and/or machinery repair work.

The three-fingered hand shown in Figure 6 has been tested at ETL. Two of these three fingers have 4 degrees of freedom (the number of joints) and one had only 3 degrees of freedom. Each degree of freedom is operated by a wire. When finger tip movement is specified, the rotation of each of the other joints of that finger is automatically calculated. Force control is utilized to make this three-fingered hand do work such as turning a shaft or tightening a nut.

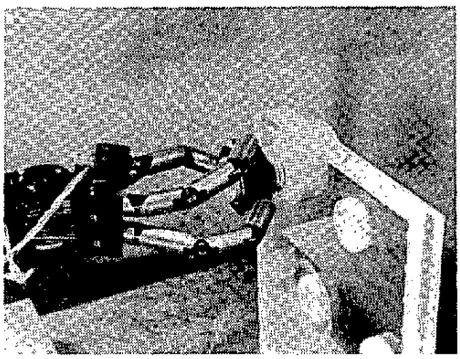


Fig. 6 Multiple jointed fingers

4. Research and Development of Eyes

4.1 The Industrial Eye

The retina of the human eye is composed of an abundance of cells which are capable of detecting and processing light and colors. The results of this initial processing are then transmitted to the brain. However, they also undergo parallel processing along the way by means of thousands of nerve cells. For an industrial eye, on the other hand, the usual input device for visual data is a TV camera with about 250 X 250 resolution. That eye doesn't utilize nearly the number of elements to process the visual data it receives that the human eye has nerve cells. Therefore, the quick recognition of a complex object by a machine isn't an easy matter at all. Accordingly, an 'eye' has been brought to practical application that gets by with simple processing.

A few industrial eyes were devised and made practical during the first half of the 1970's. Devices that recognize defects on printed circuit boards, or that determine the position of bolts so that they can be tightened or loosened are representative examples of these industrial eyes.

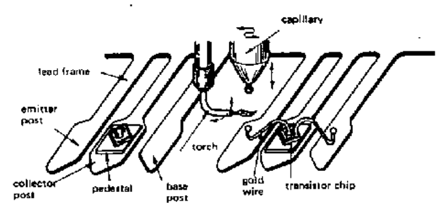


Fig. 7 Assembly of transistor

Later industrial eyes have also been applied to the assembly process for transistors. As Figure 7 indicates, they are used in the bonding process where gold wires are soldered to appropriate spots on a transistor chip and the posts which flank them. Since the spots where these gold wires must be soldered are minute, it isn't possible to get sufficient precision by ,mechanical positioning alone. Thus, precise positioning is carried out with the help of a TV camera which locates the two main points on the chip where the wires are to be bonded. Since the chip is seen as a black and white pattern by the camera, all it has to do is look around until the designated pattern comes into its field of vision. This particular method of positioning is called pattern matching. By means of automating the transistor bonding process like this, laborsavings have been realized and the cost of transistors reduced.

Folowing this, the same pattern matching method was applied to the bonding processes for ICs and LSIs, too. Applications for industrial eyes have rapidly advanced into semiconductor assembly processes such as silicon wafer alignment, positioning of semiconductor pellets and so forth. Even the inspection of IC and LSI mask patterns has recently been undergoing automation in this fashion.

The success of machine vision in the semiconductor industry has spurred on the development and practical application of visual information processing. For example, visual information processing is being applied in the inspection for flaws in film and steel sheet, the examination of container lids, the checking for flaws in tablets, the adjustment of color television sets, the grading and selecting of farm produce and the selection of fish, to name but a few.

Figure 8 shows a cucumber selector and Figure 9 the measurement method used in that selection process. A TV camera is located above and looking down on the cucumbers which are lying in individual white cases (buckets). When the visual data received by the camera is input to the processor, a binary (black & white) image is obtained with the cucumbers forming the black portions and everything else appearing as white. Thus, the measurement process outlined in Figure 9 is really quite simple.

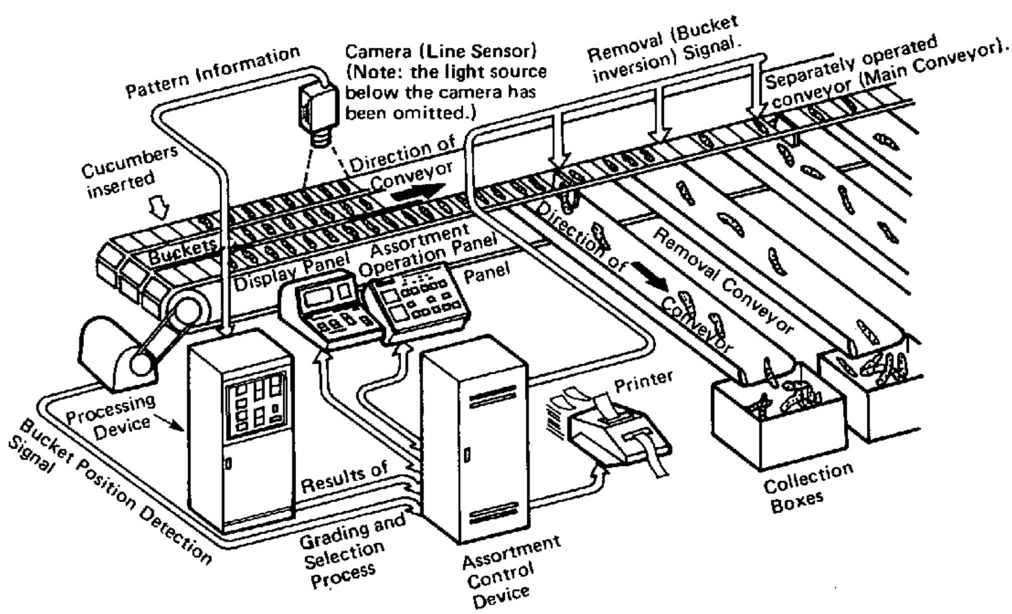


Fig. 8 Cucumber Selector

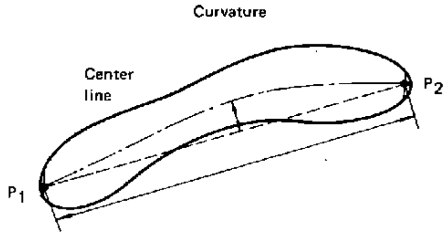


Fig. 9 Measurement of length and curvature

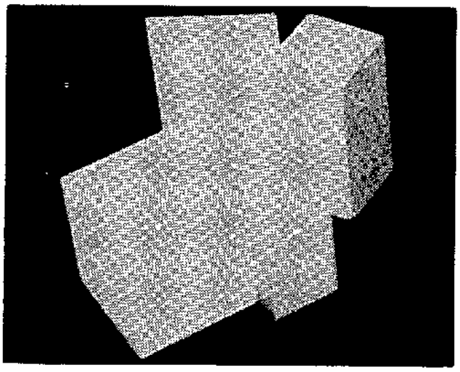


Fig. 10 Scene of blocks

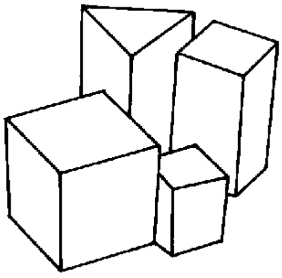


Fig. 11 Line drawing

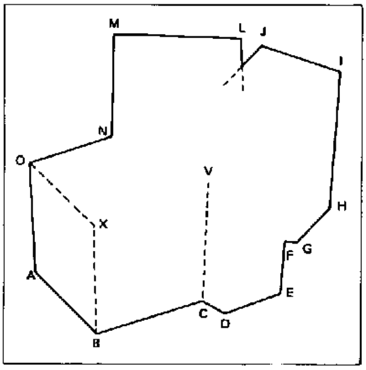


Fig. 12 Example of heterarchical method

4.2 Processing of Gray Images

As described above, visual data input via an industrial eye is most often a binary image. However, as Figure 10 indicates, a binary image isn't sufficient to recognize even simple wooden block arrangements. Generally speaking, this kind of recognition task is performed in the following manner.

(1) Those points (edge points) where the brightness abruptly changes are detected ;

(2) Edges are formed by connecting these edge points;

(3) A linear equation is fitted to these edges, and line drawings such as those shown in Figure 11 are made; and

(4) These line drawings are interpreted as a three-dimensional scene.

This kind of procedure is known as the hierarchical method. Among the steps outlined above, (3) is very easy, (4) was developed in the United States and (1) and (2) are quite difficult. When a human being looks at Figure 10, he more than likely picks out those edges most easily perceived first and, then, using them as a clue, sets about looking for the more difficult to recognize ones. A computer can be made to perform in the same manner. First, as Figure 12 illustrates, the computer locates the easy to recognize contour edges and then estimates the boundary edges between objects and based on those estimates searches for the hard to find edges. When it locates one of these edges, it then uses it as a clue in locating the other edges of that object.

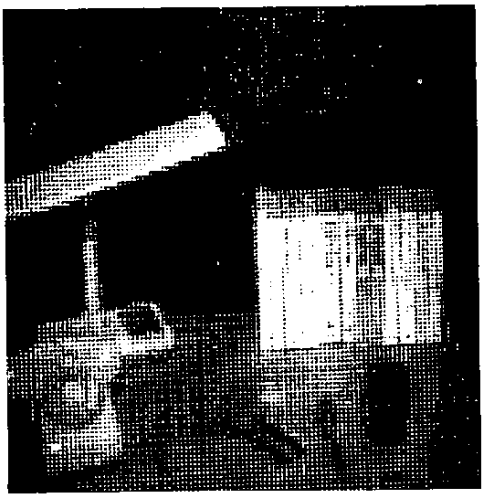
This procedure is called the heterarchical method. The line drawing shown in Figure 11 was obtained using this method.

4.3 Recognition of Complex Scenes

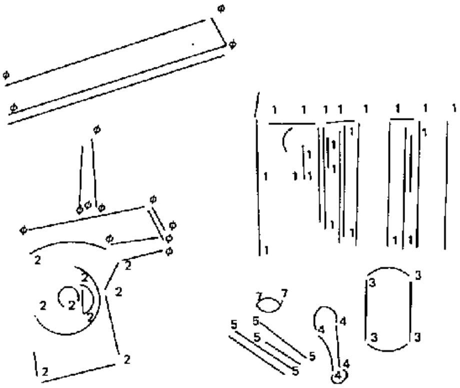
When the object of the recognition task is a complex scene, then methods for efficient processing must be carefully considered. If, for example, the task is to recognize objects in an outdoor scene, then the sky and the tops of mountains, trees and buildings will be restricted to the upper part of the scene, cars to the middle of the road and windows to the area inside of the buildings. If these constraints are used properly, recognition can be performed quite efficiently. If, however, the object of the recognition task is a desktop scene such as that shown in Figure 13, then constraints involving the positional relationships of the target objects can not be utilized. In that case the following procedure should be considered.

(1) Examine the degree of contrast at each point of the input image;
(2) Locate those portions of lines where the contrast is above uniform levels (threshold values), and trace those lines;
(3) Fit ellipses or straight lines to those lines and recognize objects by utilizing those approximated lines; and
(4) If the number of objects recognized is insufficient, lower the threshold value for contrast and begin again at step (1).

This procedure is quite efficient from the standpoint that there is no need to search for lines inside objects already known. Furthermore, since processing is carried out on those portions of the scene which are apparent,



(a) Input scene



(b) Recognition results

Fig. 13 Example of complex scene recognition

recognition reliability is increased. Figure 13 (b) illustrates the results of such processing.

4.4 Range Data Acquisition

If the degree of light intensity at numerous points within a field of vision is known as a brightness image, then data on the distance of numerous points within a field of vision can be called a range image. Input divices for range images have as yet to be made practical. Principal methods currently being utilized in this endeavor can be broadly divided into the following categories.

(1) Time of Flight
  (a) Sound – Ultrasonic waves: resolution.
  (b) Electromagnetic Waves – Laser rays: offers broad measurement capabilities, but the device is rather elaborate.

(2) Triangulation
  (a) Passive Method – Binocular three-dimensional vision: can be applied in special cases.
  (b) Active Method – Light Projection: can be used to measure distance as long as the object isn't too far away.

(3) Automatic Focus: can be applied to specific patterns.

Ultrasonic waves are used to determine the existence and approximate size of objects and are currently being tested with robots as a means of avoiding obstacles. As for binocular three-dimensional vision, it is difficult to determine the points where the two images correspond, but this method can still be used when the object of the recognition task is simple. There is also the method whereby a light is projected onto the target object in place of one of the 'eyes' in the binocular three-dimensional vision approach. ETL had developed a range finder that projects a sheet of light onto the objects of the recognition task through a slit, as well as a laser tracker which utilizes a laser spotlight. These two methods are currently being utilized in object recognition. The automatic focus method is best vis-a-vis specific patterns. This method has been put to practical use in the measurement of the thickness of ICs and has proven accurate to 2μm. This is done by adjusting the position of the lens to keep pattern contrast to a maximum.

4.5 The Processing of Range Data

Here we will discuss in simple terms a method for recognizing complex objects by processing the range data input by the range finder. Figure 15 shows an example of slit images of objects as observed through a camera. This data is better understood when it is expressed in more coherent, descriptive terms. Procedures for a scene description based on the region method are shown in Figure 16. First, the numerous 3-D coordinates (a) are divided evenly to form the surface elements (b). Then each of these surface elements are assumed to be planes and their formulas derived. Following this, it is possible to obtain elementary regions such as those shown in (c) by merging those

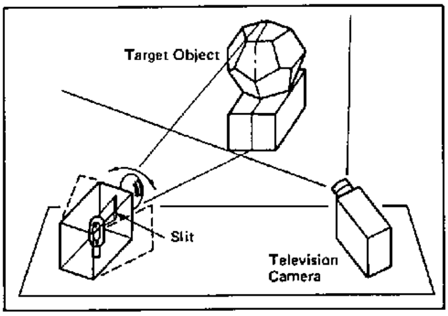


Diagram of the Range Finder Principle
Light is projected onto the target object(s) through a vertical slit. When the image thus produced is picked up by the camera, three dimensional coordinates of the surface of the objects are obtained. Under actual operating conditions, a mirror is used to change the direction of the projected light.

Fig. 14 Range Finder Principle

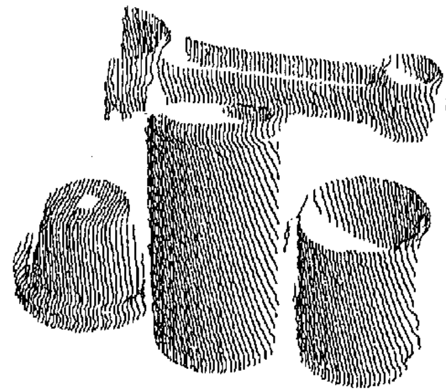
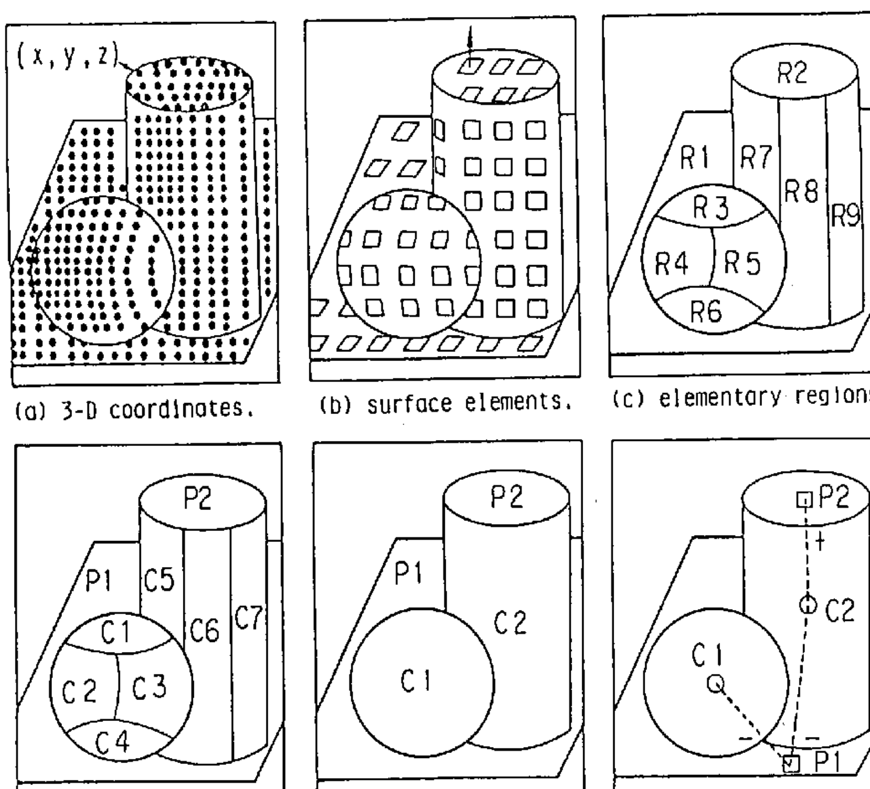


Fig. 15 Slit image taken by range finder



(a) 3-D coordinates. (b) surface elements. (c) elementary regions. (d) classified regions. (e) global regions. (f) description of the scene.

Fig. 16 Scheme for scene description process surface elements that are similar and adjacent to one another. Next, the surfaces of each elementary region are classified as to whether they are curved or plane (flat) (d). If those curved surfaces that are of a continuous nature are merged together then global regions like those shown in (e) can be obtained. The final step in the process is to pursue the characteristics and interrelationships of the global regions to get a scene description (f).

In order to carry out object recognition, models of objects must be stored in the computer prior to task execution. For example, you can show the computer the actual objects themselves. If you were to show the computer an automobile pulley you might wind up with a description such as that shown in Figure 17. This is a model of the pulley. After storing models of objects in the computer in this fashion, if the slit image shown in Figure 15 were to be input to that computer, results such as those shown in Figure 18 could be obtained. These results indicate the surfaces of the models that correspond to each global region.

5. Future Trends

Most of the industrial robots presently in operation in Japan are not equipped with sensors. This, of course, is quite natural. Sensors and the processing of the information obtained from them are more difficult to control than manipulators. Thus, it only stands to reason that automation would be carried out initially for that work which did not require sensors. However, as the utilization of robots continues to progress, the desire to use them in operations where vision is necessary will also increase. Experiments are currently under way to equip robots with simple visual information processing functions. Utilizing these functions these robots are then being tested as to their ability to find the tools they are to pick up, to locate a box on which to stack another box, to accurately disinguish the relative position of an object to their hands

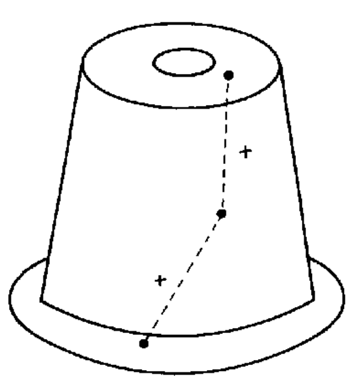


Fig. 17 Pulley's model

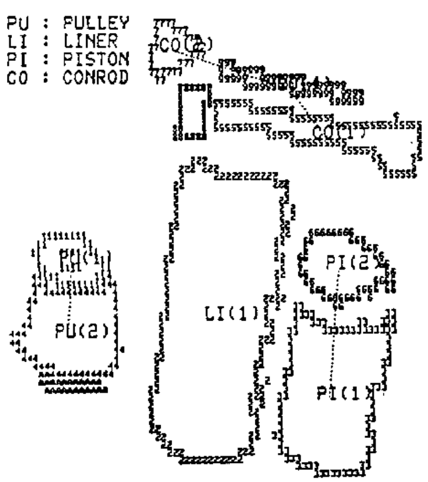


Fig. 18 Recognition result

once they have grasped it, and to follow a specified line when performing welding operations.

As stated previously, these developments are based on principles already known. For example, tests aimed at applying the principles of the range finder to welding techniques are being carried out similar to the one illustrated in Figure 19. The welding position is determined by a sheet of light projected onto the target object. Points B and C are detected as points where the bright line being observed by the camera bends, while point D is seen as a discontinuity. This type of detection operation is quite simple when viewed in terms of the research being done on object recognition. Nonetheless, the problem of precision detection under the severe working conditions imposed by welding operations remains to be solved.

Yet another trend in this area is the development of special hardware for image processing. This type of equipment is needed to speed up the work of image processing, a task that has required considerable time to date. Such hardware is also useful for research and development.

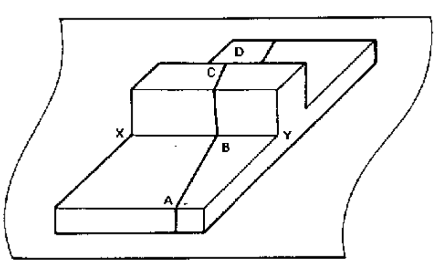


Fig. 19 Application of range finder to welding

Automation of the factory involves more than simply introducing robots into the work processes. As Figure 20 shows, the automation of production operations is being considered from the design phase through to the final product. A certain amount of research work is being devoted toward the study of CAD/CAM systems where it is advantageous to utilize object models designed via CAD in a variety of applications. Though some work has been done on CAD/CAM systems, it has not yet been combined with robot software. When we are capable of using designed object models to write semi-automatic robot manipulation programs and recognition programs for robot eyes, then perhaps we can come up with a genuine FMS (Flexible Manufacturing System). Research aimed at realizing this kind of Advanced FMS has been initiated recently at a number of universities and research laboratories in Japan.

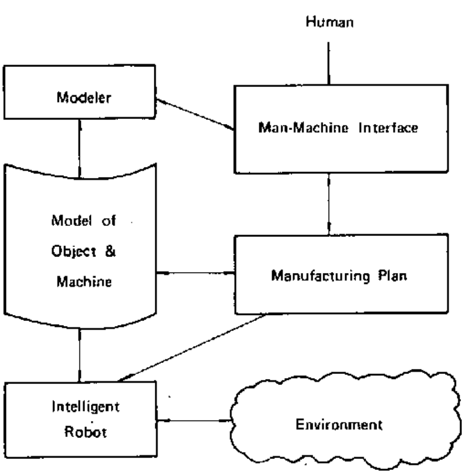


Fig. 20 Advanced FMS

Examples of Industrial Robot Applications and Their Problems

Tohru Wozumi
The Chunichi Shimbun
The Tokyo Shimbun

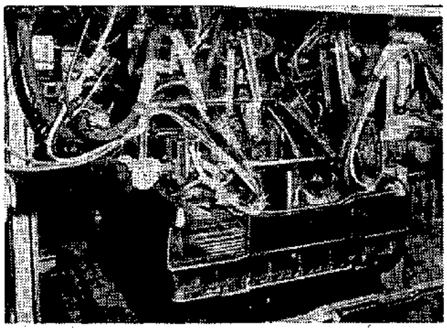
In Europe and America recently, when people talk about "robots" it is taken for granted that they mean "industrial robots". However, it wasn't so long ago that people in Japan, which is considered the robot center of the world, still equated robots with a cartoon character quite popular here for many years named "Tetsuwan Atom". In fact, even nowadays its not uncommon for businessmen to refer to the shape of industrial robots in terms of how different they are from Tetsuwan Atom.

This phenomenon isn't as strange as it may seem. In the United States, for example, cartoon characters like Popeye and Olive Oil or Superman are known and loved by millions of children and adults alike. Every nation throughout the world has its favorite cartoon characters. In Japan, for many years one such beloved national cartoon character was Tetsuwan Atom created by the very popular cartoonist, Osamu Tezuka.

In the cartoon series, Tetsuwan Atom was a child-like robot built by a certain scientist in the image of the son he had lost in an automobile accident. This human looking robot would pit itself against the forces of evil each week, taking on the villains no matter where they might be, on the ground, under the sea or far out in space. Children raised in Japan during the past 20 or 30 years all experienced the thrill of watching Tetsuwan Atom in action on the T.V. every week.

Stories about robots like Tetsuwan Atom are numerous all over the world.

The term "robot" was first coined as early as 1920 by a Czechoslovakian playwright in a play about a company that manufactured "invincible robots". Then again in 1926, in a West German work entitled "Metropolis," a child-like robot with the same origins as Japan's Tetsuwan Atom appeared. However, it was America's Isaac Isimov who first attempted to define robots. In his work, "I, A Robot," Asimov suggested that robots must adhere to three principles: 1) Robots must never do harm to man, 2) they must always obey man and



3) to the extent that it doesn't go against the first two principles, robots can protect themselves from harm.

The cartoon Tetsuwan Atom has all the makings of an immortal masterpiece about robots, and it was this cartoon that shaped Japanese ideas concerning what robots would be like. Of course, it is microelectronics that have proven to be the biggest single contributing factor to today's robot engineering, but as Osamu Tezuka says, "Tetsuwan Atom had a miniature computer for a brain, one so small that it could supposedly fit in the palm of your hand. In fact, it was while I was considering the possibilities of artificial intelligence based on such tiny computers that the idea for Tetsuwan Atom was born". Isn't it fascinating how a cartoon character created some thirty years ago could be so remarkably similar, technologically speaking, to the advanced industrial robots in actual operation today.

Japanese citizens do now know that industrial robots differ from the Tetsuwan Atom-image of robots that they grew up with, and in fact most are quite well versed in robotics. One factor that has played a particularly big role in deepening the Japanese understanding of industrial robots has been mass media descriptions of Japan from the U.S. and Europe calling it the "... leading nation in the world in the field of robotics". If the truth be known, however, these reports formed a principal part of criticisms aimed at Japan from overseas, and were an attempt by foreign journalists to pinpoint the reasons for the increased exports of small cars, color televisions and video tape recorders from Japan. In this regard, then, the seemingly honorary title of "Leading nation in the field of robotics" also carried with it some rather unpleasant aspects for the Japanese people.

Nonetheless, it was these overseas news reports that touched off a series of "Robot Exhibitions" all over Japan. In the fall, 1981, hundreds of thousands of people including children turned out at one such exhibition, which until that time had only been attended by people related to industry. They all wanted to see for themselves just what industrial robots were all about. Similar robot exhibitions are scheduled to be held in more than 10 different locations throughout the country during 1982.

This phenomenon has afforded the Japanese populace a chance to deepen its understanding of industrial robots and to discuss the merits and demerits of these advanced machines. It is our aim to introduce just a few such pros and cons here.

According to Isaac Asimov's three basic principles concerning robots, one would expect that they are incapable of doing harm to man. Nevertheless, during the summer of 1981 there was a robot-related accident involving a worker at the Akaishi Plant of Kawasaki Heavy Industries located in the city of Akashi, Hyogo Prefecture. This was the accident played up worldwide by the New York Times as the "Killer Robot Incident". Kawasaki Heavy Industries, together with Mitsubishi Heavy Industries and Ishikawajima-Harima Heavy Industries, is one of Japan's most prominent heavy industries enterprises engaged in shipbuilding and the manufacture of aircraft and industrial machinery. They also import technology from America's Unimation Corporation for use in the production of the "Unimate" welding robot. Whatsmore, Kawasaki Heavy Industries has recently begun to market robots developed via a technological arrangement with Unimation in Europe utilizing Unimation's European distribution network. This is one enterprise that can truly be called a professional in the field of industrial robots.

As for the accident, it occured at around 5 : 00 A.M. on the morning of July 4, 1981, at that site in the Akaishi Plant where automobile gears are put through the finishing process. The worker involved in the accident, Kenji Urata (37) was crushed to death between the arm of a materials handling robot and the processing machine onto which it loads and unloads gears for finishing.

There were, I believe, two major problems posed by this incident: 1) What kind of safety measures were in effect at the time of the accident? and 2) Is it really possible to build an industrial robot that is accident-proof?

Safety measures at Kawasaki Heavy Industries included roping off of the area immediately surrounding the robots to prevent workers from haphazardly entering into the danger zone within the reach of a robot's moving arm, and a device which automatically shuts off the robot should someone undo the chain portion of this safety rope which serves as the entrance/exit point.

In addition, there were also shut-off switches located on the bodies of all the robots as an extra precaution. It would appear then that Kawasaki Heavy Industries' safety measures were about as close to being foolproof as modern technology will permit.

Yet in spite of this an accident occurred.

First of all, it seems there was some kind of malfunction with the processing machinery that made it stop, and the robot, detecting this, also stopped functioning as it is supposed to. This is where the trouble started. Mr. Urata got flurried and ignoring established safety procedures jumped over the safety rope to adjust the processing machine. As soon as he finished fixing the malfunction in the processing machine, however, the robot began to operate once again and its arm pinned Mr. Urata to the processing machine and crushed him to death.

Had Mr. Urata complied with the safety procedures and entered the robot area by unfastening the chain portion of the safety rope and then immediately flicked the shut-off switch on the body of the robot prior to having taken steps to repair the processing machine then this extemely unfortunate accident would never have occurred.

Following the accident, Kawasaki Heavy Industries isolated all the robots in the plant behind six foot high metal enclosures and installed photoelectric sensors within the enclosures to further reinforce safety measures. Stricter safety measures are all well and good, but the question still remains as to what is being done technologically to develop a robot that will automatically stop operating when it comes in contact with an object other than that which it is programmed to work on. This brings us to the second problem posed by the robot accident.

From all indications it would seem that robots with this capability are indeed a possibility, and all the major Japanese makers are busily engaged in research efforts along these lines right now. Shigeru Watanabe, President of the Metropolitan College of Technology in Tokyo, explains that the aim of this research is to come up with a method for giving robots a sense of touch. He says, "There are any number of ways to prevent accidents, but in the end its going to be necessary that the robots themselves are capable of 'feeling pain', so to speak. It is for this reason that current research is concentrating on finding ways to provide robots with tactile sensation". There are already two ways of equipping robots with tactile sensation, one which utilizes temperature sensors and another that employs strain measuring devices. But the main problem at this stage it would seem is one of cost. If mass production of such tactile sensors were to begin soon, it's possible that they could be attached all over the robot's body giving it an almost real sense of touch.

However, present technology for this type of an endeavor is still far too costly. This is compounded by the fact that the current high degree of international competition shows no signs of letting up in the near future making it unlikely that either Japanese or overseas makers will be able to apply these methods too soon.

But even having said this, there is a good chance that if international safety regulations were to be passed which stated, in effect, that robots were prohibited from being sold unless they were equipped with this type of safety feature, robots that were capable of 'feeling' would be realized incread-ibly quickly.

It is our understanding that the majority of labor unions in Europe and the U.S. are of the opinion that "As long as it doesn't lead to lay-offs and unemployment, the unions will not oppose robots and the technological revolution they represent".

Japanese labor unions possess similar feelings as their counterparts in the U.S. and Europe. In the case of the Japanese enterprise, however, there was a strong tendency to introduce robots into the workplace to supplement the labor supply when there was a shortage of skilled welders, for example. For this reason, it seems that the labor unions in Japan didn't feel that there was any incompatibility involved in the incorporation of robots into factories.

In fact at Nissan Motors' Zama Plant the robots have names such as MOMOE or JUNKO, names of popular female singing stars in Japan, and at Toyo Kogyo (Mazda) plants the robots have been named after baseball stars who play on the team owned by Toyo Kogyo, the Toyo Carps. Rather than being looked on as 'enemies' by the workers in Japan, robots are considered tools that help to improve their work environment, reduce their heavy labor requirements and even raise the level of their wages by improving productivity. In short, they are looked upon as follow workers.

However, recently another way of thinking has begun to take shape in Japan, a new movement which is delving much more deeply into the pros and cons of robots.

The person who first proposed that a more critical eye should be turned to the robot situation was Chairman Ichiro Shioji of the Japan Automobile Workers (JAW), one of the most influential individuals in the automobile labor union, the industry which has been the major proponent of robots in Japan to date.

At a regularly scheduled general meeting of JAW held in the fall of 1981, Chairman Shioji pointed out that, "The number of robots in operation in the Japanese automobile industry now accounts for as much as 40% of the total number of robots installed throughout Japan.

However, to the best of my recolection, I don't recall that we (the unions) put up any kind of opposition to this rationalization process when all these robots were being introduced into the workplace. I can't help but wonder, though, whether its such a good idea to continue on like this."

The Japanese automobile industry experienced a period of great dispute in the mid-1950's. Both labor and management came away from this struggle in more reconciliatory moods, and the unions have been cooperating with the enterprise side ever since. Chairman Shioji, too, opted for a policy of cooperation between management and labor at the time of the big Nissan Motors dispute. With this kind of career behind him, Chairman Shioji's posing of the robot problem came as somewhat of a shock, to say the least.

Chairman Shioji explained the main points of his thinking as follows. "I wasn't refering to the near future when I brought up this question, but rather I was thinking of the situation ten years from now. Just like car industries in Europe and America, the Japanese automobile industry is also approaching the maturation stage. The next major problems that will confront us will have to do with the relationship between technological innovations and employment. I raised the problem of robots because I felt strongly that there will be a need in the not too distant future to deal with problems of technological innovation vs employment from the standpoint of new management-labor relations".

As one concrete theme in his re-examination process, Chairman Shioji stresses the problem of annual working hours and paid vacation. He points out that "In America and Europe it is the obligation of management to give workers a certain amount of paid vacation each year. In Japan, however, workers merely have the 'right' to take such paid vacations. If, for example, the entire Japanese labor force were to begin to use up all its paid vacation time, then the criticisms from overseas to the effect that 'Japanese work too hard' would quite likely stop completely. The surplus time created by future 'robotization' should make this a very real possibility indeed".

Seemingly in step with this JAW sponsored movement, some 540 thousand workers from manufacturers of electric home appliances and industrial electronics products who comprise an organization called the Electrical Labor Association have undertaken a project titled "Mid-term Employment Prospects in the Electrical Industry During the 1980's." One of the major objectives of this project also is to sufficiently address the problem of robots.

The current situation in Japan, then, is one where the JAW, the Electrical Labor Association, and even enterprise groups such as the Shipbuilder's Association of Japan are all debating problems related to robots from various points of view. The major theme to be tackled in future is the problem of 'worker relocation.'

The Japanese steel manufacturing industry has a fairly large share of the world's steel market. One big plus that the Japanese steel industry has going for it is its continuous casting plants which in effect can be called giant 'robot' plants. For the 60 thousand members of the Nippon Steel Federation of Labor Unions who accepted this kind of robot plant the problem of worker relocation is taken as something that can't be helped. "Mechanization is something that is undertaken to eliminate human error in order to standardize product quality.

In other words, since mechanization is designed to do away with skilled workers, relocation is inevitable, it can't be helped." Let's see just what the actual situation is as far as worker relocation is concerned.

The manufacture of digital quartz clocks and watches is part of the precision machine industry. For the past several years digital quartz clocks and watches produced by Japan's precision machine industry have enjoyed increasing popularity worldwide. Seiko and Citizen Watch are representative of such Japanese watch manufacturers. At the Citizen plant in the suburbs of Tokyo there are a number of 20 meter long assembly lines lined up side by side. On each line 10 or more robots are installed, each possessing different functions.

One robot just places parts on the line, while another's only task is to blow out hot air to melt the solder that connects the wiring. Taken one by one, all these robots possess really simple functions. If this were America or Europe they wouldn't be called robots at all, but rather would more than likely be grouped together with automatic machines (fixed sequence robots).

When they throw the switch that starts one of these lines in the morning, it takes about 15 minutes for the first analog quartz watch to be completed, but then every 2.5 to 3 seconds thereafter another watch comes off the line. Just one line is capable of turning out 10,000 watches per day without having to work overtime.

Seiko even outdoes Citizen, ranking as Japan's top watch company.

As might be expected then, Seiko has more assembly lines than Citizen. Quartz watches and clocks are those timepieces which run by means of a battery-powered quartz crystal oscillator. Compared to conventional mechanical watches, quartz watches have considerably fewer parts a feature which has enabled their being mass produced. Also, quartz movements have brought with them the age of the truly accurate timepiece, so much so that it is said that with a quartz watch or clock, "Accuracy is taken for granted." Even before the advent of the quartz age, in addition to being cheaper than Swiss-made products, Japanese watches were known worldwide for their fine precision construction and accuracy. This accomplishment was due primarily to the skill with which Japanese female workers adjusted these mechanical timepieces. Where in the world did all those skilled women workers disappear to? They are currently employed in the manufacture of the new crystal oscillators and as overseers in the final inspection process, jobs that demand even greater attention to detail than was necessary for the mechanical timepieces. Please understand that this switch was only possible thanks to their being successfully retrained in-house.

Next let's take a look at what worker relocation is doing to the number of workers actually employed at the factory. A good place to start is with the Fanuc Ltd., which is a manufacturer of robots that uses robots in its production processes.

The Fanuc Fuji Plant is located in the foothills just north of Japan's highest mountain, Mt. Fuji. This plant is world famous due to the fact that it is a completely automated, unmanned factory where robots make the parts for the construction of other robots.

This plant is capable of producing $40 million worth of robot parts annually, but the total number of human workers employed here doesn't amount to quite 100 in all. Furthermore, since the majority of these workers are engaged in the assembly of robots, if assembly robots are introduced into the plant at some future date, then the number of human workers at the plant will be cut almost in half.

In a speech which he gave recently titled, "In Pursuit of the Unmanned Factory," Seizaemon Inaba, president of Fanuc Ltd., introduced yet another new idea for automated factories. This is the company's Luxembourg Plant which it plans to bring on stream in Europe in August of 1982. It seems this plant will utilize both conveyance and assembly robots in its mass production processes, but will employ only three human workers, including the president.

By operating this plant just one hour a day starting from 10 o'clock in the morning Fanuc says it expects to turn out 100 automatic tape perforation machines for use in numerically controlled machine tools per month. The decision to limit operation to just one hour a day was taken to prevent overproduction.

Both of these Fanuc plants are unmanned, fully-automated factories where robots and NC machine tools are effectively integrated into the manufacturing processes, a system known as FMS (Flexible Manufacturing System). However, robots are machines that can be introduced into plants that are currently in operation to realize this FMS. And when this happens, the workers heretofore employed at those newly FMS-ized plants will most certainly have to be relocated somewhere else. It is predicted that in future this problem of worker relocation will not be as easily solved by mere re-education programs. For this reason, it is felt that the governmetns of the world will have to give some careful thought to the prospects of further increasing the propagation of robots in industry in future. In line with this some new industrial and employment policies will also have to be prudently worked out.

New problems will also appear at those plants where FMS and/or robots are currently being utilized. These new problems will arise from the influence that the switch from physical labor to supervisory, i.e. monitoring, jobs will have on the workers themselves.

Monitoring of each of the separate work sites at the Fanuc Fuji Plant is conducted by means of industrial TV cameras which transmit the images they receive to monitoring screens located in a central control room. Even though the plant is fully-automated, someone has to carefully monitor these monitoring screens. This is in case one of the machines should suddenly go haywire and start to produce defective products. If someone isn't watching the monitoring screens when this phenomenon takes place then the machine in question will continue to turn out defective goods until such time as it uses up all of its materials. Needless to say, this would prove quite costly to the company concerned.

Thus, this kind of monitoring work has been on the increase lately. Let's take one more actual example, this one a plant dealing in the assembly of integrated circuits (IC's).

This plant carries out a process called bonding whereby connectors are affixed to the IC chip by means of ultra-thin gold wires. In the past young women employees soldered these fine gold wires to the chips one by one. Now, however, this process has been made automatic by means of bonding machines and the production output of this plant has increased tremendously. The young women workers, too, were undoubtedly greatly relieved to be liberated from the eye-straining task of soldering all those extremely fine wires into place.

But even so, one woman worker who had been at that job for eight years confessed that, "It's a fact that soldering those wires was a strain on my eyes, but the old job was still better than what I'm doing now."

She went on to say that, "I'm now in charge of 5 bonding machines. My job is to monitor the little red lamps on these machines that blink when they run out of wires. I can just about figure out when each of the lamps is going to start blinking, but every time they do I get all flustered. I feel uneasy all the time." In short, this woman is troubled by the emotional distress these lamps are causing her.

This kind of problem at IC plants isn't something limited only to Japan, but also occurs in the U.S. as well. This is because IC manufacturers in the U.S., which used to have their bonding operations performed by plants in Southeast Asia, have recently 'repatriated' the process to their domestic plants with the coming of the bonding machine. These kind of automatic machines cause the people who must monitor them a good deal of stress and make them experience a new kind of fatigue, what in Japan is called "emotional fatigue." Unlike physical and mental fatigue from which we can recover with a good night's sleep, emotional fatigue is harder to get over.

If this emotional fatigue is allowed to accumulate, then such physical disorders as autonomic imbalance, alopecia areata (patchy baldness) and even impotence can appear. In medical terminology, these kinds of psychologically caused ailments are labelled "psychosomatic disorders."

Thus, robots are not simply to be praised as the ultimate tools for improving quality and raising productivity. If their effects on man are not taken into serious consideration, then it may be impossible to realize an environment wherein man and robots are capable of 'coexistence.'

Lastly, let's wind up by touching on the point as to whether or not Japanese and overseas robot manufacturers will continue to enter into technical and other tie-ups in future at the same lively pace that they are now.

This poses a problem from the standpoint that robots are a big factor in the employment situation of all countries and Japanese robot manufacturers don't want to be accused of increasing economic frictions between Japan and the West any further. However, even though the effects of robots go far beyond this, the size of the robot market in terms of value is exceptionally small.

Robot sales for the Japanese industry during 1981 reached approximately $500 million. Sales of low level robots are also included in these figures. By comparison, 1981 robot sales in the United States only amounted to about $160 million. The 1981 world market for robots according to the American system where only top level robots are considered in the calculations was roughly $500 million if we view the Japanese, American and European markets as being pretty much equal.

The American robot market is expected to expand tremendously in future, reaching the $2 billion dollar level by 1990. However, this will still only amount to slightly over 1/15 of the '81 annual turnover of IBM ($29 billion) which entered the robot market in March of 1982. With a market as small as the one for robots is, even if the big enterprises sink a bunch of money into research and development, it will be too long before they can reap any profits from their investments. Between 1981 and 1982, four major American firms, General Electric, Westinghouse, IBM and General Motors all entered the robot market. Each of these companies is involved in technical tie-ups with firms in Europe and Japan. These tie-ups aren't a matter of which country has the most advanced technology or is technically behind, but rather, are compulsory from a business standpoint in a market which is so small.

Unless the world's consumers purchase ten times the amount of goods in future that they are purchasing now, this trend will in all liklihood continue. This is because even if purchasing power increases two- or three-fold, this is something that can easily be dealt with just by operating existing robots at night and won't, therefore, have any affect on the size of the robot market.

News in Brief

Fujitsu, Britain's ICL Formally Sign Technical Assistance Agreement

December 7, 1981

Fujitsu (Takuma Yamamoto, President) and International Computers Ltd. of the UK, having reached an accord earlier in the year concerning the terms of a technical assistance agreement in the field of computers, formally signed a contract to that extent in London, it was announced December 7. The signatories were Fujitsu Chairman Taiyu Kobayashi and C.C.F. Laidlaw, Chairman of ICL.

The specific terms of this agreement were as follows: 1) Cooperation in the development and production of ICL's large-scale computer, ESTRIEL–Together with consenting to allow ICL to utilize Fujitsu technology in the development of the ESTRIEL, Fujitsu will also undertake the production and supply of that computer's mainframe, 2) The supply of semiconductor LSIs for use in ICL's medium- and small-scale computers, DMI – Fujitsu will develop and supply ICL with semiconductor LSIs for use in its DMI series of computers; 3) The supply of Fujitsu products to ICL on an OEM basis – Fujitsu has agreed to supply ICL with its giant FACOM M380/M382 computers, as well as the license for the software utilized therein, for sale under the ICL brand name; and 4) Future technical cooperation – Fujitsu also agreed to cooperate technologically with ICL in the development of computers in future as well.

Fujitsu to Introduce TV Conferencing System Linking Tokyo and Numazu

December 9, 1981

Fujitsu announced December 9 that it plans to commence construction of a Television Conferencing System that will link its Systems Laboratory in Kamata, Tokyo with its Numazu Factory in Numazu Shizuoka Prefecture. Completion of this system is scheduled for fall, 1982. The Tokyo – Numazu link is only the beginning, however. The Company also plans to join three more sites via the new system by the end of 1983.

This TV Conferencing System is made up of television cameras, large-sized screens, facsimiles, word processors and an electronic blackboard capable of reproducing what is written on it on screens located at distant sites. The first stage in the construction of this system will be the Tokyo – Numazu link. When completed this portion of the system is expected to run around ¥200 million for construction and facilities.

Following the first stage of the project, Fujitsu will extend the system to include the FACOM Building in Shimbashi, Tokyo, its Kawasaki Plant in Kanagawa Prefecture and its Oyama Plant in Tochigi Prefecture by the end of 1983. When completed the Company will be able to conduct conferences and meetings at all five locations simultaneously using this closed-circuit TV system.

JIPDEC Publishers '81 Computer White Paper

December 14, 1981

The Japan Information Processing Development Center (JIPDEC) came out with its '81 Computer White Paper on December 14. According to that publication, the number of general purpose computers in operation in Japan as of the end of September, 1980, totaled over 79,000 units valued at more than ¥3,850 billion. The White Paper went on to report that investments in computers over the next 5 years are expected to average about 1.9 times that of 1980 levels, thus indicating that the spread of computers will steadily progress in the near future.

The '81 Computer White Paper also revealed that the total number of general purpose computers in operation in Japan could be broken down as follows: large-scale computers – 3,060 units or 3.9% of the total number of units in operation; medium-scale computers – 8,697 units or 11.0%; small-scale computers – 23,045 units or 29.1%; and very small computers – 44,479 units or 56.0%. Total number of general purpose computers in operation thus amounted to 79,281 units. Small-scale and very small computers accounted for nearly 90 percent of this total.

The value of these computers, the White Paper reported, amounted to ¥2,280,315 million for large-scale computers (59.2% of overall value), ¥881,252 million for medium-scale computers (22.9% of overall value), ¥427,081 million for small-scale computers (11.1% of overall value) and ¥262,116 million for very small computers (6.8% of overall value) for a total value of ¥3,850,763 million. Large-scale computers accounted for over half of the total value.

When it came to the cost of maintaining these computers as a percentage of monthly business results, the White Paper calculated that computers cost an average of 2.99 yen for every 1,000 yen earned for all the industries concerned, down slightly from the 3.66/ ¥1,000 results for the year previous. The monthly cost of computers per employee worked out to an average of 17,100 yen per head for all industries concerned. This figure had changed little from that of the year before.

Electronic Industries Association Compiles Results of Electronic Equipment Output for 1981

December 17, 1981

The Electronic Industries Association of Japan published the results of production output of electronic equipment for 1981 and put together a forecast for said output for 1982. According to this report, production output for 1981 exceeded initial predictions of ¥9.8 trillion, increasing 20% over the previous year's figures to reach ¥10.4 trillion. This was the first time production of electronic equipment surpassed the 10 trillion yen mark. The reports forecast for production output during 1982, while down slightly compared to the '81 growth rate, is nonetheless expected to stay in the double figures increasing by about 12% over last years performance to around ¥11.7 trillion.

Furthermore, industrial machinery, especially computers, are seen as achieving double digit growth for the next 6 straight years as the degree of reliance on private and foreign demand by demand sector continues to increase. Also, electronic parts are expected to show the highest growth rate of the three (electronic equipment, industrial machinery and electronic parts) thanks to rising demand for growth products such as VTRs and information equipment as well as the creation of new demand by means of the development of new products.

NOMA Survey on Microcomputer and Personal Computer Usage

December 22, 1981

The Nippon Administrative Management Association (NOMA) compiled the results of a survey it conducted into a report titled "Utilization of Microcomputers and Personal Computers." The survey itself was targeted at two broad groups, enterprises and individuals. Thus, the subjects of the survey comprised 2,000 companies randomly selected from among both listed and unlisted companies, educational institutions, hospitals and so on, and 2,000 individuals randomly selected from among participants at NOMA-sponsored Business Shows and members of the Japan Microcomputer Club.

The number of respondents to the survey from among those randomly selected came to 267 enterprises and 558 individuals.

According to the report put together from the results of this survey, 55.6% of the respondents answered that they were currently utilizing microcomputers and/or personal computers, while 2.2% admitted that they had installed these computers but rarely used them. As for the number of units installed, an overwhelming 63.8% of the respondents replied they had 1 to 5 units, 11.4% said 6 to 10 units and 16.1% of the respondents had from 11 to 50 units installed. Reasons given for failing to use microcomputers or personal computers after having them installed fell primarily into two categories, 1) the computers had been installed on a trial basis only, and 2) there had been problems with programming.

Principal uses to which these computers are being put, according to the report, are for business purposes (34.5%) and the handling of administrative data (26.1%), which together come to more than 60% of all the uses stated. Further, the number of cases where these computers were being utilized to perform technical calculations in the manufacturing industry was also noteworthy.

Respondents who claimed they were putting microcomputers and personal computers to personal and/or family uses figured out to a high 61.9% of those surveyed. Another 14.8% of the respondents stated they had no plans for purchasing these types of computers, but would like to try and use them sometime, while 8.6% said they were interested in them but had no plans to utilize such computers. Only 7.1% of those surveyed claimed they had plans to purchase such computers in the near future.

Institute Compiles Survey Report on OA Situation in Japan

March 4, 1982

The Japan Institute of Office Automation (JIAO) announced March 4 that it had put together the results of a survey it conducted last November on the "Office Automation Situation for 1982." The survey itself targeted 2,000 enterprises, both those listed on the 1st and 2nd sections of Japanese stock exchanges and major unlisted companies. The results of this survey were compiled and analyzed based on responses received by the early part of December from 270 of the 2,000 subject companies.

Among the responses received concerning the subjects' perceptions of office automation (OA), 60% of the respondents (162 companies) felt that "OA has progressed in line with computerization to date." Of these respondents, 74.7% (121 of the 162 companies) understood the automation of offices to be "a comprehensive revamping of conventional computers and OA equipment and their subsequent union for the purpose of improving efficiency."

To the problem of "How should OA be undertaken?" 78.5% of the respondent (212 companies) replied that "Investment in OA equipment should be carried out to the extent that it corresponds to the business needs of an office." The next highest number of responses to this question worked out to 14.8% of the total (40 companies) and was negativistic from the standpoint that it stated that "The reconsideration of current working conditions should have priority over equipment investments."

"The introduction of such OA equipment as facsimiles, personal computers, word processors (WP) and on-line terminals has grown in particular," was the main response to the question of "What types of OA equipment have increased lately." Broken down by percentage the report noted that utilization of facsimile equipment was up 54.8%, personal computers up 48.5%, Japanese-language WP up 40.0%, on-line terminals up 35.9% and office computers (small business computers) up 35.2%.

As to "Problems involved in the promotion of OA," 46.5% of the respondents (125 companies) replied that "Standardization and coordination of office routines are not being carried out prior to giving consideration to the introduction of OA equipment."

KDD Applies for Permission to Open Packet Switched International Public Data Transmission Service

March 9, 1982

Kokusai Denshin Denwa (KDD), Japan's international telephone and telegraph company submitted an application March 9 to the Japanese Ministry of Posts and Telecommunications (MPT) requesting permission to establish an international public data transmission service called VENUS-P that would be open to the public and operated by means of a packet switching system. If approved, the special feature of the VENUS-P service will be the fact that even users who utilize such international lines infrequently will be able to make use of international data communications services cheaply and easily. KDD hopes to be able to start this service by April 1.

KDD has an international data communication network that links Japan with numerous overseas nations and is currently undertaking the "VENUS Project" in order to enable international data communications to be carried out in the same manner as international telephone calls. The VENUS-P service will form the first stage of this project and will be carried out by means of a packet switching system that stores digital signals sent from a source terminal in that terminal's node where the data is divided into fixed-length packets and routed as such to its destination.

KDD is capable of data communications with the United States, Great Britain, France, West Germany and Spain at present, and will make such services available to Italy, Switzerland and Canada in the near future. Areas that will be capable of utilizing this new service will be limited to the 23 wards in the Tokyo metropolitan region as well as the inner city regions of Osaka. Prospective users in areas other than these will also be able to avail themselves of this service by paying a domestic line (additional service) fee.

IPA Publishes Survey Results on the Information Processing Industry

April 2, 1982

On April 2, the Information-technology Promotion Agency, Japan (IPA) announced the results of its survey conducted in July, 1981 on the growth and financial condition of information processing firms (software houses and computer service companies) during Fiscal 1980. An overview of those results is as follows:

(Growth) Software development,

which occupied 54.9% of total sales by composition for the software industry, increased 24.2% over the year before level and showed a high 26.2% average annual growth rate over a three-year period. The average three-year annual growth rate for consigned computing jobs, which occupied 62.0% of gross sales in the information processing service industry, only reached 14.7%. This was below the 16.0% growth rate recorded for the information processing service industry as a whole. This low 3-year average annual growth rate can be attributed to the sluggish 13.2% growth rate of batch services as well as the recent rapid spread of office (small business) computers.

Viewed in terns of number of workers employed, the growth rate for companies employing so or less workers in the software industry was the highest at 28.1%, while information processing service firms with between 101 and 300 employes were tops in that industry, recording a growth rate of 18.9%.

(Profit and Losses) Of the enterprises surveyed, 61.7% showed increased profits over their year prior results, 8.6% exhibited flat growth and 29.7% recorded profit losses. Among the latter, 8.6% of the companies either went into the red or showed "zero" profits. Broken down by industry we see that 69.3% of the software industry achieved profit increases and 20.6% profit decreases, while only 53.9% of the information processing service industry realized profit increases of 53.9% and 39.0% profit decreases.

Thus, it can be pointed out that business conditions for the software industry were slightly better than those for the information processing service industry in terms of 3-year average annual growth rates if viewed only from the standpoint of those firms which showed either profit increases or decreases.

Establishment of Institute for New Generation Computer Technology Approved

April 18, 1982

The Ministry of International Trade and Industry (MITI) on April 14 approved the founding of the Institute for New Generation Computer Technology (ICOT), a non-profit organization which will become the nucleus for research and development work on the large-scale fifth generation computer systems project currently underway in Japan. This institute will assume R&D duties beginning on June 1.

The founders of this new organization consist of six main frame manufacturers – Fujitsu, NEC, Hitachi, Toshiba, Mitsubishi Electric Corporation and Oki Electric –plus two other companies, Matsushita Electric Industrial Co. and Sharp, bringing the total to 8 enterprises in all. All of these companies will be taking an active hand in the research and development of the fifth generation computer. The endowment for this development organ amounted to ¥50 million at the time of its inauguration and its operating funds, which will be shared by all 8 founding companies, comes to ¥400 million.

Fujitsu's president Tokuma Yamamoto will act as president of ICOT and Managing Director Tadashi Yoshioka of the Electronic Industry Development Association will serve as executive director. The central force behind this institutes research activities will be a team of about 30 full-time researchers gleaned from among the staffs of technical experts of the 8 founding companies, NTT (Nippon Telegraph Telephone and Public Corporation) and the Electrotechnical Laboratory.

The new institute is looking for supporting members in order to expand the basis of its research. Membership fees will also be applied toward research as well as other areas.

The research and development work is scheduled to be carried out at intervals, with the initial term covering a span of 3 years, the midterm 4 years and the final term 3 years. Total costs for this project are being estimated at around ¥100 billion.

ICOT can be contacted by writing to ICOT, 21 Fl, Mita Kokusai Bldg., 4-28 Mita 1-chome, Minato-ku, Tokyo 108, or phoning 456–2511.

Administrative Management Agency Compiles Survey Results on Computer Utilization in Administrative Organs

May 2, 1982

The Administrative Management Agency (Yasuhiro Nakasone, Director) compiled and published a "Basic Survey Report on the Utilization of Computers," in administrative organs and special status corporations.

According to this report, there were 331 units installed in 210 departments of 22 of this nations administrative agencies as of the end of Fiscal 1981, or 22 units more than there were at the end of the previous fiscal year. The value of these installed units (in terms of their purchasing price) amounted to ¥224.7 billion. Special note was made of the fact that the value per unit has gone up 1.6 times that of 5 years ago, and the trend toward introducing large-scale computers is continuing.

In line with this, the advancement and diversification of utilization have also progressed with 67.4% of all installed units (223 units) being used for on-line processing. In addition to such conventional applications in the services area as large-scale computations involving statistics, wages and mutual aid, pensions, insurance and registration work, a variety of dtabase information retrieval work is being carried out at 8 agencies and this trend is on the rise. Japanese language (KANJI) information processing is being put to use in 32 departments of 15 agencies to perform work such as information retrieval, tabulations and the like. This type of utilization has increased compared to figures for the previous year. (21 departments in 12 agencies)

The 57th Annual Business Show Held Starting May 12

May 7, 1982

The 57th Annual Business Show was held for 4 days starting May 12 at the Tokyo International Trade Center in Harumi, Tokyo. This event was co-sponsored by the Nippon Administrative Management Association (NOMA) and the Tokyo Chamber of Commerce and Industry.

Some 15,000 exhibits were displayed by 173 companies in the most spacious area ever utilized at a Business Show, measuring 18,600 square meters.

General purpose and office computers were displayed by 28 firms (only 22 firms showed such computers the previous show) and 25 companies exhibited personal computers.

Japanese-language word processor were put on display by 34 companies, and a special "Japanese-language Word Processor Corner" was established for the first time. CAD/CAM system and Decision Support systems were shown by 9 companies.

In addition, other products exhibited at the Show included typewriters, copying machines, facsimiles, calculators, computer peripheral and terminal devices and other business machines and equipments. There were also other supplementary events and booths such as the 12th All Japan Computer Technology Competition, the '82 Office Automation Symposium, the '82 Business Form Contest, the '82 Good Filing Prize, a Management Consultation Booth and a Computer Consultation Booth.

NOMA Report on Small Business Computer Usage

May 9, 1982

The Nippon Administrative Management Association (NOMA) recently published a survey report on small business computer utilization in Japan. According to that report, of the 511 firms which responded to the survey, 52.8% were currently utilizing small business computers. It was also reported that for every 5 small business computers in use, one is a Japanese-language (KANJI) computer.

The most often given reason for installing these small business computers was to raise business efficiency and 58.7% of those enterprises employing these computers said that their operations had indeed become more efficient.

This survey was carried out in January of this year by mailing questionnaires to 2,000 companies including those listed on Japanese stock exchanges. NOMA received responses from 25.6% of the target firms, or 511 companies in all.

As the results of this survey indicated, the types of companies using small business computers fell into the telecommunications, publishing, service, precision, transportation machine and food industries for the most part.

Following those firms which responded that they were currently using small business computers, the most frequent response was that "We have no plans for utilizing such computers in the near future," occupying 27.0%

of the total number of responses. Those respondents that replied that they had "Introduced small business computers but are not utilizing them," only amounted to 0.5%. In addition to the fact that 19.2% of the respondents are currently utilizing Japanese-language small business computers, another 31.6% replied they are presently considering introducing such to their companies. It can thus be gathered that the need for Japanese-language computers is running high.

"To improve business efficiency," registered 82.1% of the responses concerning why small business computers had been installed.

This was followed by reasons such as "To improve business accuracy," and "To raise the level of management." As for the mode of utilization, cases where these computers were being used at the section and department levels to process jobs that weren't processed by the host computer were numerous. Key points for selecting certain machines over others ranged from "Easy to Operate," to "Inexpensive." From the aspect of software, a major factor was apparently a "Superior operating system."

The Business Machine Makers Association's Visions of Business Machines in 1990

May 13, 1982

The Japan Business Machine Makers Association (Yoshio Komai, Chairman) announced May 13 that it had put together a report title "Business Machine Visions" for the period covering up to 1990. This report notes that performance for the industry during 1981 by value was ¥2,196.6 billion (up 14.4% over the year before), and predicts that having achieved the 2 trillion yen level the industry will continue to grow, attaining total sales of ¥4,138.5 billion in 1985 and a staggering ¥7,152.1 billion by 1990.

If 1981's performance is broken down by value per type of machine, we see that sales of copying machines reached ¥420.6 billion (up 24.9%), while that for calculators only amounted to ¥147.6 billion (down 27%) and for cash registers ¥80.1 billion (down 7.8%). Sales of typewriters was up to ¥67.8 billion (up 30.9%), word processors to ¥19.3 billion (up 3.02 times), microphotographing machines to ¥14.0 billion (up 7.7%) and other business machines to ¥55.4 billion (up 25.6%). Small business computers achieved sales of ¥300.0 billion (up 35%), while sales of personal computers also rose considerably, up 2.97 times that of the previous year to ¥100.0 billion. Facsimile recorded sales of ¥107.8 billion (up 27.2%) and ofiice supplies also rose slightly to ¥874.0 billion (up 5.1%).

The mid-term forecast for these principal machines sees 1985 sales reaching ¥583.3 billion for copying machines, ¥255.6 billion for calculators, ¥112.0 billion for cash registers, ¥109.0 billion for word processors, ¥750.0 billion for small business computers, ¥400.0

billion for personal computers, ¥257.9 billion for facsimile and ¥1,482.9 billion for office supplies. 1990 sales of business machines are expected to be even better with copying machines achieving ¥843.8 billion, calculators ¥335.4 billion, cash registers ¥169.1 billion, word processors ¥260.0 billion, small business computers a whopping ¥1,660.0 billion, personal computers ¥800.0 billion, facsimile ¥600.0 billion and office supplies ¥2,219.0 billion. The greatest degree of growth, then, is expected for word processors, small business computers, facsimile and personal computers.

JIPDEC

Japan Information Processing Development Center