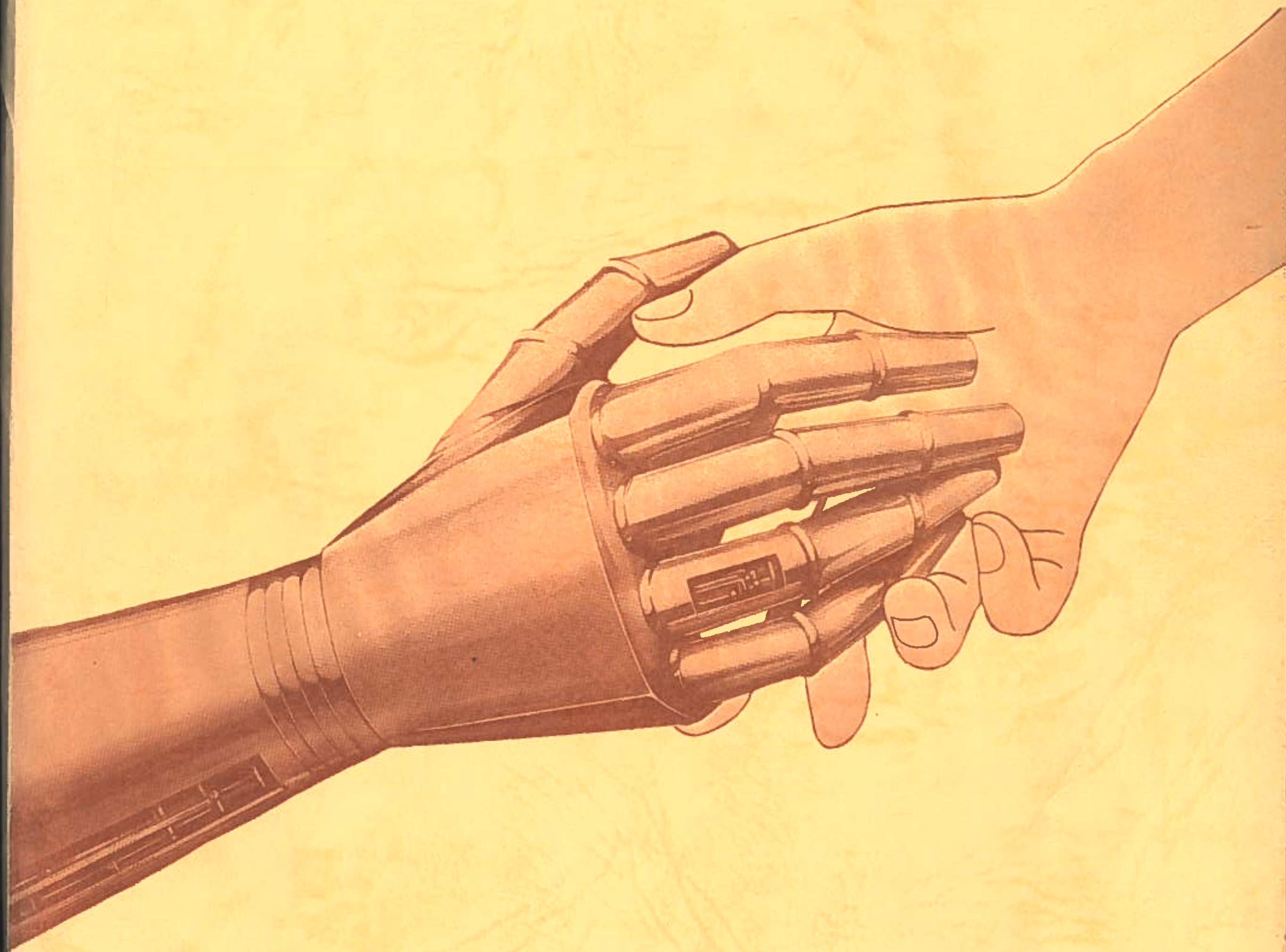
人間ーロボット学

大阪シンポジウム

CONTRIBUTION OF MICROELECTRONICS TO THE ENHANCEMENT OF HUMAN LIFE



AUG. 19 & 20, 1982 国立民族学博物館(National Museum of Ethnology, Osaka, Japan)

THE THREE ROBOT COMMANDMENTS

1. Thou Shalt Not Harm Humans
2. Thou Shalt Obey Human Orders
3. Thou Shalt Defend Thy Robot-hood

Osaka Symposium on the Contribution of Microelectronics to the Enhancement of Human Life

HOST

Japan Society of Human-Robotics

President: Kiyoji Asai (Professor, University of Osaka Prefecture)

Osaka Symposium-Steering Committee

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(No special order is observed.)

SPONSORS

Ministry of International Trade and Industry

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The Yomiuri Shimbun, Osaka Head Office

Yomiuri Telecasting Corporation

(No special order is observed.)

WITH THE COOPERATION OF:

The Foundation of Osaka Science and Technology Center

Kansai Institute of Information Systems

Kansai Productivity Center

The Japan Ergonomics Research Society

Society of Instrument and Control Engineers

Japan Association of Automatic Control Engineers

Information Processing Society of Japan

Society of Bio-mechanism

Japan Industrial Robot Association

(No special order is observed.)

PROGRAM (1)

August 19th (Thursday)

Opening Ceremony (10:00～10:20, at Auditorium)

Opening address: ∘ Kiyoji ASAI
(President, Japan Society of Human-Robotics)
∘ Tadao UMESAO
(Director, National Museum of Ethnology)

Keynote Speech I (10:20～11:10, at Auditorium)

"Robot Anthropology: Machinery as Partner"
by Sakyo KOMATSU (Author)

Reports (11:15～12:45, at Auditorium)

"How Has Society Accepted Robots?"

Case 1: In Europe ...... A. WISNER (Conservatoire National des Arts et Métiers)

Case 2: In the U.S.A. .. David A. THOMPSON (Professor, Stanford University)

Case 3: In Japan .... Yukio HASEGAWA (Professor, Waseda University)

Break (12:45～14:15)

Workshops (Introductory addresses: 14:20～15:20, Panel discussion: 15:40～16:40)

Workshop A "Robots and Human Beings"
— The Future of Automated Machinery —

Chairman: Ichiro KATO (Professor, Waseda University)

A1: "Robotics and Automation" ... Saburo TSUJI
(Professor, Osaka University)

A2: "Robots and Human Beings" ... Hiroyuki YOSHIKAWA
(Professor, University of Tokyo)

A3: ... David A. THOMPSON
(Professor, Stanford University)

Workshop B "The Computer and Daily Life"

Chairman: Kaoru ANDO (Advisor, Fujitsu, Ltd.)

B1: "Application in Livelihood and Home Appliances that Will Lead to Changes in Computers"
... Hiroaki TERADA
(Professor, Osaka University)

B2: "Basic Characteristics and Impact of Microelectronics"
... Ryoichi MORI
(Professor, Tsukuba University)

B3: ... R. HIRSCH (IBM)

Workshop C "Technology and Art"

Chairman: Kenji EKUAN
(Director, GK Industrial Design Institute)

C1: "ART and Robot" ... Takeshi MORIYA
(Associate Prof., National Museum of Ethnology)

C2: "Traditional Technology and Robot"
... Shigeharu SUGITA
(Associate Prof., National Museum of Ethnology)

C3: "Humanization of Technology"
... Otoichi KITAMURA
(Professor, Kyushu Institute of Design)

Welcome Reception (17:00～19:00, at Guests House)

All participants will be invited.

PROGRAM (2)

August 20th (Friday)

Keynote Speech II (10:00～10:50, at Auditorium)

"Microelectronics: The Human Challenge"
by Alphonse CHAPANIS (Former President, IEA)
(Professor, The Johns Hopkins University)

Workshops (Introductory addresses: 11:10～12:10, Panel discussion: 12:15～13:10)

Workshop D "Human Beings and Aviation/Space Technology"

Chairman: Hidemaro NAGANO
(Advisor, Japan Air Lines Co., Ltd.)

D1: "Automation of Aircrafts" ... Isao KURODA
(Commander of Aeromedical Laboratory, J.A.S.D.F.)

D2: "Manned Space Flight and Microelectronics"
... Hiroyuki MATSUMIYA
(National Space Development Agency)

D3: "Future Environmental Measures for Air Transportation"
... Teruo SAWADA
(Professor, University of Osaka Pref.)

Workshop E "Medical Treatment and Technology"

Chairman: Masamitsu OSHIMA
(Chairman of Directors, the Medical Information System Development Center)

E1: "From the Hospital Information System to the Hospital Automation — Expectation on the Medical Robots —"
... Hiroshi INADA
(Assistant Prof., Osaka University)

E2: "Technology and Medicine — Their Equilibrium Relationship —"
... Kageyu NORO
(Professor, University of Occupational and Environmental Health)

E3: "Medical Technology, Especially Medical Instruction Technology and Robotization"
... Yasuhisa SAKURAI
(Professor, Tokyo Women's Medical College)

E4: "The New Concept BIOMATION — From Mechanical to Spiritual Civilization —"
... Kazuhiko ATSUMI
(Professor, University of Tokyo)

Workshop F "The Energy Industry and Safety"

Chairman: Sakyo KOMATSU (Author)

Contribution of robots to Safety in energy industry

F1: ... Yoji UMETANI
(Professor, Tokyo Institute of Technology)

F2: "Ergonomics and Safety in the Generation, Distribution, and Use of Electrical Power" ... Richard G. PEARSON
(Professor, North Carolina State University)

F3: "Remotely-Operated Equipment for Field Inspection and Maintenance Work, and Advanced Centralized Monitoring and Control System: Their Development and Use"
... Tsuneo IWATA
(The Kansai Electric Power Company, Incorporated)

Break (13:15~14:35)

Conclusive Session (14:40~16:45, at Auditorium)

A KATO
B ANDO
C EKUAN
NAGANO
D OGHIMA
E KOMATSU

Chairman: Sadao SUGIYAMA
(Professor, Kwansei Gakuin University)
(Council Member, IEA)

1. Reports from Workshops (14:40~15:40)
Each workshop chairman will report on his meetings.

2. Video Film Projection (15:50~16:10)
"From Mechanical Puppets to Intellectual Robots"
— Robots and Social Life —
(The film is made by the Yomiuri Telecasting Corporation with the support of Mr. Sakyo KOMATSU.)

3. Conclusive Speech (16:15~16:45)
Sadao SUGIYAMA
(Professor, Kwansei Gakuin University)
(Council Member, IEA)

Closing Ceremony (16:45~17:00)

Closing address: Kiyoji Asai
(President, Japan Society of Human-Robotics)

→ maintenance of nuclear power station
– mines (explosion)
– work in the sea

redundancy
majority logic

→ maintainability (computer aids for diagnosis of faults and for permanent control of system)

800 words of technical english for computer

Japan
no death
8% ... of workers injured by robots
28% zero accident
Safety standards for robots

Agenda of Symposium

August 19th (Thursday)

9:00 – 10:00	Registration
10:00 – 10:20	Opening Ceremony
10:20 – 11:15	Keynote speech I
11:15 –	Reports: Case 1: In Europe / Case 2: In the U.S.A. / Case 3: In Japan
– 1:00	Orientation about lunch break and place for workshops
1:00 – 2:15	Lunch break
2:15 – 3:20	Workshops: Introductory address — A 1・2・3 / B 1・2・3 / C 1・2・3
3:20 – 3:40	(Coffee break)
3:40 – 4:40	Workshops: Panel discussion — Same as left / Same as left / Same as left
4:40 – 5:00	Location Change
5:00 – 7:00	Welcome Reception (Guests House)

August 20th (Friday)

9:00 – 10:00	Registration
10:00 – 10:50	Keynote speech II
10:50 – 11:10	(Break)
11:10 – 1:15	Workshops: Introductory address, Panel discussion — D 1・2・3 / E 1・2・3・4 / F 1・2・3
1:15 – 2:40	Lunch break
2:40 – 3:40	Conclusive Session: Reports from workshops (A ∼ F)
3:40 – 4:15	Conclusive Session: Video Film Projection
4:15 – 5:00	Conclusive Session: Conclusive speech
5:00	Closing Ceremony

English ⟷ Japanese simultaneous interpretation will be performed at each meeting place.

講演要旨集

ABSTRACTS

Edited by:

Kiyoji ASAI
(Professor, University of Osaka Prefecture)

Toshihiro TSUMURA
(Professor, University of Osaka Prefecture)

Sadao Sugiyama
(Professor, Kwansei Gakuin University)

印刷の都合上、掲載できなかった要旨があります のでご了承下さい。

Please note that some abstracts were not in time for printing.

KEYNOTE SPEECH

K1: "Robot Anthropology: Machinery as Partner"

Sakyo KOMATSU
(Author)

K2: "Microelectronics: The Human Challenge"

Alphonse CHAPANIS
(Professor, The Johns Hopkins University)

MICROELECTRONICS: THE HUMAN CHALLENGE

Alphonse Chapanis
Professor and Director, Communications Research Laboratory
The Johns Hopkins University

Since this year--1982--is Information Technology Year, I think it is particularly appropriate and timely that we should be here participating in this Symposium on the Contribution of Microelectronics to the Enhancement of Human Life. This symposium is timely in another respect as well. When electronic digital computers first became commercial just after World War II, forecasters predicted that no more than a dozen machines would ever be needed. IBM at first even decided not to sell computers because the market seemed so small at that time. But this year for the first time there are more computers of all sizes than there are people on earth.

The history of microprocessors parallels the history of computers. When Intel Corporation first introduced the microprocessor just about 10 years ago, the company directors were so uncertain about the future of their invention that they couldn't agree on whether they should begin selling it. Even their corporate marketing department expected that the little integrated circuit would be nothing more than a replacement for the minicomputers of the day and they foresaw sales of only a few thousand units a year. Today we have 51 different microprocessors, made by 42 different companies and this year more microprocessors and microcomputers will be shipped than there are people in the United States.

Small computers are appearing everywhere as desktop or personal computers and they are disappearing into ovens, toasters, watches, thermostats, typewriters, communication equipment, medical equipment, and video games. In fact, there are so many tiny computers in the engines of modern automobiles--to increase gas mileage and decrease pollution--that a single car maker in America, General Motors, actually manufactures more computers every year, although smaller ones, than do International Business Machines Corporation, Digital Electric Corporation, Burroughs Corporation, and all other computer-system manufacturers combined.

These vignettes tell us two things: (1) In technological areas, it's difficult, I might say impossible, to forecast the future, and (2) computers have revolutionized our society.

Microelectronics has provided components that are so small, so cheap, and so reliable that devices that ten years ago were a scientist's pipedream are today, literally, child's play. Ten years ago few people would have believed that we would have today a $100 machine that plays chess better than 90 to 95 percent of the population, or a set of programs that interprets electrocardiograms better than most doctors and even better than some cardiologists. But both have come about. Microelectronics means telephones for the deaf, reading devices for the blind, personal computers, interactive TV for the home, electronic mail, electronic newspapers, paperless offices, digital communications networks, satellite links, remote shopping, computer-aided learning, electronic funds transfer, and--above all--instant access to virtually limitless amounts of information. This is indeed a dream come true. A dream? Or is it perhaps a nightmare? What do these things mean for all of us?

I find it impossible to come up with satisfying answers to these questions because the developments we are experiencing have happened much too recently. In fact, the pace of invention and innovation is so rapid these days that devices, techniques, and ways of doing things are almost outmoded before we have had time to become adjusted to them. For social and behavioral scientists the dizzying rate of change in the world around us means that we no longer have the luxury of studying many social phenomena, because by the time we have completed our study, the world will have changed so much that our findings no longer apply to the world today, but rather to the world of some time past. These are times of transience, of change, of impermanence. Under the circumstances, the best I can hope to do is to share with you a few thoughts about what is happening and some speculations about what it is likely to mean for most of us in the future.

Let me start by talking about how I think modern technology has contributed to five powerful trends that are changing the United States and to varying degrees the other developed countries of the world.

But first let me describe the source of some of my data. I shall be drawing heavily on a study called the Trend Report prepared by Yankelovich, Skelly and White (now the Naisbitt Group). This firm analyzes social trends in America by making content analyses of local events and behavior as revealed in 150 daily newspapers throughout the country. The technique was developed by two social scientists, Paul Lazarsfeld and Harold Lasswell, as an alternative to conducting public opinion polls. The rationale underlying the method is that there is a limited amount of space in any newspaper and that this amount of space does not change very much over time. So when something new occurs to merit space in a newspaper, something else has to be dropped to release space for the new item. The principle involves a series of forced choices within a closed system. In this forced choice situation societies add new preoccupations and forget old ones. If new problems or concerns are introduced, some existing ones must be given up. By aggregating information about major issues collected in this way throughout the country, one can gauge the temper of the times. No attempt is made to extrapolate from the information. Rather, the information is searched for patterns--patterns of what seems to be happening to the society as a whole. With that digression into methodology, let me turn now to what the data show.

The first and perhaps most important major trend is that the United States is rapidly shifting from a mass industrial society to an information society. The final impact of that shift will almost certainly be more profound than the 19th century shift from an agricultural society to an industrial society. Let's look at some numbers. In 1950 65 percent of people working in America were working in industry. Today the figure is around 30 percent. Exactly the reverse has happened in the information occupations, and by information occupations I mean those involved in creating, processing, and distributing information, in banks, stock markets, insurance companies, education and government. In 1950 the number of people in the information sector of our society was 17 percent. It now exceeds 55 percent.

Although we've been hearing for years that we are moving into a service society, the proportion of people in service occupations--if we exclude those in the information occupations--has been a fairly constant 11 or 12 percent for decades.

So, to sump up, it seems clear that the post-industrial society is an information society. Two hundred years ago about 90 percent of the entire labor force was in agriculture. Fifty years ago most working people were factory workers. Today the number one occupation in the United States is clerk. So we have a progression: farmer, factory worker, clerk. What comes after clerk? I leave that for you to speculate about.

This shift from an industrial society to an information society has many consequences. For one thing, Philip Abelson, editor of Science, sees these changes in the nature of employment as potential sources of societal problems. Highly intelligent and well educated persons will, he predicts, find themselves in even greater demand in the future whereas those who are less well endowed or less adequately trained will find it increasingly difficult to find work. This will create new tensions and new dichotomies--the more intelligent will be pitted against the less gifted, the well educated against the uneducated. If these predictions come true, the developed countries of the world will face new challenges that may require entirely new approaches to education and employment.

The strategic resource of the industrial society was capital and natural resources, the latter of which was mostly non-renewable. The strategic resource of the information society is knowledge and data, both of which are renewable and self-generating. Moreoever, the organizations needed to support an information society are completely different from those needed for an industrial society. The two kinds of organizations deal with different things. In his book Future Shock Alvin Toffler describes it as a difference between a bureaucracy and an ad-hocracy. What he means by ad-hocracy is a fast-moving, information-rich, kinetic kind of organization, filled with transient cells and mobile individuals. The old industrial organization was characterized by permanence, hierarchy, and a division of labor. The new ad-hocracy is characterized by transience, high mobility between organizations, never-ending reorganizations within them, and a constant formation and termination of temporary work groupings.

These changes may be responsible for, among other things, a marked decline of labor unions in America. In 1950 more than 30 percent of the workers in our country were members of unions. That percentage has now decreased to 19 percent, and it seems to be headed even lower.

A related kind of change is an increase in professional loyalty replacing organization loyalty. What I mean is that the loyalty of the professional man has shifted to his profession away from the organization in which he happens to be working at the moment. The people that the chemist or the computer programmer think of as their colleagues are fellow professionals doing the same kind of work throughout the world. They do not think of the other workers in the same physical organization as their colleagues. As a result, the professional man has ties to widely-dispersed people doing the same kinds of things he is doing. He is highly mobile and is almost like an outsider working within the system. I understand that these attitudes do not hold in Japan where ties to an organization tend to be life-long. But I can't help wondering if you will begin to see the same kinds of things that we have seen in our country.

The second major trend in American society is a shift from centralization to decentralization.

Three great centralizing trends in America were the Great Depression of the 1930s, World War II, and the centralizing impact of industrialization. We are now beginning to see a retreat from these centralizing influences. For the first time in American history power is shifting from the President and Congress to the states and localities. Those of you who have been following the policies of our President Reagan are certainly aware of those trends.

At a more personal level this shift from centralization to decentralization manifests itself as a movement toward diversity. America has always been a polyglot nation, but for years we used to describe ourselves as a great melting pot. Peoples from all over the world came to America, were assimilated into its culture, learned to speak the same language, and gradually became imbued with the same system of values and expectations. That has gradually been changing until now the emphasis is most definitely on diversity. Blacks are recognized as different and are encouraged to be blacks. In some schools they are even taught Black English. What has happened to the Blacks of America has happened to the Hispanics, Poles, Vietnamese, Indians, and dozens of other ethnic groups. All are now encouraged to be different, to maintain their own cultures, to speak their own languages, to have their own newspapers and restaurants--in a nutshell, to preserve their ethnic identities.

This decentralization, or diversity, manifests itself in other ways as well. Large, general purpose sources of information have been dying off everywhere. It started about 10 years ago with the collapse of Life, Look and Post, those national magazines that had huge circulations and were general purpose magazines for everyone. At the same time as those magazines were dying, 300 special purpose magazines began publication. There are now more than 4,000 special interest magazines being published in the United States and no general purpose magazine. Much the same is happening to our television networks. We see them beginning to lose out to an incredible array of cable, video discs, and new special purpose networks. America is becoming even more diversified in its culture, in its interests, and in its information sources than it has ever been. All of which has been fostered by new technology.

At the business and managerial level we are seeing more decentralization of offices and office facilities. Electronic communication with video terminals lessens the need for much of the travel that now takes place and even for many of the personal encounters that take place in offices. In fact, the cottage industries of a couple of centuries ago are now being replaced by a new kind of home industry--thousands of operators now sit at video terminals in their homes inputting data to computers remotely. Computers meanwhile count keystrokes and measure the productivity of these remote operators under conditions that are the electronic equivalent of the "sweat shops" of a century ago. This is indeed one of the nightmares to which I referred in my rthetorical question earlier!

The third major trend is that we are now a truly global economy because of instantaneously shared information. Sir Arthur Clarke said that the two inventions that accounted for America's swift economic growth in the last two centuries were the telegraph (later the telephone) and the railroads. The two great inventions that are making us all a global village are the jet airplane and the communications satellite. Events that happen almost anywhere in any of the developed countries can be seen anywhere else on the earth as they are happening. Monetary transactions can be and are made almost instantly anywhere in the developed countries as easily as they can be made at one's own neighborhood bank.

Because we are now a global economy, the world seems to be undergoing a redistribution of labor and production. As part of that redistribution, all of the developed countries are de-industrializing. What we are seeing is a gradual movement of the steel, automobile, railroad equipment, machinery, apparel, shoe, textile, and appliance industries out of the United States and other developed countries into the Third World countries. It has been predicted that by the end of this century, Third World countries will make about a quarter of the world's manufactured goods. The new technological area of opportunity for the developed countries are in electronics, bioengineering, alternative sources of energy, and mining the seabed. If these trends continue, they will result in a more tightly knit global economy with a redistribution of our industries throughout the world, a greater dependence of one country on another, large changes in worldwide employment patterns, and perhaps massive shifts in the geographical distribution of the labor force, such as we have already seen in the movements of laborers from Spain, Italy, Greece, and Yugoslavia into Germany, the Benelux countries, and Switzerland. Coping with such changes presents challenges of heroic proportions.

The fourth trend we are experiencing is a movement in the directions of high technology and what John Naisbitt refers to high touch. What he means is that as each new technology is introduced, there is a compensatory human response to it, the technology needs to be humanized. If a new technology cannot be humanized, the technology is rejected.

Teleconferencing provides a good example. Modern technology has created the possibility for widely separated persons to communicate with each other electronically in many ways, for example, by telephone, by teleautograph systems, through computers, by slow-scan video, and by closed-circuit television. Research has shown that the video part of teleconferencing systems generally adds little to the practical work that needs to be done in conferences. What video does add is the personal touch, and that personal touch is important.

In a somewhat different area, the high technology of medical equipment, particularly of life-sustaining systems in hospitals, has led to new concerns about the quality of life and its opposite, the quality of death, and ways of dying.

In a more direct sense, Miss Elizabeth Zoltan and I have recently reported on the results of an attitude study we conducted on what professional persons think about computers. Over 2000 certified public accountants, lawyers, pharmacists and physicians in the Baltimore area were sampled to find out about their experiences with, and attitudes towards computers. A factor analysis of the data yielded six major factors. The first, that is, the factor that accounted for the largest proportion of the variance, reflects a view of the computer as a sound working machine. It is characterized by such adjectives as efficient, dependable, precise and organized. But the second largest factor in terms of the variance accounted for is made up of a negatively-toned set of adjectives: dehumanizing, depersonalizing, impersonal, cold, and unforgiving. It is attitudes of this kinds that technology must somehow overcome if it is to be at all successful. As you know, the response of the computer industry has been to try to make computers "user friendly," something that ergonomists have recognized as a challenge that will occupy them for a long time to come.

The last major trend on the American scene is a basic

restructuring of the work environment from top-down to bottom-up. Top-down organizations are run in ways that reflect the stereotypes of the past. The president of the organization makes the strategic decisions which are then conveyed to the managers who in turn deliver orders to the workers. But workers today are not satisfied with being treated as robots in the service of increased productivity and their attitudes are producing some revolutionary changes in the workplace. Workers are demanding more satisfaction from life and from the work place where so much of their lives are spent. They are no longer content with monetary or material benefits such as increased pay, four-day weeks, or better health benefits. They want to feel that they can get deep personal satisfactions from their work.

These new demands cannot be met in a top-down organization. They require instead that the working environment be designed from the bottom-up, with more worker participation, and with greater opportunity for workers to be more creative and self-motivated. Attempts to do this have been called personal growth, the human potential movement, and participatory management. But whatever they are called, meeting these objectives is certainly abetted by our new technology which holds the promise of automating many routine human tasks, leaving workers with the freedom to be human and to bring their human-ness into the workplace. Finding out how to do this well is a challenge that cannot be ignored.

Let me turn now to something that is related to one of the points I just made. One of the most important contributions of microelectronics to society has been to sharply reduce the cost of computers. Since the early 1950s the price of small, general-purpose computers of comparable power, in dollars per instruction executed per second, has been dropping at an annual compound rate of about 25 percent per year. The average rate of change for the largest general-purpose computers has been around 15 percent per year--somewhat less than for comparable small machines because the newer large computers offer more functions as well as more computing power. It's hard to think of any other segment of our economy or technology that has shown such a dramatic drop in the cost of getting work done. Some engineers have estimated that if comparable improvements had been made in automotive engineering during the past 20 or 30 years we would now be able to buy a Honda Civic Accord for about $5 and travel around the earth several times on a gallon of gasoline.

As the costs of computer hardware and computer processing have decreased, there has been a marked relative increase in the human costs associated with the use of computers. In a paper published in Science this year, Lewis Branscomb, Vice President and Chief Scientist of IBM, showed programming costs as a fraction of the total cost of operating computers. In the early 1950s software accounted for about 30% of total computer costs.

approach thousands of potential contributors with a personal appeal and instant response. "Don't wait to write a check. Just touch the button with your finger and let us receive your support immediately."

As you can see, this is indeed a wide variety of consumer services, each with its own appeal. The potential advantages are obvious enough. Let me mention a few serious concenrs that may not be immediately apparent to customers who are offered these services or the persons who offer them.

My first concern has to do with the adequacy of the data that come out of these various services. I think especially of instant opinion polling. It is intriguing to think that one can instantly get the pulse of the nation by going on a cable TV network and asking viewers to give their opinions about important issues. But let's think about how you could legitimately interpret any result that such a survey would yield. From a scientific standpoint I think you have to agree that the results would almost certainly be useless. In the first place, you would have no idea about the representativeness of the sample. Only the more affluent persons would have such a service in their homes and they certainly are not representative of the population as a whole.

But that is not the only problem. In any opinion poll conducted in that way, you have no way of knowing about the representativeness of the sample of viewers at the time the poll is taken. If the poll were taken at a time when, let's say, wage earners are at work, there would obviously be a serious bias in the data. Still another problem is that we have no way of knowing who in the household is responding to any poll. If the question were, let's say, "Should the city raise additional taxes next year to build a new stadium?" how can you be sure that the people pushing the "Yes" button are the tax-payers in the family, and not little children who happen to be playing with the system?

These questions apply equally to banking, shop-at-home, and other services. Imagine the consternation that a parent might experience if he were to find that his seven-year old son had ordered a new computer game, or had made a $1,000 withdrawl from his bank. The problems of accidental, unintentional, mischievous, unauthorized, or malicious misuse of these services is a concern that we should all be aware of. I don't think that there are any completely satisfactory solutions to this problem.

Much more serious in the eyes of many Americans is the privacy issue involved. In providing these services the operators managing these systems will be collecting an important pool of personal data from their subscribers: information about checking and charge account expenditures, personal spending habits, reading preferences, times when alarm systems are not activated, sensitive medical and health problems, and opinions about a wide variety of social issues. This is an extremely large and potentially

threatening pool of information to have about individual subscribers because the information can be misused in several ways.

The operator of the system could sell the information to other persons without the subscriber's knowledge. For example, lists of subscribers with certain derogatory characteristics might be sold to landlords, insurers, credit agencies, or employers. Second, there might be breaches of confidentiality of the information by third parties through illicit cooperation with persons who manage the system or through breaches of the system's security measures. Third, pressure might be exerted on subscribers to release their profile data. Each new release of such data would then make the information available to third, and fourth, and fifth parties. Finally, investigative agencies might secure access to personal data and use those data in ways that are detrimental to the person.

These are serious concerns to Americans. Indeed, many potential abuses of these systems probably cannot even be anticipated at this time. Nor are there any ready answers to these concerns at the moment. About all that we can hope for is a thoughtful consideration, study and analysis of the problems with the aim of eventually adopting privacy rules that will protect rather than impair the fundamental values of a free society.

To conclude, I have tried in this talk to give a few perspectives on what I think are some of the human challenges that have been created by new electronic technologies. Although I see no ready answers to most of the concerns I have raised, I do see us becoming a much more complicated society, a much more participatory society, a society that will be more interesting, creative, and nourishing, and a society in which each of us can more fully realize our human potentials. The challenge is to make that dream become a reality.

REPORTS

"How Has Society Accepted Robots?"

CASE 1: In Europe

A. WISNER
(Conservatoire National des Arts et Métiers)

CASE 2: In the U.S.A.

D. THOMPSON
(Professor, Stanford University)

CASE 3: In Japan

Yukio HASEGAWA
(Professor, Waseda University)

SOCIETY'S ACCEPTANCE OF ROBOTS IN THE UNITED STATES

David A. Thompson
Professor, Stanford University

The robot revolution is generally viewed as an extension and continuation of the computer revolution and the automation/closed-loop control revolution before that. It is either one step further along toward "progress" or one more step towards a technological "disaster", depending on whom you listen to. This talk will attempt to sort out some of the major issues raised by the interested constituencies, and suggest two actions that would ease the transition into increased robotization.

The basic issues raised in this talk are:

1. All work is changing in its nature - some much more than others - as a result of increased technology in general. How these changes are perceived by individuals is a function of how these individuals see themselves affected by technology and its particular consequences in their own lives.

2. The primary effect of technology appears to be an expansion of jobs caused by the efficiency and productivity effects of these "labor-saving" devices.

Closed-loop control/Automation/Computerization has been expanding industrially for 25-30 years in the US-covering more than a generation of workers - and throughout this time the workforce in the US has continued to expand from 1 million to 2 million new jobs each year. The present rate of expansion is about 2 million new jobs per year, and this is projected to continue throughout the 1980's.

These long-term technological influences on employment levels should be distinguished from the effect of cyclic fluctuations in the economy, inflation, and increased labor supply from the World War II "baby boom", working wives, and expanded immigration of third world nationals.

3. The robot revolution is seen as very exciting and challenging by man young people and those in technology as being a new adventure (for those now jaded with computers) and as providing new, creative solutions to problems not previously solvable with existing technology. Technically, industrial robots are referred to as "soft automation," "programmable automation," "smart automation," and "programmable manipulators," terms more descriptive of their functional role in manufacturing. As extensions of "hard" automation, utilizing digital computer programming capabilities, robots can handle a much broader range of tasks and functions than can standard automation. For example, robots are used extensively now to feed and remove parts from other existing machines, to manipulate tools, spray guns, and welding guns, and to assemble parts manufactured by other devices into finished products.

4. Robotics, along with automation and computerization, are absolutely necessary and inevitable in industry today.

Industry is having continuing problems with generating the productivity increases necessary to remain competitive in domestic and world markets. Robotics is viewed as a possible solution to handling increasing labor costs and a way to continue to remain competitive while managing to meet expanded union demands for higher wages by increasing each worker's "value-added" effect.

In addition, industry is having increasing problems with attracting, motivating, and retaining workers to do the sort of work robots do well - routine, boring, hot, repetitive, possibly dangerous, mechanical work. The labor force, more and more, wants more chanllenge, more flexibility in what they work on at any given time, more variety and more interesting work.

Consequently, the acceptance of Robotics is a function of how individual workers, businessmen, engineers, housewives, school children, salesmen, etc. see it as affecting their employment and the content of their jobs and lives. For example, engineers see robotics as a new opportunity to solve problems; businessmen as increased productivity; housewives as not relevant to them; and industrial workers as mixed - on the one hand threatening job security and on the other hand making work less monotonous and giving them more responsibility. The manner in which robotics is introduced directly affects its perceived effect on one's employment and one's life.

Each of these constituancies will be attempting to influence government and industry as a function of their perceived threat or advantage.

This paper makes two recommendations.

1. Industry executives should not just replace workers with robots whenever economically feasible, but rather plan an integrated robot systems integration involving restructuring the product and jobs with a view to the long run. The cooperation of industrial engineers, personnel specialists, and organized labor should be sought to assist in this process. One possible robot integration scenario might be that one of the workers who used to assemble motors or paint-spray tubs now becomes the "trainer" and supervisor of a set of robots, helping with set-up and "coaching" the robots which now do the job, assisted in this new arrangement by appropriate staff support. Other workers assist in programming, installing, and maintaining the robots, to the extent that their skills and interest permit. Any other workers, not so involved, would be transferred elsewhere within the company, with appropriate retraining, whenever practical. If none of these alternatives is feasible, the company should make a concerted effort to place the displaced workers with other companies, as part of its overall productivity improvement program.

2. The Federal Government should use tax incentives to encourage companies to follow the above approach. In addition, it should encourage retraining programs as part of industry apprentice programs, and as standard offerings in community colleges, to handle workers not accounted for within their own company. Unemployment insurance should be conditioned upon seeking new work and/or taking appropriate new training courses.

If these two recommendations are followed, the transition to increased robotics will be eased, and the considerable benefit of robotics will be more acceptable to those who may now feel insecure about its effects.

HOW ROBOTS HAVE BEEN INTRODUCED INTO THE JAPANESE SOCIETY

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1. Introduction

Only a little more than a decade have passed since the machine called "robot" came to practical use. Seeing from a long, historical flow of civilization of mankind, it has quite a short history and it may well be said that "Robot Age" has just come to its very beginning.

The functions and the performances of robots themselves will make a rapid progress and industrial society will anticipate to make a great progress by the introduction of robots. Under the circumstances, it seems that the prudent consider-ation is necessary for discussing the historical process of introduction of robots in order not to be lost in the stream.

Therefore, the author dare express opinions and try to suggest varying problems on the matter.

2. Age of longing and resignation for robots

It is originated in a mythology that mankind first thought of making an artificial man who undertakes painful tasks instead of him. And it was about 60 years ago that man named the machine "Robot". However, they were all existences only in imagination displayed in the windows at toy shops as mobile dolls.

It was in 1962 that the flexible machine called an "industrial robot", which substituted human hands, was born in the United States and 5 years later in 1967 it was introduced into Japan. It was not until then that the NC machine tools built several modern facilities such automatic warehouses or automatic transportation systems which were used only experimentally in some part of business field.

Later, about 15-16 years ago, in order to solve the problems of diversified production system, the reliable and advantageous tools could hardly be available for the sake of technical and financial difficulties. According to the results of the investigations which the author made through the Japan Society of Mechanical Engineers, 90% of the manufacturing companies were suffering from the problems of diversification at that time, and the main means of solving the problem was to try to decrease the number of production items by way of standardization, simplification and specialization. Videlicet, it may probably be said that there was no other way but go toward the decrease of the types of production items because the technology, which could improve efficiency, taking the diversified production system for granted as it was, had not developed yet.

Among the manufacturers of durable consumer goods or productive goods were many whose expectation to decrease the number of product items was disappointing and the rationalization of the diversified production system was the most essential theme in this type of industry.

Although expecting the appearance of flexible (short in setting time) production facilities which could stand against diversified production system, actually, nobody could forecast its future at that time. Therefore the image of the manufacturers who were compelled to be engaged in diversified production system was dark and the laborers concerned had a very strong sufferers' consciousness.

3. The most robotized country - Japan

Tables 1 and 2 show the total number of recent production of industrial robot and manufacturers in the world according to the investigation for 1982 made by JIRA. This material was made under the cooperation of the organizations concerned with industrial robot in the world. It is an obvious fact that, for these ten-odd years since when the industrial robot was introduced into Japan, Japan has enjoyed the reputation as the biggest producer and user of industrial robots.

In other words, the robots used in industry were born in the United States, but has grown up in Japan until today. The velocity of production and diffusion of robots is conspicuous in Japan among the developed countries. Our social, economic, labor and cultural background may have something to do with it.

Here the author would like to follow a series of the process of the introduction and the diffusion of robots into this country and consider about the reason why.

4. Historical process of robot introduction into this country

It was in 1967 that the first robot for industrial use, which was involved in the first international definition, was introduced into our country. Prior to this, some domestic movements for the development of robots in the category of robots of the present Japan Industrial Standard were seen, but they were of fixed sequence type so to speak, and not something like so-called robots internationally acknowledged.

This playback type robot is the machine called Versatran manufactured by AMF in the United States, which, with the help of attached computers, could teach and reproduce various movements and it gave a great technical impact to the people concerned. This was said to be the actual start of the introduction of robots into this country.

Here the author would like to look back some of the history of robot introduction following the steps of its development.

1) First Term (enlightenment)

In the car manufacturing companies they immediately began to discuss the possibilities of practical use of robot, as they observed the United States made robots which had been introduced into Japan.

With this as a turning point, not a few companies tried to have technical collaboration with overseas robot manufacturers, or even tried to make robots which they had developed for themselves. In the preceding year of 1967, an organization by the specialists who were interested in robot or prosthetic arms and legs were inaugurated as A Study Group of Artificial Arms (the present Society of Bio-Mechanisms) and then the first symposium on robots was held in the same year. The next year The Special Committee of Industrial Robots in the Electronics Industry Promotion Association was settled.

Thus we had a quick innovative action toward robot age. Symposiums, seminars or robot exhibitions were held in many different places and people gradually began to be interested in robots. However, they did not wide spread but remained only enlightenment and introduction as a sample case.

2) Second Term (start of diffusion and soon slow down)

In 1972, Industrial Robot Club was settled which was the first association consisted of robot manufacturers and soon it was re-organized as Japan Industrial Robot Association and here the systematic activities such standardization of industrial robots and acceleration of its introduction into the country and so forth were started.

It was also the right time when the society was enjoying the rapid economic growth, and as the shortage of a large quantity of labor force was anticipated, then automobile, electric appliances and other manufacturing companies decided the positive introduction of robots into their own plants.

At the same time many companies started to produce robots one after another and the leading robot manufacturers seemed to establish themselves receiving a great deal of orders. In the end of 1973, however, the oil crisis suddenly attacked our country and its influence lasted long. Consequently it caused the cancellation of the orders of a great number of robots and thus the robot manufacturers were forced to walk a long distressed road. Naturally, as the result, there were many companies who had to retire from robot manufacturing or reduce robot production.

3) Third Term (recover from slow down by the discovery of the new significance)

The oil crisis braked the economic growth and the capital investment for the production expansion completely stopped. Following this, because the impact was perhaps too strong, the worst situation lasted for a long time that they abstained themselves from increasing the productivity and investing for the facilities for the reinforcement of the enterprises. But, menawhile, an implicit effort was being made to renew the significance of robots.

There was one enterprise who had been willing to introduce robots since before the oil crisis, trying to reinforce the structure of the company by managing the number of the employees. In general, companies suffered from the problem of over-populated employees caused by the decrease of the amount of orders after the oil crisis.

But in this enterprise they found their way out by adjusting the working time of robots, rather than having employees with payment without work. The stress of the study on management moved from how to grow to how to survive and the introduction of robots came to be realized again for the sake of the defense of enterprises by the reinforcement of surviving power under the depression.

At same time it was also realized that the flexibility of robots was effective for changing the products or shortening the conception period of time until the new products have a good sale.
Another point that they began to deepen understanding about the effect of robots was the contribution to the laborers' welfare by releasing them from painful and dangerous work. As well as the reflection upon rapid economic growth, such merit of robots was high evaluated by the managements and they began to consider the introduction of robots when they made their capital investment plan.

The special features of robots' were acknowledged and the demands increased abruptly since around 1976 in spite of the depressing period of time after the oil crisis.

4) Forth Term (new development as the kernel means which bears the coming technical innovation age)

Until the third term robots were used only partially, whether individually or in groups, and the effect was not epock-making enough to change the constitution of enterprises.

But in 1980's factory automation appeared which was a synthetic system composed of automatic machine tools, robots, automatic handling and transporting systems, automatic warehouses, monitor systems and so forth.

Human workers engage in setting and maintenance work for 8 hours during the daytime but the machines do the fantastic un-manned production work and keep working for 24 hours without rest. Consequently, it was possible to save labor, to shorten manufacturing lead time, to reduce the quantity of inventory, and to increase the production capacity as well. In the case of one factory, the dramatic results were obtained that the amount of supplementary value per one person reached nearly 10 times as much of that of other average company in the same line of business.

This gave a great impact to the rival enterprises and therefore the fact is that many of the companies of the same field of business are grappling with the construction of the newly robotized plant to survive the competition.

Incidentally, the appearance of intelligent robots is expanding domain of them with economical justification by the help of development of sensors equivalent to the human senses of seeing, hearing and touching, and mechanisms of computers for control, and robots. For example, robots have come to be used for inspection, assembly, complicated arc welding, undersea survey and so forth. Meanwhile, recently, along with the wide spread of robots, they began to introduce robots into small enterprises who are suffering from labor shortage. Accordingly another new management problems outbroke to the small enterprises such as safety, engineering man power shortage problems and so forth.

5. Promoting and hindering conditions which supported the quick introduction of robots

In figure 1 the trends of introduction of robot from the first term to the forth term is shown in a graph in quantity. As the promoting conditions which the introduction of robots into Japan has made more rapid progress than in any other country in the world, we can see the following items.

1) Less opposition by the people for the new technology

In western countries, during the introduction of the developed modern technology after the first industrial revolution, there occurred a sad historical event of resistance known as Luddites Movement for example. On the contrary, in our country, since the introduction of modern technology by opening the country to the world in early Meiji Era, the technology fundamentally kept giving plus influences to the people and they took it for granted as a good image.

2) As the result of life-long employment system, the management could challenge, not short-sightedly, but bravely the difficult themes

Unlike the stock exchange committee in the United States, where they are evaluated according to their short term business results, the Japanese management can have enough time to enjoy to follow their dreams, as they serve in the company their whole life.

3) Labor unions are organized independently in each enterprise and the management and the union act in harmony so that they can reassign laborers to new positions easily by the introduction of robots

When it becomes necessary to change the jobs because of introduction of robots, it is possible to change positions because the formation of the labor unions' is identical to each company and from the viewpoint of improving the working conditions, the management and the union are easy to cooperate to strengthen the enterprises.

4) Autonomous activities of blue collar workers made the introduction of the innovative technology easy

Among the discussing themes, which are practically taken up in the production field are many items toward new technologies adaptation. Therefore we can expect cooperative relations in the production field which support the introduction of robots.

5) Companies do their best to give education and training to the operators

Some of the earnest enterprises, who are eager to introduce robots, opened robot schools to give very dense education and training, spending time and money for the betterment of the laborers' ability in the production field.

6) There are comparatively many people who are graduated from science and engineering shools.

There are enough engineers who are able to be engaged in the jobs using and maintaining robots in the companies.

7) They have an encouragement back-up by the government

They can obtain the governmental back-up for the subjects by joint researches of robots by means of new technology promotion laws for example.

8) Information is delivered far and wide by the mass communication systems

Thanks to the mass communication reporting about robots very often, common people have a sufficient knowledge about robots and have no sense of incongruity.

9) Financial agencies are cooperative for the development and introduction of robots

The security value for land is extremely high in this country and the system on financing and leasing is well planned, so it is easier to obtain a capital for the introduction of robot.

10) Because of vividness in economy there is a tendency to challenge new things

It is difficult to calculate the merit of robots correctly from the economic standpoint, but even so, there is a tendency to try to challenge the new technology positively and master it.

Contrary to the precedings, we can think of the following hindering conditions but at the present stage they are not so severe problems yet.

1) Insufficient capacity of robots

The function and the performance of robots are not sufficient enough for the operation to be expected to introduce. Although there is much need for robotization, there are some operations which the robots can not work for, because the capacity of robots is not sufficient enough.

2) High price for robots

Although the wage increases and the price of robots decreases, there are some kinds of machines of which the prospect for capital withdrawal is still difficult.

3) Lack of engineers who can take care of robots in small enterprises

Especially in a small business this problem is very serious.

4) Difficulty in robot operation

Especially for the middle aged and aged people, it is a big problem to master the new skill to operate robots.

5) Problem of the space shortage for robot installation

Especially in the plants of small enterprises this kind of problem occurs often.

6) Difficulty to ensure sufficient amount of work in some cases

There is not enough amount of work for robots constantly and the company cannot operate robots long enough.

7) Difficulty to laborers' job assignment

There are laborers who have special skill of manual work but not willing to learn about new jobs, or lack in ability.

6. Social impact of robot diffusion anticipated in our country

It is desirable to consider the matter in advance as much as possible. The plus and minus impacts we can think of now are as follows.

1) Plus impacts

a. Promotion of laborers' welfare

Laborers can be released from disasterous, pains-taking, poor environment and monotonous operations.

b. Improvement of productivity

By utilizing robot we can obtain the improvement of working conditions and the betterment of the constitution of enterprises without increasing the price of goods and service.

c. Release from working time and place

By introducing the robots of remote-controlled type, the operators can operate the robots from a safe and pleasant place apart from the production spot, and also released from time restrictions by introducing automatic type robots.

d. Easiness to keep quality standard

Robots can repeat the same kind of work for hours without getting fatigued.

e. Easiness of production scheduling

Robots are not absent from duties and always even in the operation speed, so it is easy to achieve the production schedule.

f. New, high leveled jobs to be created

New jobs such as manufacturing robots and taking care of them are created, and given to the engineers or skilled workers.

2) Minus impacts

a. Un-employment problem

When a number of robots are introduced, an un-employment problem will break out among the unskilled workers who can not do any other sophisticated operations.

b. Break out of a new discriminating treatment

Even the skilled workers who have been working with pride as specialists will be treated as equal as the unskilled workers if he would not try to learn how to operate robots or get another job and try to be a new skilled worker again.

c. A possibility of shortage of engineers and newly trained skilled workers

As the robotization proceeds, un-employment problem will break out, while engineers or skilled workers necessary for operating robots and taking care of them will become insufficient.

d. The great movement of labor population from the 2nd sector of industry to the 3rd one

As well as the former great movement from the 1st sector of industry to the 2nd, another movement from the 2nd sector of industry to the 3rd, will be anticipated. In this case the capacity of the 3rd sector of industry will become a big problem.

e. Possibility of concentration of production capacity which is not proportional to the member of workers

In the robotized factories, with a few able workers and a capital, and even if the number of workers is very few, they will be able to achieve the productivity equivalent to the scale of as several or scores times as much.

f. The job flow from developed countries to developing countries will change

Up to this time, there was a flow from the countries where the labor cost was high to the countries where the labor cost was low, which is so-called catch-ups of developing countries. However, as the robotization proceeds, in developed countries many types of goods will be made automatically which are of high quality and low cost. So the flow will stop and there will be a possibility that the income difference between developed countries and developing countries will become bigger than before.

g. At the point of interface with men and robots

There is a possibility that a problem will break out at the point of interface with men and robots. In the future when man workers work surrounded by many robots there will be a possibility that safety of man and psychological pressure given by robots will appear as a new problem.

7. Several problems to be considered, prior to robot age

Until today the introduction of robots into our country has been done smoothly supported by several profitable conditions. However, the arrival of robot age will come in earnest in the near future and in order to well utilize this product of civilization, it is necessary to consider the following items.

1) Settlement of subjects by the preliminary evaluation

   a. To make investigation on the new operation features materialized by the introduction of robots. Participation from the wide range of fields is necessary for that purpose.

   b. To decide the order of priority of what to be done, not only from the technical and economic standpoints, but also at the same time from the public standpoint such as safety and laborers' welfare and so forth.

2) Improvement of the function and the performance of robots from the standpoint to promote harmonious cooperation with men and robots.

   a. To simplify the operation of robots as much as possible so that ordinary workers can change the position to be a robot operator after taking some education and training.

   b. To make the exchange of information easy by developing the new robot language very close to a human language expressions.

   c. To review the features and the operating the speed of robots so that a sense of incongruity between robots and men will not break out.

   d. To keep man safe so that he will not be hurt by robot

3) To make the utilization of robot easy and prevent from accidents by international cooperation, we must promote global standardization.

   a. Standardization of the definition, classification, terminology, symbols and the method to measure the function and the performance.

   b. Standardization of the layout of control panel and operation method of robots.

   c. Standardization of installation and the way of connection of cables and pipes.

8. Conclusion

The author has written this report from the personal point of view about the problems on robots and the society mainly in Japan. Whenever the author comes across with the discussion on robots he cannot but think that, in most cases, they look at robots as new invaders to the earth where human beings had already been living a various styles of life, and they hardly stop to think about robots.

Robots could often be an uninvited invaders and a troublesome existence for human beings who have been enjoying peaceful life among themselves. Since the time of human civilization started it has been a dream to gain a means that does painful work instead of man. If the author were to locate "today" in the progressing history of science and technology, it would be a moment of a dramatic opening of the Robot Age, which will even change the human beings' way of living, too.

Observing the way of progress of science and technology and the development of social structure, it seems to him that the delay of the social adaptation toward the new technology always causes the friction.

The author hopes that the symposium, which is being held in the same place as the previous world exposition, will make a great contribution to the establishment of new society of "Human-Robot Age".

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Table 1 IRs population in the world

(excluding Manual Manipulator & Fixed Sequence Robot)

Country	Units	Regional total	Group total	World total
Japan	14,250[1)] (62.6%)	(76,700)		22,779 (100%)
U.S.A.	4,100[2)]	America 4,350 (19.1%)	Western 8,529 (37.4%)	
Canada	250[3)]			
Belgium	42[2)]	Europe 4,179 (18.3%)		
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)]			

Remark
1) JIRA Survey (1980 end), ( ) including Manual Manipulator and Fixed Sequence Robot
2) RIA Survey (1981)
3) National Research Council (1981 end)
4) Jetro, Paris Survey (1981, 11)
5) Italian Industrial Robot Association (1981)
6) RIA Survey (1980)
7) Swedish Computors and Electronics Commission, Ministry of Industr (1981

British Robot Association Survey (1981 Dec.);

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

Source (JIRA, May 1982)

Table 2 Number of IRs' mfgers in the world

Country	Number	Regional total	Group total
Japan[1)]	75 (149)		
U.S.A.[2)]	16	America 17	Western countries 85
Canada[3)]	1		
Austria[3)]	1	Europe 68	
Denmark[2)]	1		
Finland[2)]	3		
France[3)]	8		
W. Germany[2)]	18		
Italy[3)]	16		
Netherlands[2)]	2		
Norway[3)]	3		
Sweden[3)]	7		
Swiss[2)]	1		
U.K.[4)]	8		

Remark
1) JIRA Survey (Nov. 1981), ( ) including Manual Manipulators' and Fixed Sequence Robots' mfger
2) Robot Institute of America(RIA) Survey (Oct. 1981)
3) JIRA Survey (June, 1981)
4) estimation

Source (JIRA, May 1982)

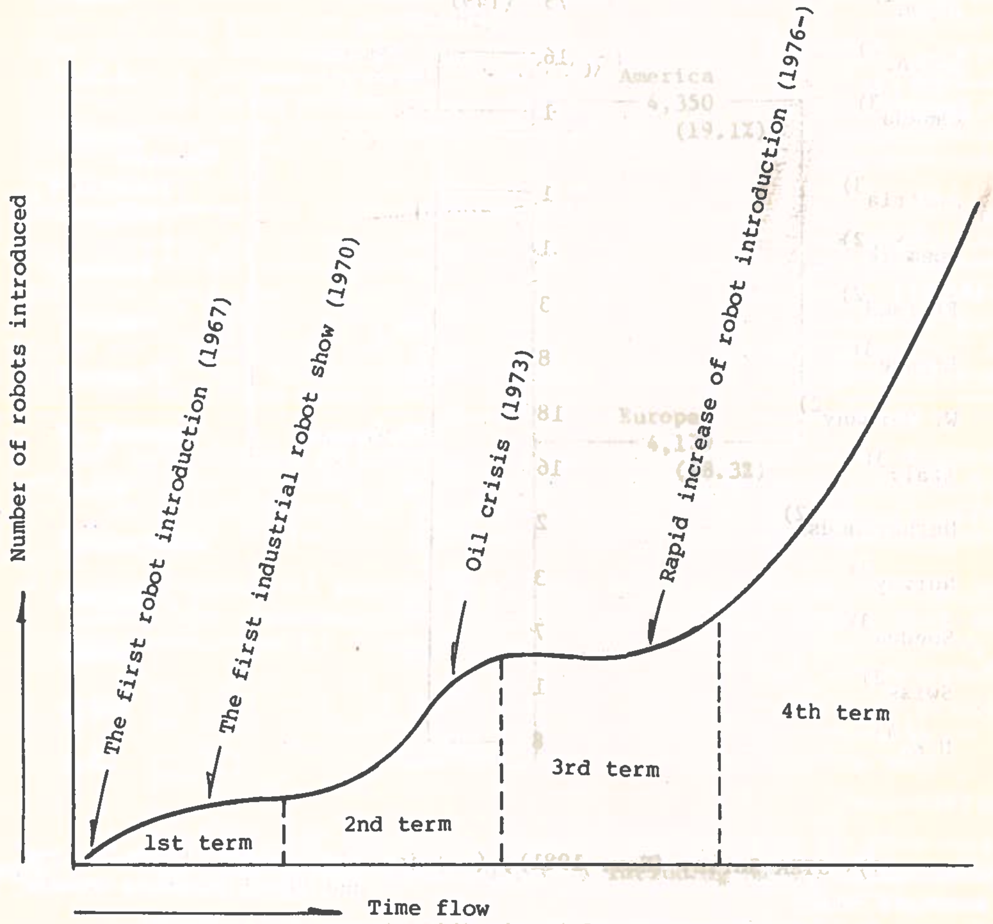


Figure 1. Robot introduction trends in Japan

WORKSHOP A

"Robots and Human Beings"

A1: "Robotics and Automation"
Saburo TSUJI
(Professor, Osaka University)

A2: "Robots and Human Beings" work design
Hiroyuki YOSHIKAWA
(Professor, University of Tokyo)

A3: Acceptability. Hardware improvement robot interface
D. THOMPSON
(Professor, Stanford University)

Safety

— Language used by the worker — More precise but in simple step command, More research on sufficient and necessity of quantity of information. Typical of MTM level 2

— Enough intelligence in robot system to sense difference with program, but diagnose cause and recommend what to do.

— Geometric input and output command [digital reality] discrete type: Normal computer program

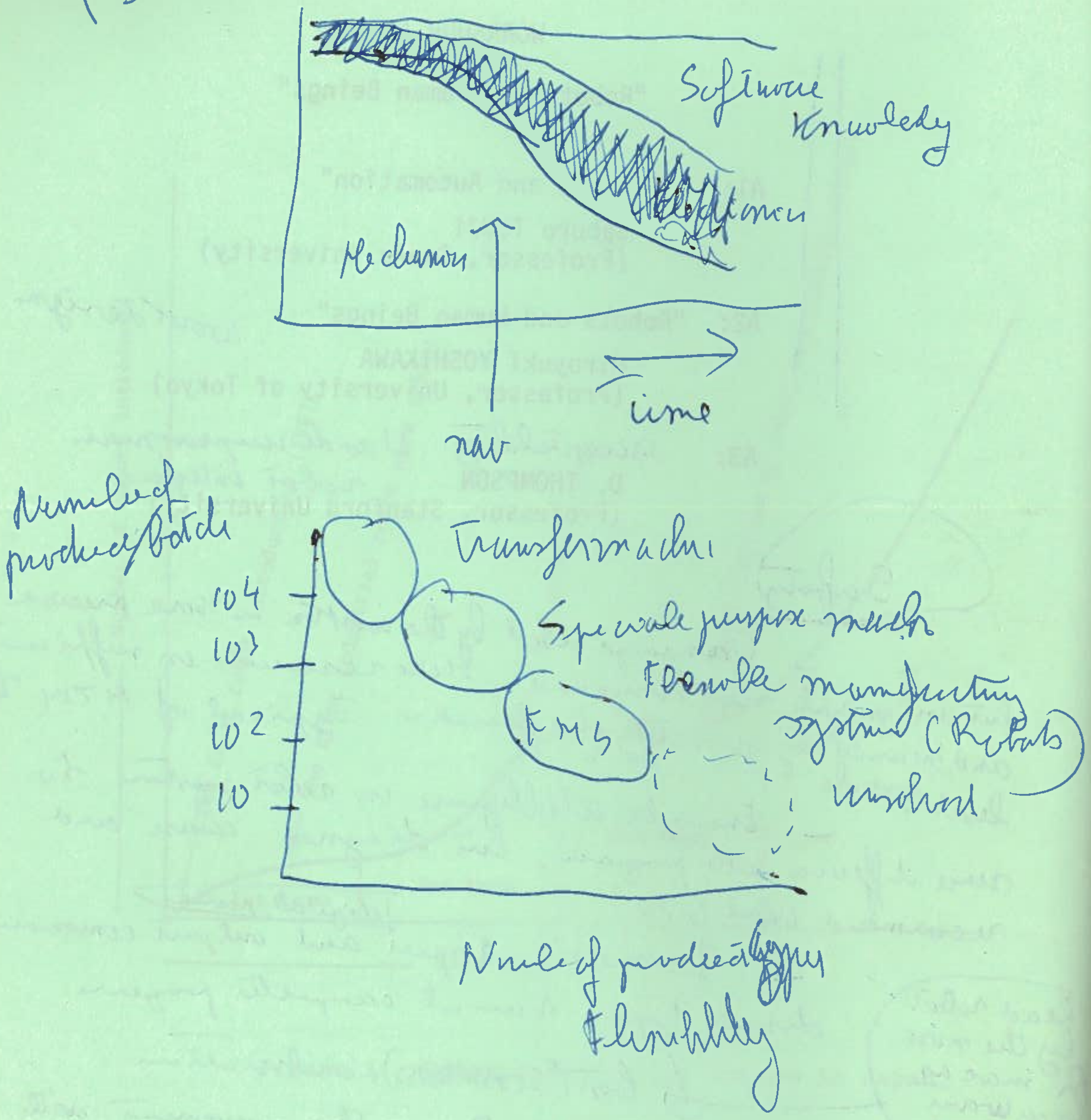
→ best (STANFORD) combination

lead robot by the nose, R. move as you want, understand / analog positioning

worker precision .8 in the movement with 10 cm limit. Change to 20 cm without new programming.

— Need of intelligent robots as assistant or colleague and not as slaves. feedback from robots on quality defects on spare parts delivered to the robots.

TSUJI



A1

ROBOTICS AND AUTOMATION

Saburo Tsuji
Professor, Osaka University

In order to foresee what direction the automated equipment heads for in the future, one has to take account of the following factors.

(1) What does the society we live in expect for the automated equipment and system?

(2) What are, and will be, the automated equipment capable of doing now and in the future?

(3) How will newly developed automation change the society and the inhabitants thereof in their way of thinking?

This paper places emphasis primarily on the issue (2) mentioned above and discusses what functions intelligence robots play at present or will play in the future.

Automation

The job contents of workers engaged in production process can be roughly classified into processing, assembly and inspection. Among these categories, the computer-based automation has been increasingly employed in the processing of parts as NC machine tools have developed. The introduction of CAD (Computer Aided Design) in designing work is already commonly observed nowadays as well.

Nevertheless, the application of computer technology lags behind in such more labor-intensive areas as assembly and inspection. In assembly process, for example, the automatic assembly machine has been developed and placed in service. This machine in fact is an effective device for massive production of limited number of product types where limited kinds of products are massively manufactured over the long period of time. This unit, however, is not well suited to production in small quantity of wide-ranging product types. In view of the above characteristic, researches have been made on the automatic system which adapts to product diversification and market fluctuation, as the need for high value-added products has become more vocal. This new automatic system is called flexible automation. In processing area, application of computer technology is advanced as mentioned earlier. By the name of FMS (Flexible Manufacturing System), the system which consists of NC machine tools, automatic warehouses, mobile robots for transportation, material handling robots for transportation, material handling robots and the computer for planning production and commanding each factory unit has been put in practice in various locations.

Robot Technology Development

The industrial robots initially developed for practical use in the late 1960's are of simple structure with one arm and storage. They repeat simple operations as programmed beforehand. Therefore it may look as if those robots can be utilized in assembly to manufacture diversified products in small quantity because the alteration of work programs theoretically expands their scope of work. This possibility, nonetheless, is null in terms of practicality.

This is because these robots are still low-levelled in sensor information processing and work programs. Moreover, their hardware, i.e. the fingers, are not so skillful to create precise motions.

With the recent progress of microcomputers, the development efforts have shifted to information processing side to create the industrial robots, microcomputer controlled, of the second generation. As shown in Figure 1, the technology acquired via researches of intelligence robots have been further developed to put these robots to practical use.

Men's Work and Robot's Work

In perspective of technological development as described above, let us think about the works to be performed by men and robots. The robots were initially created for the purpose of replacing men in dangerous work and any other work men are reluctant to undertake. With technology development, the scope of application has expanded to the extent where research and development for unmanned factory is being made. Nowadays, however, not all the works men dislike cannot be necessarily substituted by robots, and most of the substitution concentrates upon the areas where mechanization and productivity improvement is relatively easily accomplished. As a trend, it can be seen that works not suitable to men are still left unmechanized.

Adaptability to changes is one of areas where mechanization is hard (even in cheap labor) while men can adapt oneself easily. For example, while men do not have to concentrate substantially when they handle parts randomly disposed, the existing robotic technology requires the environmental conditions to be set and the hand-eye system to be programmed. Men have to contemplate measures and program the outcomes thereof to cope with variation in part items and product design changes. Moreover, the human worker checks on his own the operating performance and minimizes adverse effects of defective machinery or items upon detection. The functions, while they look natural to men's eyes, can be gained by the robots only when intelligence information processing capability is upgraded. The genuine industrial robots will emerge in practice on that level.

Industrial robots and intelligence robots are designed to work under the selected environmental conditions. However, the ability

to adapt itself to the unexpected changes in the environment will be prerequisite to the robots which work under dangerous settings in place of men. There lie piles of pending problems such as hardware, reflex and restoration functions to sustain that ability. The researches have to be made to learn a lot from biomechanisms in order to allow the robots to serve truly for men.

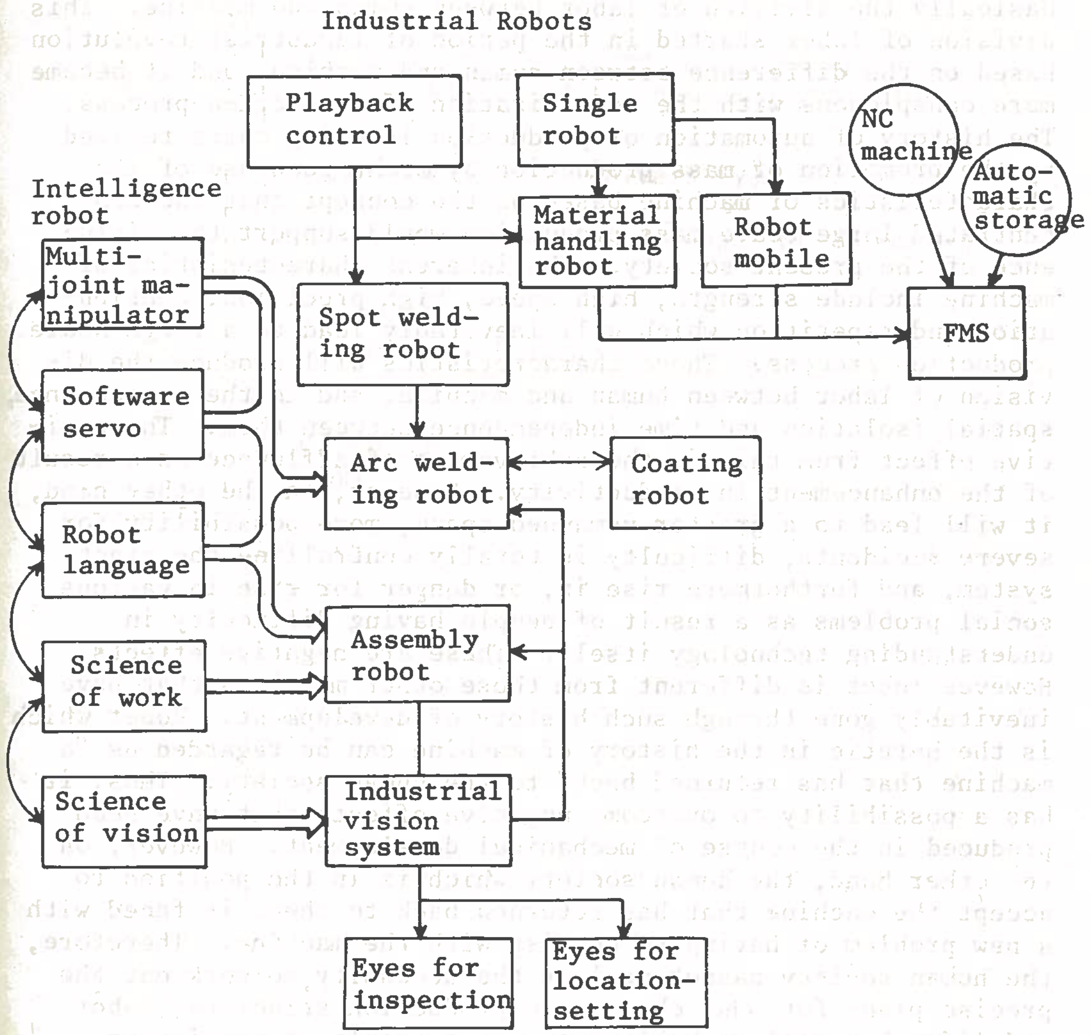


Fig. 1 Industrial Robot Technology Development

A2

ROBOTS AND HUMAN BEINGS

Hiroyuki Yoshikawa
Professor, University of Tokyo

mutation from bowl to tea cup
60% of the bowl full of hot tea

When studying the history of development in mechanical technology, especially when focusing on the history of automation of production technology, an unique trend can be identified. That is basically the division of labor between human and machine. This division of labor started in the period of industrial revolution based on the difference between human and machine, and it became more conspicuous with the modernization of production process. The history of automation of production is being characterized by the promotion of mass production by making good use of the characteristics of machine based on the concept that the concentrated large scale mass production would support the affluence of the present society. The inherent characteristics of machine include strength, high speed, high precision, continuation and repetition which will inevitably lead to a large scale production process. These characteristics will produce the division of labor between human and machine, and in the consequence, spatial isolation and time independence between them. The positive effect from this is the achievement of affluence as a result of the enhancement in productivity. However, on the other hand, it will lead to a greater unmanned space, more possibility for severe accidents, difficulty in totally controlling the giant system, and furthermore rise in, or danger for rise in various social problems as a result of people having difficulty in understanding technology itself. These are negative effects. However robot is different from those other machines that have inevitably gone through such history of development. Robot which is the heretic in the history of machine can be regarded as "a machine that has returned back" to the human society. Thus, it has a possibility to overcome negative effects that have been produced in the course of mechanical development. However, on the other hand, the human society which is in the position to accept the machine that has returned back to them, is faced with a new problem of having to coexist with the machine. Therefore, the human society cannot neglect the necessity to work out the precise plans for the changes in production structure, labor and life that will probably occur as a result of coexistence. For this purpose it is necessary to correctly anatomize the robot and establish a methodology for symbiosis.

WORKSHOP B

"The Computer and Daily Life"

B1: "Application in Livelihood and Home Appliances That Will Lead to Changes in Computers"

Hiroaki TERADA
(Professor, Osaka University)

B2: "Basic Characteristics and Impact of Microelectronics"

Ryoichi MORI
(Professor, Tsukuba University)

B3:

R. HIRSCH
(IBM)

A3

THOMPSON
Fault logic diagnosis using the algorithm conceived for medical diagnosis in the direction of mecanics or electronic diagnosis

B1

"APPLICATION IN LIVELIHOOD AND HOME APPLIANCES THAT WILL LEAD TO CHANGES IN COMPUTERS"

Hiroaki Terada
Professor, Osaka University

1. Application in Livelihood and Home Appliances That will Lead to Changes in Computers

   a. It is first necessary to recognize that the age has come in which we have to reconsider the history and environment of the development of the conventional computer.

   b. The first step for this will be to eliminate overconfidence on the general purpose computer that was made possible by the program function. The hardware technology has reached a stage in which highly efficient mono-functional chips can be used economically. The hardware technology-oriented development with continue in the future, or at least the trend will not be changed in the near future.

   c. At least as far as application or utilization in the livelihood is concerned, conventional programming method or the idea of computer language will not be applicable. There must be no need here to point out how premitive these are.

   d. If overconfidence on the general purpose computer is eliminated an environment will be created in which people can conceive freely.
   The actual application of computer in livelihood and home appliances is already indicating such trend.

2. What Sort of Computer Should We Suppose?

   a. To make the explanation easy, imagine the recovery of servants in various fields that existed in the age when labor cost was very cheap

   b. There are variety of servants, such as doorkeeper, houseman, nightwatch, cock, sales clerk, messenger, secretary, etc. Thus, what you have to do is to assume various servant-like service occupations that exists in the mass society.

   c. The functions themselves of these servants are simple, but it is necessary to jointly strengthen the data principle sufficient for the mutual understanding with the master and autonomic judgement-making function.
   For example, in the case of a doorman, the function he has to perform is to open and close the door in accordance with voice prints, palm prints and finger prints; several formal reception, recording of visitors and

acceptance of messages. Therefore these functions in principle, must be limited to mere human action and must not require specific instruction.

d. These servants should not always act like comical eccentric robot, but should act in accordance with the life environment.
Many of the invisible servants such as timers built in the equipments, that are very simple in shape are already being introduced in our life.

3. Application in the Field of Livelihood and Home Appliances that has Supported the Development of Computers

a. As has already been pointed out, the fields that support VLSI technology must be those in which mass production is performed, in principle.

b. VLSI technology has similar characteristic as Gutenberg's printing technology that has popularized static intellect. However, one big progress seen in VLSI technology is that it has a capacity to duplicate and distribute dynamic or active intellect. Such capacity can be made most of in the mass.

c. The application of VLSI in this field may change the pattern of technological development, especially in Japan. For example, we already see some phenomena in which technologies for livelihood and home appliances are converted into industrial technologies.

d. The most important fact is that excessively severe competition sometimes exist in this field. Therefore there is sufficient motivation for actually implementing free thoughts in a short period of time.

4. What is Necessary for Computer Development in the Field of Livelihood and Home Appliances?

a. First diversion of conception is required. It is only recently that it became possible for the computer to develop in the environment such as this field. Thus, it is necessary to forget the image of conventional computers.

b. The concept of tool must be reconsidered substantially. We have only very little experience in the concept of intellectual tool, which lacks dream and imagination.

c. We must confirm that all human activities exist for human life. If this cannot be accomplished, we cannot say that we are living in the post-industrial society.

BASIC CHARACTERISTICS AND IMPACT OF MICROELECTRONICS

Ryoichi Mori
Professor, Tsukuba University

Microelectronics has the four basic characteristics listed below.

1. Microelectronics itself handles exlusively information.
2. Microelectronics requires the demand of a huge quantity of the same product.
3. The ease of the transition from a product or a network of products of a given generation to the next one plays an important role.
4. The technological progress is rapid and continuous. However, unlike human being, microelectronics products and systems are not able to cope with unexpected situations.

One of the conclusions obtained by examining the 4 basic characteristics mentioned above is explained here. The discussion of the development occurred in subjects typically related to computer, electronics and communication is omitted here, because it is a self-evident subject. Our conclusion is as follows.

The kind of robot which is expected to play the most important role in Japan as well as in the world in the future is the traffic robot. It is presumed that Japan will play a leading role with regard to the matter.

This is one of the conclusions we consider valid for the coming several decades. Next, it is explained how this conclusion can be naturally led from the characteristics 1 to 3 mentioned above and how it is influenced by the characteristic 4.

It is expected that most of the traffic robots will have an appearance similar to the currently existing automobiles. The most important differences compared with the current automobiles are as follows.

- Most of the price of the traffic robots will be composed of electronic equipment.
- The traffic robots will be provided with couplers at the front and rear sides.
- The traffic robots will have the appearance of an "one-box car", unlike the "2-box car" and "3-box car" configurations, which compose the majority of the currently existing automobiles.

The use of traffic robots is expected to start in Japan, expanding gradually to other areas with high demographic density. The aforesaid process of diffusion of use of traffic robots can be described as follows. Currently the living standard of Japan is ranked below tenth in the world, but it is improving gradually. However, in this case there is one problem of difficult solution, namely, the problem of land and housing. In other words, it is expected that Japanese people will have a living standard ranked at top level in the world, while the housing situation will be classified as a third- or fourth-class one. Under such circumstances, it is expected that a huge flow of capital will take place aiming at solving the aforesaid problem if the currently existing social and economic system continues to work effectively. It is presumed that the solution of the problem will assume the four forms mentioned below, in addition to the adoption of obvious measures like construction of multi-storied buildings.

a. Acquisition of land from foreign countries in a peaceful way, able to bring mutual benefits.
This kind of "land trading" is desirable, and it is presumed that people of political and economical circles have similar idea, but on the other hand there are also obvious difficulties.

b. Land reclamation and floating cities
These alternatives are valid, but the creation of 3777 km^2 is required in order to increase the Japanese territory by 1 percent.

c. Emigration to the cosmos
This is a good alternative too, but it is necessary to send more than 1,170 thousand persons to the space in order to reduce the Japanese population by 1 percent. Under such circumstances, it is presumed that within the scope of the scale of time taken into consideration currently, the efforts related to this alternative will be oriented toward new progresses in the fields of cosmic science, technology and art.

d. Improvement of the means of communication
This is the alternative which the author considers more feasible. If the average traffic speed is increased by 0.5% and at the same time the consumption of fuel required to travel the same distance is cut by 0.5%, the residential area suited for communting is increased by 1%. There are various methods for materialization of this alternative, but the extension of the road and railway networks is accompanied by many difficulties. In the last 3 decades microelectronics attained an improvement of 100,000 times in its performance. However, the opposition of the population against the construction of new roads, the conservatism of the landowners against selling their properties, the exorbitant prices demanded by the landowners when they occasionally agree to sell over their land and other difficulties inherent to the matter remained unchanged during the aforementioned period and no change can be expected in the future.

In view of the considerations above, the only feasible method left for a considerable improvement in the means of communication is the upgrading of performance. It is expected that the relation between the progress of microelectronics and the gigantic networks will play a fundamental role for the sake of attaining the aforementioned improvement of performance. In other words, the microelectronics technology progresses at an astonishing rate and low-priced products of stand-alone type accompany without delaying the said progress. Desk-top calculator is a typical example of such

a case. However, the situation is entirely different in case of expensive large-sized products. Expensive and large-sized products can not be replaced and discarded with ease. As a consequence, the upgrading of performance is attained by means of partial modifications, know-how, software, addition of external accessories, etc. The accumulation of the aforesaid minor improvements increases the "inertia" of the whole system, making as a consequence further difficult to get rid of them. Therefore, the large and costly systems are prone to be left behind the progress of microelectronics. The large-sized computers of the early times are typical examples of the aforesaid situation. Railway networks and telephone networks are examples of further large systems. With the elapse of time it becomes more advantageous to update the product, even by discarding everything accumulated in the past and under such circumstances the whole system is replaced at once. When it is replaced it momentarily catches up the most advanced technological level prevailing at the time, but the larger and costlier the system, the longer the period for replacement.

Now, let us make a comparative study of road network, railway network and airway network. In the first place, airway network is omitted in this study. The importance of the airway network is evident, but within the scale of time taken into consideration in this discussion, airway network is not able to play any important role. It is presumed that the traffic network of the future will be a system having the merits of both road network (in this discussion road network is assumed to be the whole system including the automobiles) and railway network and the appearance of the current road network. There is no doubt that railway systems like the Shinkansen are important, but its discussion is omitted here. The system of the future should have the following merits.

A. The user should not be required to drive the vehicle.
B. Door-to-door transportation without transshipment should be possible.
C. The system should be versatile (described later).

The currently existing railway and bus have only the merit A, while the road network has the merits B and C.

Now, let us focus our attention on the basic characteristics of microelectronics. For example, handling of information mentioned in the characteristic 1 means the detection of speed and other data, judgement of the situation and execution of the control required to change the speed. The rapid improvement in the performance/cost ratio of this detection and control section thanks to the progress of microelectronics contributes to eliminate the rail of the railway and to reduce the size of products of various kinds. As a consequence, it acts favorably toward the road network side.

The demand of huge quantities of products of the same kind mentioned in the characteristic 2 is another factor acting favourably toward the road network side. With regard to this aspect, imagine two different cases, namely, one where all TV sets existing in the country are possessed by a single organization, and another one where the TV sets are possessed individually, like the current situation in Japan. It is easy to conclude which situation is more favourable for the diffusion of TV.

The ease of transistion between generations mentioned in the characteristic 3 is another factor favourable to the road network. Better products are sold in larger quantities and as a result an appropriate renewal takes place when in the system as a whole there are many parts which are possessed individually and privately. When the decision-making is entrusted to a big organization, the status quo may remain unchanged even when there are some partial inconveniencies, but in the present case there is less possibility of occurrence of such inconvenience. To ensure an easy transition between generations, taking into consideration the facts mentioned above, is the most important point in the gigantic network to be introduced in the future. For this pupose, it is necessary to concentrate on the side of the system where the "terminal vehicle" makes possible the possession of the widest variety of functions by each individual owner (e.g. automobile).

From the discussion above, the advantages of the road network are evident and as a result the form of its most effective use is axiomatically determined. Increasing the speed does not solve the problem if the current configuration of the road network remains unchanged, because the distance travelled from the moment when the danger is discovered to the moment when the brake is put on is proportional to the speed, and the distance travelled from the moment when the brake is put on to the moment when the vehicle stops is proportional to the square of the speed. Accordingly, increasing the speed would rather reduce the efficiency of transportation, because a wider gap is required between vehicles going in the same direction. Vehicles travelling with no gap at all between them would be a solution to this problem. In this case dozens of vehicles coupled with each other accelerate and decelerate at the same time and as a consequence the couplers located at the front and rear side of the vehicle transmit the information. The elimination of the gap between vehicles contributes to reduce the consumption of energy and the noise. In view of the considerations above, the vehicles are expected to have the "one-box car" configuration, like the current vans.

The improvements brought by this system to the traffic problem are not restricted to the speed and efficiency of transportation. People may spend the communting time in different forms, like listening music, watching TV, shaving, dressing oneself, having meal, sleeping, setting forth the work by communicating with the office, etc. This versatility can be attained only when in principle each vehicle is privately possessed. This system makes

possible a convenient and efficient door-to-door transportation.

It is presumed that the aspect mentioned in the characteristic 4 will be the most important element of this traffic system. The "unexpected situation" mentioned here does not mean accidents like fire in the vehicle or a punctured tire. Troubles like these ones can be expected and the procedures to cope with them can be programmed in advance. The problem is what to do when fire breaks out in the vehicle, the fire-fighting system does not work as programmed and in addition the second and third preventive countermeasures do not work as well. There are two alternatives regarding the mode of operation of the system, depending on the judgement of a wide variety of persons, ranging from experts to laymen, as respects to the reliability and automatic operation of each element composing the system. The two alternatives are full automatic operation with a relatively low speed or a high speed system with intervention of the man only when required.

Low speed automatic operation is useful to solve the problem of parking space at the city center. In this case the passenger is not required to go to the parking area, and he can send his automobile to the parking lot after stepping off, and to call it back whenever required. There is no space in this paper to discuss the system with small (or constant) gap between vehicles, but this is a subject worth studying. The latter system can be materialized immediately in some limited cases.

WORKSHOP C

"Technology and Art"

C1: "Art and Robot"

Takeshi MORIYA
(Associate Professor, National Museum of Ethnology)

C2: "Traditional Technology and Robot"

Shigeharu SUGITA
(Associate Professor, National Museum of Ethnology)

C3: "Humanization of Technology"

Otoichi KITAMURA
(Professor, Kyushu Institute of Design)

C1

"ART" AND ROBOT

Takeshi Moriya
Associate Prof., National Museum of Ethnology

Personality and Seniority in Art

When you search a word in the traditional Japanese language that is equivalent to "Gijutsu (skill)" in the modern language, you will find a word "Gei (art)". It is certain that no one can find better word than "skill", when trying to translate "art" into modern language. However, it is also a fact that two words "art" and "skill" give us completely different impressions. This is probably because there is a wide gap in the understanding of the word "skill" between ancient Japanese who called the skill "art" and modern Japanese who regards skill as mere "skill".

This difference may be well explained by making detailed analysis of "Geidan (artist's talk on his art)" we had in the past. However, instead of going through that procedure, let me note my conclusion first. "Art" in traditional sense was not a result of the "skill", but its greatest characteristic lay in the fact that the standard of its value was placed on the personality and seniority of a person who possesses that "art".

This sense of value may sometimes lead to perversion of logic, indicating that as the development of "skill" is the result of the personality and seniority of the person who possesses the high level of "skill", he is definitely, well experienced and has noble character.

The fact that the biographies of people who are called masters are full of praiseworthy anecdotes in routine life and episodes of superhuman efforts is due to great emphasis placed upon personality and seniority in "art".

It is not so unusual that this concept of "art" is still deeply rooted in the field of modern and traditional technical art and traditional public entertainment, but we must note here that this concept is surviving even stronger in the field of sports.

In this field, the sense of value that supported "art" is still in existance as "Konjo (willpower). The unique characteristic of the Japanese view on the traditional skill is indicated by the fact that it is not so erroneous to replace the work "art" with "willpower".

Tool, Machine and Robot

The concept of "art" described above was a product of the so called "the age of tools". Needless to say, tool is united with the user. The affection for long used tool often leads to impersonation of the tools. In Japan, there has been some indication of goods being impersonated or a man entering into an object. Those phenomena were seen most in the tools. Furthermore, it was easy for the people to understand that a man can enter into "skill" called "art" --- thus, skill and man can be united.

However this view on "art" will not be accepted once we enter into the "age of machines". This is because machines were developed in order to perform jobs that are impossible for the man. Therefore it is not exaggerating to say that man was in hostile relationship with machine. And the modern word "skill" that sounds somewhat cool has a tone suitable for this "age of machines". The words, skillful and mechanical are used as interchangeable words.

Thus the traditional concept of "art" found a place to survive in the field of sports which is normally unrelated with machines. On the other hand, emphasis on personality and seniority that supported "art" was relieved slightly and presently survives in the modern Japanese society as a standard for assessing one's job performance. The seniority system is the systematic relationship that is gaining support from the majority in the Japanese society.

Today, we have entered into the "Age of robots". Robot is, of course, a kind of machine, but one big difference it has with the conventional machine is that the robot is designed to act in very similar way to the man. And furthermore Japanese, at least, have started treating the robots as if they have human personality. In another word, we did not regard it as the advent of stronger machine, but rather felt that it was the emergence of cheerful friend. Not confrontation but unification.

I think that at this stage the idea of traditional "art", although somewhat distorted, is starting to be revitalized or the concept of "art" is beginning to be applied. As we impersonated the tool in the past, we are accepting the human characteristics in robots.

If people are beginning to think that our friend, robot, has restored what was once given to the machine back to the level of human beings, what will happen to the relationship between robot and man in the future?

Furthermore there is a separate but serious problem as to whether or not robots will be experienced, refine their personality and become masters in accordance with the expectation of the man.

"TRADITIONAL TECHNOLOGY AND ROBOT"

Shigeharu Sugita
Associate Professor, National Museum of Ethnology

1. Progress in Technology

The word "hand-made" is often used to describe that a product is of a high quality. This is probably a result of appreciation for the works that are created with utmost care and devotion in the world of traditional art and weaving. This clearly shows one of the aspects of recognition in Japanese society in which greatest importance is placed upon not the finished product itself, but the psychological aspect in the process of its creation. However, that finished product may also be produced by machine. Even the so called masterly performance that has been cultivated in the course of one's life can in most cases be accomplished by machines if costs are neglected.

As indicated in Fig. 1, a technology that has reached a certain level of maturity will face technological innovation at the point when the technology makes no more progress, and as a result, the technology will proceed in two paths. In one path based on the conventional technology, minor improvements will be made gradually. This is what we call the traditional technology. In the second paths, through the adoption of new technology, the conventional objectives will be achieved more remarkably and efficiently. The technology will evolve by repeating such divergences. For example, in some cases almost a same product with that could have only been made one at a time by the conventional method may be mass produced at a high speed. Or there are products such as tools that will become easier to use, as a result of technological development.

2. Technology and Art

This happens as the traditional technology that takes over the conventional technology is replaced by a new technology from the practical point of view. At this point, the traditional technology will be formalized and will turn into more of an art. Art and play have a common characteristics as they are both unpractical. Conversely, many of the present art may have been originally very practical. Such situation is easily found also in the art of public entertainment and ceremony.

Wouldn't it be possible to say "Emergence of a new technology will turn an old technology into art," although this is a sort of expression that is apt to invite some oppositions. The old technology will not become an art automatically, but it will have no option than to proceed the path of art. In the past, pole and line fishing of bonito was a skill of a brave man. However, due to the invention of the mass fishing method using nets, the skill of pole and line fishing turned into a mere hobby. As a result, enter into "skill" called "art" --- thus, skill and man can be united.

However this view on "art" will not be accepted once we enter into the "age of machines". This is because machines were developed in order to perform jobs that are impossible for the man. Therefore it is not exaggerating to say that man was in hostile relationship with machine. And the modern word "skill" that sounds somewhat cool has a tone suitable for this "age of machines". The words, skillful and mechanical are used as interchangeable words.

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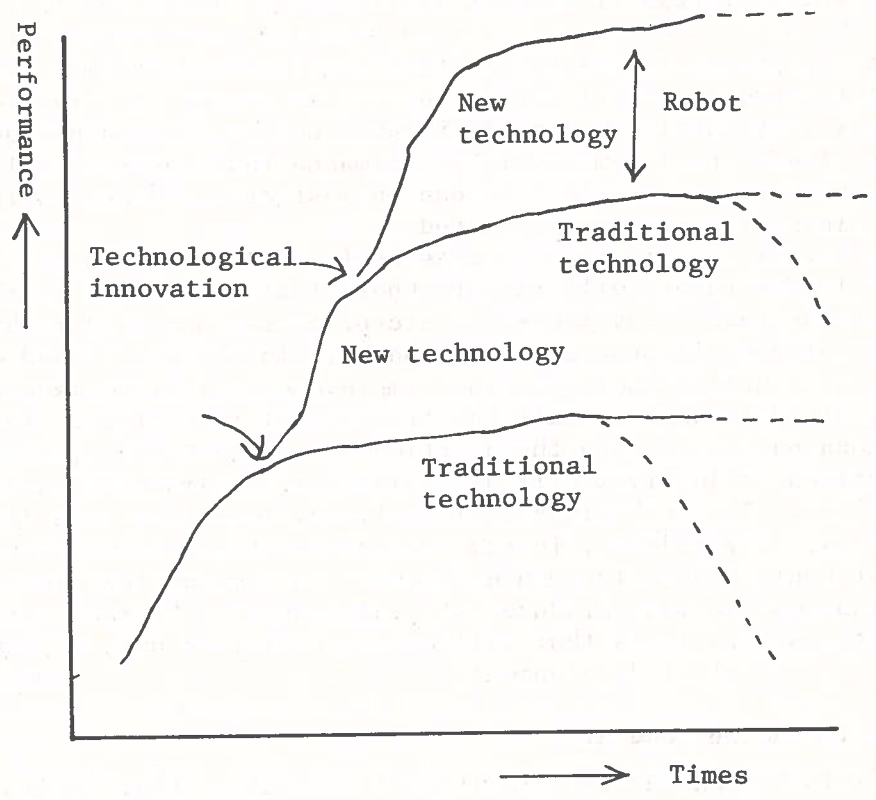

Fig. 1 Development of Technology

The religious rituals or creation of paintings and stone images in hope for the fertility in the past developed into independent arts losing their original incantational meaning.

From this background, technology and art often have a some origin and are interrelated with each other. Therefore when studying the artistic aspect of technology or technological aspect of art, you will find that the boundary between the two is not so clear.

3. Possibility of Robot

What is the technological innovation in the present day. It

is definitely the appearance of robot with built-in computer.

Before the development of computer, functions of machines and tools were simply the extension of abilities of hands and legs, even in the case they were more capable than human beings. However computer is not merely electronization of abacus, but clearly substitutes a part of brain activities. Furthermore, the development of microelectronics brought about a wider application of computer, as it became possible to accommodate the computer in a very small area of space.

While the conventional machine could only perform a single function, the characteristic of robots, especially those with built-in computers, is that they may have flexible function in which very detailed works similar to the man's manual works are possible by the combination with various sensors. Thus the computer can provide multiple-purpose function to one machine, making it possible to produce small amount of wide variety with high quality, which is the merit of hand-made products, and at the same time to produce large amount of small variety. Thus, the function of robot covers a wide range from new technology to old technology as indicated in Fig. 1.

Of course, application of robot in mass production process and works that accompany dangers will increase in the future. However, the objective for introducing robots must not be solely to increase and speed up the production, but must also be to succeed to the traditional technology that is deeply related to the ethnic life and to make new developments. We must deal robot as life-size technology which is well harmonized with human and also seek further quantitative and qualitative improvements that were not possible in the past.

Tradition is not only succeeding to the old technology as it is. Rather it is to inject the highest wisdom of race at each age.

Traditionally, the terms "wisdom of race" or "wisdom of life" in most cases only indicated prominent factors within a limited field, and did not indicate the most superb factor among a great deal of possibilities. The development of scientific technology presents us with opportunities to attempt new possibilities. It will be fatal for us if we do not make use of these opportunities by our negligence. We should consider about positively introducing robots in the field which is called the traditional technology of Japan. And as a result, we may recognize the merits of the conventional technology. However, if we hold prejudice against introducing new technology, without even attempting to do so, we cannot object to a criticizm insisting that we are being protectionist based on our ignorance.

4. "Were You Defeated too, Robots?"

We must always remember that "Humanization of machine will in the consequence" lead to mechanization of humanity." (L. Manford), at the present age when new robots are developed one after another. The distance between human and robot is still very significant when overall comparison between the two is made. However, in parts, it is possible for us to develop a robot that is more capable than human beings. There is already a possibility of a machine creating works in the field of art and public entertainment that are similar to works made by human beings in every way.

However we are not aiming at making robot mimic the production of art by human beings. Our ultimate objective is to seek what is human nature by clarifying the extent of the mechanical portion within the world of art, which up until now as a result of over-confidence of human was regarded to be the unique activity of the man.

If we promote mechanization without recognizing this goal, competition will occur between human and machine, resulting in some defeats on the part of the human.

It is important to seek the symbiosis of human and robot from wide point of view, so that human will not ultimately be betrayed by the robot which was orginally developed to become supportor for man, and lead themselves to self-destruction. I sincerely hope that we do not have to face the age in which we have to claim "Were you defeated too, Robots?", by the repetition of the history.

C3

HUMANIZATION OF TECHNOLOGY

Otoichi Kitamura
Professor, Kyushu Institute of Design

1. Humanization of Technology

"Technology and Art" is the topic of Workshop C. Department of Art Technology of Kyushu Institute of Design, where I teach, deals with this very topic. Therefore I would like to tell you what we mean by this name in the first place. I would like to quote from the "Mission of School" which most clearly represents it. Here is the first half of the mission.

"Specialization of science and technology of recent days" helps to make significant progress, to invite unprecedentedly high rate of innovation and to radically reform the production system as well as to give our daily social life drastic changes. These changes have brought us both good and bad results. One is the favor of civilization and the other is human alienation as a result of placing too much emphasis on "technology".

How to shrink this unfavorable phenomena and place "technology" at the right place for right function is one of the greatest problems of the modern civilization. The solution is very difficult to obtain and very much diversified.

The most important factor in solving this problem is "humanization of technology. Humanization of technology means promotion of technological improvements based on human criteria and to make best use of the improvement for the well-being of human beings as well as for better human life. It is to integrate "science" which is the basis of technology and "art" which is the free representation of human mind. This integration will plan the way for technology and design its functions. This is nothing but establishment of higher design".

In this mission "the freest expression of human mind" is declared. I understand that art is considered as representation of humanity. Art technology is the science which aims at humanization of technology. In this sence I understand the topic of this workshop "Technology and Art" as "Humanization of Technology". Here are two problems: One is to deeply understand what man is. Another is the method of humanization or how to establish the method to design humanization.

2. Importance to Have Understanding of Man

Importance to understand man has been claimed by many people. It is explained in "Man- this unknown being", written by Alexis Carrel in 1935. The Section 5 of Chapter 1 is entitled "Remodelling of environment by science is harmful to man for it has been made without understanding nature of man" (translated by Nyoichi Sakurazawa) or "Civilization in disregard of providence of nature is harmful" (translated by Shoichi Watanabe".

the consequence" lead to mechanization of humanity." (L. Manford), at the present age when new robots are developed one after another. The distance between human and robot is still very significant when overall comparison between the two is made. However, in parts, it is possible for us to develop a robot that is more capable than human beings. There is already a possibility of a machine creating works in the field of art and public entertainment that are similar to works made by human beings in every way.

However we are not aiming at making robot mimic the production of art by human beings. Our ultimate objective is to seek what is human nature by clarifying the extent of the mechanical portion within the world of art, which up until now as a result of over-confidence of human was regarded to be the unique activity of the man.

If we promote mechanization without recognizing this goal, competition will occur between human and machine, resulting in some defeats on the part of the human.

It is important to seek the symbiosis of human and robot from wide point of view, so that human will not ultimately be betrayed by the robot which was orginally developed to become supportor for man, and lead themselves to self-destruction. I sincerely hope that we do not have to face the age in which we have to claim "Were you defeated too, Robots?", by the repetition of the history.

C3

HUMANIZATION OF TECHNOLOGY

Otoichi Kitamura
Professor, Kyushu Institute of Design

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Environment remodelled for convenience at present disregarding the long term effect on man alienates man and makes him unhappy. Technical assessment in broader sence is required. For this wide, deep and time consuming study on the nature of man" is required.

3. Study on Design Method

Establishment of design method for humanization of technology is another important problem. Various multi-dimensional factors such as physical, chemical, psychological, physiological, economical, social and geographical ones are correlated in a complicated manner. Integration of these factors and decision making for its design are inevitable for man's real happiness. This is the theme of study in the future. The result of successful design not only creates short-term effect but also makes each individual feel real happiness of life. In other words, these two will serve as criteria for the good design.

4. Necessity of Education on Humanization of Technology

It is very important to educate designers to humanize technology. It is not easy to deeply understand man and technology for designing humanization of technology.

At first, we must increase the number of such designers who have this philosophy in mind. It is clear that technological instructions alone to the students majoring in technology is insufficient. Though they must specialize in each field, they have to see other parts of the world. We should not educate students into experts without any knowledge in other fields.

"How to educate" requires more time before establishment. I think it important to educate students for better sensitivity in various fields.

5. Philosophy in Humanization of Technology

I think it very important to stress three principles of creation, maintenance and modification, which Toyohiko Kagawa introduced, as a basis for humanization of technology. Further, design must be based on humanistic and heartily ideas. This leads us an idea of design based on full consideration of each individual's characteristics.

WORKSHOP D

"Human Beings and Aviation/Space Technology"

D1: "Automation of Aircrafts"

Isao KURODA
(Commander, Aeromedical Laboratory, J.A.S.D.F.)

D2: "Manned Space Flight and Microelectronics"

Hiroyuki MATSUMIYA
(Consultant, National Space Development Agency of Japan)

D3: "Future Environmental Measures for Air Transportation"

Teruo SAWADA
(Professor, University of Osaka Prefecture)

AUTOMATION OF AIRCRAFTS

Isao Kuroda
Commander, Aeromedical Laboratory, J.A.S.D.F.

1. Historical Review

There is few field other than aircraft that has made such a significant development in less than eighty years since the first flight by Wright brothers.

When reviewing the history of eighty years, we find that it was a history of trial and error for filling the gap between human being that makes little functional improvement and the aircraft which is a machine that makes great improvement in efficiency.

Flying in three-dimensional space at a fast speed required man to quickly form completely new combination of various human functions that had been developed since the creation of human beings.

The incongruence between man and mechanical systems in the early ages of the aircraft cost many valuable lives, and as a result, continuous studies and efforts have been made to overcome this incongruence between man and mechanical systems. These efforts are clearly shown by the safety improvement. The accident rate in 1928, when the first periodical flight started in the United States was 667 cases per 100 million flight miles, while that of the present third generation Jumbo jet has improved 3,000 times to 0.21 cases out of the same.

2. Process of Improvements for the Aircrafts

Followings were the procedure for improving the aircraft which is the man-machine system, from the point of view of man, especially when viewed from inside the cockpit.

1) Accurate acquisition of sensory data in short period of time

Various instruments have been developed in order to acquire data that exceeds the sensory data processing capacity of the man, or when there is no measures for acquiring them. Furthermore, improvements were made in the arrangement of instruments, readability of characters and figures, function and lightness, etc, so that correct data can be acquired in a short period of time.

2) Simple, quick and accurate operation of the operational equipments

As it is necessary to make many operations during aviation process with little spare hours, many improvements were made to switches and handles themselves and locking mechanism that is required for their arrangements and functions in order to perform accurate and quick operation.

3) Introduction of alarm equipments

In order to draw the crews' attention to especially important informations during high work load period when they have to make a great deal of decisions and operations, various measures were taken, such as alarm light, alarm bell, audio alarm and vibration of control lever etc., making continuous improvements to avoid errors and overlooks.

4) Automation of operational control

Automation was introduced in order to free the pilot from performing operational control for a long period of time, and also to control the high speed to which man cannot follow. Thus, automatic steering control, INS (Inertial Navigation System), automatic landing system, etc. were introduced.

5) Automation of monitoring on operation

The results of operations made by man are monitored continuously, and any abnormality shall be informed. These equipments included proximity warning system and air collision avoidance system and these equipments give comprehensive supervision based on various data, while attention drawing equipments noted above are mainly for informing the equipment defects.

6) Decision making aiding system

With the development of the micro-processors, substantial automation was made to the flight management systems that greatly reduces the work load of the pilot and helps the decision making by complex data processing from the fourth generation B-767.

3. Man and Automation

For bridging the gap between the aircraft and man, the automation of equipments is essential.

As for the data processing of the man, man-machine interface has been improved with the aim to bring a qualitative and quantitative enhancement to the sensory data, which is the input. And further developments were made to simplify the sensory data to suit the characteristic of man which is the single channel processor, or even to preprocess the data so that they can directly be used in the decision making. Thus, there has been a gradual move towards brain type automation.

On the other hand, as for the operation, that is the output, the needs for simplifying the operation, preventing the operational errors and reducing the operation lead to freeing the pilot from standardized continuous operation and detection and implementation of the optimum control method from the combination of given conditions.

From these improvements, many merits were identified such as reduction of work load and fatigue, highly accurate operation with no individual difference and enhancement of economic efficiency, etc.

Sharing of role in aircraft between man and machine still requires extensive and diversified decision making due to the complexity of aviation services. Therefore it will be very difficult to realize full automation and unmanning as is seen in other general industrial fields.

In the case of the aircraft that depends on only a small number of crew members, who are placed at the most important decision-making position in the man-machine loop, and at the same time who are under the danger of having to replace the machine in the case of abnormality, automation faces new problems perculiar to the aircraft that cannot be seen in any other field.

4. Problems Related to Automation

Wiener et al. (1980) warns that the rapid automation of the aircrafts is already presenting following problems.

1) Demerits

a. Loss of human identity, decrease in motivation,
b. Decrease in caution on the part of the man who operates.
c. System breakdown may lead to a significant error.
d. "Silent breakdown" may be caused which no one will notice.
e. Reduction in skill that may cause trouble when operation has to be performed manually.
f. Excessive reliance on the machines.
g. Decrease in reliance due to erroneous alarm.
h. Breakdown as a result of automation.
i. Increase in the mental load.
j. Operational feed back cannot be acquired.

2) Questionable points

a. Will the overall work load truly reduce?
b. What is the difference in the total aviation cost?
c. How to change the crew training program?
d. What is the appropriate number of crews and combination of skills?

3) Unclear points

a. Return on capital investment.
b. Whether or not the same hardware can be used.
c. Maintenance and repair cost.
d. Necessary and desirable redundancy.
e. Safety from long term perspective.
f. (Physical and phychological) effects on pilot and other crews from long term perspective.
g. Long term problem related to capital and labor.
h. Problem of responsibility in the case of accident.

Above problems are not only identified in the aviation field, but they may appear as common problems in other fields that are promoting the introduction of automation and robots. Therefore, we must not only pay attention to the merits but make more serious considerations.

MANNED SPACE FLIGHT AND MICROELECTRONICS

Hiroyuki Matsumiya
Consultant, National Space Development Agency of Japan (NASDA)

1. Introduction

The role of human being in the development of space is extremely important and is not replaceable with robots or computers. Assurance of safety living and of effective performance of human in the space environment is one of the most important tasks in space development. Human being and other living organisms are alive and active under the environmental condition of earth surface. The environmental condition of space is, however, remarkably different from that of earth surface. To know the effect of space environment on human being and to establish any necessary contermeasure for the effect are thus important to accomplish the task. The contribution of microelectronics in the field of space medicine and its significance are discussed in the current paper.

2. Effect of Space Environment of Human

Important environmental parameters of space and of ground are compared below;

	Space	Ground
Atmosphere	None	
Composition	(except other planet surface)	Oxygen 21% Nitrogen 78%
Atmosphere Pressure	0 7×10^{-6}mmHg(140km)	760mmHg
Temperature	-140 ∿ +130°C(moon)	-40 ∿ +40°C (room 15° ∿ 25°C)
Gravity	0 G	1 G
Acceleration	3 G spaceshuttle (depend on space craft flight profile)	-
Periodicity	100 min. (lower orbit) 27.3 days (one day on moon)	24 hrs. 29 days 365 days

Among of those environmental conditions, atmospheric composition, pressure and temperature are maintained as the same one at the surface of the earth even in space by the life support systems of spacecraft. High acceleration during launch and entry, and the microgravity during the orbital flight can not be altered, and give large impact on human being. The periodicity in the space is different from those on the earth surface such as day, month and year, and gives effect on the rhythmicity of human body.

Measurement of human physiology and its alteration in space have been carried out from the beginning of manned space flight. However, there is a great limitation on the weight of instrument to be installed in space-craft. US experience in early stage in Mercury program and Gemini program indicates that only a limited items especially electrocardiograph was measured during flight and that most of physiological measurements were made only before and after the flight. The increase in the measurement items was planned in Apolo program, but the accident cancelled this plan. The first exhaustive and systematic experiment on physiological change during the space flight was carried out in Skylab program. Various physiological observation made in this program identified the effect of space flight as follows;

- Space motion sickness immediately after the entry to 0G great personal difference)
- Cardiovascular deconditioning
- Masculoskeletal deterioration
- Change in blood volume and quality
- Immune reaction suppression
- Loss in readaptability to the ground environment (1G)

Skylab program needed the more items of measurement, continuous receiving data on the ground, and monitoring the health condition of flight-crew by real time data processing. The light weight and miniature sensors and transducers, telemetry systems, and computor and software have been developed to meet such needs. Sensors (electlode) and transducers were miniaturized, and attached to space-crews, but the amplifier and further systems were installed in the rack of spacecraft and connected with transducers with harness.

Skylab 4 carried out space experiment from November 73 to February 74, and the equipments used were mostly developed in the later half of 60s. USSR carried out many medical experiment in a similar nature as a Skylab program from 70s till today with using Soyuz-Salut program, but the instrumentation has not been publicized.

3. Space Shuttle program and its future

NASA is planning and is going to implement the experiment to study on the physiological phenomena in a space flight and to establish countermeasure for any hazard in human generated in space environmental condition. The progress in microelectronics is remarkable within past one and half decades, and gives large advantage to space experiment. Physiological monitoring systems (PMS) was miniaturized to great extent and almost all instrument is attached to subject crew. The appearance of micro-processors improved the quality of obtained information due to the progress in elimination of noise. Consequently the reliability was

advanced. The quantity of information also increased by the introduction of multi-channel telemetry in physiological measurements.

Micro-processors also improved the efficiency of space experiment other than physiological measurements, and enabled automation of experiment and measurement, and distribution of computation and data storage. Experiment can be commanded directly from P1 on the ground and the load on the pay-load crew was decreased to large extent.

Space-shuttle program is ultimately explored to Space Station or Space Platform, and the duration of staying in space will be extended. The study on human being including physiological phenomena in space flight is needed and expected to be progressed in near future.

4. Significance in ground based medical technology

The instruments developed to fulfill the need of space medicine and physiology have contributed to the ground based medical intrumentation. Some examples are; infant breathing monitors, pressure transducers for intravascular measurement, biopotential electlodes, improved heart pacemakers and automatic blood pressure devices. The advancement in telemetry offers application to the health care service in remote area especially in urgent situation. Combination of miniatulization telemetry decreased complexities involved in the monitoring patients during surgical operation, and increased the application to the exercise and its study.

5. Future of space activity

There are still many limitations in human space activity due to the capacity of spacecraft in near future, but the introduction of Space Station or Space Platform is expected to enhance human space activity.

One of such area is the space science and technology experiment that uses space environmental conditions especially 0 gravity aiming at the increase in scientific knowledge and that development of various technology. The space environment is expected as to be a new field for producing new materials. Progressive use of space is also planned in such a way as construction of solar power satelite or other large structures. Other proposals for the use of space are numerous. There is no doubt that the direct involvement of human activity is extremely effective and economical means in space development. The longer vision of space development is depicted as space colony. The thorough understanding on the adaptation of human being into space environment must be the solid base for future space development.

FUTURE ENVIRONMENTAL MEASURES FOR AIR TRANSPORTATION

Teruo Sawada
Professor, University of Osaka Prefecture

1. Airplane and Environment

Human dream to fly the sky like birds was materialized when airplane was invented by Wright brothers.
However, this machine flies not by human power, but by the power of engine. Thus the success of Wright brothers greatly owes to the development of the gasoline engine which is much lighter than the steam engine. The engine that rotates at a high speed by burning fuel originally has a negative impact on environment. Furthermore the airplane invented by Wright brothers substantially developed by its use as arm in the first and second world wars. The demand for arms is solely high efficiency and considerations for environment are not required.

The turbo engine developed during world war II was improved rapidly after the war as its characteristics suited airplane, expanding its application into the commercial airplanes. The use of jetliners was increased rapidly not only in the international lines but also in domestic lines as it was faster, it could be larger in size, and more comfortable compared with the conventional propeller planes.

As a result, the number of users of airplane grew every year, being regarded as a convenient means of transportation.

However the convenience of jetliners accompanied the environmental destruction. In accordance with the increase in jet services, residents around the airport started suffering not only from noise but also from air pollution. This lead to anti-jetliner movement, which in consequence restrained the development in air services.

In order for a heavy aircraft to fly, high speed is necessary, which must be sustained by high-power engine. The turbo engine exerts driving power by absorbing air from front and emitting it at a high speed from the rear. High-speed jet stream produces the jet noise when it is mixed with the surrounding atmosphere. Furthermore fan and compressor for compressing air are necessary for producing jet stream, which will also produce noise as they rotate at high speed, slicing the air. Also engine consumes a great deal of fuel and harmful contaminants that will cause air pollution are produced through the combustion process.

2. Environmental Measures for Airplane

The driving force produced by engine can be calculated by multiplying the amount of air absorbed by engine by the speed of jet stream. Thus if amount of air is increased, driving force can be maintained while reducing the speed of jet stream. On the other hand, as the power of jet noise is proportional to the eigth power of the speed of the jet stream, the reduction in speed is

very effective for reduction in jet noise. In the case of the turbo fan engine with high bypass ratio used in the present sky truck, large fan is being adopted to increase the air flow in order to reduce the jet noise. However as utilization of large fan will increase the fan noise, duct walls are covered with sound-absorbing materials for reducing the noise. These measures brought about the success in enhancing the engine power without increasing the noise level. Therefore although sky trucks utilizing such engine are much heavier in weight than the conventional aircrafts, their noise level is comparatively less.

As noise level restriction standard is set for aircrafts, aircraft manufacturers have to design and manufacture airframe that meets this standard and at the same time most economical. If decrease in economy is permitted, it is technically possible to manufacture an aircraft with lower noise level.

3. Practical Limit for Noise Reduction

Recently it is very difficult to construct a new airport. This is because public opinion against constructing new airport is becoming stronger. However as their opposition is due to environmental destruction as a result of establishment of an airport, it seems that opposition will not be as strong if the noise level of aircrafts was as low as that of propeller planes. As noted earlier, little consideration was given to the environment in the process of the development of jetliners. Therefore residents around the airport believe that they cannot coexist with jetliners. However owing to the technological development, jet planes with noise level comparable to that of propeller planes have now appeared. Ae 146 type plane accommodating 80∿100 passengers developed by BAC utilizes four compact engines, succeeding in reducing the noise level down to that of propeller plane YS-11 with capacity of 60 passengers. Although increase in the number of engines will accompany higher airframe and maintenance costs, it is not uneconomical from total point of view as reduction in noise level will lead to less environmental development cost in areas surrounding the airport. Under the aviation policy of the government today, very large investment is made for the environmental development in areas surrounding the airport. However it is considered more effective if the same investment is made for conversion into lower noise level aircrafts.

4. Setting of Restriction Standard Based on Regional Characteristics of Airport

The present noise restriction sets the upper limit of the noise level in accordance with the weight of each type of aircraft. Thus restriction is imposed according to the airframe. However, the actual environmental problems by noise are caused in areas around airports, and their degree depends on the site conditions executed to gradually enlarge them stepwise, and that from the beginning all of departments are totally systematized. Practically which system is better than the other depends on the external and internal environments of the respective hospital, but so far the former can be seen more domestically and abroad.

Out of those subsystems in Table 1 the details actually systematized are fairly different from the respective medical conditions of each subsystem. Table 2 simply summarizes such state and problems on systematization as to the major subsystems.

3. Expectation on Development of Robots for the Hospital Work

As known from Table 2 when the information system is introduced to each department of the hospital, a fairly large part of the problems can be solved therein, but still there remain certain problems. Therefore, for such work in the department not only of the information system but also a robot should be developed and introduced, by which those problems are expected to be solved or somehow relieved.

Table 3 shows those robots needed for the hospital work. Some of them are already used actually or on trial, but most of them are not set to work yet or still in the planning stage. The role to be played by such robots are simply outlined as follows:

(1) Guide robot

It is expected for this robot to have functions not only to show the way to reach the respective department upon request but also to be able to tell a patient which department he should visit depending on his conditions and symptoms by means of voice, output and illustration.

(2) Receptionist robot

This is to receive the patients for diagnosis and treatment, one for the first medical examination and another for the reexamination. The former is rather hard to develop because of complicated procedures involved in various steps, while the latter is well possible with the present level of techniques.

(3) Assistant robot for medical examination

This is to help the doctor upon examination showing him the necessary data in a simple form or handing him necessary medical instruments on request.

(4) Robot for examination

This works to perform various clinical examination automatically. As to the laboratory examination already fairly good numbers of the automatic equipment have been developed and used, but at the present time manpower is still required for delivery or pretreatment of the specimens. Therefore, a robot to do such work is very much anticipated in future.

On the other hand for physical examinations such automation must be planned very carefully as it must directly work on the patients. It is advisable to restrict the development to the data analyses such as automatic ECG analyzer, etc., being used at present.

(5) Assistant robot for surgical operations and treatment

This robot is expected to hand the necessary instruments to the doctor with appropriate behavior, to promptly withdraw and wash the used ones, and to watch and indicate the conditions of the patient in good timing during the operation or treatment.

(6) Nurse robot

This is to take care of the bedridden patients seriously ill, the functions of which are already on trial partly.

(7) Dispenser robot

This is to dispense medicines automatically according to the prescription prepared by the doctor. A few automatic dispensers have already been developed on trial although the respective functions are limited to a certain extent.

In connection with the above it is also requested to develop a device to automatically pick up the respective tablets and pack them into an envelope when no dispensing work is required.

(8) Robot for retrieval and storage of the clinical record

This is to pick up the clinical record upon request and return the same after use, a so-called automatic warehouse for the clinical record. Already a few instruments are available in practical use.

(9) Robot for delivery

This is to deliver things from a department to another in the hospital. Already certain equipments have been developed and used, such as the air duct, the conveyer, etc. Since those are principally for delivery of papers and alike, it is requested in future also to be able to carry fluidal medicines and specimens or to deliver meals.

(10) Patient robot for medical practice training

It is difficult to give sufficient training to the medical students and interns actually with the patients from the beginning because of various restrictions. Thus, this robot will give the same results as that from the training with the live patients. Already some equipment for training of anesthetizing, diagnosing diseases of the cardiovascular system, first aid resuscitation, etc., have been developed. The authors are now developing a robot for training of arrhythmia diagnosis on ECG.

4. Conclusion

As stated above those functions various robots should have were explained to develop the present hospital information system to

Systems	Major Systematization	Problems in Hospital Automation
	• Retrieval of the test results	
Clinical examination system (physical examination)	• Computer analysis in a part of tests, such as ECG, respiratory function test, etc.	• Automatic operation of testing instruments are less available • Automated processing of test results are less available • Problems remain in filling of test results
Patient monitoring system	• ECG, blood pressure, heart beats, temperature, respiration, etc., of seriously ill patients with heart disease, cerebral angiopathy, respiratory disease, and post operative patients, prenatal pregnants, newbrons, are automatically measured and when critical conditions arise a warning is given to doctors and nurses.	• Items automatically measurable are limited • Insufficient criteria for giving warnings
Ward system	• Various instrutions for nurses from doctors are put in order and listed • Orders necessary to every department are directly transmitted from the wards • Retrieval of test results on patients from the ward	• Delivery of papers, materials, medicines and specimens within the ward and to other departments are mostly relying on the manpower

Systems	Major Systematization	Problems in Hospital Automation
Medical record management system	• Storing and retrieving summary of medical record information • Automation of storage and retrieval of medical record	• Full-scale medical record information management system by the computer is still under research • X-ray film, ECG, etc., are not automatically stored and searched yet
Dispensary information system	• Automatic checking of prescriptions • Typing out of labels on medicine envelopes • Drug information system (partial) • Stock control of drugs	• Packing of tablets into envelops and dispensary work are done by hand • Drug information services are still insufficient
Meal management system	• Calculation of calories • Diet management • Management of meals in number • Management of materials for meals	• Meals are served by manpower • Meals are cooked by manpower
Clerical and hospital management system	• Registration of patients • Information processing as to clerical work such as patient's accounting and hospital fees and expenses billing • Stock control • Salary calculation, accounting, various statistics in the hospital	• Patients reception, accepting payments and issuing receipts are done by manpower in many hospitals

Table 3 Various Robots for Hospital Work

(1) Guide robot
(2) Receptionist robot
(3) Assistant robot for medical examination
(4) Robot for examinations
(5) Assistant robot for surgical operations and treatments
(6) Nurse robot
(7) Dispenser robot
(8) Robot for retrieval and storage of clinical records
(9) Robot for delivery
(10) Patient robot for medical practice training

TECHNOLOGY AND MEDICINE - THEIR EQUILIBRIUM RELATIONSHIP -

Kageyu Noro
Professor, University of Occupational and Environmental Health

1. Necessity of Medical Support in Technological Development

It was evident that tenosynovitis and irvico-onobrachial syndrome that marked high incidences at the beginning of 1970's were caused by data input equipment to computer and cash registers (Fig. 1) that began to become popular in those days.

The key that was used in the data input equipment in the non-enclosed type mechanical switch that produces ON/OFF signal by mechanical contact. The force required to press that key top with the finger was 800g for ten key and 1.1kg for transaction key. However at about the same time (1968), a new type key was developed. This was also operated by mechanical contact, but the contact was enclosed in the gas tube with insert gas. The pressing force for the contact shall reduce substantially as a pair of lead type magnetic pieces open and close due to the strength of the magnetic field of permanent magnet. The pressing force was approximately 100g ± 25g at that time, although it depends on the type of the equipment, and approximately 60 ± 25g for the recent products. This difference is substantial for the finger, and this improvement had quite a large impact on the reduction of the invico-ono-branchial syndrome.

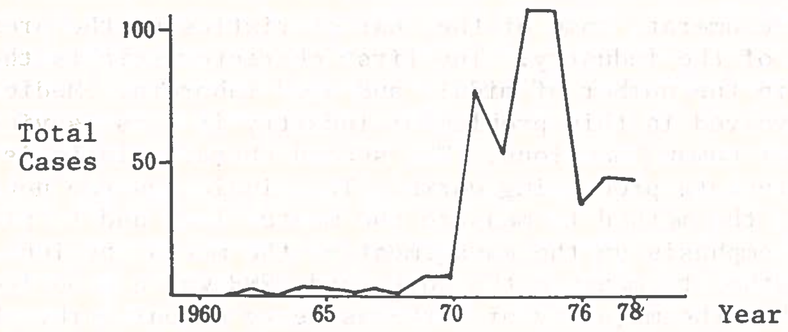

Fig. 1 Total Cases of Telegraphers' and Writers' Cramp

The same can be said for the relationship between chain saw and Vibration Syndrome. Today, the development of remote controlled chain saw is under way, which can be regarded as the most decisive measure for cutting the link between the job and disease. These examples, if not all, indicate the possibility of technology inducing disease and technology exterminating desease. This shows the difficulty in solving problems only by medicine and at the same time, it is necessary for engineers to fully understand the aforesaid indication. However, it is impossible to only depend on the engineering, in the present day science which is leading towards detailed fractionation. We must expect on the influence of the medicine. In more detail, this means that presentation of medical criteria is necessary for the engineering design. However, this is never an easy task in the present medical education system. This is because traditionally, medicine directly or indirectly, is regarded to be accumulation of knowledge and skill for treatment. When expressed in engineering terms, it is a technology for repair, and not for design. The necessity for medical support in engineering can be summarized as follows;

- Introduction of knowledge on structure of organism for the development of engineering.
- Consideration for man can easily be forgotten within the sole framework of engineering. Systems in the future society, regardless of the scale, will be strange to us in many cases. Therefore medical criteria is necessary for introducing these systems.

This system in engineering is called "engineering medicine". It is regret not to explain here what is engineering medicine (EM) because the space is not sufficient. However, one thing that must be pointed out here is that EM requires to change the traditional medicine for treatment to preventative medicine, and to predictive medicine.

2. Actual Example of Medical Support to the Industry

Let me enumerate some of the characteristics of the present situation of the industry. The first characteristic is the increase in the number of middle and aged laborers. Medicine can be involved in this problem of industry if this is viewed as aging of human functions. The second characteristic is the increase in data processing works. This indicates the necessity to enhance the method to measure the mental load and to place preponderant emphasis on the management of the mental hygiene. As for the method to measure the work load, RMR was a good index in the age when the majority of work was heavy manual work. However in the present industry, there is little significance in measuring the work load, due to the very small energy consumption as represented in data processing work and to the characteristic of the work. Furthermore, in accordance with the diversification of the work in the future, we shall be forced to adopt more than one method to measure the load. If medicine cannot cope with these changes, it will be left behind from the progress of the industry.

The third characteristic of the industry today is the mass introduction of the robots. How should we understand this phenomenon. In our intuition, this phenomenon is thought to force substantial reformation to the doctrine and method of medicine that

have been fostered in the process of long history. In the present age in which bloodless man, robot is developed to replace the role of the man in the industry, not only the medicine or methodology of doctors will become absolutely unnecessary, but it will also present antithesis to the fundamental role of medicine. Nothing shows the limit of viewing industry from medicine as clearly as this. It may be logical to say that there is no need for the medicine to deal with the robot as it is not a man. However as robots have intervened into man's role in the industry, the problem related to robots are problem of man, and at the same time that of medicine's.

Above three characteristics that I have noted as they came into my mind were never discussed except by some futurists ten or twenty years ago.

Thus, to consider what problems we will face in the future is important for deciding what knowledge and skill medicine should acquire in the future and what medical students should study after graduation. This issue belongs to the category of predictive medicine as predictions must be made to the future relationship between industry, medicine and medical care.

3. Proposals for Research on Robot Medicine

Conventionally, there is an idea that robots should replace only heavy and harmful duties among those works that man performs. However in actuality, it is not rare that robots replace those works that man wants to perform himself. The researches that must be promoted in order to establish better man-robot relationship must be undertaken by specialists of both technology and medicine in cooperation with each other. Robot medicine described as above is included in a part of engineering medicine.

Research on the robot medicine consists of following five themes,

(1) Diffuse of robots and changes in industrial ecology

The recent changes in industrial structure that accompanies innovation change not only social and life environment, but also disease structure. The robot is rapidly diffusing into recent industry and disease structure created as a result of changes in the industrial structure shall be clarified.

(2) History of changes in robot and occupation and predictions for the future.

In recent years, there is a rapid penetration of robots into industry, substantially reforming the industrial environment. The actual process of this industrial revolution shall be investigated and future industrial environment shall be predicted.

(3) Expansion of occupational field for resources of older age or with high educational background due to the introduction of robots

Man's work is largely revised in the job site where robot and man coexist. There is a shift towards light work, knowledge intensive work, planning and programming. This indicates the gradual improvement of job site so that aged employees and those with high educational background with abundant knowledge and experience can make most of their ability. In order to expand the occupational field of older age or with high educational background, research and development shall be made including designing of job environement that employs robots.

(4) Robot and safety
1 Physical safety - hardware -
2 Mental safety - software -

The recent introduction of robots in industry naturally formed a production system in which man and robot coexist. The aspects that must be solved for the coexistance of the two in the same environment shall be systematically identified by dividing the problems into physical aspects that included safety of the machine and mental aspects that include psychological problems. Furthermore job allocation in the job site between man and robot shall be considered.

(5) Prediction and design for a society where robot and man coexist
- Design for work and leisure -

In the case of robot, importance is placed upon software together with hardware, making it very diversified in its character. By the symbiosis with robot, man will be able to develop his own personality and be engaged in creative job and leisure. The conditions for the symbiosis of the robot and man shall be clarified and accommodated in the job and leisure plans in order to investigate how industry should be and to avoid disease.

"MEDICAL TECHNOLOGY, ESPECIALLY MEDICAL INSTRUCTION TECHNOLOGY AND ROBOTIZATION"

Yasuhisa Sakurai
Professor, Tokyo Women's Medical College

1. Medical Technology

As the society grows aged, promotes health insurance medicare and becomes more welfare oriented, needs for medical services will be expanding in terms of volume and quality.

This is indeed a historically inevitable result in the human society of science, technology and civilization. Medical services can be classified in the maintenance and promotion of health, prevention and timely detection, diagnosis and treatment of diseases, maintenance of adult and chronic diseases, post-therapy rehabilitation and auxiliary treatment of functional disorders. Along with these moves, medical services have been extended to cover the people as a whole.

Conventionally, a doctor and a patient would sit face to face, with the doctor more or less performing medical diagnosis and treatment as though it had been a "subjective empirical and authoritative art." Along with a prominent progress in the peripheral science and technology, however, modern medical treatments are becoming increasingly science and technology oriented. More specifically, it is the medical engineering that supports the technological foundation of medical treatment and ushers in scientific and technological approaches. In providing medical service, conventional "ethical" approach is, needless to say, important, but at present, medical treatment cannot be dissociated from scientific and technological approaches.

Though functionally diversified, medical technology is primarily based on three main pillars; pharmacology, molecular biology and medical engineering (ME). (Fig. 1)

2. Medical Instruction Technology

In the course of medical education, it is indispensable to deal with this subject from a human engineering point of view, including review of mental problems and needs of human intercourses. At the same time, it is also essential to inspire medical professionals with a large store of knowledge and information efficiently and correctly and to develop their technical skill. Under the circumstances, in order to implement medical instruction efficiently in ways to meet the changing needs of the times, diverse medical engineering techniques and approaches must be introduced into the educational sector.

Table 1 enumerates various types of tools and apparatuses for medical instruction, including those under conceptual stage, most of which have been made available by the modern technological innovations in microelectronics. The authors have in the past successfully developed "robotized patients" designed for "live" teaching material as a substitute of human patients in order to facilitate practical training of emergency resuscitation, anesthetization, abnormal neuroreflex, etc. The medical instruction technology has a substantial growth potential as one of the key sectors in medical engineering.

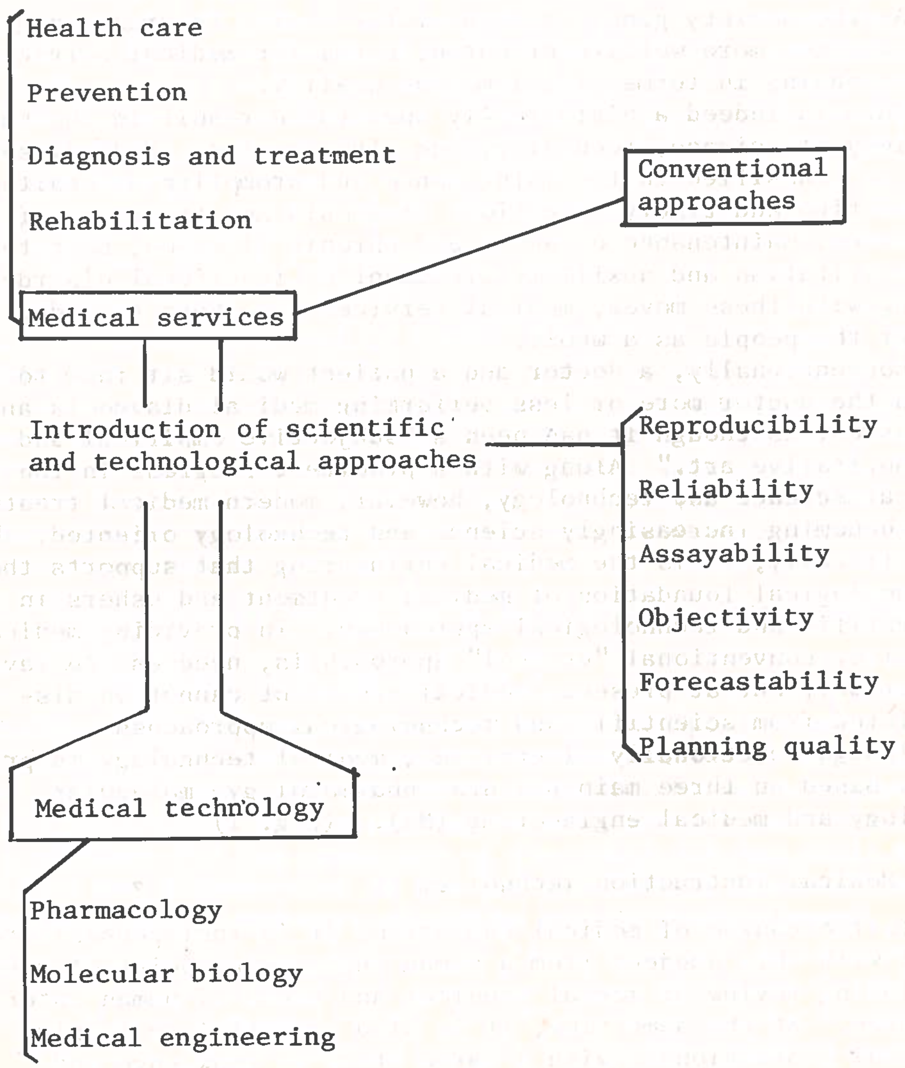

Fig. 1 Medical Technology and Treatment

3. Medical Robotization

Table 2 compares the robot with man. There is an ample possibility that the robots may be widespread in the medical welfare application (Table 3). Medical robotization is among key potential solutions to a number of problems involving massive increase in medical service demand, manpower requirements, needs for medical supplies and in operating costs.

Table 1 Medical Instruction Appratuses (Sakurai)

		intestinal irrigation and injection	
		For sterilizing practice	
		For dressing paractice	
		For artificial respiration and cardiac massage	
		For breast massage	
		For	
		For nursing practice	
		Joint function phantom	
Active function bio-simulator	Bioelectric simulator	ECG simulator	Displays bioactivities in active mode Displays various types of electrocardiograms
		Arrhythmia and ventricular defibrillator	Designed for curing irregular pulse and ventricular defibrillation
		Other bioelectric simulators	Simulates electroencephalogram, electromyogram, nervous and myocardial excitation conduction
		Cutaneous ECG	Projection of electrocardiographic potential distribution on body surface
	Biodynamics simulator		Blood and respiratory flow visual model
	Biosound simulator	Cardiac sound simulator	Stethoscopic training on normal and abnormal heart sounds

Note: Not only actually applicable ones but author's ideal ones are included.

Table 1 Medical Instruction Appratuses (Sakurai)

Note: Not only actually applicable ones but author's ideal ones are included.

Major classification	Subdivision	Appratuses	Descriptions
Morphological phantom			Simple morphological models and solid figure representation
	Anatomical training models		Acquisition of medical knowledge by professionals and nonprofessionals
		Skeleton, muscle and organ models	Presentation of solid figures and structural demarcation by multicolor printing
		Otorhinolaryngological transparent plastic model	Three dimensional arrangement of acoustic meatus, inner ear and nasal meatus
		Vascular and neurodistribution models	
		Vascular and neurodominated sites models	
	Resin impregnated corpse model		Designed to familiarize medical professionals with anatomy
		Corpse	Resin-impregnated and sliced corpse tissue
		Carcass	
	Embryology instruction model		Three dimensional presentation of the process of growth and changes
		Fetus growth model	Process of fetal growth by month
	Pathology and bacteriology model		
		Dermatosis model	
		Bacterial, parasitic and pathohistological models	
Function Phantom			Passive, morphological and physical biosimulator
	Physical properties phantom		Various physical simulators
		For measurement of radiation quantity	Designed to determine in vivo dose distribution during radiotherapy
		For measurement of supersonic characteristics	Designed to identify supersonic characteristics during supersonic diagnosis and treatment
	Physical properties and cubic forms simulator		Used mainly for medical training and practices
		For gastric cleansing	
		For catheterisation, intestinal irrigation and injection	
		For sterilizing practice	
		For dressing paractice	
		For artificial respiration and cardiac massage	
		For breast massage	
		For	
		For nursing practice	
		Joint function phantom	
Active function biosimolator			Displays bioactivities in active mode
	Bioelectric simulator	ECG simulator	Displays various types of electrocardiograms
		Arrhythmia and ventricular defibrillator	Designed for curing irregular pulse and ventricular defibrillation
		Other bioelectric simulators	Simulates electroencephalogram, electromyogram, nervous and myocardial excitation conduction
		Cutaneous ECG	Projection of electrocardiographic potential distribution on body surface
	Biodynamics simulator		Blood and respiratory flow visual model
	Biosound simulator		
		Cardiac sound simulator	Stethoscopic training on normal and abnormal heart sounds

Major classification	Subdivision	Appratuses	Descriptions
		Breath sound simulator	Stethoscopic training on rhonchus
		Other biosound simulator	Intestinal and percussion sounds
Integrated intelligent biosimulator			Portable slide generator
	Computerized patient robot		Computerized patient robot modeled exactly after human body
		Emergency resuscitation training	Shows bioreactions in response to data input, i.e., artificial respiration, cardiac massage, injection, etc.
		Anesthetization practice	Robotized patient for anesthetic administration, maintenance and awakening practices
		Diagnostic practice on cardiac diseases	Robotized patient which generates heart sound, electrocardiogram and pulsation
		Atypical reflex training	Generates cutaneous or tendon reflex by applying oppression or percussion to body surface
	Logic simulator		Designed for imparting knowledge and theory, like CAI
		Simulators for various diseases	Standardized textbooks, and diversified and time-flexible simulator
		Metabolism trainer	Biochemical mechanism simulator
		Circulation analogue simulator	Dynamic simulator which identifies circulatory peripheral interrelations among blood pressure, blood flow, peripheral vascular resistance and capacitance.
	Simulator which prescribes treatment based on test results.	ECG-based diagnostic simulator	Helps doctors to diagnose patients, for example, in the intuitive location of myocardial lesions on a heart model using a lamp indicator upon entry of a desired ECG.
		X-ray based internal diagnostic simulator	Useful for diagnosis
CAI			Computer-aided instruction of knowledge and theory; useful for computerized teaching, performance evaluation and consultation.
	For education and training	Computer teacher	Can operate on the random access slide.
		Computer evaluator	Evaluates the effect of instruction and provides successful teaching.
	Computer doctor		Designed for medical consultation, and also useful for self-oral diagnosis
		Rehabilitation practice evaluator	Evaluates training performance, encouraging trainees with a praise in the case of good performance.
	Computer book		The textbook designed for supermini-computers
	L.L. CAI		Available for individual training
	Information eraser		Updates data on records, tape recorders, slides, autoslides, random access slides, overhead projectors, movies, TVs, VTRs and CATVs films.
Audio-video (AV) teaching aid	Main unit (AV)		
		Jukebox AV instructor	Desired buttons should be pressed for specific AV education.
		Hologram AV diagnoser	Three-dimensionally visible and mobile holograms
		Dermatosis diagnoser	Helps doctors determine diagnostic validity by means of AV findings
		X-ray image collator	
	Peripherals (AV)	Portable slide generator	
		FAX transmitter	

Major classification	Subdivision	Appratuses	Descriptions
Remote con-trolled instruction	Remote AV transmission	Picture-phone transmit-ter TV-phone transmitter Phone transmitter	Mainly useful for general medical educa-tion and for medical services in outlying districts and at private homes.

Table 2 Advantages and Disadvantages of the Robot
(by Masato Sakurai)

	Good points	Shortcomings
Character	Diligent, ardent, and not lazy.	Tacit and obstinate
	Indifferent to others and obstinate.	Cannot work at its own discretion.
	Does not get tired of repeated operations.	Gloomy impression.
	Not sales-oriented (vending machines).	Not tactful.
Ability	Capable of performing consecutive (simple) operations.	Not creative
	Never forgets what it has once learned (checks and inspections).	No more than imitative.
	Size and form can be optimized.	Not intuitive or perceptive.
	Powerful for delivery of materials and equipment.	Not self-developmental.
	Does not hesitate at hazardous operations.	Not easily available for multifunctional operations.
	Does not get exhausted with consecutive work.	Devoid of flexible, pliant movements.
	Operates accurately as in clerical job processing, drawing, etc.	Stereotyped.
	Tough under heavy, rigorous working conditions.	Cannot adapt itself to environmental needs.
		Cannot make progress on its own.
Ecology	Unnecessary to accommodate meals, bath and toilet.	Cannot produce offsprings.
	Devoid of metabolism and growth.	Has no second life (no afterlife).
	Does not get caught with infectious diseases.	No hobby.
	Free of physical exhaustion or degeneration.	

	Good points	Shortcomings
During operation	Does not need to pay salaries or wages. Demands neither wage hike nor betterment of labor conditions. Does not advocate for "human rights" in performance of filthy work. Performs risky, hazardous job with ease. Does not resort to labor strike. No welfare or pension schemes is required. Industrious (guard man). No emotional frictions with fellow workers.	Does not get enthusiastic with job. Needs maintenance and care. Performs only what it has been directed to.

* Robotization can be optimized for the parenthesized types of works.

Table 3 Robots for Medical and Welfare Applications

Artificial blindman's dog (Bureau of Industrial Technology, MITI)

Nursing of the physically handicapped (Bureau of Industrial Technology, MITI)

Assisting the seriously handicapped in daily living (Engineering Dept., Tokyo University)

Rehabilitation training aids

Braille translation

Character reading and vocalizing

Conversion of voice to hand conversation

Pharmaceuticals preparation

Diagnostic support

Operational support

Self-care support

Cleaning of medical institutions

Delivery of materials and equipment in medical institutions

Disposition of night soils

Table 3 Robots for Medical and Welfare Applications (continued)

Reception of patients

Computerized patient robot (Tokyo Women's Medical College)

Now, time is mature for positive undertaking of introducing the robotization technology into the medical sector.

E4

THE NEW CONCEPT "BIOMATION" - FROM MECHANICAL TO SPIRITUAL CIVILIZATION -

Kazuhiko Atsumi
Professor, University of Tokyo

The steam engine invented by T. Newcomen in 1912 was an epocal landmark which allowed the mechanics to substitute for human beings in heavy works. Needless to mention, this invention triggered the Industrial Revolution later. The railways and automobiles, subsequently invented, contributed to the transportation of men and commodities. The advent of telegraph and telegram likewise lead to the development of communication in place of traditional modes of communication function for human beings.

The twentieth century saw such inventions as radio, xerography and tape recorder. These devices came to replace men in the areas of public notification and transcription. The emergence of computer, furthermore, meant that the computer would, and actually did, supersede men's computation power both in its speediness and accuracy.

The recent progress in computer area has lead to the developments represented by audio response, character recognition or voice recognition, all of whose units have been on the successful path to the replacement of men's five sensory functions in speaking, reading and hearing. The learning function, presently under the development process, will possibly duplicate men's experience in the near future. There have been ideas in fact that even men's creativity, the most prerogative facet of human beings, might be superseded by machines in the future.

The possibility described immediately above can be said to constitute the basic task the information science bears for the future.

In any case, mechanical civilization nowadays seems to have almost climbed up to its peak. It is no exaggeration by any means to say this modern civilization is distinctly characterized by automation backed up by information technology. Almost all machines and apparatuses in the possession of men are now automated. The scope of automation broadly covers from production to cultural activities including automations of production process, transportation and communication, commerce and banking, office and various types of services, and education and/or home. One may be easily convinced from these facts why the present age is labelled as information society.

On the other hand, this surge of automation has brought upon some adverse effects. They have been taken up as shady side against sunlight. This shady side consists of such social problems as uniformity, human alieanation and controlled society.

The technology ought to have been developed to the benefits of people. The fact it brought drawbacks discloses that the technology was not perfect yet thus still in the immatured stage.

The computer should never be reckoned as perfect where the huge

vacuum table occupies every single corner of the room and makes disturbingly noisy computation. The computer, however can be compacted to ultra-small size, placed in tiny corner of the room or built inside the wall, and compute in noiseless manner. Nobody can perceive even the computer is there. This must be exactly the level where the computer technology is deemed to have reached maturity.

Isn't the present automation technology still immatured?

In order to allow this automation technology to survive as top technology for next generation, sophisticated functions on organism performs have to be interbred with the technology.

The smallest unit of an organism is cells. Even inside the small cell whose diameter is only several microns, the marvelous life mechanism is contained compactly. The cells sense ever-changing external environments, adapt flexibly themselves to those changes, metabolize, grow and proliferate as they retain their internal environments constant (homeostasis). Built inside the delicate space, cells, are such diverse and sophisticated functions.

The biomation can be defined nothing but as a hybrid of man-made technology "Automation" and naturally made masterpiece "Organism".

The human society will grow into a new sphere of spiritual civilization when this biomation technology is developed and applied.

During this process, the new technologies such as "humanization of robots", "software development for pattern recognition and cerebral thinking," "completely duplicated artificial organs" and "cyborg" will be pursued thereby render upon completion boundless benefits to human beings.

The biomation in some sense directs itself to the simulation of organism and even to the simulation of men.

To contemplate simulating men and build the model of men will necessarily follow the quest for the ever-lasting proposition: "What is a man?"

As the methods pertaining to how to macroscopically approach men is gradually identified, there lies possibility that the path to elucidation of such questions as "disparity between men and other beings" "intrinsic nature of men" "how men should be" and "raison d'être of men" might open up.

WORKSHOP F

"The Energy Industry and Safety"

F1:

Yoji UMETANI
(Professor, Tokyo Institute of Technology)

F2: "Ergonomics and Safety in the Generation, Distribution, and Use of Electrical Power"

Richard G. PEARSON
(Professor, North Carolina State University)

F3: "Remotely-Operated Equipment for Field Inspection and Maintenance Work, and Advanced Centralized Monitoring and Control System: Their Development and Use"

Tsuneo IWATA
(Kansai Electric Power Inc.)

F2

ERGONOMICS AND SAFETY IN THE GENERATION, DISTRIBUTION, AND USE OF ELECTRICAL POWER

Richard G. Pearson
Professor, North Carolina State University

The era of microelectronics, information technology, and telecommunications is bringing vast changes to industrial and business operations as well as to our private lives. Within industrialized countries we are seeing the advent of computer aided manufacturing, automatic process control, and robots; within the office we see increasingly sophisticated machinery -- VDT's, small business computers, and copying machines. And, in the United States, we are witnessing a rapid explosion within the home of personal computers and video games based upon micro-processor technology.

These rapid developments pose problems for the field service engineer and maintenance personnel who must deal with new designs, installations, and modes of operation. As Meister has observed, in the next two decades the increasing sophistication of computer systems and artificial intelligence will lead to even more complex human-machine systems that will be increasingly more difficult to maintain.

This paper will discuss some of the emerging evidence relative to the electrical hazards and safety problems associated with these technologies, with emphasis on maintenance practice and maintainability design.

The safe generation of power is, of course, a concern to all of us. With regard to the operation of nuclear power plants, for example, industry is at that point where it is changing from a traditional process control approach toward one which involves newer computer-based display and control technology. Currently, industry thru research and development is focusing its efforts on the area of control room operations involving such topics as panel backfits (thru paint, label, and tape), CRT displays of safety parameters for transient detection, diagnostic decision aids, reactor operator selection and training, emergency operating procedures, human reliability, and simulator development. The area of maintainability has been relatively neglected so far in terms of priority, but attention is shifting. In the next few years, hopefully, maintainability will receive greater attention. The reliability of alarms and annunicators must be ensured thru better maintainability design. The maintenance of hardware and software involved in the computerized operator procedures now under development will be critical to effective plant operations. New job performance aids will need to be developed for maintenance tasks. Ultimately we shall see computer-based aids for diagnostic decision-making by maintenance personnel, such as involved in symptom analysis.

The power delivery area, involving high voltages, is a challenging topic for the ergonomist concerned with the safety of field installation and maintenance personnel. As one example, there is the problem of contact between cranes or tunneling equipment with high voltage lines. Proximity sensors are a recent adjunct to traditional safety devices used in such tasks, but a problem occurs with the failure of associated visual and auditory warning devices to attract the attention of the worker. At the industrial plant the non-uniform physical configurations involved in electrical power source cabinets and enclosures among different models of the same equipment often leads to maintenance errors, accidents and injuries, and equipment damage and loss. In one accident case reviewed by the author there was a change of circuit breaker location in a new model enclosure (as compared to older models); the line and bus terminal sides were reversed, leading to a service engineer's error and serious electrical shock. The safety concerns of service departments are, it appears, not commonly heeded by the original-equipment designers. A dialogue needs to exist between these two groups so that greater emphasis is given to maintainability design involving ergonomic concepts in order to reduce human error potential.

At the user-operator-cunsumer level the task of the service engineer is changing. One may recall earlier days of mechanical typewriters and adding machines. Today we have more electronics at the office and industrial workplace, with their associated voltage hazards. In short, there is a convergence between the two types of service, electrical and mechanical, that we once encountered. The power delivery specialist must, on occation, deal with relaticely small, "low voltage" power sources, and so must the office equipment repairman. Typically the training of these personnel, and their job performance aids, are lacking with regard to these new tasks. Such shortcomings were documented in an interview survey of 100 service engineers directed by the author.

The survey indicated a concern on the part of these personnel about being hurt or killed at tasks where their training and safety manual guidance (which emphasized power delivery and high voltage) were irrelevant. Overall they felt the corporate safety program was not designed for them. They noted that smaller, less expensive components changed in their design more frequently, yet in their job they might not encouter a particular model only once every one or two years. In working with CRT's high voltages can be encountered, yet many of these engineers felt they lacked the proper training and equipment to work safely. Often the job was complicated by the fact that information concerning CRT high voltage supplied by the vendor at the time of delivery was later lost by the customer.

With increased automation and microtechnology there have been efforts to involve the worker in equipment maintenance. While positive benefits may be realized by this approach to job enlargement and to reducing production-line boredom, the safety consequences can be of concern unless effective maintenance and

safety training are involved. A recent news release by the International Labour Organization observes that Japan has taken the lead here in training their industrial workers and equipment suppliers to deal with the problems of adapting its workforce to the microelectronics area.

As computers become smaller and more portable we face the desire of many users to install and service their own components. The same is true for home "personal" computers and their video-game counterparts. Already there is evidence of traumatic injury to individuals involving this new form of consumer products. To deal with the user installation and service of its products one computer manufacturer is now conducting research on software packages that would guide the buyer in safe self-maintenance of his or her purchase.

Finally, and apart from the maintainability design considerations noted above, the ergonomics approach needs to consider the risktaking "personality" of the service engineer. The survey mentioned above noted several example: working on "hot" equipment by defeating interlocks and not de-energizing; taking short-cuts, skipping procedures, substituting and improvising tools and test equipment; inadequate job coordination with others; sloppy work practices. The reasons for such practices are clear: the service engineer is under pressure to get the job done quickly, either from customer pressure or from self-imposed pressure, i.e. to get "home" at a reasonable hour. Under such conditions the individual may fail to recognize that he or she is an unsafe component of the system, whether from pressure or overwork. There is growing evidence of a risk-taking personality -- a correlation between accident potential and such dimensions as impulsivity, neuroticism, and sensation-seeking. Ultimately we shall have to address this factor also for the safety of those who maintain our human-machine systems.

F3

"REMOTELY-OPERATED EQUIPMENT FOR FIELD INSPECTION AND MAINTENANCE WORK, AND ADVANCED CENTRALIZED MONITORING AND CONTROL SYSTEM: THEIR DEVELOPMENT AND USE"

Tsuneo Iwata
The Kansai Electric Power Company, Incorporated

1. The development program of nuclear power generation in Japan specifies 46 million kW and 90 million kW respectively in 1990 and 2000, heralding the era of 50 to 100 units from the present level of 24 units or 17.17 million kW capacity. In order to facilitate this development, betterment of the level of nuclear power safety and reliability is sought after.

Each phase of design, construction, operation and maintenance shares the important role in its own way in upgrading the level of nuclear power safety and reliability. The importance of operation and maintenance resides in confirming, maintaining and embodying the quality incorporated with the expectation at the time of design and construction.

Hereunder describes the development and utilization of remotely-operated equipment for field inspection and maintenance work under high-radiation environments of nuclear power plants to delineate how robots and computers are put to practical use in maintenance and operation respectively. The experience thereof and the development trend of associated technologies in the Kansai Electric Power Company, Incorporated will be introduced as well. Seven units or 5.67 million kW are currently operated and two additional PWR units or 1.72 million kW are under construction in the company.

2. The soundness of equipment and facilities in nuclear power plant is checked via annual inspection and routine inspection. Those equipment and facilities are classified by priority in terms of plant safety, and the method and frequency of checks and maintenance works are specified into rules. Because of the workers' exposure to radiation accompanied in the maintenance work of the plant, a variety of measures, including application of robots, have been implemented in an attempt to reduce the level of radiation exposure.

High radiation environment is particularly distinct inside the reactor pressure vessel and steam generator channel head. Human access to those areas is impossible or strictly restrained.

Remotely-operated equipment developed and already in service range from steam generator eddy current test equipment and pressure vessel ultrasonic test equipment for maintenance purposes, spent fuel inspection equipment and pipe ultrasonic test equipment for remotely-operated field inspection, steam generator channel head manipulator and pressurized vessel heater replacement equipment for remotely-controlled operation, to steam generator channel head decontaminating equipment as remotely-operated decontamination.

The remotely-operated equipment thus far have been in great demand, as they serve under high radiation environments and constitute critical paths in annual inspection processes which require long time to complete. Their effects have been clearly demonstrated at the same time. Those equipment were introduced as the improved devices in the improved and standardized plant, thus appreciably contribute to reductions of total radiation exposure doses and of the time requirement for annual inspection.

(Note) The improved and standardized plant is a plant under Improvement and Standardization Program, which was initiated in 1975 jointly by public and private sectors in order to improve reliability and operation rate of LWR and reduce workers' exposure level by voluntarily developed technologies.

3. As for nuclear power plant operation, the centralized monitoring and control system is applied from the central control room.

The control of reactor system can be categorized into such three levels to build defense in depth for plant safety as regular remotely-operated control by reactor control system, automatic safe shutdown by reactor protection system in case an excessive external disturbance should occur and automatic actuation of engineered safeguards system to prevent accident from escalation.

For plant control, automatic load-following operation system where reactor output follows turbine generator loading during output operation is employed.

(Note) Presently left for manipulation are plant startup and shutdown as well as intermittent operations of the auxiliary system.

As described above, nuclear power plants rely on automatic controls in principle in terms of both plant safety and control. However how to take recovery actions when instrument and control system and/or equipment system breaks down, as well as resetting operation after reactor trip and the actuation of engineered safeguards system are still remained in the realm of manual control and manipulation. The operator is in particular is expected to detect and correct abnormalities before the reactor trips when instrument and control system fails.

In the above case, the plant is grasped in the framework of man-machine system and the operator is positioned as feedback element in the system, thereby the latter is expected to not only maintain safety but also judge and manipulate the phenomenum outside the automatic control coverage in order to avert unnecessary reactor trips.

The central control panel as plant monitoring and control system has grown in size, complicated monitoring, judgement and manipulation works, and augmented the operator's workload. Mounted on the panel at present are approximately 400 units of indicators and recorders, some 600 annunciators, and approximately 500 units of controllers and manipulation switches. Encountering the abnormality or abnormal occurrence, two to three operators would have to face a number of rapidly charging parameters via indicators and annunciators. The operators in this case will be specifically anticipated to deduce causes from the event he is facing, project future sequential development, determine and implement measures to be taken.

In view of the maintenance of safety and reliability, judgement and manipulation by operator is likely to render both negative and positive contributions in any circumstances.

Here then come the questions of what pieces of plant information, and what kind of training and operation manuals should be given to the operators.

The accident in TMI-2 in 1979 was bound to seriously raise the issue of man-machine interface. The investigations, subsequently made, disclosed that improper manipulations (human errors) had contributed negatively to the development of the accident, recommended actions be taken in the areas of the control room design, operation manuals and operator's training, and further suggested the improvement of man-machine interface. The lessons from TMI-2 accident were learned in modest posture in Japan as well to initiate the improvement of man-machine interface in systematic manner. Wide-ranging measures, properly sorted out into short-term objectives and long-term developments, were immediately executed.

The centralized monitoring and control system of improved monitoring and operating capability, making use of color CRT, computer-based information display technology and ergonomic design, have been developed and part of its development efforts are already reflected at the plants in operation.

The central control room in the existing plant is equipped with additional two CRTs for monitoring so as to digest information obtained from the existing large-scale central control panel. Meanwhile in the plants under construction, monitoring function regardless of normal or abnormal operations is upgraded by the introduction of six to eight CRTs and two or more large computers.

The development of advanced centralized monitoring and control system has been directed so as to digest information for operators' easy understanding of the abnormal occurrence or abnormality going on at the site, and to furnish the operator with systematic and hierarchical display of all the relevant information with an ultimate aim of reducing the operator's workload and upgrading reliability in his judgement and manipulation.

The plant operators jointly took part in each stage of development to make consultation and suggestion for any improvement.

4. The MITI-sponsored project called "Development of Nuclear Power Generation Supporting System" offers good reference pertaining to the future direction of development for robots and centralized monitoring and control system in nuclear power industry.

This project purports to reductions of the operators' or maintenance workers' workloads and of damages incurred out of abnormal occurrences and abnormalities. The project holds the following two as its themes, and will be completed in 1984.

1 "Instruction System"

This system provides the operator with the overall information at the time of plant startup and shutdown or during operation, and guides the operator when manipulation is required. The system diagnoses the phenomenon or existing conditions which are liable to develop into abnormality or abnormal occurrence, and supplies plant information and manipulation guide on the basis of the results thereof.

2 "Automatic Monitoring System Inside Containment Vessel"

This automatic monitoring system runs on the rail or floor surface inside the containment vessel, and detect conditions of individual instrument.

The developments of robots capable of travelling, abnormality diagnosis and manipulation, and of its application system inside the containment vessel will open up a new horizen for the maintenance robot system.

As a future target of the development of centralized monitoring and control system, its supporting function to the operator in case of abnormality or abnormal occurrence has to be improved and strengthened. "Instruction System", once developed, will raise the level of and broaden the scope of expectations directed to the operator's judgement and manipulation.

The demand for upgraded nuclear power plant and safety has a trend to swell the workloads in operation and maintenance. Design works for high reliability and good maintainability are needless to mention being attempted to this end, and moreover, the efforts are bent to improve man-machine interface, or robots and computers in man-machine systems.

We extend
our heartfelt thanks to the following
organizations for their support given to a success of
Osaka Symposium.

The Science Council of Japan

Kansai Electric Power Co., Incorporated.
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Hakuju Institute for Health Science Co., Ltd.

(As of July 31, 1982)

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THE JAPAN INDUSTRIAL ROBOT ASSOCIATION

was established in 1971 to meet the requirements of industrial circles for automation, labor-saving, and industrial safety. JIRA aims to promote technological development, diffusion of industrial robots, and international exchange of technology. JIRA was the sponsor of THE 11TH INTERNATIONAL SYMPOSIUM ON INDUSTRIAL ROBOTS and THE INTERNATIONAL EXHIBITION OF INDUSTRIAL ROBOTS in 1981.

Recent JIRA publications:

- Proceedings of the 11th International Symposium on Industrial Robots..... $100.00 (Seamail)
  $130.00 (Airmail)

  Distributors: Society of Manufacturing Engineers – U.S.A.
  IFS (Publications) Ltd. – Europe
  Fuji Corporation – Rest of the world

- The Specification and Applications of Industrial Robots in Japan..... $ 90.00 (Seamail)
  $110.00 (Airmail)

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THE ROBOTICS INDUSTRY OF JAPAN

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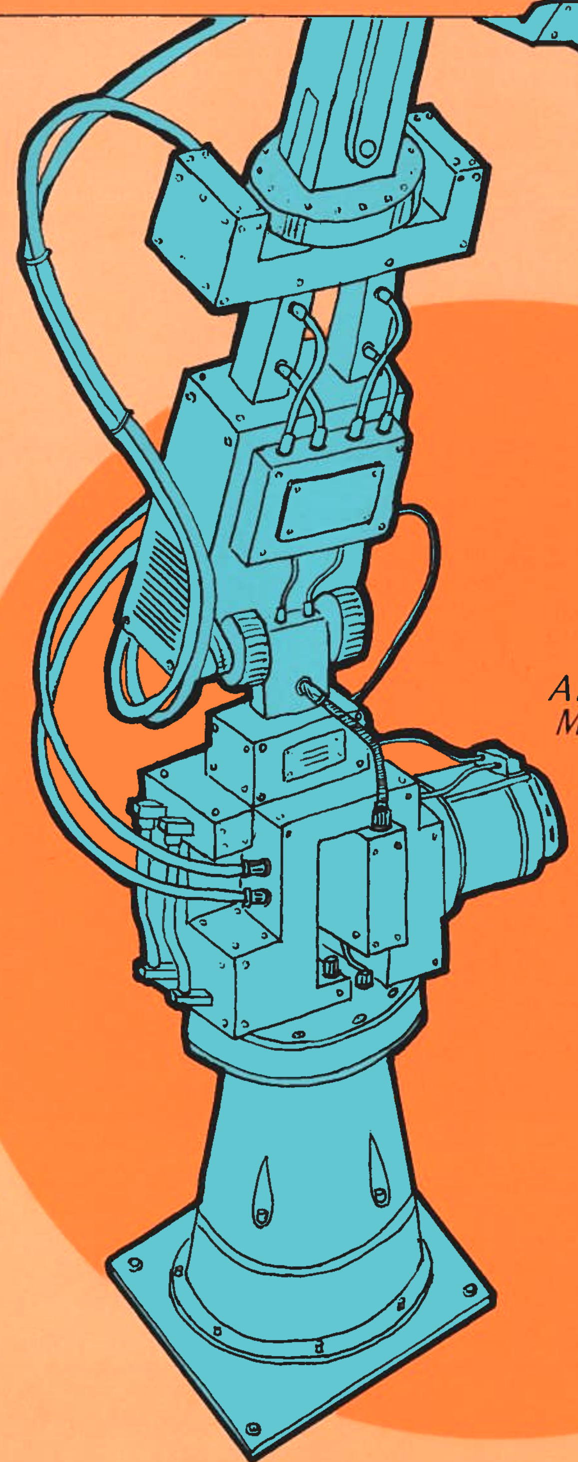

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THE JAPAN INDUSTRIAL ROBOT ASSOCIATION

AN IN-DEPTH Report Covering Both Manufacturing & Non-Manufacturing Industrial Sectors

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THE ROBOTICS INDUSTRY OF JAPAN

The advancement of industrial robots will affect all industries, both economically and socially. It has already brought many changes in the manufacturing sector in such areas as productivity improvement, prevention of occupational hazards, and conservation of resources. With the development of intelligent robots capable of more complex functions, robots will gradually replace men employed in hazardous and/or harsh working environments.

Robot production in 1980 alone numbered 199,000 units representing a $340 million investment. Currently most robots are employed in the manufacturing sector, but as the technology advances, their application will broaden to include the non-manufacturing sector as well, such as agriculture, forestry, construction, marine development, medical/ social welfare, and nuclear based industries. This will further accelerate production; it is forecast that production in 1985 will be $1,260 million and soar to $2,560 million in 1990. There is no doubt that the 1980s will be the era of popularization of industrial robots.

This report, based on more than 1,200 questionnaires and on-site interviews, covers such subjects as manufacturing and sales conditions, R&D activities, long-range forecasts, and actual use of robots. For both manufacturers and present and prospective users of industrial robots, this report is an indespensable guide to the current and future trends in the country leading the rest of the world in robotics.

Robot Literature

The following is a list of publications on industrial robots published in Japan during 1981 & 1982. (E) indicates those in English.

Books

"Challenge for the Robot Technique – Toward the production revolution –", by Genichiro Kinoshita, pub. by Kogyo Chosakai, Feb. 1982, 294pp., ¥1,700.

To deepen the R&D of the robot technique, it is necessary to study natural and social sciences covering a wide field. Intending to explain the robot technique from various aspects, the author relates robot senses, such as sight, hearing and tactual sense, robot languages, robot intelligence, robot mechanism, arms and so on.

"Illustrated Robot Hands", ed. and written by Ichiro Kato, pub. by Kogyo Chosakai, Dec. 1981, 172pp., ¥2,200.

This book succeeding "Illustrated Mechanical Hands" explains designs of 86 robot hands and fingers designed or for which recently patents have been applied for. Each of 86 robot hands is explained concisely with some distinct illustrations.

"Robot Revolution" ed. by Nikkei Mechanical, pub. by Nihon Keizai Shimbun, Nov. 1981, 222pp., ¥980.

Explaining the present states of the so-called production revolution caused recently by robots, CAD and FMS(CAM), the authors intend to point out the road from the "fleximation" (the flexible automation) to the robotical automation, collecting materials from production sites.

"Robots in the Japanese Economy", ed. by K. Sadamoto, pub. by Survey Japan,Oct. 1981, 266pp., ¥15,000, $65. (E)

The first book ever written in English on robotics in Japan. This book gives full details of Japanese robots and their economic significance, with a list of industrial robot manufacturers in Japan.

"Specifications and Applications of Industrial Robots in Japan, 1982", ed. and pub. by Japan Industrial Robot Association, Oct. 1981, 454pp., ¥15,000. (E)

"The Practical Manual of Industrial Robots", ed. by K. Uzawa, pub. by Shingijutsu Kaihatsu Center, Oct. 1980, 688pp., ¥42,000.

This large book publishes concretely systems engineering by employment of industrial robots, with catalogues of domestic and foreign industrial robots.

"Industrial Robot – The New Production Revolution Started–" Ed. by Nikkei Sangyo Shinbun, pub. by Nihon Keizai Shimbun, Oct. 1981,110pp., ¥2,000.

This documentaly book written by front line newsmen reports scenes in factories where IR's or NC machine tools are working and the prospects of unmanned factories, the so-called FMF (flexible manufacturing factories) with outlines of makers of industrial robots and their allied machines.

"The Forefront of the Robot Industry", by Takeshi Iwasaki, pub. by Shijo Shinbunsha, Oct. 1981, 280pp., ¥1,300.

The author aims to offer a simple explanation of industrial robots and their social roles and to disclose the secrets and problems of the Japanese robot industry.

"Industrial Robot", ed. and pub. by Kogyo Chosakai, Oct. 1981, 210pp., ¥1,700.

This handbook compiled by editorial staff of the 15 years old magazine "Kikai to Kogu" (Tool Engineer) contains introduction of new robots written by R&D staff of 32 Japanese robot makers such as Osakadenki, Kyowa Denki, Ohkuma Tekkojo, Ikegai Tekko, Okamura Seisakujo and so on.

Research Papers

- On the Development of Intelligent Robots.
  by M. Kakikura and S. Wakamatsu
  "Machine Design", Vol.25, No.12, pp.26~28, '81.
  (This October Number of "Machine Design" publishes more 10 articles explaining mechanisms of intelligent robots.)
- Software for Robots.
  by H. Suehiro et al.
  "Machine Design", Vol.25, No.12, pp.49~55, '81.
- On the Development and Introduction of Industrial Robots.
  by I. Tanaka
  "Industrial Efficiency", No.239, pp.7~14, '81.
- The Trend of Paint-Coating Robots.
  by T. Onoda
  "Auto Technique", Vol.35, No.7, pp.836~841, '81.
- NC Robots and their Peripheral Techniques.
  by S. Sato
  "Tool Engineer", Vol.25, No.8, pp.49~53, '81.
- Transfer Robot
  by H. Koga
  "Automation", Vol.26, No.11, pp.44~45, '81.
  (This October number of "Automation" publishes 37 articles explaining mechanisms of industrial robots such as UNIMAN 7500, NAS-ACE MAN-II, MHY-1700II, PUHA-1, etc.)
- The Mechanism of Robots.
  by O. Shimotsukasa
  "Oil Pressure Technique", Vol.20, No.9, pp.39~43, '81.
- The Application of the Pattern Recognition Technique to the Intelligent Robot.
  by M. Yachida
  "Automation", Vol.27, No.2, pp.16~29, '82.
  (This Feb. Number of "Automation" publishes more than 8 articles explaining Pattern Recognition Equipment which realize the Eyes of Intelligent Robots.)
- Automatic Tool-Exchange by Robots and Peripheral Techniques for Unmanned Factories.
  by T. Hurukawa et al.
  "Mechanical Engineering", Vol.30, No.3, pp.54~56, '82.
  (This March Number of "Mechanical Engineering" publishes 6 more articles explaining the introcution and the employment of robots in machining operations.)

The Japan Robot News

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FEBRUARY 1982 VOL. I/No. I

Major IR Makers Step Up Int'l Ties

There are strong indications that the world's leading industrial robot (IR) makers are making increasing efforts to strengthen their partnership in technology and distribution for greater mutual cooperation between companies in different countries. Observers note this is partly because IRs, unlike other export items, are in themselves, not readily exportable.

The period between the summer and end of the year, 1981, saw industrial robots almost monopolize conversation concerning Japanese industry, with the large-scale introduction of IRs into automobile and semi-conductor manufacturing plants.

With mass media following every bit of new information about robotics, it seems that not only manufacturing plants, but also the whole industry, or even society for that matter, be being washed by the waves of "revolution." An indication of this was the International IR Exhibition held at Tokyo's Harumi Fairgrounds in October, which attracted more than 330,000 spectators during its five-day period.

This robot fever apparently shows Japan as leading the world in both their production and use, and also no less important, that she ranks top-most among the advanced countries in robotic engineering and is capable of producing one innovation after another.

Events, symbolic in this context, were the tie-ups made to pass technology to US and European companies made by Hitachi, Fujitsu Fanuc and Mitsubishi Heavy Industries (MHI). This means that Japanese robotic technology, intially imported from Western countries, then improved for domestic use, is now being exported back to them.

In October 1981, Hitachi signed a seven-year contract to grant its high efficiency robot manufacturing technology to General Electric (GE). According to the contract, Hitachi will offer:

- All the patents and technology concerning its arc welding, painting and other robots,
- For the initial three to four years until GE's production system is put together, Hitachi will supply

(Continued on Page 7)

A Major Tie-up Listing

Major technological tie-ups between robot manufacturing companies are as follows:

Technology-offering firms	Technology-recipient firms
Unimation (US)	Kawasaki Heavy Industries (Japan)
Trallfa (Norway)	Kobe Steelworks (Japan)
Trallfa (Norway)	Devilbiss (US)
DEA (Italy)	Amada Engineering Service (Japan)
Hitachi (Japan)	General Electric (US)
Hitachi (Japan)	Automatics (US)
Fujitsu Fanuc (Japan)	The 600 Group (UK)
Mitsubishi Heavy Industries (Japan)	Voest-Alpine (Austria)

CONTENTS

Robot Patents Are Mainly Control Techniques

Since 1967 when the first industrial robot (IR) was imported into Japan from AMF, of the US, the development of IRs has been remarkable; in 1976 the number of IR related patents reached its first peak. (See Fig.1.)

According to Patent Office, applications of patents are classified and examined on the basis of IPC (the International Patent Classification), but there is no specific heading for IRs in the list. The only classification for IR's techniques in general, is item B25J under IPC: 'Manipulator". Nowhere in the full IPC list is found the word "robot." It will be some time before the word "robot" gets citizenship in words used for patent classification.

From 1975 through 1979, over 50% of patents opened relating IR's techniques were for their control. The transition in the number of patents opened follows a little different trend from that of utility model patents opened. (See Fig. 2 & 3.)

While gripping mechanisms account for a major part of the utility model patents, control techniques have gained momentum recently. This indicates that control techniques are now being applied not only to the main parts of robots but also to smaller parts and functions.

Till about 1977, nearly half IR patents were held by such large firms as Hitachi and Toshiba, but from 1978 through 1980 the number of applications for patents made by exclusive robot-makers increased sharply.

An outline of notable techniques which have been opened recently, is as follows:

- **Wrist Joint**
  Recently the number of patent applications for multi-joint robots has been increasing. Requiring complex calculations of coordinates to develop them, few patent applications were made till about 1976, but from 1979 through 1980 such patent applications increased remarkably outstripping those for cylindrical coordinates and polar coorinates robots. Due to their higher degree of freedom and easier operation, the introduction of multijoint robots is expected to grow much further.
- **Robothand**
  Applications for robothands are not only large in number but also great in variety. Most concern the opening and closing mechanism of grippers. One of them has come from IBM, and is equipped with a pressure sensor (the patent was opened in 1981, Patent No. 13598.).
- **Sensor-equipped Robot**
  The number of opened patent for sensor robots reached first peak in 1976. However, a major problem facing each company has being remained as the actual application. For this to be realized, it is important not only to increase the ability of a computer's storage and information-processing, but also to develop basic software.
- **Microcomputer-equipped Robot**
  It was in 1974 that the word microcomputer was used in patent literature for the first time in Japan. Now that microcomputer-equipped robots are performing not only subsidiary but also central roles, greater demand for significant development of software, of course, can be expected.

Fig. 1 The Transition in the Number of Opened patents & Utility Models

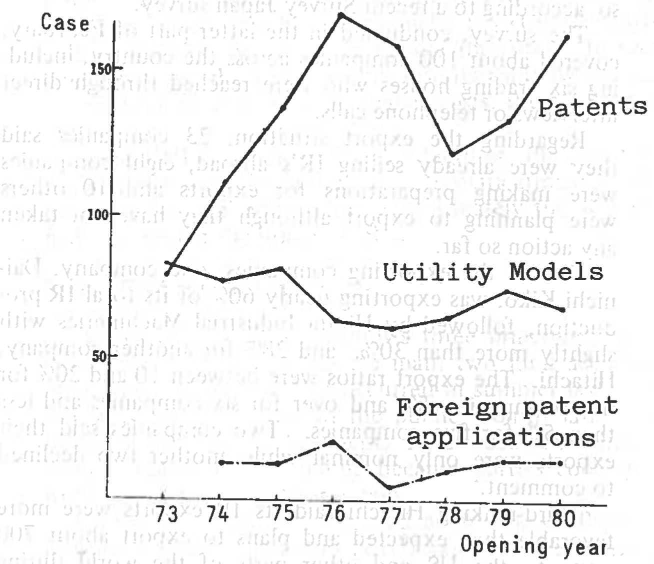


Fig. 2 The Transition in the Number of Patents by Techniques

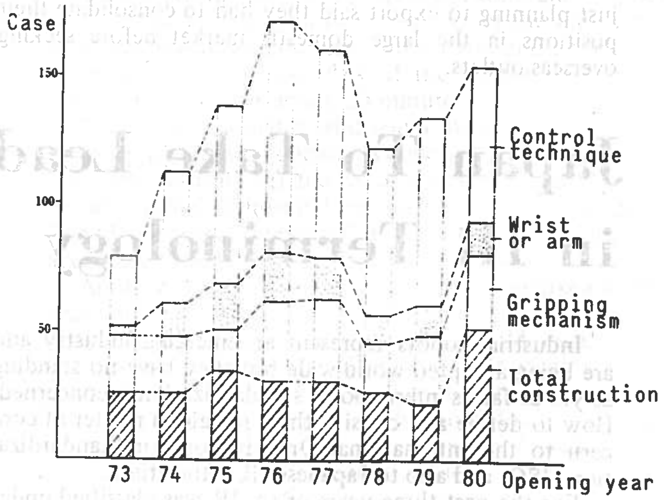
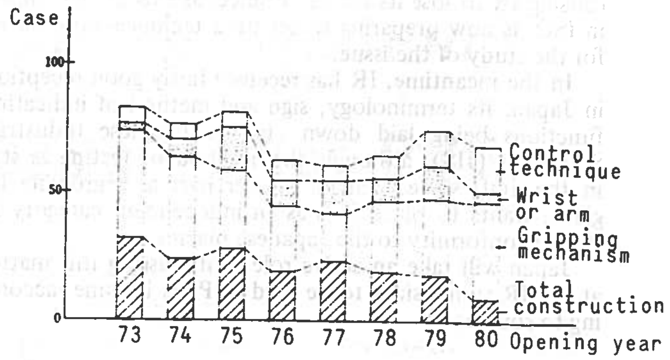


Fig. 3 The Transition in the Number of Utility Models by Techniques



In 80s-21% Demand Growth Expected

The demand for industrial robots (IR) in Japan's manufacturing industries will achieve an estimated 21% annual growth throughout the 1980s, recent forecasts indicate. This is valued at ¥290 billion in 1985, and ¥520 billion in 1990.

During this period, the demand for manual manipulators and fixed sequence robots, it is expected, will slow down, whereas that for high-grade robots, such as playback, NC robots and intelligent robots will enjoy rapid growth. An average 17% growth is forecast for playback robots and over 25% for NC and intelligent robots.

In the meantime, exports are expected to begin rising moderately because of increasing foreign users' interest in Japanese IRs. So far, IR exports have remained a low 3.2%, or the average, of domestic shipments over the past 5 years. This low percentage can be attributed partly, to the necessity of systems and applications engineering involved in IR exports.

Hitachi To Market Assembly Robots

Hitachi will commercialize its first assembly robots in spring next year. According to sources close to the company, three types of robot with microcomputers built-in to each control system will go on sale.

MITI Launches Committee To Study Robot Impacts

The Ministry of International Trade and Industry (MITI) has set up a committee to study the economic, social, technological and other impacts of industrial robots.

The Committee to Survey Trends of Industrial Robots, composed of 17 members, includes IR makers, users and scholars, and held its first meeting on February 15. It will compile a report on the results of its survey by January 1983.

A MITI spokesman predicted no series problems in employment would be caused by IR's for several years from now but expressed concern with the long range view, thus emphasizing the need for such a committee.

Budget for IR Survey

The Labor Ministry will also launch a research program to examine the impacts upon labor from technological innovations involving IR's, starting this fiscal year (April 1982).

Appropriations for this purpose, amounting to approximately ¥60 million, were approved in repeated negotiations between the ministry and the Finance Ministry.

ANNOUNCEMENT

Survey Japan welcomes questions and opinions concerning the development of robotics in Japan and related business. They will be duly discussed in our new column "Questions & Opinions" to show up in the next issue.

Company Profile (1)

Fujitsu Fanuc - NC Machine Maker Growing With IRs

Fujitsu Fanuc, Ltd. is a company most closely watched, just now in Japan. Their business results are outstanding. This company was separated from Fujitsu, a leading computer manufacturer, nine years ago, to become independent. Their sales turnover (¥82 billion), is less than one tenth Fujitsu's, but profits compare favorably (for the year 1980). With current profits amounting to 34 percent, they are a top grade enterprise.

Fujitsu Fanac's principal product is numerical control equipment for machine tools, with their Japan share of this field at over 70 percent and throughout the world, close to 50 percent, surpassing all other companies. The extent of their superiority is clearly spelt out in that on January 22, their stocks hit a record high of ¥7,150, the highest since Japan's security market came into being.

In their factory, which produces ¥18 billion yearly, one hardly ever encounters a human being. Throughout the spacious factory, machinery of all kinds is lined up orderly, and all you see is an unmanned carrier, flashing a red light as it moves about.

There are 100 employees working at Fujitsu Fanuc's Fuji factory; machine operators, 19, assemblers, 63, inspectors, 4, and those in administration work, etc., 14. At night, the construction department stops work but the machining division continues to operate in silence, and the only people left are the two supervisors remaining in the control center.

The President, Mr. Seiuemon Inaba responds, "Train the brains instead of cultivating one's skill. Man must not work under a machine. In our company, we think of all our workers as engineers. Only man can have control over robots."

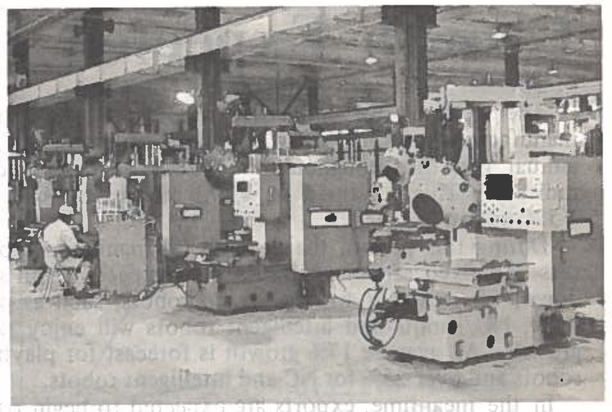
For example, in developing new products, first of all, the project leader makes a thorough survey of the market and sets up a sales price level at which other companies cannot compets. Then, the manufacturing cost is determined within 65 percent of the selling price. They do not set the selling price calculating initially from the manufacturing cost.

Fujitsu Fanac has an "Administration Policy" that President Inaba has established. On sales, "We will endeavor to reduce prices but will never make any discounts." On technology, as mentioned previously, "Cost reduction will be achieved through reducing the number of parts." On administration as a whole, "To strive for unmanned factories by utilizing self-manufactured N/C equipment and robots." Fanac's administration policy is the guiding principle and leads the way to training the brain.

There is an automation research center within the company and all cost lowering procedures are initiated there. One fourth of the total employees are attached to this center and explore all grounds for cost reduction.

In brain training, the management's instructions must be specific and to the point. The instruction that Mr. Inaba gave the automation research center was "Weniger Teile". This German phrase means "with less parts." To bring the cost down with fewer parts but without loss in efficiency. Technicians have grappled with this assingment and trained their brains.

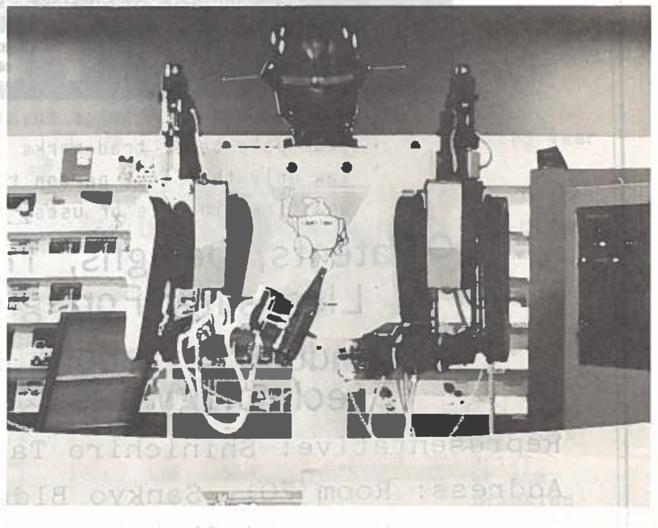
When this instruction was fully followed, Mr. Inaba put forth another assignment. This was "Boosting Reliability," aiming at reliability of 0.02. This figure indicates that the rate something goes wrong with their N/C equipment is once in 50 months. At present, the figure is 0.03, and their aim is to lower this further to 0.02, then hopefully to 0.01, meansing a product having fault only once in 100 months – 8 years and 4 months.



Mini CNC machine tool assembly line

Fujitsu Fanuc, Ltd.

- Incorporated: May 12, 1972
- Capital: approx. ¥2,600 million
- Operating revenue: ¥82,100 million (FY 1980, ending March 1981)
- Current profit: ¥27,100 million (FY 1980)
- Employees: approx. 950
- Main shareholders: Fujitsu, Ltd., Siemens AG, Fuji Electric Co.,Ltd.
- President: Dr. Seiuemon Inaba
- Headquarters: 5-1, Asahigaoka 3-chome, Hino-shi, Tokyo 191



A "commercial" robot with a bottle of beer in the right hand and a glass in the left is seen about to pour. View of robot "PARTTIME-500", manufactured by Dainichi Kiko, as shown recently at a local demonstration.

Easy Robotics (1)

RY ROBOT SYSTEM

By Osamu Ohmori
Second Design Section
ORII Corporation

Generally speaking, there are two kinds of automatic machines for presswork, one for primary processing, that is blanking of coils and sheets inserted into the press, and the other for secondary processing, that is plastic working.

The RY Robot System to be introduced here is a series of automatic machines developed as a transfer system for a secondary presswork.

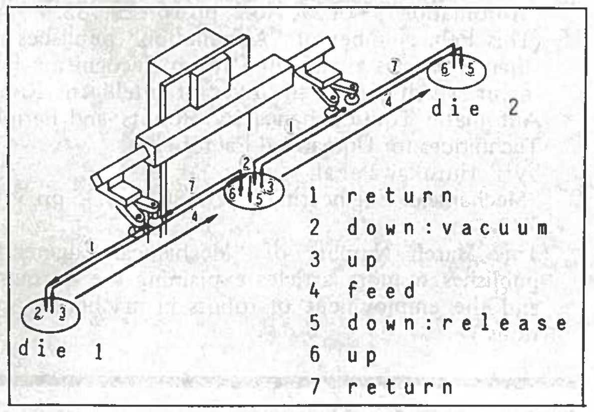
Usually secondary presswork is carried out over wide range of varying work processes, so the users of those press machines arrange a number of units tandem, process materials, transferring worked workpieces successively from one press to another.

Hitherto most multi-process press work has been either of a progressive type or a transfer type. These types of presswork can be performed with speed, and so result in high productivity. Being extremely effective for mass production, these types of presswork need expensive equipment and take much time for arrangement.

Recently the life of products has become very short and the production number of products has also become small, so the need for automatic machines which are suited to small production runs of a large range of products has grown.

To answer this, the RY Robot was developed.

This robot system is consists of three fundamental operations, such as: (1) arranging press units, (2) setting up transfer equipment for each, each with its independent drive, and (3) transferring workpieces by means of suction power. This is the robot system which typifies future machines for secondary processing.



Features of RY Robot

1. Driven mechanically by cam drivers, the RY Robot is fed accurately at speed. Controlling the force of inertia, it transports workpieces smoothly and reliably.
2. Because the amounts of materials transferred or variations in the amounts, are easily controlled, the RY Robot can be used for a variety of presswork.
3. The production line can be set up freely by connecting or separating units of robots as required. The line configuration can be changed for a particular job operation. According to the user's purpose, the best configuration of a line is easily and economically arranged.

Nissan Leads in Robotization

Nissan, Japan's second largest car manufacturer after Toyota, has announced that its industrial robots reached slightly over 700 as of the end of 1981.

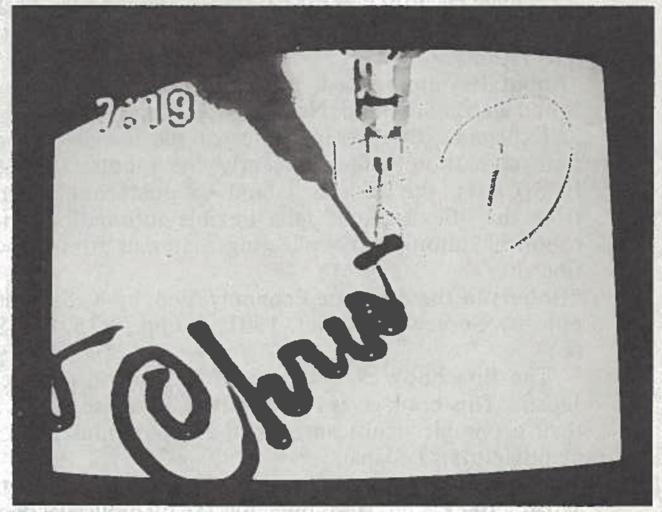
In the meantime, Toyota estimated its robot ownership was between 650 and 660 as of the end of last year. In its stepped-up efforts to strengthen automation on the car assembly line, the company introduced more than 250 painting and welding robots in 1981 alone.

A Nissan, spokesman said, now that 90 percent of its welding division has been automated, robotization of the car assembly line may have reached its peak.

Unmanned Coating Line

Nissan Motor Company is studying plans to introduce a completely unmanned coating line into their car production. Each line, closed to the outside world, is to provide 15 to 20 painting robots to complete all work from undercoating, painting, recoating to sealing without the aid of man.

The world's most advanced automation system will be introduced initially into three plants to finally in the future will cover all coating lines in its domestic plants.



"Toffky" robot, manufactured by Taiyo Tekko, of Osaka, which capable painting and drawing, tries its hand in a scene from a TV production. The company recently delivered a machine of this type to a major confectionary maker to decorate Xmas and similar cakes, and will manufacture about 10 more through March. The robot, which is capable of applying adhesive and sealing for industrial purposes, comes in five models. Price ranges between ¥8 and ¥12 million.

(Continued from Page 1)

Major IR Makers

- OEM manufacture to be based on supplying annually 200 robots for distribution throughout the world.

GE, the world's largest heavy electric machinery maker, boasts of an annual sales of approximately ¥6,000 billion, nearly three times that of Hitachi, which is the largest company of its kind in Japan. The transaction between the two companies caused mixed reactions in the Japanese robot industry. One was a high appraisal of Hitachi's robot technology, which is now advanced to to export level and the other, a criticism that Hitachi, through this act, was going to abandon its pormising world market. There was even considerable concern from those companies now thinking seriously about launching their own exports toward the US.

THE SPECIFICATIONS AND APPLICATIONS OF INDUSTRIAL ROBOTS IN JAPAN 1982

ANYONE whose job it is to gather together information of the specifications of current Japanese robots knows just how difficult the job can be.

Not surprisingly, therefore, one of the most valuable publications to come out of the Japan Industrial Robot Association is the report entitled: Specifications and applications of Industrial Robots in Japan, 1982.

Running in all to some 447 pages this mine of information gives details of over 150 robots produced by some 46 companies in Japan. In addition to giving names and addresses of robot makers in Japan the report also provides the principal specifications of all robots together with diagrams outlining the general configuration.

Also included are details of grippers and associated equipment.

In the same report, covering some 260 pages, is a major section detailing over 100 robot applications. This is especially useful for anyone wishing to see the extent of Japanese technology and who now has information to hand in one book covering many different areas of manufacturing industry.

Among the areas covered are:

Machining, plastics moulding, assembly, press feeding, spot welding, arc welding, die-casting, transfer handling, painting, forging, inspection and measurement, heat treatment and miscellaneous applications.

Each application includes the name of the robot supplier and the user together with diagrams and information about the application. Those who are interested in specific user companies will have to wade through the entire section to seek out their company of interest since there is no index of users, although the contents does include the robot supplier adjacent to each application.

Some of the applications have no user indicated, though from the component involved it is possible on occasions to establish the user.

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THE SPECIFICATIONS AND APPLICATIONS OF INDUSTRIAL ROBOTS IN JAPAN 1982

Japan Industrial Robot Association

THE JAPAN ROBOT NEWS

A Quarterly Newsletter by Survey Japan, 61, No. 6 Kojimachi Bldg., 4-5, Kojimachi, Chiyoda-ku, Tokyo 102. Tel:(03)262-7476

MAY 1982 VOL. I/No. 2

Computer Makers Set Sights on IRs

Major Japanese computer makers have begun tackling in earnest their robot ventures, in belief that full use of their computer technology, ultimately, will make factory automation and development of intelligent robots possible.

As industrial robot (IR) users' demands become more sophisticated, such computer makers foresee a new market developing promptly in the near future, in a way that combines high-computer technology with IR technology.

In successive developments that have occurred during the period commencing at the end of last year through to this spring, these computer makers have established new divisions specializing in IR's. More specifically, they are the Mechatronics Business Division of Fujitsu, which is Japan's largest computer manufacturer, the Factory Automation Strategic Committee of second-ranking Hitachi, and the Robotics Business Division of the third-running Nippon Electric (NEC).

Mitsubishi Electric, having already launched its IR business, has also added its "Industrial Mechatronics Business Division" while creating an "Industrial Mechatronics Development Division" within its research institute for applied equipment to assemble studies on the development of artificial intelligence, control systems and other computer technologies that can be applied to robotics. Possibilities are that the organizational consolidation of each computer maker in relationship to IR business will quickly lead to a merger of IR technology and computer technology that have so far been progressed separately.

A spokesman for NEC said: "The development of intelligent robots is a big task for computer makers to cope with. We are pitching in on this in terms of both our own and in joint developments".

In the meantime, a spokesman for Fujitsu has said: "For the moment, our emphasis will be on using robots

(Continued on Page 8)

ASEA Lands In Japan

ASEA, Europe's biggest manufacturer of industrial robots has begun marketing its articulated robots in Japan through its joints venture, ASEA GADELIUS (Tokyo, cap.: ¥300 million). The company also intends to found a further joint venture with a Japanese firm for manufacture by the end of June and will construct a factory in Kansai by the end of 1983, said a spokesman of ASEA GADELUIS.

First arrival of an imported ASEA robot, at Tokyo International Airport on May 19 has apparently sent shock waves through domestic IR makers who have already oversaturated the market. Reaction has been mixed, however. A spokesman for Fujitsu Fanuc said:

(Continued on Page 7)

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June 1982

ANNOUNCEMENT

The Japan Robot News

Following the first comprehensive report of its kind, "Robots in the Japanese Economy," Survey Japan has just published a quarterly newsletter featuring technological innovations in robots, government policies, technological and business tie-ups, both domestic and international, new related products as well as other latest events concerning robotics. Although it is an eight-page or more, A4 size publication, it covers the most significant developments in robotics centering around Japan. (For a sample page and contents of the just released second issue, see the back of this announcement.)

If you are interested, please fill in the form below and return it with the cost: Annual subscription rate US$50.oo, including air postage.

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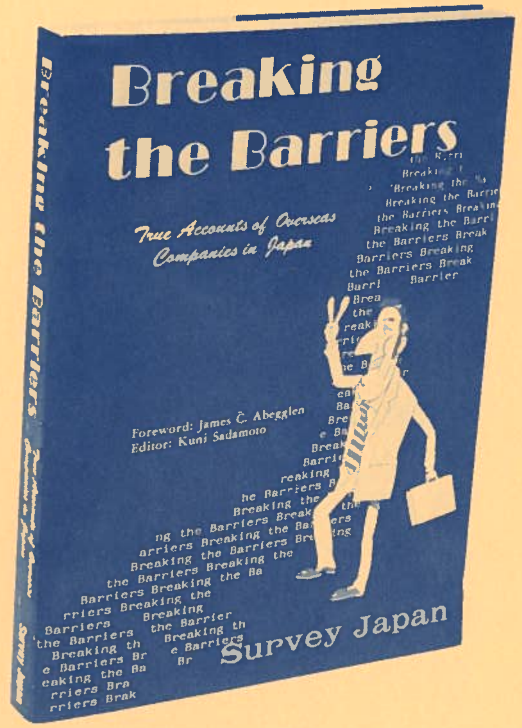

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Other publications by Survey Japan:

- Robots in the Japanese Economy

  This 280-page book gives full details of the present status of IRs in Japan and their economic significance. (price: US$65)
- Japan Pharmacentical Report

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ANNOUNCING A NEW IN-DEPTH STUDY AND ANALYSIS OF

The Robot Market Explosion

Strangely, although cost-effective industrial robots have been available for more than fifteen years, the U.S. market for these versatile products developed very slowly, and did not even manage to reach the relatively modest $100 million level until 1981. Then suddenly the market spurted ahead, heartening the established vendors and emboldening many new suppliers to try their hand -- or their arm -- at automating U.S. factories. Westinghouse, GE, Bendix, IBM and others all entered in rapid succession; however, the entry of these giants seems to bother established leaders (Unimation and Cincinnati Milacron) less than the specter of a full-scale onslaught by Japan Inc.

International Resource Development Inc. has completed a new in-depth research report on THE ROBOT MARKET EXPLOSION (#196). The report seeks to address some of the issues most disturbing to both potential large-scale users and suppliers of industrial robots. Included in the report are ten-year market forecasts for robots, probable future robot applications and detailed descriptions of several dozen current and future robot suppliers. The report is available immediately and costs $1,285.00. A detailed table of contents and order form are attached.

The report contains 151-pages and the following nine sections:

1. Executive Summary
2. Introduction
3. Robotic Technology -- Current State of the Art
4. Applications
5. Professional & Research Organizations, and Information Sources
6. The Economics of Robots
7. Social Consequences
8. Future Trends and Ten-Year Market Projections
9. Supplier Industry Structure

Section 3 gives an introduction to the robot industry as it stands today, examines the place of the robot in the Factory of the Future, and looks at the latest developments in "seeing" robots. Though robots are currently used primarily for heavy jobs such as automobile manufacturing, this will change during the next decade as smaller, lighter, and "seeing" robots are increasingly deployed in industries such as electronics and pharmaceuticals. Section 4 takes a look at the current and potential uses of robots, and gives ten-year trends in robot applications. Specific projections of future robot usage in more than twenty applications are provided.

Section 5 looks at the wide range of research being done on robotics, through the government and universities, and describes the professional robot organizations operating in the U.S.

Section 6 describes the types of criteria which are used by typical users to establish the financial justification for procuring robots, and presents typical guidelines for desired payback periods, etc.

In Section 7 the social consequences resulting from the expected increase in robot usage are explored. As well as the actual displacement of "blue collar" labor, the perception of labor displacement on the part of labor unions and other opinion leaders is explored. The likely future trends in the robot market are discussed in Section 8, which provides a quantitative ten-year projection for robot shipments in the United States.

The rapidly evolving supplier industry structure is explored in Section 9, which also summarizes information on the principal products available in the U.S. market and provides profiles of more than two dozen vendors. Much of the information was obtained in an exhaustive interview program with these vendors and with leading edge users.

This new report is a sequel to IRD's well-received and widely-quoted 1979 report on Industrial Robots in the 1980's. That report was remarkably on target in predicting the probable future interest in robots by IBM, Texas Instruments, and other firms not traditionally associated with the machine tool industry. Now that the market and supplier structure have great- ly broadened -- even to the point at which some observers are considering the robot market to be a branch of the computer market -- IRD feels it is time for a new look at the market. Project leader Lawrence Skutch was supported by the IRD data base of industry, market and financial information.

International Resource Development Inc. is an independent consulting firm, specializing in the measurement and analysis of technological and financial services markets. IRD reports have been purchased by several thousand government and commercial organizations, from every major country in the world. In addition, IRD has conducted significant consulting assignments for scores of leading organizations, including GTE, AT&T, General Electric, Rockwell International, Nippon Electric, and Texas Instruments. The report is available now and can be shipped immediately upon receipt of an order by phone, mail or telex. (Federal Express can ship to most parts of the U.S. for next-day delivery, if desired.) To order the report, or obtain more information, please telephone IRD or complete the attached form and send it to us.

Sincerely,

Nancye L. Horak
Marketing Coordinator

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THE ROBOT MARKET EXPLOSION

EXHIBITS

Proceedings

of

the 11th International Symposium

on

Industrial Robots

7,8 and 9 October 1981.

The Organizing Committee of
the 11th International Symposium on Industrial Robots

Society of Biomechanisms Japan (SOBIM)
Japan Industrial Robot Association (JIRA)

FOREWORD

We are very much honored to organize the 11th International Symposium on Industrial Robots (ISIR) in Tokyo, the third time of the ISIR held in J

Since the first ISIR held in Chicago 1970, symposium participants and presented papers have increasingly developed both in number and significan at each subsequent meeting. This favorable progress has paved the way for ISIR to grow into the world most authoritative symposium on industrial rob technology, contributing a great deal to industries and human welfare in a regions of the world.

The steady development of the ISIR has been largely supported by clos cooperation from the National Coordinators and other interested organizati as well as the cumulative results of their daily activities in their own countries.

The highlight of the 11th ISIR includes:

1. Trends in the next stage of development in robot technology;
2. Perspective of future industrial robots from a global viewpoint; and
3. Social-economic consideration of the robot age toward the 21st centu

The robot technology, so far represented by mechatronics itself, is n developing from the first to the second stage. This means that it is shif ing from mechatronics to biomechatronics, from a specialized system to a versatile one, or from a means of manufacture to that of services.

Some 100 reports to be presented at the 11th ISIR from more than 20 countries will no doubt help us clearly perceive the new movements in the industrial robot technology on a global basis. They will also give us a useful hint on our future study.

We firmly believe that the slogan, "Human Age and Robots," adopted fo all ISIR sessions held in Japan has been realized step by step during the past seven years.

Numerous robots introduced into our society are now opening a new era when man and robots have to get along harmoniously. Social, economic consideration of this subject will perhaps indicate how we should envisage human society in the 21st century.

Participation in the ISIR gives us a chance to discuss all essential aspects of the robot, dealing with this creature of human ingenuity as a n technological subject as well as that of time and space.

We wish to express our heartfelt thanks to the National Coordinators, session chairmen, speakers, and other interested organizations for their assistance and cooperation.

Ichiro Kato
Prof. Ichiro Kato
Chairman of the Committee of
the 11th I.S.I.R.

Tsuneo Ando
Tsuneo Ando, President
Japan Industrial Robot Association

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WESTERN EUROPEAN ROBOTICS

Instrumentation Industry Analysis Service

Creative Strategies International

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From the Executive Summary...

.... Historically, Unimation has had a major share of the European market for industrial robots, but this is now under threat from U.S. and Japanese companies, as well as from other European competitors.

The Industry

Robot technology is not new, yet many industrialists are only just beginning to realize the impact that robots can have in manufacturing industries. The maximum benefit from robot technology, however, will only be obtained when robots are fully integrated with manufacturing resources, planning systems, computer-aided design, automated warehousing, and computer-assisted manufacturing.

Although the robot is perceived as a multipurpose machine not limited to a particular task, most manufacturers have developed expertise in one type or range of robots for specific applications. Many new companies are being established, often dealing with specialized sectors of the market, such as control software.

In the diverse European markets, the varying reactions of unions could be a determining factor in the differential rates of growth. One of the factors that may depress the introduction of robots is job displacement. Unions have tended to not oppose the introduction of robots for hazardous tasks; unions are very concerned about increased unemployment, however, especially in assembly tasks. In these situations, the relationships between unions, government, and management need to be clearly assessed. Many European governments are actively supporting both the manufacture and use of industrial robots with a variety of funding operations.

The Market

There will be major variations in the market growth within each European country, reflecting the current installed base, labor costs, and attitudes of unions and management. Growth rates will be highest through 1983, with many orders coming from companies that already have one or two robots and that now have sufficient operating experience to commit themselves to additional investment.

Robots cut across traditional market sectors, and the market is most effectively defined according to application area, rather than in terms of industrial end user. The assembly and arc welding application areas will show the most growth over the next five years. Assembly work is labor-intensive and ideally suited to robots; in terms of units installed, assembly may well come to be the dominant sector of the market. Other major application areas included in the report are spot welding, surface treatment, die casting and injection moulding, metal processing, and machine tools.

Manufacturers place much emphasis on the value of a technical "edge" in the marketplace, and buyers do seem to be attracted by highly sophisticated robots. These may not be the most appropriate solutions, however, and many companies will enter the robot market by buying low-technology equipment, later upgrading to more flexible equipment.

Both technical and competitive factors will affect robot costs. Price adjustments will take place mainly at the lightweight assembly end of the market. Decreases in the cost of electronic circuits will result in a wider range of programming and control options, rather than a decline in price.

Technology

Industrial robots have three elements – a mechanical structure, a power unit, and a control system. The mechanical design of the robot must enable it to reach work pieces or tools and to be capable of handling the weights involved. Various types of arm configurations are used, the ultimate choice depending on the purpose to which the robot will be put, the sophistication of the control system, and the physical location of the robot.

Industrial robots can be controlled by a wide range of techniques: from mechanical stops, limit switches, and sequencers, to minicomputers. The power unit can be electrical, pneumatic, hydraulic, or a combination. Pneumatic power is used in about 30% of all robots and is most common in limited sequence robots.

Flexibility and adaptability – the cornerstones of robotic automation – are a more relevant commercial criterion than universality. Areas now under development that are most likely to impact the robot market in the long term are those which are the key to flexibility—intelligence, software, sensory capabilities, mobility, voice recognition, and improved self-diagnosis. Although there will be a major growth of robots with sensor-based capabilities, these will represent only a small part of the European market by 1986 .

Competition

All major European countries have robot manufacturers that supply varying percentages of the "home" market, with the rest supplied by both European and non-European producers. New entrants to the industry in Europe will include major multinational engineering and electronics companies, and small entrepreneurial companies that offer specific products and services. In addition, companies that presently manufacture robots mostly for their own internal use will be in a position to rapidly expand their external sales. Adequate service support, however, is of paramount importance.

Both in Europe and on a worldwide basis, the robot industry is characterized by a complex mesh of manufacturing, distribution, and technology transfer agreements. Recently, Japanese companies have been especially active in establishing marketing and service/support agreements with European companies, in some cases selecting more than one company in order to gain marketing expertise in specific industry sectors . . .