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The *Microelectronics Monitor* proposes to accept industry-related advertisements from companies interested in reaching planners and policy-makers as well as entrepreneurs and members of the scientific community in some sixty developing countries throughout the world and inform them about their products and services.

The *Monitor* is published four times a year and distributed free of charge to individuals and institutions on an approved mailing list which includes at the moment 1300 entries. The *Monitor* has been published since 1982 and has built up a sound reputation both in developed and developing countries.

Our activities in the field of advertising are directed towards helping to finance the preparation, publication and mailing of the *Monitor*, which will continue to be distributed free of charge.

Advertisements will be printed in black and white and in English only. Prices in Austrian Schillings or the equivalent in $US will be AS 5,000 for a full page; for half page advertisements, AS 3,700; and for a quarter page, AS 2,500. Requests for placing of advertisements, accompanied by a layout, illustrations and text, should be submitted to the Editor, *Microelectronics Monitor*, at the address below.

Editor's note

A reader survey initiated in 1986 has now been completed. 25 per cent of you have taken the trouble of replying. Better yet, nearly all questionnaires returned contained interesting and valuable suggestions for further improvement of the Microelectronics Monitor. We wish to thank all readers who have replied and who have been wonderfully supportive.

An analysis of responses was made and the following emerged:

The "New Developments" section was clearly number one in reader preference, followed by "Country Reports", especially from developing countries, coming in second. These were followed by "Market Trends and Company News"; "Applications"; "Software"; and "Robotics and Factory Automation". Also popular were special review articles and reports on government policies. Quite a few readers wished for more tables, graphs and drawings to enliven the text. We do include these to the extent possible but as they have to fit into the double column text layout and original size is reduced in the printing process, most of them have to go to the back page where their immediate relevance is lost.

A general complaint was that the Monitor should be more timely and be published closer to the date of events. This, however, is beyond our control as UNIDO shares printing facilities with the International Atomic Energy Agency and United Nations Vienna, all located at the Vienna International Centre. The manuscript of the Monitor has to queue for printing together with all other documents.

Distribution, as we have pointed out on several occasions, is done by surface mail in view of high airmail cost for which we have no budget. A scheme to have interested readers pay for airmail charges was not yet launched due to lack of interest on the part of our readers.

One interesting suggestion was for inclusion of software needs as most journals carry only information on software available. We will gladly publish information on specific software requirements if it is indicated to us.

As regards requests for product reviews, this is beyond our scope and a number of technical journals are specializing in it. The main objective of the Monitor is to outline the major trends and developments in the field of microelectronics and their impact.

On a personal note, I shall be leaving UNIDO at the end of this year and I wish to thank readers - with some of whom I have been in contact since the publication of the first issue of the Monitor six years ago - for their continued interest and encouraging comments. The Monitor will continue to be published and one of my colleagues will assume editorial responsibility. May I wish you all the best for the future.

Ingeborg Schwab

CONTENTS

I. UN NEWS AND RECENT EVENTS

UNIDO convenes second meeting of COGIT

A meeting of the Consultative Group on Informatics Technology for Development (COGIT) will be held at UNIDO's headquarters in Vienna on 14-16 December 1987. The Group, reported on in earlier issues of the Microelectronics Monitor, was established following a meeting in 1984. The objectives of this year's meeting will be to review practical experience in the application of informatics for development and to identify concrete measures of co-operation at the international level including co-operation among developing countries. UNIDO's activities in this field will also be reviewed and a programme of action suggested. We will report on the outcome of the COGIT meeting in the next issue.

Mastering microprocessors

A consultative meeting on a possible UNU research and training centre for software development, to meet the needs of developing countries, was held in Macau from 2-4 March 1987. Hosted by the Government of Macau, the meeting heard the opinions of experts from North and South who had been asked to assess the need for an international effort that might lead to the establishment of a research and training centre for software development.

The meeting was one of a series which built on activities carried out under a project of UNU's Global Learning Division on the Mastering of Microprocessor Technology. An effort to help developing countries to benefit from the technological advances in this area, the project is aimed at raising scientific and technological capabilities to the level necessary for understanding, using and innovating with microprocessors.

Important components of the microprocessor technology project include: a fellowship scheme, supported by the Irish Government, which gives special training in microprocessor technology to scientists from developing countries, and co-operation (with Italian Government backing) with the International Centre for Theoretical Physics, Trieste, Italy in the organization of regional training colleges in the third world, of which three have been held so far.

Further combined training and capacity-building activities have been initiated with universities in Africa and Latin America, and an advanced joint research project in the use of microprocessor technology has been organized with the University of Malaya and the Tunku Abdul Rahman College in Kuala Lumpur, Malaysia.

For further information, contact:
Dr. Iner Wesley-Tanaskovic, UNESCO National Commission of Yugoslavia, Mose Pijade 8/VI, 11000 Belgrade, Yugoslavia. (ACCIS Newsletter, July 1984, p. 4)

First IFIP* seminar in China

Beijing was the site of the first technical meeting IFIP has ever held in China. IFIP's Technical Committee on Computer Applications in Technology (TC5) organized this event, a Seminar on Introducing Computer-Aided Techniques in Manufacturing, Engineering and Management (SICATMEM '87), which took place from 1-3 April 1987.

Two thirds of the 81 registrants were from China; the rest were from 17 other countries. Eighteen papers, approximately half by Chinese authors, were presented. Prof. Qiangnan Sun (PRC) headed the national Program Committee that selected the Chinese papers; TC5 chairman Prof. Asbjørn Rolstadås (Netherlands) headed the International Program Committee that chose the remaining papers. Several of the papers by non-Chinese authors were written by members of TC5. Eight of the non-Chinese registrants were invited by Chinese universities and technical institutions to be guest lecturers before or after the Seminar.

Proceedings of the Seminar, edited by Profs. Sun and Rolstadås, were published as a special issue of Computers in Industry, the international journal of TC5 (Vol. 8, Nos. 2&3).

The keynote paper of the Seminar, "General Review of Computer Technology and Application in China", was written by Prof. Ping-Xin Guo, China's representative to IFIP, and Prof. Sun. In it, they present a history of information processing in China. Parts of it are quoted here: **

> The history of the computer industry in China comprises three periods:
>
> 1956-1971: Initial period
>
> In this period, work began by our copying foreign models and evolved to our designing by ourselves. Computer systems of three generations - vacuum-tube, transistorized, and integrated-circuit - were manufactured. Research and development, education, hardware manufacture, and component production grew up.
>
> The computer industry advanced rapidly, characterized by a variety of models, small production lots, and narrow fields of application. The main users were military and research organizations. The main fields of application were complicated calculations for aerospace, nuclear energy, etc.
>
> 1972-1979
>
> This period marked the transformation from research to industrial development. In this period, the scope of computer applications was extended to process control, automatic testing, data processing, information management and retrieval, CAD, etc., but still in limited areas. Most machines were installed in research institutes and universities. The number of installed computers amounted to only 2,000.
>
> 1980 to the present
>
> This is a new period for computer production and application. The policy is "growing through applications" and to start China's computer industry complex.
>
> In this period, radical change has occurred in computer production and application. The direction of research has changed from hardware-product-oriented to system-oriented. The style of industrial production has changed from assembly of parts and components to domestic manufacture. The fields of application have changed from research, defence, and a few industries to the entire society.
>
> By the end of 1985, the number of organizations taking part in computer research, production development and technical service amounted to over 250, and the total number of staff and workers to over 100,000. Seven thousand

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* International Federation for Information Processing.

** Copyright IFIP.

mainframes and minicomputers had been installed, as well as 130,000 microcomputers.

In recent years, due to the policy "domestically, make the economy active; internationally, open to the world", China's computer technology has advanced significantly from its original basis, by applying new foreign technologies.

The policy of developing families of computers has promoted the progress of computer technology in China. All computer families are equipped with system software and application software. Also, tens of peripheral equipment projects were undertaken to tackle key technical problems.

The paper goes on to discuss research and development in Chinese character information processing and other areas. Applications in technological modernization of conventional industries, mananagement, energy savings, and transportation are also discussed. Finally, the paper concludes as follows:

> The above brief introduction of the general status of computer technology and application in China shows that:
>
> 1. After 30 years' development, the computer industry in China has advanced significantly. An initial computer industry complex has been formed.
>
> 2. The policy "growing through applications" is fruitful.
>
> 3. There is still a long way to go to reach an advanced international technical level. Besides China's own efforts, technical exchanges and co-operation with developed countries and learning and importing sophisticated international technologies are also necessary.

(<u>IFIP Newsletter</u>, Vol. 4, No. 3, September 1987)

<u>Computers against poverty</u>

An international workshop on "computers against poverty - poverty through computers?" was organized by the German Computer Society in co-operation with the North/South Conference CONTACT 1987 as part of the 750th anniversary celebrations of the city of Berlin. It took place on 2-4 October 1987 in Berlin (West), at the Technical University of Berlin (Mathematics Building, Strasse des 17. Juni 136, D1000 Berlin 12. The programme included such topics as: development theory and information theory; computers in education; production; applications in agriculture, health and for grass roots; and implications of information technology.

<u>Restructuring industrialization strategies</u>

The Institute of Development Studies at the University of Sussex, Brighton, England is planning another study seminar from 21 September to 21 October 1988. The seminar will update the 1985 seminar on the same theme of microelectronics and new work practices. The seminar will focus on lectures by representatives in the microelectronics industry, the capital goods industry and will include a one-week tour of British leading edge firms in sectors of relevance to participants' home countries. The implications for industrial and corporate policy in developing countries will be discussed. (Institute of Development Studies, University of Sussex, Falmer, Brighton BN1 9RE, England)

<u>National issues on computers in education</u>

An international workshop on the above topic was held on 16-18 March 1987 at the Indian Institute of Technology (IIT), Bombay. It was jointly sponsored by Technical Committee 3 of the International Federation of Information Processing, the Computer Society of India and IIT, Bombay. The purpose of the workshop was to arrive at recommendations and conclusions on the effective exploitation of computers in education. Sixty participants from 23 countries participated. It was agreed that the major problem now facing all nations is a lack of adequately computer-trained teachers. This is a long-term problem that has no simple solution. The report of the workshop, which is available from the Office of the Director, Indian Institute of Technology, Powai, Bombay 400 076, contains conclusions and recommendations which may be adopted or adapted by individual countries depending on their own national strategies.

<u>CHEMEX - expert systems in chemistry and the chemical industry</u>

The meeting will be held in London, in November 1987. The major aim of this meeting is to promote a greater awareness among chemists of the industrial, analytical and other applications of expert systems technology.

For information write to the organizer, F. Edwards (CHEMEX), Department of Physical Chemistry, University of Leeds, Woodhouse Lane, Leeds LS2 9JT by 30 June 1987.

<u>Fourth international congress on computer applications in fermentation technology</u>

The congress will be held at Cambridge, from 25-28 September 1988, at Robinson College.

The congress will be structured to encourage papers on both new discoveries and applications and on descriptions of how new technology is being applied in practice. It is envisaged that the papers will concentrate on the following areas:

> Measurement - novel sensors and biosensors; intelligent instruments and estimation of variables.
>
> Modelling - development and application of biological and reactor models; identification; system and state parameter estimation.
>
> Control - adaptive and hierarchical; expert systems; optimization; strategies.
>
> Data management - off-line data collection; processing and interpretation; statistical analysis etc.

<u>International Conference on Artificial Intelligence</u>

The 10th International Joint Conference on Artificial Intelligence (AI) was held in Milan, Italy, from 23-28 August 1987. The programme included two distinct tracks, science and engineering. The science papers focused on computational principles underlying cognition and perception in man and machines. The engineering papers dealt with issues involved in applying the computational principles. In addition to the papers, an exhibition of AI-relevant hardware and software was available. Inquiries can be sent to John McDermott, Department of Computer Science, Carnegie Mellon University, Pittsburgh, PA 15213, USA. (Phone: 412-268-2599) (<u>European Science Notes</u>, May 1987)

IFIP Congress '89

The 11th World Computer Congress will take place in San Francisco, California, USA from 28 August to 1 September 1989. The programme will emphasize the evolution of information processing. Its scope and organization will be geared toward EDP professionals and application systems designers and developers. For further information please contact A.J. Basili, AT+T 30 Knightsbridge Road, Piscataway, N.J. 08854, USA.

MEDINFO '89

The 6th world congress on medical informatics will be held in Beijing, PRC on 16-20 October 1989. The event is organized by MEDINFO '89 Secretariat, Ms. Shan Huiqin, China Computer Technical Service Corp., 55 Xueyuan Nalu, Weigong Cun 10081, Haidian District, Beijing, PRC.

II. NEW DEVELOPMENTS

More on superconductors

Superconductor research warms up

The hottest temperature at which superconductivity works has reached a new record high of 225 K. This is more than double the record temperatures of 90 to 100 K achieved earlier this year. A group led by Paul Chu, at the University of Houston, discovered this new phenomenon.

Though 225 K (or -48°C) is far from room temperature, it exceeds the lowest temperature (of -89.2°C) recorded on the Earth's surface. The Soviet Union's Vostok station in Antarctica recorded this temperature on 21 July 1983.

Chu's group was working with the ceramic materials in which the superconductivity at 90 to 100 K was discovered earlier this year. Pei Hor, one of Chu's colleagues, said that magnetic measurements showed that a very small amount of the material (a second phase) superconducted at 225 K. Hor said: "The sample's second superconducting phase is not stable at 225 K; it comes and goes. You can observe it once, then after a while it disappears, but you can see it again."

Lockheed's Palo Alto Research Laboratory measured the resistivity of the material, and the National Magnet Laboratory, operated by Massachusetts Institute of Technology in Cambridge, Massachusetts, studied its magnetic properties. There have been persistent hints of materials that superconduct at temperatures of about 200 K, but this is the first evidence that this is so, albeit for part of a single sample.

Alex Zettl's group at the University of California at Berkeley provided the strongest hint that superconduction at temperatures above 200 K might be possible. Zettl's group observed an anomaly in one of its samples at 240 K during the first burst of high-temperature superconductor research earlier this year. Zettl said that it failed to confirm superconductivity at that temperature. However, it could resemble the results seen by the Houston group.

The measurements are reliable enough to convince the Houston-Lockheed-MIT team that they have seen superconductivity at 225 K. However, they are not sure of the material's structure or why superconductivity seems to come and go. Hor said that "We are looking into" what makes the 225 K superconducting phase reappear. That second phase seems to have a different structure to the materials which superconduct at 90 K. Details remain unclear.

The Houston group is keeping secret the chemical composition of the new material, although it is in the same family of ceramics as the 90 K superconductors. Chu's first samples were of yttrium-barium-copper oxide, but some other rare earths can be substituted. Hor said that the 225-K sample was in the same 1-2-3 phase, with one atom of rare earth, two of barium, and three of copper, but he would not identify the rare earth. (This first appeared in New Scientist, London, 4 June 1987, the weekly review of science and technology)

US spending to keep up with the Japanese

In tune with the popular theme of industrial competitiveness, the US National Science Foundation (NSF) has announced that special funds will be available for research into the new superconductors. The overt hope is that a solid foundation of research will enable US industries to gear up quickly for the anticipated commercial applications.

Three materials research laboratories, at Northwestern and Stanford Universities and at the University of Illinois at Urbana-Champaign, will benefit from an immediate award of $1 million. Another $60,000 will be distributed as 'quick start' grants to researchers with promising techniques for turning the ceramic superconductors into usable forms and devices. (Nature, 7 May 1987)

US: superconductor race attracts MCC

Microelectronics and Computer Technology Corp. (MCC) is pursuing a new research programme into superconductive materials. The initiative was proposed by the Austin, Texas, research consortium's packaging researchers, many of whom had left the superconductor field a few years earlier when the prospects of the technology ever being used were dim. Now that superconductivity is hot, MCC hopes to have a major programme under way in the fall. ...

Laboratories around the world are following the progress, and many have set up at least small research efforts. At this point, MCC perceives an opportunity to help provide for even its smaller members a level of research usually available only to the biggest companies. What the consortium aims to do is find new applications for superconductors and study techniques for producing the new materials.

MCC officials admit that superconductor research is now ideally suited to the consortium, since few electronics companies are likely to fund such research on their own. Indeed, they are hoping that the project will attract new members. MCC vice-president Barry Whalen says the consortium will present a finished proposal in July to a group of non-member US companies that might be interested in joining the programme and MCC. Outsiders note that the superconductor programme came at a good time for the consortium, which had been losing members during the semiconductor industry recession. MCC wants to develop analytical modelling and simulation techniques to help identify applications, says Whalen. At first, he adds, the programme will have modest funding. ... (Reprinted from Electronics, 25 June 1987, pp. 33-34,

USA Government calls for joint superconducting effort

President Reagan has called for a joint industry-government programme to develop new superconducting electronic devices and circuits with incredible speeds. He said the Defense Department will launch a three-year $150 million programme to help develop new devices, and the Department of Energy and National Science Foundation will vastly expand funding of supercomputing research at the national laboratories and at universities.

Federal agencies were also asked to reallocate some funds from the current fiscal year's budget to new superconducting research projects and "put a high priority" on such programmes in coming up with future fiscal year budgets. The President launched the new superconducting research initiative at a White House conference of industry and government, which also heard reports on advances in the new materials.

John Rowell, director of AT&T Bellcore Laboratories superconducting programmes, warned, however, that far greater research must be done on materials and device processing before viable electronic units will be possible. He estimated it may be at least a decade before usable devices are available.

Roland Schmitt, General Electric's (US) vice-president of research, told the conference that Japan, although hard at work on developing new superconductor devices, is at about the same stage as the US. But he warned that the US could not afford to let up on any effort to exploit the new technology, lest the Japanese beat the US to the market and achieve leadership in the field.

Mark Rochkind, director of North American Philips Research Center, reported that Europe is only now starting to jump into superconducting research, with CEC expected to have 65 scientists working on the project, Siemens of Germany about the same, and Philips somewhat less. He feared that European research might once again be fragmented because of national interests preventing any joint endeavours. (Electronics Weekly, 5 August 1987)

Japan:

Research on new superconductor materials

Following the success achieved in new types of superconductors, a number of large electronics companies in Japan (Fujitsu, NEC and Hitachi) are stepping up their research and development efforts in this field in order to be the first to lay the bases for this future industry.

More than one hundred groups of specialists, headed by Prof. S. Tanaka of the Faculty of Applied Physics of the University of Tokyo, are carrying out experiments at a f... rate in order to discover which materials are most resistant even at relatively high temperatures and which can therefore conduct electricity without a dispersion of energy.

The Japanese are expanding their research in the field of ceramics, non-metallic and non-organic materials based on nitrides and oxides. Advanced studies are under way on the reaction of elements such as silicon and zirconia at various temperatures and in controlled environments. The aim is to develop certain ceramics called 'engineering ceramics' which, due to their lightness and strength, are particularly adapted to aerospace applications. According to MITI (the Japanese Ministry for International Trade and Industry) the domestic market for superconductor ceramics will reach US$7 billion by the year 2000.

There has also been a strong interest in amorphous silicon, a non-crystallized form of silicon commonly used for the production of semiconductors. This material, which is currently very expensive to produce, presents numerous advantages, for example better electric characteristics for application in photocopiers and solar cells, as compared to the crystallized form.

Approximately US$4 billion have been earmarked by several large Japanese firms which founded the Japan Space Utilization Promotion Center for research in the possibilities of producing conductor materials in space taking advantage of the absence of gravity. According to the promoters, within the next few decades semiconductors, medicines and alloys will be able to be produced in space in their pure form. (Bulletin IBIPRESS, No. 140, 31 August 1987)

United Kingdom:

Britain's superconductor teams compare notes and budgets

The first major meeting of British scientists working on high-temperature superconducting ceramics was held at the Rutherford Appleton Laboratory. The meeting, arranged by the Science and Engineering Research Council (SERC), aimed to identify "the strategy that should be followed by the UK for the new high-temperature superconductors".

The organizers hope that the meeting will result in greater collaboration between various groups, to avoid duplication and make best use of scarce funds. Talk of room-temperature superconductivity has now largely ceased, and the British groups are concentrating their efforts on the fundamental physics of the new ceramics. But chronic shortage of funds remains the major obstacle to Britain's chances of competing realistically with foreign countries, particularly the United States and Japan. ...

In the short term there seems little hope of cash from other sources. Industrialists were present at last week's meeting, but it was felt that the potential importance of the present work was not impressed upon them sufficiently strongly. The Department of Trade and Industry (DTI) sent a representative with a statement to assure delegates that DTI was aware of the importance of the field. However, he had no hard proposals for funding, and few delegates held out much hope for the rapid cash support that is needed. (Nature, 7 May 1987)

Plessey's super chip bid

UK's Plessey plans to make superconducting chips in the laboratory within the next two years, and aims to build them into electronic systems in the early 1990s, according to the company's technical director, Professor William Gosling.

Such chips could be used in fast computers, optical communication systems, signal processors for big radars and switches for wideband telecommunications, said Gosling. The major advantage of the superconducting chips is that they will be between 10 and 100 times faster and will use less power than comparable silicon chips.

The chips will be based on a superconducting switch, called a Squid, and can be manufactured in much the same way as conventional chips, according to Gosling.

"They will use the same sort of resolution as silicon semiconductors and the same photolithographic processes, so the packing densities should be about the same," Gosling said.

"Right now, with silicon, we're running out of speed and straining cooling systems. Superconductivity opens the door for future computers," he said. "We had hoped to use gallium arsenide but it looks like it will be superconductors."

But he pointed out that the superconducting switches are only really suitable for digital applications and that gallium arsenide will still be used for fast analogue devices and microwave applications.

Scientists at Plessey's Caswell research laboratories working under Dr. Frank Ainger have developed a ceramic material which superconducts at -182ºC, some 14ºC above the boiling point of liquid nitrogen. This margin is important because all electronic systems generate heat. Gosling thinks 14ºC enough to engineer systems with liquid nitrogen-cooled components.

He expects to increase the margin by about another 100ºC within a year or two. He is less confident about room-temperature superconductors. He thinks that liquid nitrogen cooled superconductors are more practical than earlier superconductors because liquid nitrogen cooling is more economic and relatively easier to work with than either liquid hydrogen or liquid helium-based cooling systems. (Electronics Weekly, 20 May 1987)

UK advance in superconducting

A British company has announced a robust superconductive material, working at liquid nitrogen temperatures, which can be used immediately for certain commercial applications.

The tubular solenoid, which handles large current densities, was developed by Dr. Tavares and his company Basic Volume. The applications claim has been made by Dr. James Watson at the Southampton University, who tested a Basic Volume solenoid.

One of the drawbacks of current superconducting materials is that they are brittle and hard to use. But Basic Volume is claiming its material is much more durable. "These are the finest samples I've ever seen," Watson said. The magnetic separation of minerals is the initial application identified by Watson, and a $100 billion market in mining beckons.

Basic Volume made its claim through the Advanced Energy Research Institute. This recently formed private body was set up as a "new kind of research vehicle, an invisible college of professors", according to Leonard Holihan, AERI's chief executive. AERI has also made public a prototype superconductor quantum interference device (SQID), developed by Strathclyde University.

The SQID will be used in the detection of small magnetic fields and works with liquid nitrogen as opposed to the conventional supercooling method using costly liquid helium. Holihan expects that the Strathclyde device will also be commercially applied. (Electronics Weekly, 22 July 1987)

Canada:

Superior superconductor

Scientists at the National Research Council of Canada (NRC) have made a major breakthrough in materials research, defining the atomic structure of a new superconducting material. This revolutionary material is already foreseen to have applications in computer science, applied physics and medical technology. The superconductor could also improve the design and construction of power-transmission lines.

Dr. Yvon Le Page, a crystallographer with NRC, solved the puzzle using X-ray diffraction. Running experiments day and night, Dr. Le Page beat out researchers throughout the world in a race to analyse the atomic arrangement of a chemical whose composition had been identifed by scientists in the United States and China just two weeks before. The superconducting material, a yet-unnamed oxide composed of yttrium, barium, copper and oxygen, loses all resistance to electricity at 90 K (-183ºC). The relatively high temperature at which the material becomes a superconductor means it can be cooled with liquid nitrogen at relatively low cost. (Canada Report, Summer 1987)

The Netherlands:

Dutch fillip for superconductors

Philips of the Netherlands has formed a team of 25 top scientists to seek a breakthrough in the development of superconducters for commercial applications. The team, working in Eindhoven in the Netherlands, Aachen in West Germany and Briarcliff Manor in New York State in the US, is the first privately funded initiative in Europe aimed to produce a superconducting material that has no electrical resistance at room temperature.

Speaking in Eindhoven last week, the team's leader, Piet Bongers, said that Philips would work closely with researchers at several Dutch universities. The researchers are to rely on a technique called electron microscopy to find the best combination of materials to achieve their objective. The company will also call on applied physicists whose work on Josephson junctions and simple switching devices could lead to new methods of producing on a large scale superconducting chips. (This first appeared in New Scientist, London, 18 June 1987, the weekly review of science and technology)

Seminar cools conductor fervour

Do not, warns IBM, place an order yet for your superconducting computer - there is a long way to go before shipping starts. Alex Mueller of IBM's Zurich Research Laboratory, discoverer of hot superconductivity, brought this note of realism into the superconductivity hype at a London seminar recently. The seminar also heard that IBM will not be reviving its Josephson Junction programme, abandoned in 1983.

According to Praveen Chaudhari of IBM's Yorktown Heights Research Centre, the problem is not temperature, but gain, which for the Josephson Junctions is only a factor of 2-4. As switches they cannot yet compare with transistors, which show a signal gain of between 16 and 20. A major invention is needed before superconductive logic is practicable.

Instead, IBM is concentrating its efforts on superconductive interconnections - the wiring between the switches. The critical factor here is not voltage, as for switches, but current. Until recently the biggest current was 100 amps/cm^2, but IBM announced in April that it had achieved over 100,000 Amps/cm^2 at 77 K. Even once a sufficiently large superconducted current has been attained, the major problem of turning the black lumps of superconducting but brittle ceramic into usable devices remains.

IBM is developing techniques of "spray-painting" surfaces with superconducting material, but, says Chaudhari, "A great deal still needs to be done."

Simultaneously with refining the processing techniques, work continues on testing more compounds for superconductivity and raising the stable transition temperature at which it switches on.

The scientific community is also busy investigating the physics of hot superconductivity, and contending theories are proliferating. Already it seems that the established theory is being re-evaluated. (Computer Weekly, 9 July 1987)

More superconducting surprises

Physicists already in a high state of excitement over the discovery of a new form of superconductivity operating at relatively high temperatures now have something else to watch out for. According to Qi-Guang Luo, of the Chinese Academy of Sciences, and

Rong-Yao Wang, of Tsinghua University, Beijing, cobalt, a ferromagnetic element previously regarded as an unlikely candidate for superconductivity, should indeed be superconducting at low enough temperatures.

Luo and Wang make this prediction on the basis of a study of the electronegativity of various elements. Electronegativity is a concept introduced into chemistry more than half a century ago by the pioneering quantum chemist Linus Pauling. It can be regarded as a measure of the power of the grip an atom has over the electrons with which it is associated. Atoms with low electronegativity easily lose their grip on electrons, which can wander through an atomic lattice, carrying electricity - a typical property of metals.

Metals are good conductors, by and large. Some physicists have suggested that all metals should become superconducting at low enough temperatures and high enough purities. But there is no obvious relationship between conductivity at room temperature and superconductivity at temperatures of a few degrees Kelvin.

Some metals that are relatively poor conductors at room temperature, for example, turn out to be very good superconductors at the right temperature. In their attempt to find out why there is so much variation in the properties of metals at superconducting temperatures, Luo and Wang seized upon electronegativity as an index of just how metallic an individual element is.

When the two Chinese researchers plotted out the elements in order of electronegativity, they found that all the superconductors occur in a band of electronegativity from 1.3 to 1.9 (Journal of the Physics and Chemistry of Solids, Vol. 48, p. 425). By the usual criteria, an element with electronegativity greater than 1.9 is very nonmetallic, whereas an element with electronegativity less than 1.3 is very metallic. The superconducting elements in the band of interest include copper, silver and gold, all of which are certainly regarded as metals in everyday life (they are all good conductors, for example) but which chemists sometimes describe as "inert metals" because they are reluctant to combine with nonmetals, and they do not oxidize easily.

By this criterion, all superconductors are in a sense intermediate between metals and nonmetals. If the idea holds up, cobalt, which has an electronegativity of 1.7, should certainly be a superconductor. This has not yet been tested by experiment, partly because it used to be thought that no ferromagnetic substances were superconducting. In the late 1970s, however, some special cases of ferromagnetic compounds which become superconducting at low temperatures were found. "We suggest," say Luo and Wang, "that it would be worth while to search for the superconductivity of cobalt." (This first appeared in New Scientist, London, 4 June 1987, the weekly review of science and technology)

Superconductors dig into mining

The discovery of high temperature superconductor materials is to start as big a revolution in the mining industry as it already has in the electronics industry.

Rare earth elements, such as yttrium and scandium are the vital ingredients in the newly discovered superconducting compounds. Until a few weeks ago hardly anyone had heard of these elements and their uses were few and far between. Now the race is on to mine these elements which may become a thousand times more precious than platinum.

Yttrium and scandium are found in a mineral called monazite. Rich deposits of monazite are found in the United States, China and Australia. Substantial quantities of monazite are also mined in India, Brazil and Malaysia. The latter three countries and the US have their own monazite processing facilities and so are well placed to take advantage of the expected boom in these elements.

In Europe, processing is concentrated in France, Federal Republic of Germany, Austria, Norway and the UK. In Japan there are a number of companies involved in processing rare earth elements from various mineral ores. A mining company in Australia, Allied Eneaba Ltd., has announced that it plans to build a processing plant with a capacity to process up to 12,000 tons of monazite a year.

Scandium has never been produced or used in commercial quantities; indeed a single pound of scandium produced in 1960 had been the largest amount of scandium ever produced at the time. Yttrium, on the other hand, has several applications and is recovered from the 50,000 tons of monazite and bastnasite dug up by mining companies each year. Yttrium's most important application before the discovery of high temperature superconductors was in neodynium/yttrium aluminium lasers, used extensively for surgery. (Reprinted from Electronics Weekly, 15 April 1987)

* * *

Supercomputers

Cray Research's 70 per cent strangle-hold on the world supercomputer market is about to be seriously threatened by rivals taking advantage of the rapid advances in parallel processing technology. The threat facing Cray comes from at least two separate quarters - giant Japanese electronics companies and aggressive US start-ups. An assortment of exotic supercomputer technologies were being brandished by US hopefuls at the recent world supercomputer exhibition in Santa Clara, California.

Although Cray dominates the market with 70 per cent of all supercomputer sales, new companies are attempting to exploit the lower end of the market. The demand for superminicomputers has spawned a variety of start-up companies touting new parallel processing architectures that promise Cray-like speeds at much lower prices.

Two Californian companies, Chopp Computer and Saxpy Computer created a stir at the conference by demonstrating for the first time their unique supercomputer architectures.

Chopp claimed that its new machine is capable of computing speeds 10 times higher than any other commercially available system. The Chopp computer is designed for scalar computations and can achieve a throughput of 200 megaflops compared to 19 megaflops on other systems. The air-cooled system will be ready for shipping in mid-1988 costing about $4 million.

Saxpy is also claiming high computational speeds through the use of what it calls Matrix processing. This allows for computational speeds of between 250 million and 1 billion operations per second at a system price starting as low as $896,000.

Californian company Cydrome also showed its Cydra minisupercomputer. The Cydra 5 uses a dataflow architecture to achieve high computational speeds through multiple 68020 Motorola microprocessors.

Low-cost supercomputing power means that commercial applications are now feasible. The large $20 million Cray supercomputers have so far been restricted to the Government defence and scientific users that can afford them.

Gene Amdahl, founder of Amdahl and now president of superminicomputer manufacturer Elxsi Computer, said that although supercomputer architectures may vary, there is no reason to change from silicon-based chips.

"Gallium arsenide has been the great hope of the future but silicon ecl (emitter coupled logic) isn't quite dead yet. In some implementations, silicon ecl ram chips have faster access times than their equivalent gallium arsenide devices," Amdahl said.

The international nature of the conference did not prevent some dire warnings to US supercomputer companies about threats from abroad. Peter Patton, director of the Minnesota Supercomputer Institute, predicts that Japanese supercomputer manufacturers are poised for a major breakthrough.

He described how the Japanese have designed their supercomputers to be IBM software compatible. "The Japanese are working on using their supercomputers to run manufacturing processes and create large and complex engineering databases that will help improve the productivity of Japanese factories," Patton said.

Japanese supercomputers have had very low penetration into the US market because of the highly technical applications that have been the favoured use for supercomputers. But Patton now sees the IBM compatible capacity that Japanese supercomputers have an advantage. He foresees an embarrassing time when Cray software may have to be rewritten for Japanese supercomputers. ... (Computing, 21 May 1987)

The desk-top supercomputer

Electronics engineers at UK's Southampton University plan to unveil a supercomputer this year to match the most powerful machines now in service, but which could be produced and sold at about only one tenth of their price. Designed by Dr. Chris Jesshope and Dr. Denis Nicole in the University's Department of Electronic Engineering, it has been developed as part of the ESPRIT programme, the European initiative at government level which aims to keep advanced technology in Western Europe well abreast of that in other countries.

The main reason for the low cost of the Southampton computer is that it is built on a modular principle. It is assembled from 350 so-called transputers, each of which is a complete computer in miniature with its own memory and an appropriate set of connections to link it to other transputers or to other computers, all on a single silicon chip of about 100 mm^2 area. This contrasts with the design of the Cray supercomputer, for example, which is composed of four linked mainframe computers.

Transputers sell at about $500 apiece. A commercial computer built on the Southampton design could be sold for around $800,000; a Cray costs somewhere in the region of $6 million.

So far, such enormously powerful computers are used in only a few specialized applications such as weather forecasting, aircraft design and some areas of scientific research. But reducing the cost of supercomputing power by a factor of 10 would obviously open up far more applications and bring supercomputing power within the reach of many more potential users.

The transputer has been developed and is being marketed by the British silicon chip company INMOS. Each carries a processor that can be programmed to perform various tasks, a memory that contains a large part of the information the processor needs for its job, and all the connections for linking into other devices.

A single transputer is as powerful as an average full-sized mainframe computer. It is able to perform one-and-a-half million operations every second. Its circuitry is as complex as a complete street map of London with all the gas mains, electricity cables and sewers superimposed. It works faster than comparable processors, is easier to programme and is more compact. But from the point of view of assembly into supercomputers, its most important advantage is the ease with which it can be linked to other transputers or to other computers with no need for extra electronic circuitry.

Because of the Southampton project's significance for the future of the company, INMOS supplied the University with the first of a new generation of transputers, the IMS T 800. This model can handle decimal points or fractions as well as integers; it is the first microprocessor to incorporate a floating-point processor capable of dealing rapidly with decimal digits on the same piece of silicon as a conventional processor handling integers.

In technical language, the IMS T 800 includes a 32-bit integer processor which is the world's fastest, with special instructions to support graphics operations, a 64-bit floating-point processor, four kilobytes of fast on-chip RAM and four standard INMOS communications links, all on a single chip.

Jesshope and Hey see no problems in linking as many as 1,000 tranputers into a single computer. Beyond that, radical redesign will be needed because of the complexities of communication between so many modules. But there is clearly a vast amount of development potential in the present design.

The cost of the transputer is confidently expected to come down as European companies now begin to make it a mainstay of their bid for sales in new areas. The Southampton project is being backed by two French companies as well as by the UK Royal Signals and Radar Research Laboratory. Half of the development costs have been born by the ESPRIT programme. French and British companies (TELMET and Thorn-EMI) are expected to build computers based on the Southampton design. When these and the transputers they incorporate come into wide use and their cost advantages become apparent, it is predicted that large sales will reduce transputer prices still further.

Because of their ability to work co-operatively in parallel on a number of different but related tasks, transputers are well suited for use in so-called parallel processing. By designing computers which work on a number of tasks simultaneously, instead of doing everything in sequence, designers aim to mimic more closely the workings of the human brain.

Transputers are also being assigned to less futuristic applications, including desk-top supercomputers, laser printers and what have been nicknamed turbochargers where the transputer is used as an add-on unit to an existing system to upgrade its performance. High-performance graphics, engineering workstations and robotics are other areas where the transputer is already beginning to make an impact. (British Science News, SPECTRUM, No. 208/1987)

How silicon is going to copy GaAs

Advanced semiconductor devices based on epitaxially grown superlattices, quantum wells, and other exotic structures have so far been largely the stuff of gallium arsenide. But as silicon devices move toward the limits of conventional bulk structures, the same kind of epitaxial device work may soon be done in silicon.

One major indicator comes from Perkin-Elmer Corp.'s Physical Electronics Division. In November, the Eden Prairie, Minn., manufacturer of molecular-beam-epitaxy systems plans to become the first US supplier of molecular-beam-epitaxy equipment designed for silicon research. The division is building five prototype modules for delivery between November and mid-1988. The technology will be a standard option for its modular 430 MBE series.

The Perkin-Elmer entry comes at an opportune time. Silicon molecular-beam-epitaxy research is under way at a number of universities and at firms including AT&T Bell Laboratories, AEG-Telefunken, IBM, and Texas Instruments. The researchers are looking for a way to circumvent the 0.8-μm barrier expected to stop the advance of conventional silicon devices.

That interest also extends to the Defense Department. Perkin-Elmer's first module will go to California Institute of Technology as part of an extensive 430 system that includes separate modules for III-V, II-VI, and metals epitaxy, plus electron spectroscopy for chemical analysis, all linked by transfer tubes to pass wafers among modules within the system's ultrahigh-vacuum environment. The system was funded to the tune of $1.6 million by the Defense Advanced Research Projects Agency and the Office of Naval Research.

Unlike systems used for III-V compounds such as GaAs, silicon molecular-beam epitaxy requires electron-beam evaporators. Compared with resistance heaters used for flux generation at 600°C to 1,100°C in the III-Vs, the e-beam guns can hit the 1,800°C to 2,000°C needed to provide an adequate flux with silicon, a low vapour-pressure material, says Peter Chow, Perkin-Elmer staff scientist.

Perkin-Elmer isn't the only one to spot the opportunity. The Riber Division of Instruments SA in Rueil-Malmsson, France, entered the silicon molecular-beam-epitaxy market two years ago, while VG Semicon Ltd. of Sussex, UK, has supplied equipment for use with silicon for several years.

In fact, next month VG Semicon will deliver to Bell Labs a silicon MBE system believed to be the first one to accommodate multiple wafers. Based on a patented AT&T design, the system can handle up to fifteen 3-in. wafers or seven 5-in. wafers.
(Reprinted from Electronics, 25 June 1987, (c) 1987, McGraw-Hill Inc., all rights reserved)

Uniting silicon and gallium arsenide*

Silicon is plentiful and easy to work with, but its shortcomings are becoming increasingly evident. It cannot practically be made to emit light, so it is useless for making the lasers and LEDs that form the heart of fibre optics, optical disc readers, and future optical computers. Speed is another limitation. Silicon devices perform poorly or not at all at microwave frequencies (often tens of gigahertz); in digital systems, silicon's relative sluggishness puts a ceiling on the number of bits per second that a circuit can handle.

Gallium arsenide shines where silicon slumps. Electrons are about five times as mobile in GaAs as they are in silicon, resulting in proportionately higher operating speeds. Moreover, GaAs devices can emit light, withstand higher temperatures, and survive higher doses of radiation (such as the alpha particles emitted by some electronic packaging materials). Among the latest digital GaAs circuits are ultrafast memories and "gate array" chips, which users can configure into high-speed number-crunching elements. Supercomputer manufacturers are testing these devices in preparation for their next-generation systems, which will employ GaAs for some crucial functions.

Unfortunately, GaAs has its own severe drawbacks: it is difficult to produce and to work with. Whereas silicon crystals can be grown six inches in diameter (and eight-inch crystals are in the offing), GaAs ingots yield substrates barely three inches in diameter. And unlike hard, silvery silicon, greyish GaAs is soft and fragile, tending to break during slicing, scratch during polishing, and chip during handling. Typically fewer than half of the wafers remain intact. Such difficulties have kept gallium arsenide expensive; its use for large integrated circuits has been limited mainly to military systems in which high speed and radiation hardness are essential.

But recent developments suggest that gallium arsenide will ride into the commercial mainstream literally on the back of the now dominant semiconductors. The concept is simple: deposit GaAs on top of silicon to reap the advantages of both materials. The resulting wafers would combine the speed and optoelectronic properties of GaAs with the mechanical ruggedness of silicon. And almost overnight, the process could double the diameter of GaAs starting materials from three inches to six, with an attendant increase in production throughput. With silicon as a stronger base material, gallium arsenide substrates could be processed with far fewer damaged during production, and could be more easily handled by automated tools such as robot arms.

Although no GaAs-on-Si devices have hit the market, activity is widespread; commercialization seems likely during the next 18 months. Texas Instruments recently built a 1-kilobit memory in GaAs-on-Si that performed identically to versions made with straight GaAs. Start-up company Kopin, a spin-off of MIT, promises production of GaAs-on-Si wafers sometime this year. Nearby, both GTE Laboratories and Spire are building solar cells in GaAs-on-Si. The two materials absorb slightly different portions of the sun's spectrum, so if they work together they might convert as much as 30 per cent of incoming light into electricity - about twice the efficiency of conventional silicon solar cells.

And the trend toward growing one electronic material on top of another won't stop with GaAs-on-Si. Already, great progress is being made in depositing other materials on silicon - and on GaAs-on-silicon. Ford Aerospace & Communications, for instance, is working with such multilayer structures in order to increase the size of infra-red detectors used in many military systems. The active ingredient in these detectors - mercury cadmium telluride (HgCdTe) - works best if deposited onto cadmium telluride (CdTe); unfortunately, it is extremely difficult to fabricate large, high-quality CdTe wafers. Ford attacks the problem by starting with a sturdy silicon foundation and coating it with GaAs, a material with which CdTe is more compatible. CdTe is grown on top of the GaAs, and HgCdTe on top of that. Not only can Ford produce bigger sensors this way, but the silicon in the resulting device could be used for signal-processing circuits.

When GaAs and other materials are combined with silicon, each material can handle the tasks it's best suited for. Intelligent camera imagers or flat-panel displays, for example, could mate nonsilicon picture elements with silicon image-processing circuitry. And in fibre optic telecommunications, lasers and light detectors made of gallium arsenide could team up with silicon circuitry that handled memory and signal processing chores, all on the same chip.

Taking a step in this direction, researchers at MIT's Lincoln Laboratory recently reported the integration of a GaAs light-emitting diode and a silicon transistor on the same silicon substrate. Such a combination permits very-large-scale ICs to communicate with each other optically, avoiding the

* By John G. Posa, High Technology, March 1987.

electromagnetic interference that plagues electrical interconnections.

An extension of this work could result in a single-chip repeater for fibre optic communications. Light from the fibre would strike a silicon photodetector; the resulting electronic signal would be amplified and perhaps reshaped by other silicon signal-processing elements, and then fed into the GaAs laser, which would launch a light beam into the output fibre. An optoelectronic chip with several inputs and outputs could serve as a crosspoint switch to match parties on the telephone network.

While GaAs-on-Si devices have been demonstrated in the laboratory, several major technical problems are impeding attempts to launch them into the marketplace. Among the biggest difficulties:

- Silicon oxidizes easily. In conventional IC fabrication, the ready formation of silicon dioxide (SiO_2) is helpful; the oxide can be etched to produce insulating layers and masks during device fabrication. But in order for GaAs to adhere, the oxide must be stripped away to expose a bare silicon substrate.

- Gallium arsenide expands with heat about twice as fast as silicon does. Thus the cool-down to room temperature after the high-temperature deposition of GaAs results in a bowed wafer.

- Gallium arsenide can grow in two different orientations, or phases. In some areas of the substrate, gallium atoms are the first to attach to the silicon; in other areas, arsenic lands first. When islands of GaAs from the two types of starting possibilities meet, gallium will hit gallium and arsenic will hit arsenic. These "antiphase" defects hinder the flow of current.

- The atoms in a crystal of GaAs are slightly farther apart than those in silicon; at the interface there are about 24 gallium and arsenic atoms for every 25 silicon atoms. This lattice mismatch accumulates during growth, causing defects.

One way to lessen the effect of the difference in atomic spacing between silicon and gallium arsenide is to introduce a buffer layer of a third material. Germanium, for example, forms a strong alloy with silicon, and its crystal lattice matches that of GaAs. Germanium interlayers have been widely studied - at the University of Illinois (Urbana), the Tokyo Institute of Technology, and Nippon Telegraph & Telephone, for example - but the technique is falling into disfavour in part because germanium atoms tend to diffuse into the GaAs layer, causing undesirable changes in the material's electrical behaviour.

In another approach, researchers at Nagoya University separate the GaAs from the Si by a stack of thin layers, each differing slightly in composition from its neighbours. They deposit on silicon a layer of gallium phosphide (GaP). Then comes a series of extremely fine layers of GaAsP, each containing a higher ratio of arsenic to phosphorus, until at the top the material is pure GaAs. This "strained-layer superlattice" gradually relaxes the large lattice mismatch arising from the unequal atomic spacing.

But the advent of new direct-growth techniques may eliminate the need for such superlattice structures. Oki Electric (Tokyo) uses a simple two-step growth process: a relatively thin GaAs layer is grown on the silicon wafer at about 450°C; this layer does not possess good crystalline qualities, but it provides a single strained bond between the silicon and a thicker GaAs film that is deposited on top of it. Oki has fabricated transistors and LEDs on wafers made with this process, and has found that such devices perform identically to those made with pure GaAs wafers. GTE Laboratories has developed a similar process, and aims to use GaAs-on-Si to build solar cells, high-speed transistors, and digital gate arrays.

Most GaAs-on-Si fabrication involves one of two fabrication techniques: molecular beam epitaxy (MBE) or metalorganic chemical vapour deposition (MOCVD). In MBE, a silicon wafer is heated inside an evacuated stainless-steel vessel. Within the chamber are shuttered cells containing the elements that are to be deposited - that is, gallium and arsenic. Opening the shutters permits atoms to escape from the container; some of them fly toward the wafer and adhere to its surface. In MOCVD, by contrast, the silicon wafer sits in a container at or near atmospheric pressure, and the elements for deposition are contained in such compounds as arsine and trimethyl gallium. Heat from the wafer dissociates the compounds; the molecules' metallic constituents (gallium and arsenic) stick to the wafer while the remaining portion is exhausted as hydrocarbons and hydrogen gas.

MBE is an extremely powerful tool that can grow just about any material onto any other material with extreme precision. The process has several drawbacks, however. For one, the machines are expensive, costing upwards of a million dollars. Also, the need for radically low pressures reduces throughput; even the fastest MBE machines process only a few small wafers at a time, whereas some MOCVD systems can handle 10-20 wafers at once. Thus while MBE will continue to be used as the proving ground for new GaAs-on-Si structures, MOCVD appears destined to become a production workhorse.

Although MBE and MOCVD can deposit precise films to ease the lattice mismatch between silicon and gallium arsenide, they do not alleviate the materials' thermal incompatibility, which remains a major hurdle to commercialization. GaAs-coated silicon wafers sometimes bow to a radius of curvature as small as 5.5 metres, according to Ross C. Bean, principal scientist for advanced semiconductor technology at Ford Aerospace; ordinary silicon wafers, he says, are 10 times as flat. The warped wafer is prone to cracks and breakage. As one possible solution to this thermal mismatch, Bean proposes growing GaAs only on those portions of the silicon wafer that will be occupied by the circuitry; GaAs could be etched away from all other areas so that warps would not accumulate.

Even when fabrication problems are solved, there are some applications for which GaAs-on-Si will not be suitable, at least not right away. This exclusion applies, for example, to devices that rely on the conduction of positively charged "holes" as well as negatively charged electrons - a category that includes certain types of efficient solar cells as well as bipolar transistors. The problem is that the stresses created in the GaAs layer form sites where electrons and holes recombine, degrading device performance.

Another area where GaAs-on-Si might not soon compete with bulk GaAs is extremely-high-frequency analog circuits such as millimetre-wave transistors. These devices require a highly resistive substrate material so that current does not bleed from one device to another on the same chip; silicon is more conductive than GaAs and so leads to poorer performance.

And those who are sceptical about the future of GaAs-on-Si cite the fate of an earlier technology - silicon-on-sapphire (SOS). Such devices were touted as superfast and radiation-resistant alternatives to plain silicon circuits. Despite valiant attempts at commercialization by RCA and other companies, SOS remained too expensive for its speed advantage, and the technology was relegated to costly aerospace programmes.

Unlike SOS, however, GaAs-on-Si offers features that are attractive for larger markets. Kopin's President Paul Smith predicts that marrying the two premier semiconductors "might finally bring gallium arsenide into commercial viability". Gallium arsenide on silicon, he contends, could garner up to 35 per cent of the GaAs substrate business. Moreover, GaAs-on-Si wafers may have half the defects of those in conventional gallium arsenide production. With silicon as the substrate, Smith maintains, yield could soar to 70-90 per cent; and with breakage less of a problem, GaAs chip makers will eagerly use larger wafers. Smith says that Kopin will offer six-inch wafers of GaAs-on-Si at a price competitive with three-inch gallium arsenide wafers. (Reprinted with permission, High Technology Magazine, March 1987, pp. 39-41. Copyright (c) 1987 by High Technology Publishing Corporation, 38 Commercial Wharf, Boston, MA 02110, USA)

Wetware

Asahi Chemicals of Japan is planning to launch a connectionist speech-recognition device. Nestor, an American company, has developed a neural device which can read some handwritten texts directly into computers. Synaptics, another American company, has produced a neural device which imitates the retina of the eye. AT&T Bell Laboratories has built an electronic circuit which has 512 neurons on a single chip of silicon. The European Commission has announced a programme for the development of a neurocomputer. The California Institute of Technology has produced an experimental pattern-recognition system as a first step toward an optical neurocomputer. TRW is already marketing a neurocomputer in the US and is poised to release another.

Developers involved in these programmes and other researchers in artificial intelligence are attempting to build machines which model the processes of the human brain by mimicking its anatomic structure of densely-packed cells, or neurons, and synapses, or brain-cell junctions. They are hoping that these machines will eventually be able to organize data using rules that have been developed, through learning, by the machines themselves.

Most experts agree that the wetware of the human nervous system functions as if it were a parallel computer. It contains no central processor; processing power is dispersed throughout the network of cells. Each neuron, which is connected to as many as 1,000 others, collects, combines and processes the signals it receives until its resting threshold is exceeded. It then merely fires output to other neurons, which aggregate inputs in turn. Although they switch perhaps one million times as fast as neurons, transistors on chips do not have this capability to act as sluice gates.

Prototype neuron networks use amplifiers to replicate the neuron core of the brain and algorithms to determine how each pseudo-neuron will process data. Incoming lines for other cells are run through a set of capacitors and resistors that control the neuron resting threshold.

Neuron networks are able to learn by improving the efficiency of connections as they are used. Some researchers use network energy as the criterion of learning. As with neuron synapses in the brain, the net voltage of each neuron changes in response to input signals from connected cells as data are fed into the system. This collective modification continues until the entire network reaches an electrical equilibrium, the sign that it is close to solving a problem.

Other researchers use the back-propagation of errors as the criterion. In this method, the neurocomputer compares each solution with the expected answer, corrects the errors, sends the error codes back to the layers of processing cells hidden in the machine, and tries again.

In both cases, each neuron in the system modifies its own equations. The researchers do not know exactly how this is accomplished, nor are they able to predict exactly where the machines will store knowledge, but, as in the human learning process, neural networks are already programming themselves. (Bulletin IBIPRESS, No. 130, 31 May 1987)

Developments in biosensors

One area of biotechnology currently attracting a good deal of attention is that of biosensors and associated developments in molecular electronics.

Biosensors are devices which register electrical signals as a result of biochemical reactions. Enzyme electrodes, the most common biosensors, use molecular mediators to shuttle electrons between the catalyst and the electrode surface.

To date, only one compound, ferrocene, and its derivatives, has been able to satisfy the criteria for a successful mediator: namely chemical stability, low toxicity and the appropriate redox potential. However, Tony Turner of the Cranfield Biotechnology Centre told delegates of a new compound, tetrathiafulvalene (TTF), which in tests has shown certain advantages over ferrocene. For example, it is more pH sensitive and less oxygen sensitive.

Turner expressed hope that TTF would be able to replace ferrocene as a mediator for amperometric biosensors, the only biosensors commercially available.

Biosensors are currently finding applications in the areas of blood analysis, fermentation analysis and food analysis. In addition to their use in enzyme electrodes, mediators can be used in DNA probes and for immunoassay enzyme amplification.

On the subject of molecular electronics, Professor Peter Day of Oxford University told delegates that advances in the reduction in size of electronic components had put them on a par with certain biological components, e.g. viruses.

Explaining that silicon-based technology was reaching certain limits imposed by, amongst other things, the sensitivity of microscopic components, Day outlined the advantages molecular conductors promised, including their sensitivity to impurities, their self-assembly properties and their potential for high-density packing. Molecules also offer the advantage of being able to work in three dimensions. However, Day explained that research on molecular electronics still faces several obstacles. The synthesis of molecular conductors, their chemical stability and their stability to heat are still problem areas. (Chemistry and Industry, 1 June 1987)

A 16-megabit memory chip from Japan

Just as dynamic random-access memory (DRAM) chips storing 1 million binary bits of information begin to enter the market in large numbers, researchers from Nippon Telegraph and Telephone's (NTT) Atsugi Electrical Communications Laboratories near Tokyo have leaped ahead two generations with the introduction of a DRAM with 16 times that storage capacity.

The announcement was made at the International Solid-State Circuits Conference in late February in New York, where five other Japanese companies and IBM also discussed 4-megabit (4-Mb) chips. Three other firms introduced experimental 4-Mb DRAMs at last year's conference. None of these advanced DRAMs are yet ready for production, but they indicate the types of microcircuit technologies future commercial versions will feature.

The Japanese domination of the session devoted to advanced DRAMs suggests their continued control of this segment of the integrated circuit industry. Japanese firms last year reportedly made 65 per cent of the DRAMs sold in the United States, where the chip was invented, and held 80 per cent of the world market. Because DRAMs are a high-volume product where new technology often appears first, leadership in their manufacture is often taken as a marker of overall position in a highly competitive business.

Concern in the United States over loss of leadership is at a peak right now. Last week, the Semiconductor Industry Association, which represents American integrated circuit makers, announced an agreement to establish a joint research and development consortium to be called Sematech for Semiconductor Manufacturing Technology Institute. Although funding arrangements for the venture are yet to be worked out, most proposals call for substantial federal contributions to an annual budget that could be in the neighbourhood of $300 million. Earlier this year, the Pentagon's Defense Science Board released a report calling for more than $1 billion of federal spending over five years on microelectronics, much of it focused on DRAMs.

A November report from Brookhaven National Laboratory outlined a specific plan for the development of the advanced technology needed for future generations of DRAMs. The result of a series of workshops with participation by Brookhaven, industry, and academic researchers, the plan highlights one role that US national laboratories can play in aiding industry. In particular, it focuses on the use of synchrotron radiation for the X-ray lithography that could imprint circuit patterns with minimum feature sizes of 0.25 micrometer. Cost would be $395 million to be spent over six years. ... (Science, Vol. 235, 10 July 1987, p. 1,324)

Memory chips take on finer dimensions

An American company claims to be well on the way to producing a transistor. According to computer maker IBM, transistors with components one tenth of a micro across could be used to build memory chips capable of storing one billion bits - a gigabit - of data.

The present one megabit memory chips are made from lines one micron wide. The next generation of memory chips, 16 megabit chips, will have dimensions of half-a-micron. At present the parts in IBM's experimental transistor vary between a quarter and one tenth of a micron (a thousandth of a millimetre), but IBM maintains it is ahead of its rivals in the miniaturization game. The company's scientists are up against what is known as scaling theory, which predicts the points at which parts get so small that they will not work any more. For instance, at a tenth of a micron, the voltages needed to switch a transistor would also damage them.

At low temperatures, smaller voltages are needed to switch a transistor. IBM has had to cool its devices in liquid nitrogen to get them to work. Fabricating transistors of sizes around one tenth of a micron is not easy either. IBM has had to develop its own electron beam machines to inscribe the small and complex patterns on silicon. ...

The laboratory transistors are n-channel metal oxide silicon (NMOS) transistors. IBM plans to apply its shrinking techniques to complementary-channel (CMOS) chips which work in a different way from the NMOS chips, but are faster at switching. IBM acknowledges it will have to improve the techniques used to transfer chip designs to silicon still further if it is to produce what is called a fully scaled chip (one in which all elements measure a tenth of a micron or less across). (This first appeared in New Scientist, London, 20 August 1987, p. 27, the weekly review of science and technology)

III. MARKET TRENDS AND COMPANY NEWS

Winds of change sweep the industry*

A massive restructuring is now sweeping through the worldwide semiconductor industry, causing as profound and dramatic a series of changes as the business has ever experienced in its short but tumultuous history. Buffeted by the need to keep up with rapidly-changing technology on the one hand and a host of dangerous economic and political forces popping up on the other, many chip makers face what amounts to a do-or-die struggle. As a result, the industry will look vastly different by the year 2000; and along the way, chip makers will have to make it through at least two severe dislocations.

By the early 1990s, the emergence of highly sophisticated computer-aided-design tools will cause further restructuring when it becomes possible for nearly every potential user to develop his or her own circuit and then farm out the design to a foundry to fabricate. Then, by the late 1990s, the industry may have to face a restructuring at least as significant as the shift of the main integration vehicle from bipolar to MOS in the late 1960s. Indeed, if the increases in circuit complexity are to go on, it may be necessary to shift not only to a totally new transistor structure, but to new materials.

The basic factor that chip makers must face up to is that as chips grow more highly integrated, they look more and more like systems than components. The upshot is that the long-established importance of standard chip products erodes, and semi-custom or application-specific integrated circuits become more and more important. Although standard commodity chips still account for well over half of the units shipped, they generate only about half of the industry's revenue, by some estimates. More and more, the money is in semicustom parts and ASICs.

It is commonly believed within the US industry that the Japanese drive for major market share is the major factor behind the wrenching changes that it is going through. That drive obviously is having strong short-term effects, but the technology itself is behind the more fundamental, long-term shifts that can

* Excerpted from a Special Semiconductor Issue in Electronics, 2 April 1987.

already be seen. With standard products losing their dominance, the merchant IC companies will decline - unless they capitalize on the snowballing ASIC trend. But to do that, they must forge the kind of relationship with customers that ASIC houses pioneered: very close ties emphasizing large amounts of service.

The design process also must change radically, with more of the design being done by the customer with CAD tools, and with the design task focused more and more narrowly on specific systems or niches within the marketplace.

Because of these new imperatives, a landscape once dominated by a few manufacturers that pioneered in the technology can now be seen as a spectrum of many types of chip makers - at least in the US - with companies clustered in four main areas: the traditional merchant IC houses, the vertically integrated conglomerates with captive semiconductor operations, ASIC specialty houses, and the group of niche specialists who either focus on an area of design expertise or on a targeted process expertise. The members of each of these four groups each bring their own brand of strengths to the new ball game, and they each face a unique set of challenges. ...

The lines between these groups are not always clearly drawn. Intel and National Semiconductor Corp., for example, have ASIC operations and are expanding their systems activities. The semiconductor arms of Motorola Inc. and Texas Instruments Inc. have always been more or less autonomous segments of vertically integrated systems houses. And NCR is a leader in the standard-cell ASIC field.

Companies in all of these groups are struggling to stay on board the fast-moving roller-coaster of technology. And they must deal with an array of limiting economic and political factors that will determine the new shape of the industry. Among the foremost is the increasing cost and more rapid obsolescence of capital equipment. Automated submicron fab lines cost upwards of $100 million and may have a useful life of only two or three years. By the late 1990s, calculates market researcher Dataquest Inc. of San Jose, Calif., a fab line will have to produce $650 million in annual revenue to justify itself.

Another key development is the shift of the bulk of IC production and consumption to Japan and the Far East. U.S. companies have tried a variety of methods to win greater entry into Japan - from alliances of every stripe to a trade dispute of major proportions. Their inability to gain entry in any large measure, or to stem Asian dominance of US commodity markets, has profoundly affected the strategy of the US merchant chip makers.

Because they are effectively shut out of the Japanese market, these companies are turning to making advanced niche products with higher selling prices, notes Gene Norrett, head of Dataquest's semiconductor service. "Commodity products are gone," he says. "Japanese companies will maintain their closed market at home and sacrifice chip profits to support their vertically integrated structures. US companies will make high-end chips like digital signal processors and sell them to each other."

The alliances are one aspect of a consolidation that is picking up speed. Another aspect is the increasing importance of joint projects, such as Sematech, the proposed manufacturing consortium. Beyond that, mergers are expected to reshape the industry. ...

It is in this context that the traditional IC merchants are trying to survive and the newer technology-driven companies are attempting to gain a foothold. Most executives at mainstream companies agree that the trend toward higher integration is a major challenge to makers of standard ICs, because the more integrated the chip, the more system-specific or application-specific it must therefore be. They acknowledge that their companies are slower than the specialty houses to react to the trend. But they say they are attempting to develop focused strategies - such as starting ASIC divisions - while at the same time maintaining a broad product line.

The big companies acknowledge that commodity products may have turned into a losing game. But they insist that standard products will remain paramount, and that niches can't stay hidden for long. Therefore the merchants are putting top emphasis on developing proprietary standard products, while many of them move cautiously into ASICs.

And where the small newcomers make great claims for their intimate relationships with customers, TI and the other majors can offer one-stop shopping. All of the big merchant IC makers claim their customers want to cut the number of suppliers in order to improve quality and reduce their paperwork. Consequently, systems houses are reducing the number of their suppliers, and the effect on a chip maker who doesn't make the cut is severe.

The majors offer deep product lines. Motorola, for example, is buying dynamic random-access-memory dice from Toshiba and even is getting back into DRAM production itself so that its salespeople can carry a complete portfolio. National also has put top emphasis on the design of standard VLSI chips.

Getting into ASICs is forcing the majors to rethink their operations. The big merchant houses haven't been willing to allocate sufficient resources to provide the kind of support ASICs require, and in addition big-company bureaucracies defeat the whole point of ASICs: fast turnaround. Motorola therefore has isolated its ASIC operation and has made it into a quasi-independent unit.

While they change directions, the older chip makers may draw on their arsenal of patents to keep the newcomers at bay. Suddenly, "intellectual property" has become of far more than intellectual interest. Encouraged by TI's success in extracting DRAM royalties from Japanese suppliers, the merchants are, in the words of Intel's Moore, "awakening to a new opportunity".

"A lot of new entries don't have a patent position," Moore says bluntly. "Some companies could be shut down. Patents and copyrights will change the ground rules in favour of big, established companies that have developed intellectual property." Rodney Smith, president and CEO of Altera Corp. in Santa Clara, Calif., agrees that intellectual property is the key to future success in the industry - but not just for the big, established companies. "Manufacturing is no longer an art," says Smith, whose company has no fabrication facilities of its own. "The real added value is in architecture, design, and testing."

As the merchant IC houses lumber into place, the ASIC early birds are already jumping ahead with the next generation of tools for design, simulation, and layout. This kind of advanced engineering and the service with which it is supported remain their edge; ASIC companies make it easier for their customers to design complex systems. With these tools and the very nature of their business, the ASIC houses are best able to capitalize on the central problem of increasing integration: as the chips get more complex, they look more and more like the system they implement.

These companies are expanding in two directions. They are spinning off customer designs into standard products, and they are developing their own complex macrocells, such as LSI Logic's multiplier/accumulator. But the principal strengths of companies like LSI Logic remain in their ability to make use of higher levels of integration quickly, and to provide customers with sophisticated design tools and fast-turnaround service on designs.

Even as the ASIC houses distance themselves from the mainstream companies, they are finding competition from the new breed of niche companies. These companies also emphasize service and advanced engineering. Yet because they are specialists in one design area or process technology, they can concentrate their resources. At Weitek and Brooktree, for instance, that area is product definition and design. And because these newcomers do not bear the crushing burden of replacing expensive fab lines, they can spend more money on technical support, sales, and marketing. At Weitek, in Sunnyvale, Calif., there is one applications engineer for every field sales person - whereas large IC merchants may have one engineer for every 16 salesmen.

Having a wafer-fab line requires a company to scramble all the time to keep it operating at capacity, says Brooktree president James A. Bixby. Without a fab line, the San Diego company is free to focus on product definition and design, which Bixby considers the industry's fundamental art. Success at design innovation grows from close relationships with customers, he says.

But not all of the newer companies avoid owning fab lines, and some of them even specialize in it. For example, Cypress Semiconductor is known for a flexible high-performance process and a fab line implementing it that can multiplex 75 different products, including fast 35-ns programmable read-only memories and 15-ns RAMs.

One of the strengths of the small niche companies - a close relationship with the customer - is also a hallmark of vertically integrated systems houses with their own IC operations, such as NCR, because the customer is very often within the company. And the other big advantage of the verticals - the deep pockets of the parent corporation - is taking on more and more importance.

The Japanese chip makers are the quintessential vertical companies. But unless they change the way they do business, says T. J. Rodgers, president of Cypress, they will not be able to compete in the new markets, which are dominated by niche products and system-specific solutions. US merchants have sufficiently diversified product lines to survive, he says, but the Japanese are too slow-moving and too averse to taking risks to compete in such markets.

That situation may not last. Dataquest reports that the Japanese are turning away from volume manufacturing and are investing heavily in R&D for leading-edge technologies, such as 16-Mb DRAMs, 32-bit microprocessors, three-dimensional CAD systems, expert systems for designing VLSI circuits, new materials such as gallium arsenide, and bioelectronics. Between 1984 and 1988, Dataquest says, Japanese manufacturers will have opened at least 80 basic research laboratories and spent an awesome $2 billion on them.

Moreover, an increasing number of US startups are trading technology to Japan for capital, manufacturing capacity, and market access. And shifts in low-end manufacturing to other Asian countries are driving Japanese companies into direct competition with the US companies in the market for chips with a higher level of design-value content than such chips as commodity memories have. That's one reason for the increasing attention US companies are giving to the protection of intellectual property, Dataquest says.

Because of their internal synergies and their financial strengths, integrated companies are widely seen as the best equipped to survive in their current form until the year 2000. It is not surprising, then, that traditional US semiconductor manufacturers are looking to emulate these strengths. And there is more than one route to vertical integration.

The now-aborted attempt by Fujitsu Ltd. to take over Fairchild Semiconductor Corp., and Thomson CSF's acquisition of the remains of Mostek Corp., are examples of moves toward the classical vertical model. But vertically integrated IC companies have never done well in the US; they have not been able to integrate the volatile chip operations with the broad interests of the parent companies.

Another path is being blazed by Intel and National Semiconductor. They are turning themselves into a new kind of vertical organization, a systems outgrowth of an IC company.

Even horizontal integration might appear, with large IC houses acquiring smaller ASIC houses and becoming corporate hubs for satellite operations.

Another survival strategy is co-operation. The merchant houses have turned to the government, looking to the Department of Defense for help and to Congress for some way of accommodating joint industry projects by bending the antitrust laws. The manufacturing consortium the chip makers have proposed, Sematech, is supposed to put US companies on a par with the Japanese in manufacturing. The big question is whether Sematech can unite an industry that has always prided itself on its diversity.

This diversity has always been one of the strengths of the semiconductor industry, and it's likely to help merchant houses, ASIC suppliers, design and process specialists, and vertically integrated giants all live to see the year 2000. There are many strategies for survival, and the companies that successfully carry theirs out may look very different than they do now - but they'll still be around. (Reprinted from <u>Electronics</u>, 2 April 1987,

<u>The look of the industry in 2000</u>

It has never been easy to predict where the chip makers are heading. But long-term technology trends still foretell the most. With much of the technology that will be in place by the turn of the century already in various stages of development, the picture for the year 2000 emerges. By then, the industry will be completely redefined in terms of its structure, the participants, and, most important, the way products are designed, manufactured, and marketed.

The semiconductor world will be divided into two camps, each with its own distinctive set of market characteristics. One will produce high-volume commodity parts, and the other the many forms of semicustom chips, including system-, customer-, and application-specific integrated circuits, as well as other parts targeted at low-volume market niches. The commodity side of the industry, which will be in the hands of a relatively few players, will focus more on low-cost manufacturing than on interaction with customers. The semicustom side will represent a completely different way of doing business, with especially close customer relationships and high levels of service and support. On this side, the year 2000 will see a free-for-all with every type of chip maker - from the giant commodity producers to the tiny design house - still in the fray.

Some industry observers see the semicustom side of the business becoming overwhelmingly dominant by 2000, and commodity parts very nearly disappearing, as higher levels of integration and easy customization of chips lead to a world populated by highly individualized systems on chips. Even memories are beginning to be application-specific in nature, they point out. The noncommodity side of the marketplace is already flexing its muscles: Pasquale Pistorio, the chairman and CEO of SGS Microelettronica of Agrate, Italy, argues that while commodities now represent 80 per cent of all parts shipped, they account for only 50 per cent of the dollars. He predicts these high-volume products will continue to lose market share all through the 1990s.

Not everyone agrees with Pistorio's scenario. Charles H. Phipps, a former TI marketing vice president who is now a consultant, claims that "generic" products - any part that makes it to high-volume sales without requiring extensive sales support - will account for 70 per cent of IC dollar volume and will still provide 60 per cent of sales by the mid-1990s. As a result, he argues, merchant houses will retain a strong role.

But all agree that even if the noncommodity side of the industry does not push the high-volume vendors out of the market, it will be a force to be reckoned with, creating its own market environment. With the advent of powerful design tools for ASICs and other semicustom chips, the design prerogative, once firmly in the hands of the chip maker, will have shifted to the systems designer by the end of the century. In addition to intimate vendor-customer relationships during the design cycle, fast turnaround and ongoing dedication to customer service will be far more important than the ability to turn out millions of low-cost chips.

By the year 2000, innovative design and architecture will have superseded process and manufacturing as the keys to product success, an industry environment that will continue to spawn young, spirited companies whose strength lies in the development of unique proprietary products without the burden of costly fabrication facilities. These fast-moving design specialists will flourish alongside a group of specialists of the opposite type: companies specializing in leading-edge process technologies with applications in niche markets.

Straddling the fence between semicustom and commodity markets will be a number of powerful vertically integrated companies. With their deep pockets, design staffs, production capabilities, and extensive research and development facilities, this type of company may hold the ultimate edge in the battle for survival.

Meanwhile, technology in 2000 will be continuing its inexorable drive into submicron geometries, bringing the promise of generations of faster, denser chips holding a billion devices. The ramifications of such functional power on a chip are barely imaginable for both IC maker and system designer. New device structures and design tools will have been developed for them; voltage levels will have been reduced; and longstanding architectural approaches will by then have been abandoned. The process technologies required may escalate the cost of fabrication facilities to levels that only a few organizations can afford.

As chip makers move raggedly toward the 21st century, the semiconductor landscape will continue to change radically - as it has every decade (see chart). Looming is yet another shakeup in the lineup of the top 10 merchant suppliers, capped by a succession of Japanese megacompanies. Only if IBM Corp. turns merchant in the next decade, as now seems likely, will a US chip maker lead the list, and only one company, Texas Instruments Inc., can boast of having appeared on the list for 20 years. With the predicted decline in commodity markets, some observers doubt the industry can support as many as 10 merchants by the year 2000.

Underlying this turn-of-the-century industry superstructure will be a fast-developing vast and complex network of international alliances in the form of mergers, acquisitions, and technological partnerships. These alliances are being forged out of the realization that no one company can go it alone in exploiting the protean semiconductor technology. Ties will be formed between all companies of all stripes, crossing international borders to complement one another's strengths, bolster gaps in proprietary product lines, and provide manufacturing capacity.

Furthermore, such international alliances will help the IC makers penetrate overseas markets. Not just the US and Japan will be active in these alliances in 2000. European chip makers, traditionally laggards, are already showing new determination to close the technological and marketing gaps. And new forces are gathering in Asia as the Pacific Rim nations emerge as both consumers and suppliers of ICs.

One thing is certain. After all the upheaval and turmoil, though the semiconductor industry may look different and its participants may change by the year 2000, it will emerge as the single most important industry the world has ever seen. (Reprinted from Electronics, 2 April 1987, pp. 60-61, (c) 1987, McGraw-Hill Inc., all rights reserved)

The Japanese crowd into the top 10 merchant IC makers

	1966	1976	1986 (estimate)	1996 (forecast)
1.	Fairchild	TI	NEC	IBM
2.	Texas Instruments	Fairchild	TI	NEC
3.	Motorola	Philips/ Signetics	Fujitsu	Fujitsu
4.	Signetics	National	Hitachi	Hitachi
5.	Westinghouse	Intel	Motorola	Toshiba
6.	Sylvania	Motorola	Toshiba	TI
7.	Raytheon	NEC	Philips	Matsushita
8.	RCA	GI	National	Mitsubishi
9.	Philco	RCA	Intel	Samsung
10.	General Instrument	Rockwell	Matsushita	Siemens

* Source: Integrated Circuit Engineering Corp.

(Electronics, 2 April 1987)

The great ASIC wave gathers force*

Application-specific integrated circuits are a tidal wave about to break over the semiconductor industry. In fact, the takeover is coming faster now than most people had expected. ASICs are selling so fast that within three or four years they should constitute more than half of the $15 billion worldwide logic market. Because of this acceleration, the big semiconductor houses are going all out to establish themselves in the surging market. At the same time, the semicustom houses that pioneered this market are looking hard for ways to hold on to what they've got.

Along with this accelerating growth is rapidly broadening ASIC usage. A spreading universe of customers is expected to fuel exploding sales. Dataquest Inc., for example, predicts that in four years ASIC sales will nearly quadruple (see figure 1). Today, most ASICs are gate arrays sold in vast quantities to a small number of customers, notably computer makers. The new users are equipment makers capitalizing on the advantages of ASICs to build unique performance features into their products and to get to market faster. The number of worldwide ASIC design starts will zoom up dramatically from 6,000 in 1985 to 90,000 in 1990, predicts Technical Insights Inc., an Englewood, N.J., technical publishing house. That total includes design starts from both the systems and equipment suppliers as well as the semiconductor houses.

Equipment suppliers are turning to ASICs even faster than expected because they find themselves in an increasingly competitive situation. Product life cycles keep shrinking, spurring the need for ever more rapid product turnaround. The availability of improved computer-aided engineering tools - fast, powerful computers along with impressive applications software - means that equipment designers need no longer wait for standard ICs. They not only can do it themselves, but they can also do a better job of differentiating their products from the competition. All this leads to accelerating equipment obsolescence, heating up product development even more.

The ASIC market itself is changing, too, making it that much trickier for users, chip makers, and semi-custom houses alike to figure out what to do next. Top industry executives point out that the dominant ASIC market segment, gate arrays, is maturing and price-cutting is rampant - just as the next wave of ASICs is coming to market. Standard-cell-based designs are assuming new importance, and their growth rate will soon outstrip arrays.

For that matter, it's pretty hard to figure out what is and is not an ASIC, much less how to make, sell, or buy them. By the most common definition, "ASIC" means only gate arrays or standard-cell parts. But a fair number of people expand the definition to include programmable logic devices in the ASIC camp. Others argue strongly that the PLD is not an ASIC, because, by definition, it is a commodity device that comes off the assembly line with no specific functions in silicon. If PLDs are included as ASICs, that adds another $417 million or so to the value of 1987 ASIC revenues, and also changes the lineup of players. For example, Monolithic Memories Inc. is a pre-eminent PLD supplier, with 1986 sales of $150 million - about half the PLD market.

Given the growing importance of the ASIC market, it's not surprising that leading chip houses are preparing a formidable market assault. They need to protect their ownership of the vast standard-logic and VLSI markets, both from foreign competition and from the increasingly stinging penetration of the pioneering semicustom houses.

The ASIC thrusts by the major US semiconductor makers build on their strengths as standard logic suppliers. For example, they are trying to build large libraries of standard cells based around their existing standard lines, including their 32-bit microprocessors. With these broad-based product lines, they hope to compete in every segment of the ASIC market. They also hope to beat back the growing foreign competition in ASICs, mostly from the Japanese semiconductor houses that already are among the world leaders in gate arrays.

This is the second time around for most of the US majors. They first jumped into ASICs in the early 1980s, when the semicustom houses opened up the business. But almost without exception, they stumbled, fell back, and regrouped. Now companies such as Motorola, Intel, Texas Instruments, and National are solidly back in ASICs with new strategies for success.

However, executives at the semicustom houses believe that the majors will never take over in ASICs because they can't provide the kind of services that their customers will need. The startup ASIC outfits of the early 1980s, LSI Logic Corp. and VLSI Technology Inc., to name two, were organized expressly to pursue the semicustom business, mainly gate arrays and standard cells. They were the innovators and provided the vital software tools necessary to carve functional designs in silicon. The cornerstone of the newcomers' approach was twin design bombshells: the ability to emulate virtually any logic device and to integrate entire systems within one or just a few chips.

But their real strength came from building customer relationships. Not having a standard catalogue of off the-shelf functions like those from the major IC houses, the semicustom intruders broke new ground - they worked closely with customers to define, design, and supply working silicon. Working so closely amounts to handholding - it makes the customer feel that he has selected a stable semiconductor vendor with the right technology and fast turnaround of reliable parts.

This, say the major semiconductor suppliers - who have yet to make a big dent in ASICs - is something they now understand after several false starts into ASICs. They say they will bring a barrage of technology to the fray, and match prototype turnaround times and production runs more closely to customers' needs; they will provide design training and help with the systems implementation, too.

Even if the established semicustom houses are sceptical about the latest efforts of the big chip firms, they are not taking any chances. They are seeking haven in niche markets or moving up in technology, toward gate arrays with 200,000 gates or ones with on-board memory or programmable logic; or they are unwrapping new ASIC alternatives sporting new terminologies; semistandard, value-added semicustom, or customizable standard ICs. The idea here is to leverage ASIC technology into the VLSI arena and to tailor or customize chips to greater degrees of functional specificity.

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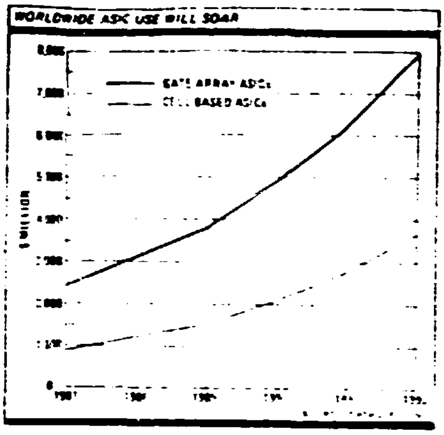
* A special ASIC issue in Electronics, 6 August 1987, from p. 60 onwards, discusses megatrends in the ASIC market.

Of course, the major semiconductor houses can try to make their chips easier to customize more fully, too. But they are likely to take a different route - by way of PLDs or gate arrays, or by incorporating customer-alterable sections into standard products, through mask-programmable circuits or compiled cells. (Reprinted from Electronics, 6 August 1987, pp. 58-59,



(Electronics, 6 August 1987)

Some chipmakers are taking a gamble on "RISC"

The current leaders in microprocessor technology, Intel, Motorola, and National Semiconductor, figure they have locked up the market for so-called 32-bit chips. These microprocessors are the "brains" of today's speediest desktop computers, and they promise to bring minicomputer power to tomorrow's desktop workstations and other electronic products.

But while the three semiconductor giants control roughly 90 per cent of the pivotal 32-bit market, that isn't deterring a flock of new hopefuls. Now in the running are a dozen or more US chipmakers, at least two American computer companies, and the Japanese. Most of these newcomers believe that they can steal business with a special breed of 32-bit chip. They claim their RISC chips, short for reduced instruction-set computing, are much faster than the usual models.

The struggle boiled over when both Sun Microsystems Inc. and Mips Computer Systems Inc. announced that they would sell to all comers the RISC chips that power their latest and fastest workstations. Sun and Mips are believed to be the first computer companies to sell the specialized 32-bit chips that are the core of systems designed to solve heavyweight engineering and scientific problems. Sun explained that it wants to capitalize on the $15 million it spent to develop the chip after concluding three years ago that the 32-bit entries from the usual suppliers would not provide enough oomph for its next high-end computers. Now the company has licensed three chipmakers - Fujitsu Microelectronics, Cypress Semiconductor, and Bipolar Integrated Technology - to manufacture and market the design.

RISC chips owe their speed to their simplicity. Normally, a microprocessor has a couple of hundred or more data processing instructions embedded in its circuitry. This "firmware" vastly simplifies writing the software that enables the chip to work in a new application. Other things being equal, the user will tend to purchase the chip with the richest instruction set because that will reduce the time it takes to write programmes. For special-purpose applications, however, many of the embedded instructions are used rarely, if ever. The old 80-20 rule applies: 20 per cent of the instructions do 80 per cent of the work. If the little-used commands are eliminated, the remaining instructions can "execute" much faster.

Thanks to the continuing decline in semiconductor costs, plus the lower cost of producing RISC chips' simplified circuits, a computer can now be assembled for $10,000 or less yet offer performance approaching that of minicomputers costing $100,000 and up. At such price/performance levels, the demand for RISC-based machines should be able to sustain several niche-market competitors for conventional 32-bit chips.

The Japanese semiconductor producers hope that the segmentation of the microprocessor business will provide the chance they have been waiting for. Mitsubishi Electric, Hitachi, Fujitsu, and NEC are working on speedy 32-bit chips and hope to steal some thunder from the US. Toshiba Corp. in late June announced a RISC chip for artificial-intelligence applications that it claims is the world's fastest.

The Japanese and other niche players hope that getting their chip designs established at the high end could put them in the running for the big-volume "supersmart" products that market researcher Dataquest Inc. predicts will emerge after 1990. Once the price of 32-bit chips has tumbled from several hundred dollars each to less than $50, 32-bit chips could be the springboard for whole new classes of products designed to make life easier. ...

In real-life situations, says Motorola, its regular chips are 90 per cent-plus as fast as RISC designs. Dataquest analyst Brad Smith says RISC may provide gains of 50 per cent to 75 per cent, but that may not be enough to persuade customers to drop full-instruction sets. That's especially true because moving to RISC can require a heavy investment in new software.

Even claims of such a performance advantage may not last long. To appeal to more customers, many RISC suppliers are grudgingly adding more instructions, while the designers of regular microprocessors are working to refine their circuits and speed up their chips. Linda E. Martelli, manager of microprocessor marketing at AT&T Components & Electronic Systems, believes the next generation of 32-bit chips will be able to execute virtually any instruction in just one tick of their internal clock. That would make the number of instructions a moot issue. So the newcomers may discover that their gamble is riskier than they thought. (Reprinted from the 20 July 1987 issue of Business Week by special permission, (c) 1987 by McGraw-Hill Inc.)

Computer integrated manufacturing (CIM) - fastest growing sector

The United States manufacturing industry - US$300,000 million produced annually by 20 million employees - hopes to use computer integrated manufacturing to regain its competitive position with the computerized factories of Japan, whose 15 million employees generate an annual total of $350,000 million. Europe has also undertaken initiatives and EEC projects which point in the same direction, all geared towards stimulating a sector which employs 27 million Europeans for an annual turnover of $240,000 million. As was already apparent from the comparative study of American and Japanese initiatives published by the Harvard Business Review, the United States would do well to consider the contrast between the mastodontic projects sponsored by a number of its larger corporations, on the one hand,

and the excellent results obtained by middle-range companies with much more practical, economical systems. The US should also keep in mind that the Japanese success story can be traced to other factors as well: the servicing of large corporations by small, subsidiary concerns; a high level of training of the operating personnel; collateral reforms in the industrial organization.

According to the National Data Corporation, the computerization of manufacturing will be one of the fastest growing subsectors of the entire computer industry: while in 1985 it represented 30 per cent of this US$11,300 million market, in 1990 it will reach 39 per cent of what will then be a US$38,900 million total. The percentage for the subsector involving process regulators will also grow (from 21 to 28 per cent), as will the robot subsector (from 5 to 6 per cent). The other areas will decrease: computerization of inspections and controls (from 12 to 10 per cent); numerically controlled manufacturing machines (from 12 to 4 per cent); equipment for transporting materials (from 9 to 5 per cent); programmable controls unchanged: manufactured informations systems will stay at 2 per cent, while machines for computerized numerical control will rest at one per cent. (Bulletin IBIPRESS, No. 138, 26 July 1987)

The world artificial intelligence market

The results of a study carried out by the BIPE (Bureau d'Information et de Previsions Economique) were presented recently during an event organized by the Artificial Intelligence Association. While up to recently the AI market has been mainly concentrated in the United States, a shift can now be seen towards Europe and Japan.

First of all, it should be pointed out that estimates have only been made for the United States. Moreover, the results only concern the area strictly linked to artificial intelligence, basically constituted by expert systems, while the wider area comprises learning, representation of knowledge, understanding of natural languages, recognition of forms, etc. Moreover, these estimates do not take into account the new advanced technologies which are emerging from artificial intelligence laboratories.

At present, the AI market is strongly concentrated in the United States which holds 72 per cent of the world market. While the American share is expected to decrease from now to 1990, it will nevertheless always remain above two thirds.

The evaluation could work in favour of Europe, which would increase from 17 to 19 per cent while Japan would increase from 11 to 17 per cent.

The European efforts, which up to now have been mainly concentrated on the development of expert systems, should be re-directed towards other AI technologies, thus causing a rebalancing of the shares in the market.

From now to 1990, artificial intelligence software should grow more rapidly in relation to the materials devoted to AI, in a market relationship of 2/3-1/3.

The total world market of AI could increase from US$700 million in 1986 to US$4 billion in 1990. (Bulletin IBIPRESS, No. 130, 31 May 1987)

ES2 opens foundry

European Silicon Structures (ES2), the pan-European custom chip house, has opened for foundry business and its plant at Rousset in the south of France has been qualified by some of Europe's largest electronics companies.

One is Philips, the $16 billion Dutch electronics giant and another is EB Technology, the Norwegian arm of L. M. Ericsson of Sweden. For large companies like these, the main attraction is quick turnround silicon prototypes: for small companies, the attraction is cheap silicon.

The possibility of ES2 spawning a clutch of new semiconductor companies in Europe is approaching feasibility. Now it will be possible to form European companies purely for the design of integrated circuits and it will not be necessary to raise the enormous sums (around $50 million) required to set up silicon production plants for each company. (Electronics Weekly, 29 July 1987)

The Datamation European 25

1986 Rank	1985 Rank	Company	Headquarters
1	1	IBM	US
2	2	Siemens AG	W. Germany
3	3	Digital Equipment Corp.	US
4	4	Ing. C. Olivetti & Co. SpA	Italy
5	5	Groupe Bull	France
6	-	Unisys Corp.	US
7	6	Nixdorf Computer AG	W. Germany
8	9	N.V. Philips Gloeilampenfabrieken	Netherlands
9	12	Hewlett-Packard Co.	US
10	10	STC plc	UK
11	13	NCR Corp.	US
12	8	L. M. Ericsson	Sweden
13	17	Compagnie Générale d'Electricité	France
14	14	Honeywell Inc.	US
15	16	Wang Laboratories Inc.	US
16	18	Control Data Corp.	US
17	19	Commodore International Ltd.	US
18	20	Mannesmann Keinzle GmbH	W. Germany
19	21	BASF	W. Germany
20	25	Atlantic Computers plc	UK
21	-	Rank Xerox	UK
22	23	Apple Computer Inc.	US
23	-	Norsk Data AS	Norway
24	-	Cap Gemini Sogeti	France
25	-	Data General Corp.	US

(Datamation, 1 August 1987)

The combination of the weak US dollar and the continued steady growth in Europe's main markets helped the 25 highest and mightiest European dp companies smash through the $40 billion barrier in 1986. The combined revenues of the top 25 companies in Europe last year - $44.5 billion - represents an impressive increase of 29 per cent over 1985.

For most of the US dp companies facing depressed revenue increases in their home market, Europe provided a growth opportunity not to be missed in 1986. But while US suppliers sought to bolster flagging corporate revenues with strong overseas sales, Europe's indigenous suppliers more than held their own. Last year, the European dp market - valued at over $70 billion - helped firms from both sides of the Atlantic achieve revenue growth.

Though the mainframe market only showed modest increases in most countries, the demand for minicomputers, personal computers, and communications products was strong.

The 1986 DATAMATION European 25 survey also reveals a number of more specific trends. The revenue difference between the first- and last-place firms on the list was again considerable. While IBM, taking its traditional place in the number one position, recorded European dp revenues of $15.7 billion in 1986, Data General was in the chart's basement with sales of $283 million. That revenue threshold for entry to the top 25 is much higher than the $219 million level in 1985, due, for the most part, to the effect of the weak dollar on currency conversions. ...

Most of the European companies had little trouble maintaining genuine growth rates either within Europe or worldwide. There are 14 European companies from seven countries on this year's DATAMATION European 25, compared to 13 in 1985. These European firms accounted for 41 per cent of the combined revenue total of the 25 companies in 1986, up from 35.5 per cent in 1985.

What's more, the combined worldwide revenues of the top 20 European-owned companies rose to $23.4 billion - an increase of 36.6 per cent over the previous year.

This healthy growth among the major European vendors did not affect the positioning of companies at the top of the European 25 table, however. With IBM still in its unassailable number one slot, FRG's Siemens remained at number two, with 14.5 per cent growth on 1986 revenues of $3.9 billion. If its foray into the UK computer market, which began last year, turns out to be successful, then it can expect to do even better in 1987.

Meanwhile, Digital Equipment Corp. kept its number three position with another strong year, registering European revenues of $2.8 billion, while Italy's Olivetti and France's Groupe Bull maintained their respective number four and number five rankings, with each recording growth rates of around 12 per cent in local currency.

Data General re-entered the list at number 25 after having been knocked off the chart in 1985. The minicomputer company's 31 per cent increase in European sales reflected last year's strong growth of Europe's mini market. That trend benefited Digital and helped Norway's fast-growing mini maker Norsk Data enter the rankings for the first time, at number 23, with revenues of $318 million and an astounding 84 per cent sales increase, measured in local currency.

Xerox's European joint venture, Rank Xerox, also climbed back into the rankings during 1986 after dropping off the chart in 1985. Rank Xerox's 1986 dp sales of $371.6 million were up by a hetty 48 per cent over 1985, putting the company into the 21st position in 1986.

Falling off the chart in 1986 was the UK's recently privatized telecommunications authority, British Telecom. The incorrect inclusion of dp revenues garnered from internal sales had placed it at number 15 in the 1985 ranking, but after the proper adjustments were made in the 1986 survey it dropped off the table. The merger of Burroughs and Sperry to form Unisys accounts for the second slot that was filled by a newcomer. Unisys grabbed the number six position on the 1986 chart, knocking West Germany's Nixdorf down one place to number seven, despite its respectable 18 per cent increase in sales, measured in deutschmarks.

But the European company that really took a nosedive last year was Sweden's ailing telecommunications company, L. M. Ericsson, which fell four places to number 12 after a disastrous 9 per cent drop in European sales. That fall follows a two-place slide in 1985, and while some say most of its problems are now sorted out on the dp side, Ericsson has an enormous task ahead of it to regain ground in the European marketplace.

Ericsson's continuing fall from grace, and the merger of Burroughs and Sperry, helped many other firms move up the rankings in 1986. The Dutch Philips group managed to rise one place to number eight despite only a modest 5 per cent increase in sales. Also moving up one position was US micro company Apple Computer Inc., which benefited from strong European demand for its Macintosh. Apple's European revenues were up by 42 per cent, measured in dollars, to $325 million. Office systems specialist Wang Laboratories also recorded a healthy growth rate of 34 per cent and moved up one rung to the number 15 position.

The big climber in 1986 was UK leasing company Atlantic Computers plc, which jumped five places to number 20 after entering the chart for the first time in 1985 at number 25. The company's 50 per cent growth surge was largely a result of increased numbers of high-value leases for IBM 3090 mainframes.

Climbing four places to number 13 was France's telecom giant Compagnie Générale d'Electricité, which recorded dp revenues in Europe of $943 million, up by 10 per cent in local currency. This company will not appear on the chart next year, however, due to the merger of its dp and communications interests with ITT.

Recording much stronger growth in its business last year was US company Hewlett-Packard, which saw its European sales grow by 37 per cent to $1.5 billion, pushing it three places up the ladder to number nine. Five companies edged up two places in the 1986 survey: NCR, Control Data, and Commodore from the US, and Mannesmann and BASF from West Germany. Only six companies remained in the same position as last year. ... (Reprinted with permission of DATAMATION[r] magazine[c], 1 August 1987, copyright by Technical Publishing Company, A. Dunn and Bradstreet Company, all rights reserved)

<u>Can ASICs drive AT&T's chip business?</u>

AT&T Co. set out to conquer the semiconductor market four years ago with an arsenal of commodity memory products. By every account, the strategy failed. The phone company's chips were greeted sceptically, well-entrenched Japanese suppliers held their ground, and within two years, AT&T had changed its focus to niche markets.

Now old Ma Bell is revamping its efforts again. With a new management team at the helm and a new charter in its grasp, AT&T's Components and Electronic Systems Division in Berkeley Heights, N.J., is setting its sights on the burgeoning market for application-specific integrated circuits.

The division's new strategy is based on two premises. The first is that whether or not AT&T sells chips on the outside, it must produce them for internal use in order to be competitive in its equipment markets. Second, AT&T has unique design, development, and manufacturing capabilities that are valuable commodities in their own right. The idea now is to market those talents to the growing number of companies that are abandoning standard ICs in favour of semicustom designs - designs that offer higher functionality and that can help differentiate a product from its competition.

AT&T, though, has a long way to go. Last year, only 17 per cent of the component division's $1 billion in sales went to external customers. And even though half of the division's total business is semiconductors, chips represented only about 5 per cent of its 1986 sales. The division's other products include power supplies, connectors, printed-circuit boards, and other components.

The division's goal is to grow the entire business "dramatically", paying special attention to semiconductors, says William J. Warwick, the new division president. He expects to double chip production overall by 1995, with about two thirds of that growth coming from outside sales, particularly ASICs. ASICs currently account for about 30 per cent to 40 per cent of AT&T's MOS chip business, a figure the company hopes will grow to at least 50 per cent by 1990. AT&T is betting that total chip sales will reach about $400 million by 1995.

To reach those goals, Warwick has left no stone unturned. He has streamlined the marketing operation and imposed a new Japanese-style business philosophy. Internal sales no longer must generate a profit; it is enough if they just generate technology. "We were not optimizing the value of vertical integration," he explains. "We're trying to bring that back."

The key to attacking the competitive ASIC market will be AT&T's ability to cultivate more relationships like the one it now enjoys with Hughes Aircraft Co. AT&T has completed three designs for Hughes in three years, and a fourth is in progress, says ASIC product manager A. Edward Walker. "We have a half-dozen similar arrangements", he adds, including an unnamed European partner for whom AT&T has produced 15 designs. These long-term deals are being used to complement sales of the division's standard products, such as digital signal processors, microprocessors, and other linear and digital devices.

AT&T's ASIC line is built around digital standard cells in 1.25-µm CMOS technology but also includes bipolar digital gate arrays and full-custom capabilities for digital and linear chips built in either bipolar or CMOS technology. The division expects to unveil its 0.9-µm cell library in less than a year. ... (Reprinted from Electronics, 23 July 1987, (c) 1987, McGraw-Hill Inc., all rights reserved)

Will Intel-TI deal speed standards?

Everyone in the application-specific IC business is trying to figure out just what impact the sweeping five-year agreement closely linking the fortunes of Texas Instruments Inc. and Intel Corp. will have. To begin with, observers expect the joint approach in CMOS devices by two of the largest US chip houses to speed standardization in a field that sorely needs it, fragmented as it is among upwards of 200 vendors and a dizzying selection of design options. On the negative side, they question whether two huge companies, each of which considers itself a top gun, can coexist peacefully.

For the two companies, standardization assumes the highest priority. "Putting TI and Intel's name on a standard will help set a clear direction for the ASIC market," says Jack C. Carsten, Intel senior vice president and general manager of its ASIC Components organization. "This agreement can help allay customer confusion by establishing new ASIC standards for all makers to work toward," he adds. But their motivation isn't pure altrusim: they know that a better-ordered ASIC business can only help the biggest suppliers.

Industry analysts agree on the need for standards, but they are equally intrigued by other provisions of the agreement. Among these are developing a common cell library, making current CMOS processes compatible, and jointly developing a 1-µm process by next year. Combining the 150 cells in Intel's VLSi-CELL library with the 200 in TI's TSC500 library should result in 200 small- and medium-scale-integration-level cells immediately, they say. As for processes, the 1-µm goal is likely to center around TI's more scalable EPIC technique (Enhanced Performance Implanted CMOS), which currently is in production at 1.2 µm. Intel's 445 CMOS process is at 1.5 µm.

But the question of whether the agreement can work remains. Based on the evidence of the past decade, the odds are against such alliances between big chip companies. An ASIC deal in 1983 between National Semiconductor Corp. and Motorola Inc. failed, for example. A second-source link between Intel and Advanced Micro Devices Inc. broke up. Deals between supplier and customer, such as the one involving National and Xerox Corp., have a better chance, say the experts.

Not surprisingly, TI and Intel executives maintain that they have a good chance to succeed, for several reasons. For one thing, they say, they do not for the most part compete head-on. For another, their product lines complement each other: TI has what is probably the most comprehensive library of logic functions, and Intel needs those functions to support its industry-leading microprocessors and controllers.

Also, the new partners have put an immense amount of advance work into identifying differences and removing obstacles, says Wally Rhines, senior vice president of the TI Semiconductor Group. The joint work, which amounts to several man-years of effort, includes identification of the most difficult parts to reconcile, detailed process comparisons, and thorough analysis of key software simulation and verification tools. ... (Reprinted from Electronics, 23 July 1987, p. 32, (c) 1987, McGraw-Hill Inc., all rights reserved)

Computer giant plays its ace

The American computer company IBM unveiled in April this year four new personal computers which will replace its existing six-year-old personal computer range. The company, whose earlier products were widely copied or cloned, hopes that its new architecture will deter competitors from producing duplicates of the System/2, as the latest range is called.

IBM has designed its own 32-bit bus (the bundle of wires that connects major components inside a computer), called a Microchannel. Rivals will not be able to purchase Microchannels from IBM. They will, however, be free to produce their own and, in that way, build compatible machines. The bus, combined with a proprietary operating system, should protect the System/2 from all but the most determined copyists until the 1990s, IBM believes.

In all, IBM announced 193 new products. The four System/2 computers start with the Model 30 (£1,100 to £1,559), a small, desktop computer with a three and half inch floppy disk drive. The model 50, also a desktop machine, is designed around the Intel 80286 chip. It comes with a 20-megabyte hard disc drive and costs between £2,658 and £2,847.

The next machine in the line, the Model 60 (£3,886 to £4,464) has a separate processing cabinet which stands on the floor. This computer also incorporates the 80286 chip and 70 megabytes of data.

The top-end Model 80 (£4,916 to £7,056) is based on Intel's 80386 microprocessor, it can support up to 230 megabytes of hard disk storage. The machine can act as a communications device as well as handling run-of-the-mill processing. But it will not be available until later this year.

Microsoft, the software company that produced MS/DOS, the existing IBM PC operating software, has devised a new system called Operating System 2. This "house-keeping" software is designed for the new Intel microprocessors. Customers will have to wait until next year for Operating System 2.

IBM has also produced a five and quarter inch optical write once read many times or "WORM" disc to go with the System/2 computers. Each disk will hold 200 megabytes of data, which must be archival material since it cannot be written over once recorded.

European production will take place at Greenock, in Scotland, where IBM has invested £30 million in a highly automated plant to assemble surface-mounted printed circuit boards. The IBM PC is already produced at Greenock, but the new technique of fixing components to both sides of a board will cut production costs.

Other British contributions to the System/2 include the design of high resolution screens for the computers. This work was done at IBM's Hursley Laboratory near Winchester. Inmos has sold IBM colour graphics chips for its screens.

IBM, which holds a stake in the chip company Intel, has not been as quick as many computer companies to incorporate the 32-bit Intel 80386 chip into its computers. In the six months since Compaq Computer became the first manufacturer to unveil a personal computer (PC) designed around Intel's 386 micro-processor (as the chip is known for short) over 20 European manufacturers alone have committed themselves to producing systems based on the 386 chip. Previous IBM-compatible personal computers, built around the Intel 286 chip, were hamstrung by the fact that the processors in the machine could only address 640K bytes of memory. Programs could not take up more memory than that. That restriction has now gone.

In addition, the 386 will run several different programs at once. It is also multi-user, which means that several operators can use those programs at one time. Apricot, the British PC firm, has produced a 386 system which it hopes to sell as an alternative to smaller minicomputers. Many proposed 386 computers will not be multi-user, but extremely powerful single-user machines. In effect what has happened is that the hardware has leapfrogged ahead of the operating software on which the personal computers run. ... (This first appeared in "New Scientist", London, 9 April 1987, the weekly review of science and technology)

Intel, AEG in automation pact

The systems group of US chip maker Intel is joining forces with FRG electronics giant AEG to develop factory automation products.

The two companies are co-operating in a multi-million dollar effort to develop a real-time operating system for 32-bit industrial computers.

The operating system will run on a machine based around Intel's 32-bit 80386 chip and the new Multibus II architecture. AEG is aiming at the fast-growing market for industrial automation where distributed computers and robots are linked by communication networks.

An Intel spokesperson said that the company would not comment on a report that Intel was talking with another FRG company, Siemens, about the joint development of an advanced computer. (Electronics, 29 April 1987)

Philips and Plessey: the latest strategic alliance in chips

In a move that could pave the way for more far-reaching technology agreements in the future, Philips and Plessey Semiconductors Ltd. will jointly develop a circuit for digital TV tuning. In their first co-operative agreement, the Dutch and UK companies will combine the functions of a prescaler and a phase-locked loop on one chip. Each will then manufacture and market the chip on its own. Peter Haywood, marketing manager at Plessey, says the companies are talking about technical and commercial collaboration only and are not planning a corporate merger. "We are feeling our way with this venture to see how beneficial it is for us to join [our technology] together," he says. "It is looking extremely promising, and we have agreed that we will co-operate soon on future chips." (Electronics, 11 June 1987)

Agreement between Toshiba and Motorola

Motorola (USA) and the Japanese Toshiba are about to sign an agreement for setting up a joint venture in Izumi City in the North of Japan. These two firms, which hold leading positions in this sector, will inject the joint venture with part of their advanced technology. The expected investment for each of the partners will amount to around US$120 million.

Toshiba will supply its powerful one-megabit integrated memory circuit thanks to which it took world lead in the manufacture of these products, whilst Motorola will supply all the technology relating to microprocessor design - a field in which it rates among the top three companies in the world. These microprocessors which constitute the brains of the computers represent, among other things, one of the main strengths of American industry.

Moreover, each firm will have access to some of the technologies of the other. Toshiba is to transfer the technical processes used for manufacturing its integrated circuits and, Motorola will allow the Japanese group to buy some of its microprocessor components. As regards the distribution of the Motorola products in Japan, as stipulated in the contract, this will be done through Toshiba. (Bulletin IBIPRESS, No. 129, 24 May 1987)

Can IBM kill the clones?

After months of speculation, IBM finally detailed its Personal System/2 (PS/2) family in April. Deliveries of the 8086-based Model 30, running PC/DOS 3.3, began straightaway. The 80286-based Models 50 and 60 followed in July, with the 80386-based Model 80 due this fall. So much for the hardware.

On the software side the outlook is not as bright. IBM's Operating System/2, which will break the 640KB memory addressing barrier of PC/DOS, is not due until the first quarter of next year. When it arrives it will open new doors to application software houses and users alike, allowing the 80286-based AT as well as PS/2 Models 50, 60, and 80 to use their protected mode and address up to 16MB of main memory per program.

The features that IBM has built into PS/2 may add up to more of what the user wants, but the company is no slouch when it comes to protecting its own interests. By modifying existing de facto standards, IBM has declared its intention of hanging on to the crucial market of end-user micros within large corporations.

As predicted, IBM has made the new PS/2 family as open to independently written applications packages as the previous PC range. Indeed, by giving software houses advance information on the applications program interfaces to the new OS/2, IBM could counter criticisms of a lack of software right from the time of its hardware launch.

IBM has also made PS/2 open to independently manufactured extension cards by publishing the electrical, signal, and size interface specifications of the extension card slots on the new PS/2 Model 50, 60, and 80 MicroChannel I/O bus. But life will get tougher for the add-on suppliers. The smaller number of slots - notably on the desktop Models 30 and 50 - and PS/2's improved screen definitions, as well as an extended range of hard disk sizes from IBM, have reduced the opportunity for offering add-on improvements.

While these two measures illustrate IBM's eagerness to encourage third-party development around PS/2, it has taken a third step with more far-reaching consequences. By making the system design as closed as possible to imitation by manufactures of 99 per cent PC compatibles, IBM has declared that it will no longer tolerate competitors for key corporate accounts.

In an attempt to make imitations of the PS/2 at least time-consuming and costly, if not impossible, IBM has modified previous PC standards in three important respects. First, it has introduced much better screen drivers, as a standard feature on the system cards of all PS/2 models. Five years ago, IBM's CGA card offered 320-by-200-point definition in no more than four out of 16 colours. Now the basic Model 30 has a mixture of clearly legible alphanumeric characters and 640-by-480-point, all-points-addressable graphics in two colours. The larger models handle 256 colours. The graphics chips driving this higher definition are, in part, IBM proprietary and are supplied to the company under an exclusive contract with U.K. chip maker Inmos.

IBM's second modification to PC standards is in the addition of a 64KB A-BIOS ROM. It is used by the new OS/2 to complement the original 64KB C-BIOS used by PC/DOS 3.3. But unlike the original C-BIOS, IBM has not published the source code of A-BIOS. Instead it has registered the copyright of the code, making copying it both difficult and illegal.

The third alteration to IBM's previous de facto standards is the replacement of the original PC Bus for I/O devices with a multiplexing MicroChannel (although PC Bus continues to be used in the PS/2 Model 30). MicroChannel has a sophisticated priority algorithm to optimize channel throughput. Again, this has not been published, but patented.

It seems unlikely that these steps will make it impossible for other manufactures to produce fully compatible PCs and that IBM can ring the death knell on the PC compatible industry. But some of its competitors will fare worse than others. IBM's highly automated PS/2 plants may give it the lowest unit production costs in the industry, but the computer giant has not brought the retail price of its entry-level PS/2 Model 30 down far enough to compete with many cheap clones... (Reprinted with permission of DATAMATION® magazine©, (1 July 1987, pp. 13-16). Copyright by Technical Publishing Company, A. Dunn and Bradstreet Company, all rights reserved)

European computer makers try to pull the plug on clones

The clone wars are getting too hot for some European computer makers. Angered by surging imports of cheap Far East knock-offs of IBM's Personal Computer, European manufacturers are quietly preparing to file an antidumping complaint with the European Commission against Korean and Taiwanese copycats.

Italy's Olivetti is trying to galvanize European manufacturers, such as France's Groupe Bull, plus U.S. companies that manufacture in Europe, such as IBM, NCR, and Commodore International. They will fight the "no-name" clones, which sell for as little as half the price of the European-made models. The no-names have only about 6 per cent of Europe's market now, but their share is growing fast. (Reprinted from the 23 March 1987 issue of Business Week by special permission, (c) 1987 by McGraw-Hill, Inc.)

IV. APPLICATIONS

Computerized hospitals in Singapore

Singapore has entered the second phase of a programme for the development of the computer system to exchange information between various clinics on the medical background of citizens.

By the end of this summer, 24 hospitals and 16 clinics will be linked to two IBM mainframes which will collect all the data concerning the clinical situation of each patient: previous pathology, surgery, medication, etc. In addition, they will manage all the information concerning hospital admissions, medical visits and the administration procedures of all the clinics and institutions concerned. The clinics and institutions will be provided with a dozen minicomputers, approximately 500 terminals and 390 printers. The first phase of the project, begun in 1984, has just been concluded. The experditure made up to now has been US$7.5 million and will serve to build up the basic information for the system. It is foreseen, in any case, that the whole programme will be extended for another three years with an additional cost of US$10 million.

Up to now, the system has archived information on 550,000 patients. The programme of medical visits manages around 5,000 daily appointments. A software house of the region has collaborated on the development of four programmes concerning: the list of the patients admitted, released and/or transferred from the hospitals linked in the network, a system for invoicing the patients, a system for an inventory control of the clinics, and a system for organizing doctors' appointments.

The integration of the information and data collected will enable both the planning and the selection of the most appropriate means for managing the country's health services. Moreover, the possibility of exchanging clinical data allows the progress of diseases in general and of epidemics in particular to be studied, in addition to increasing efficiency in diagnosing and caring for patients.

Even though at the moment only State-run hospitals and clinics are included in the system, it is expected that many private clinics will soon request to be linked up to the system in order to integrate their own information and benefit from the existing data. (Bulletin IBIPRESS No. 135, 6 July 1987)

Medical research and informatics

French and Italian companies have recently introduced computer-based tools which will have an important impact on medical research in electromyography and histology.

A French group has developed a portable medical unit which can be used to examine disease-related electrical activity in muscles and nervous systems.

The unit has a screen, keyboard and built-in thermal printer. Using the unit, a doctor can directly programme electromyography tests. Readings can be immediately seen on the screen.

The unit can aid doctors in diagnosis. Muscular and nervous-system readings can be stored in the memory of the unit, which can also analyse readings in a number of ways in order to maximize their diagnostic value.

Because it is portable, the unit can be used to carry out analysis and research in areas in which well-equipped hospitals are not available.

The collection and processing of such data would constitute a significant source of knowledge on histology. The computer-assisted analysis and storage of data on the 63 million pieces of information contained in an individual cell would lead to a better understanding of processes in biotechnology and new applications in medicine. (Bulletin IBIPRESS No. 136, 12 July 1987)

CAD/CAM being employed to make dental crowns

Scientists in the USA, France and Switzerland are working on the use of computer-aided design (CAD) and computer-aided manufacturing (CAM) to automate the production of dental crowns, according to Diane Rekow of the University of Minnesota. Crowns are substitutes for all or part of the tooth above the gum line. Rekow reported the work that she and her associates are doing last month in Cincinnati at the 1987 Biomechanics Symposium of the American Society of Mechanical Engineers.

Crowns are fabricated nowadays by casting in gold or ceramic. The process is time-consuming and, in the case of gold, expensive. CAD/CAM systems can make crowns so rapidly that they may eliminate the need for temporary restorations, Rekow says. A major goal of using CAD/CAM is to permit crowns to be made of less costly materials, such as precast ceramic or stainless steel.

In the procedure being developed at Minnesota, the tooth to be repaired and its neighbours are first scanned by a laser. The digitized images then are processed by software developed at Massachusetts Institute of Technology. The system calculates, from 6,000 data points, what the repaired tooth should look like. The completed restoration is accurate to within 20 μm, as required by the Minnesota Dental Board.

The internal dimensions of the crown are taken from the shape of the prepared tooth, Rekow says. The external surface is designed to take account of the constraints of the motion of the jaw and the relationship of the tooth being repaired to other teeth. The design completed, CAM software creates a program for machining the crown from a block of the selected material. Machining is done by a compact, five-axis milling machine. Rekow expects the system to be able to produce a full crown automatically by the end of this year.

A complete system will cost from $150,000 to $200,000, Rekow estimates. She suggests that large group dental practices may be prepared to invest on that scale. Dentists who can't hack it would probably have terminals with image-collecting equipment, an investment of about $5,000, in their offices and have the crowns made at a central laboratory. (Chemical & Engineering News, 27 July 1987)

Computers for agriculture

A series of experiments are being carried out in the agricultural sector thanks to new technologies. The use of these technologies has given rise to the awareness that the agricultural sector needs to be transformed by agronics, the science concerning the application of electronics and informatics to agriculture. A new system, called Tom, is about to be made available which will enable approximately 60 diseases affecting tomatoes to be identified. This instrument will be very useful for the truck farmers in France for reducing the damage caused by epidemics.

Cognitech, a company specialized in artificial intelligence applications, has developed this very sophisticated software which will enable computers to mimic human thought.

The truck farmers will be able to communicate with this computer thanks to a minitel linked to a telephone. Tom will pose questions to the user on the symptoms, with the assistance of illustrations displayed on the minitel screen. After a dialogue composed of approximately 20 questions and answers, the computer will be able to diagnose the disease and indicate the steps to be taken for eradicating it.

At a later stage, the same technology will be able to be used to identify other diseases affecting cultures such as fruit trees, potatoes and vines.

The computer has become an indispensable tool for the sound management of agricultural production. Today, in order to be competitive on the market, it is no longer enough to know how to work better, with or without the assistance of technicians, to be intuitive, to have experience or will.

This jump in quality, which is a necessary step for the optimization of agricultural production, is already being made by many farmers in countries such as the United States, Japan, Federal Republic of Germany, Great Britain and France. (Bulletin IBIPRESS No. 137, 21 July 1987)

Computerized diet for poultry

At the Department for Mathematical Studies of the Polytechnic Institute, Hong Kong, a programme has recently been finalized which enables poultry farmers to select the most nutritious, appropriate and least costly diet for poultry, taking into account factors such as the breed, state of growth and physical environment of the animals as well as the type of ingredients available in that particular geographical area.

This programme will enable the poultry farmer to produce, by himself, the feed mixture to be given to his poultry on the basis of scientific and rational criteria besides economical needs.

The database of the programme contains details on a hundred or so ingredients which are easily found in the area, including their price and nutritional value.

The various purposes for which poultry is raised is taken into account in the programme: for egg production, as edible meat or for reproduction. Great importance is also given to the state of growth of the poultry when defining the diet.

For the finalization of the programme, which takes into account many variables, a mathematical linear programming model was used, partially modified in order to best satisfy the needs of the farmers. In this way, specific ingredients which the farmers may want to use can be entered into the computer and the appropriate diet duly formulated, modifying the dosage of the other feed ingredients. (Bulletin IBIPRESS No. 140, 31 August 1987)

How PCs can police the mating of animals

Zoos in Britain now have access to a computerized database that will contain information about the pedigrees of all their animals. The system will make it much easier for zoologists to devise effective breeding plans for animals in captivity.

There is already an International Species Inventory System (ISIS), based in Minneapolis. Although the data in the system are computerized, member zoos must rely on printouts. The ISIS does not yet have the global cover essential for rational captive breeding. The British system, which is called NOAH (National Online Animal History), could make good these deficiencies.

NOAH allows zoos to interrogate the database directly. This means that zoos can seek a mate for one of their animals, or can work out superior breeding and management plans. Because NOAH stores pedigrees, it shows how closely two prospective partners are related. This information is valuable to zoologists because they can avoid the harmful effects of inbreeding.

ISIS does make available to its member zoos a computerized record-keeping system. The British Zoo Federation modified this system to allow online access to the database. For roughly £1,800, each zoo receives an IBM personal computer, a modem, and the NOAH software.

A zoo can keep its own day-to-day records on the computer, and each month send a disk to the nerve centre of the system at London Zoo. This disk helps to keep the countrywide records up to date. The London centre, which runs on a machine donated by IBM, forwards all its British records to ISIS. (This first appeared in "New Scientist", London, 23 April 1987, the weekly review of science and technology)

V. SOFTWARE

Intelligent machines

One of the first true AI programs was written in the mid-1950s in America by Dr. Allen Newell and Dr. Herbert Simon of Carnegie-Mellon University along with Dr. Clifford Shaw at the Rand Corporation. Called "Logic Theorist", this was a program designed to prove theorems in mathematics. In at least one instance, the program deduced a proof that was actually neater and shorter than the standard textbook answer.

Logic Theorist was the first of a number of surprises that AI has sent rippling through the scientific community. Indirectly, it also led to the creation of AI as a separate scientific discipline. During the summer of 1956, 10 American researchers gathered for a two-month "think-in" at Dartmouth College, New Hampshire, to discuss some of the strange new goings-on in computers, mathematics and psychology.

The founding group - including Dr. Marvin Minsky, Dr. Claude Shannon and Dr. John McCarthy, as well as Dr. Newell and Dr. Simon - went on to establish three academic centres of AI excellence. To this day, Carnegie-Mellon University in Pittsburgh, Stanford University in Palo Alto, and the Massachusetts Institute of Technology in Cambridge remain the world's most creative powerhouses for clever computers.

The Dartmouth meeting also set the research style for AI. As a result, the brightest ideas have tended to come from the use of computer languages that manipulate symbols (representing mental concepts) instead of the numbers (representing information) manipulated by conventional languages.

Another advance came in the mid-1960s when Dr. McCarthy (of MIT and later Stanford) developed a symbolic language called Lisp. Short for "list processing", Lisp was designed to manipulate lists of objects and has become the standard research tool used by AI scientists in the United States. Another computer language called Prolog ("programming in logic"), developed in 1972 at the University of Marseilles, is now widely used by AI researchers in Europe. Japanese AI scientists, who normally follow the lead of their American colleagues, have adopted Prolog instead of Lisp for their "fifth-generation" computer project.

Prolog has a simplicity that makes it easier for newcomers to use, while Lisp requires programmers to be expert in handling its tortuous syntax. But Prolog, while it can run on smaller (and cheaper) computers, is a "declarative" language. It is really a means for declaring everything that is known about a problem, rather than a means - like Lisp - for solving it.

Computer languages like Lisp and Prolog have made it possible for AI scientists to capture aspects of the way human experts solve problems. The inspiration for these so-called "expert systems" came in the late 1960s from Carnegie-Mellon's veteran researchers, Dr. Newell and Dr. Simon. They argued that much of human knowledge could be represented by a series of fairly simple "if-then" statements - e.g., if it looks like a duck, and if it waddles like a duck, and if it quacks like a duck, then it probably is a duck.

An expert systems needs two things. It has to have some kind of reasoning mechanism; and it needs a database of knowledge about the field it is concerned with. The reasoning mechanism is known in the trade as an inference engine, the most popular of which is a set of if-then rules. Its other component - the knowledge base - has to be built up (painfully) from thousands of cause-and-effect relationships. This involves getting human experts to explain precisely how they approach a particular problem and each of the steps they go through in solving it. The cause-and-effect relationships are then programmed into a computer as a lengthy list using a language such as Lisp.

When it is fed a problem it has not encountered before, the expert system's inference engine looks up the corresponding data in the knowledge base and examines the causes and effects involved. It then starts making a series of decisions on how well elements of the new problem match elements of the expert's solution - and goes on doing so, just like a human, until it is confident it has the right answer.

All of which is far easier said than done. As they stand, expert systems are only just beginning to have an impact. There are still only a couple of dozen or so expert systems earning their keep in American industries. There are probably fewer than twice that many in the whole world. Among the more successful ones are Stanford University's Dendral, which works out the chemical structure of compounds, and Mycin, which is used for the diagnosis of infectious diseases.

Today's expert systems can cope with perhaps 500 rules before they pack up under the weight of the mathematical workload. But a chess master has no trouble handling the mental equivalent of 50,000 rules or more. To make things easier for machines, AI scientists have spent the past decade trying to find ways of codifying information so that computers can deal with problems better.

Two promising approaches have emerged. One, proposed by MIT's Professor Minsky and known as "frames", provides an encyclopaedic description of any chosen topic, complete with cross-references. The other, developed by Dr. Roger Schank at Yale University and known as "scripts", presents the sequence of steps involved in achieving a particular goal. Researchers are using scripts to codify the intuitive grasp some people have of music or mathematics.

Three years ago, expert systems such as Internist-1 (for internal medicine), Prospector (for oil prospecting), Puff (for lung complaints) and XCON (for customizing Vax computers) got such publicity that investors went chasing AI scientists with cheque-books in hand, because they believed that a new boom business was in the making. It was not, and the fad for financing AI ventures has now largely fizzled out.

When they work, expert systems can be useful as assistants, carrying out some of the more routine tasks for a professional; or as instructors, passing on the skills of experienced workers to newcomers. But treating each individual application as a unique problem (as expert systems do) is tediously slow and inefficient.

Moreover, expert systems require experts to know how they reason. A lawyer, or a doctor, might be able to show you their reasoning; but try asking an art critic or a cook how they reach particular conclusions. More to the point, ask anybody how they understand speech, or recognize their grandmother. They cannot begin to tell you.

Most researchers have now come to realize that human senses such as vision and hearing, and human skills such as movement and speech, rely heavily on unconscious intuition, and that it is no good looking to humans for training. They have also come to realize that it is futile to replicate intelligence in the absence of these senses and skills. A robot that is intelligent but deaf, blind, dumb and immobile is not useful. If they are to replicate intelligence, scientists will first have to understand the brain's rules for unconscious intuition.

Speech recognition is a good example. Several companies are on the brink of replacing secretaries with machines that can turn dictation into typewriting. These machines may or may not work in the same way as human beings. They take two separate approaches at the same time. The first is to analyse the sound the machine hears and try to match it with some stored version of each word. This means dissecting each sound by pitch, harmonics, inflection and so on, and, at the same time, distorting the time-course of the sound in various ways to fit it to stored examples. The second is to use elementary rules of grammar and so predict what kind of word the machine is most likely to hear in a given context. For example, "in America", makes more sense than "it America".

The grammatical rules are like an expert system, because they are if-then rules. But they are not derived from a human expert; they are worked out specially for this purpose. Human experts (everybody is an expert at this task) may use entirely different rules to reach the same interpretations.

The accustic mechanism is even less like an expert system. It does not consist of if-then rules, but of mathematical tricks for finding similarities between patterns. In recognizing a visual image, the expert-system idea must be abandoned altogether and replaced largely by mathematical techniques for pattern matching.

To these two approaches - debriefing experts and figuring out rules from scratch - a third is now being added: copying human learning. Not only do AI researchers need to find out more about how people go about learning new things, they also need a better grasp of the mental processes people use in adapting the knowledge acquired in solving problems in one field to solving problems in another.

Just how do people perceive, recognize, draw inferences, understand analogies and learn? Researchers do not have answeres to these questions. They cannot, therefore, teach computers the answers. They must instead ask their computers to work them out for themselves.

The most successful method so far of getting machines to learn is by using examples. One approach that AI scientists are watching carefully is Marvin, a machine-learning program proposed by Dr. Claude Sammut and Professor Ranan Banerji at St. Joseph's University in Philadelphia, based on a language that gets "richer" the more it learns. Marvin not only learns from experience (with the help, of course, of a human trainer), but also stops itself from falling into the trap of over-generalizing.

Two outstanding difficulties must be resolved before machines can be programmed to learn as people do: how to handle analogies, and how to behave creatively. The concept of analogy involves viewing two dissimilar things as essentially similar. In a sense, creativity is even more irrational. Creativity typically involves - at the very least - seeing a relationship between two things that nobody had noticed before. In AI, researchers call this the "Eureka" or "Aha" syndrome.

Some attempts have been made to develop programs that handle analogy by comparing and matching elements of two sets of ideas. Programming a computer to make such analogous leaps of imagination is a mind-blowing task. Imagine trying to teach a computer Cockney rhyming slang (in which, e.g., a "suit" is known as "whistle", because it rhymes with "whistle-and-flute").

Such rule-based approaches to learning have enjoyed a measure of success, but none has emerged as the answer to the AI scientist's main problem - namely, how to get a machine to solve general (rather than narrowly specific) problems. The frustration has led a group of AI researchers, most of them ex-physicists, back to an idea first floated in the 1960s.

Brains are much more complex than computers, but both work in fundamentally simple ways. Both manipulate electric currents. Computers consist of many electric switches. Each switch can be on or off and can represent the ones and zeros of binary arithmetic, or the true and false of elementary Boolean logic. Brains consist of cells that act like amplifiers, picking up, adding together and passing on signals from other cells. This feature alone gives AI scientists a glimmer of hope.

The "new connectionists", as they are called, believe that all they have to do is wire up circuits in the same way as brains are wired up and, hey presto, the things will start to learn. In one sense they are plainly right: brains derive much of their power from being "parallel" machines that can do lots of things at once, and computers would do well to emulate this.

At present, most computers work by sending data from their memories through a central processing unit in sequence. But in another sense connectionism suffers from hubris. Brains learn certain things because they are wired up in certain ways: they are not random collections of cells. Computers that copy brains will also have to be wired up, or programmed, in certain ways. Back to square one. (The Economist, 20 June 1987, pp. 86-87; excerpted from "Schools Brief")

"Well, it is either 'intelligence', or it is not 'intelligence'! Where do you get that 'artificial' stuff?"

(Machine Design, 11 December 1986)

Expert systems

At a recent colloquium on artificial intelligence, a keynote speaker woke up an early morning audience with the following story:

Suppose you were working with one of the expert system programs that is designed to diagnose human diseases. Further suppose that the symptoms you entered were true, but did not pertain to humans.

Enter patient's name: 1978 Chevy

Enter patient's age: 9 years

Does the patient have brown spots? Yes

Conclusion: The child has measles.

The speaker's point was that expert programs, like most computer software, have no way of knowing their own limitations. The program is helpless if faced with a situation its author did not anticipate.

Few people understand this insight about expert software. Early successes with the technology have resulted in unjustified expectations. Without a good understanding of expert system limitations, it is hard to know where the expert approach runs out of steam.

Fortunately, limitations of the approach are becoming more widely understood, as are the technology's less publicized benefits. One such trait is an inherent logical flow. Expert programs are organized into rules and facts with a structure that is easy for non-programmers to grasp.

This is important when working with individuals who are unfamiliar with programming. People serving as sources of expert information can often look at the programe code and understand the intent of the rules and facts, simply because the information is expressed in ways that resemble English sentence structure. This enables the human expert to examine program code and see at a glance whether it expresses the right rule or fact.

The logic structure of expert programs is also such that programmers can come up to speed quickly when joining a project. This is especially good in large software efforts where personnel may turn over several times. Similarly, expert programs are often easier to maintain and change than software written in languages such as Fortran or Basic.

In all, many problems tackled with expert systems could be handled with conventional programming techniques as well. But the branching and decision trees needed in ordinary languages are often more difficult to implement.

Typical uses for expert systems to date include situations where the expert program substitutes for service manuals or instructions. In applications currently under development, such software serves as a smart business form by guiding users through instructions. Programs check entered answers for reasonableness and consistency and verify entered data to make sure they do not contradict other information entered elsewhere on the form.

Many such applications are in manufacturing and industrial settings. For example, estimates are that over 1,000 expert systems have been started for use in manufacturing planning. Some 90 expert projects are in progress within IBM alone. One program in the company's San Jose plant diagnoses 98 per cent of the faults in disk drives. The software replaces about 30 lb of manuals that guide technicians through the diagnostic process. Another IBM program performs capacity planning for System 38 computers, estimating the CPU and disk facilities needed to provide specified response time for a given number of terminals.

The term expert program is actually a misnomer. Most expert systems fielded today provide advice that is not really at an expert level. At best, such programs give guidance that allows rank amateurs to be mediocre performers. As the person using the expert system gains enough experience to make better judgements, the software is often used less and less. In this manner, many expert programs function simply as training and productivity aids. Thus, a rule of thumb is that expert programs make sense where less than optimum performance is acceptable.

One key reason for the subpar performance of programs fielded thus far is that most solve problems by selecting solutions from a predefined list of possible candidates. Problems that these programs solve are formulated as diagnosis. This format has worked well with troubleshooting applications in electronic equipment, and in planning schedules for manufacturing machines on an assembly line.

In general, the diagnostic approach can be appropriate when the problem at hand involves a finite number of strategies or solutions, each of which can be prescribed based on the existing conditions. Expert programs can give good advice if all possible solutions have been identified and entered in the program.

However, an expert program cannot suggest a solution that it does not know about. If a more creative plan, diagnosis, or answer can solve the problem better, the program will miss it. This is a significant limitation of the expert system technique that potential users and developers should understand.

Qualities that expert programs lack include insight, inspiration, and common sense. People often rely on these human traits when solving problems that do not fit easily defined categories. Thus, the best problems for the expert program approach are well-ordered and narrowly focused.

The planning and diagnosis programs that typify most expert applications to date are sometimes called first-generation systems. The term refers to programs that employ only basic expert techniques. Though a number of basic methods are used, most involve a simple search through existing rules to determine a best answer.

However, first-generation systems may be impractical for more complicated applications. One shortcoming is in working with a large number of rules or facts. Most simple expert systems always search through their rules in the same order each time they receive new information. This approach may be too slow when hundreds or thousands of rules must be checked.

More sophisticated second-generation systems may use what are called opportunistic search methods to deal with large bodies of rules. The principle is to start examining rules that are most likely to apply to the situation at hand, thereby reducing the search time.

An example of the approach can be found in an expert system that plans kitchen layout.. Developed at Carnegie-Mellon University, the Wright program uses the fact that sinks and stoves are likely to be placed near unmovable architectural objects such as windows. The program uses these placements as a starting point for applying rules, rather than following a predetermined order each time.

Another example of a second-generation expert system is a program called Grease. Carnegie-Mellon researchers created the program to select cutting fluid in machining. The program first diagnoses machining operations to determine the fluid qualities needed, then selects a cutting fluid.

The diagnosis part of the problem is simple, but picking the single best fluid is difficult. The fluid selected must provide the best mix of qualities for a variety of machining operations. Complexity enters the problem in that a suggested remedy can be produced in many ways. For example, lubricity can be boosted by any number of different combinations of increased fatty content and increased viscosity.

Many satisfactory solutions are usually possible in such situations, but Grease is designed to find an optimal fluid that maximizes tool life. To do so, it generates an ideal fluid, then determines the closest matches to this ideal from an available product line.

A second area where simple expert approaches are likely to suffer is in handling unanticipated problems. Most such programs employ shallow knowledge, predicting outcomes based only on the experience of the human expert who provided knowledge for the program. If the program runs into an unforeseen situation, it has little information to guide it to a solution.

In contrast, second-generation systems employ what is called deep knowledge in an attempt to diagnose unforeseen problems. Deep knowledge refers to facts about how the underlying process or machine operates. The program uses deep knowledge to predict outcomes based on principles of operation when none of the human expert's rules seem to apply.

Researchers now exploring the use of deep knowledge say that the technique allows modelling the human expert's world, rather than just the expert's knowledge. Eventually, deep knowledge programs may provide a level of performance exceeding that of a human expert.

Just as spreadsheets provide a structure for entering calculations, shell programs provide an analogous framework for constructing expert systems. Basically, shells enable a user to easily enter rules and facts just as a spreadsheet allows the entering of formulas. The shell program takes over much of the underlying logic needed to compute results.

Many shells are available on personal computers. The programs are often categorized in terms of the way they represent knowledge. In general, shells are based on rules, facts, or learning by examples. The latter type usually employs an algorithm called ID3, which takes a set of examples and classifies the results. This classification allows the program to derive rules from the data.

Shell programs on PCs can serve as an inexpensive way to construct simple expert programs. However, PC-based shells are probably best for constructing small, narrowly focused systems typified by first-generation programs. One reason is that PC-based shells often provide only simple rule-searching techniques. This may prevent them from handling complicated problems calling for novel searching to reach a goal.

Some recent PC-based shells provide ways of overcoming some such barriers, however. One called Guru, for example, allows programmers to search rules in different orders, based on 84 selection criteria. The program might first search through rules having the least number of unknown conditions, then perform another search using an assigned priority, and so forth.

Another feature in newer shell programs is the ability to connect with external programs and data. This facility allows the use of information from a spreadsheet or database file as input to the expert system. The Guru program, for example, directly addresses spreadsheet and database files.

In all, PC-based systems seem best for both developing expert programs comprised of a few hundred rules at most, and as vehicles for fielding expert system that have been perfected. Indications are that few shells provide an adequate framework for particularly complicated expert applications characterized by the use of innovative rule searching or clever knowledge representation.

Dedicated engineering workstations are often preferred for developing more sophisticated experts and larger programs containing several hundred rules. The development of expert programs containing 1,000 rules or more calls for more specialized hardware such as workstations that have architectures optimized for artificial intelligence languages such as Lisp. (Machine Design, 21 May 1987)

UK rapped over expert systems use

Top managers in British industry are ignorant of the benefits of expert systems, and this could put them at a disadvantage with foreign competitors, according to Brian Oakley, director of the Alvey Directorate.

Expert systems can help people make better and faster decisions, and managers in Japan and America are already using them, according to Oakley. "It worries me," he said, "but the evidence of what one's competitors are doing is perhaps the best spur." He made these comments last week at a presentation of the findings of a report into the use of expert systems in British business, that was prepared for the Alvey Directorate by information technology consultant Alex d'Agapeyeff.

The report highlights the lack of awareness of expert systems among senior managers in UK industry. It also points out that the spread of expert systems is being hampered by excessive secrecy as well as myths and falsehoods about the nature of these systems. ... (Electronics Weekly, 15 July 1987)

AI for MIS managers

MIS managers seeking new ways to improve applications development and productivity can now turn to the artificial intelligence (AI) arena for some answers. There are a number of knowledge programming tools on the market and more are on the way.
MIS chiefs shopping for these products can make smart

buys in everything from small expert shells to large expert sytem building tools that speed the development of more massive and complex applications.

The most important thing for you to keep in mind when examining the alternatives is that AI is not a product. It is an academic discipline, just like physics or biology. Therefore, it is going to be around for a long time and will continue to spawn new developments. The current focus of commercial activity is on a set of concepts, techniques, and methods that have come out of AI labs over the past decade. While some of the techniques are linked, others are only loosely related.

At the most basic level, AI offers techniques to MIS that will aid application development and maintenance and ease user/computer interaction. On a broader scale, AI promises a competitive advantage to those companies that implement the technology in an effective manner.

Several industrial sectors will be changed in fundamental ways when some of the large strategic systems now under development become operational in the next two to five years. Those changes should be most apparent in the financial services world, where big improvements in productivity and in the quality of decision-making are expected as a result of the application of AI.

Before you can make a smart buy, you need to have a strategy. There are roughly four strategies that have been adopted, either individually or in combination, by companies that are actively and successfully using artificial intelligence techniques. They include using AI technology to:

. Improve conventional mainframe applications;

. Improve or develop midsize micro or workstation applications;

. Support users who want to purchase or develop small- to medium-sized applications; and

. Implement major new strategic applications that will transform the way a company does business.

A decision to focus on improving conventional mainframe applications allows MIS to control the introduction of AI technology. Since this strategy is aimed at leveraging applications that are already well understood, the risks are relatively low.

Up until about eight months ago, the products needed to implement this strategy were not available. Now there are several companies, including IBM and Cullinet, which offer mainframe-based products. Most of these vendors would like to see the MIS community using mainframes to develop and deliver systems that capture significant amounts of human expertise. In other words, they would like their customers to pursue an AI course that would lead to the implementation of medium-sized expert systems or to major new strategic applications. (Many practitioners prefer "knowledge-based system" or "inference-based system", but these terms are in fact synonymous with expert system.)

Developing large expert systems on mainframes may eventually become a viable option, but today the risks are high and a big investment is needed to reap real rewards. A safer route, and one that could yield significant benefits much sooner, is simply to use AI techniques to reduce maintenance costs and boost applications development. ...

... Another tack that some companies have pursued is to develop or enhance midsize, knowledge-based applications that can be run on micros or mainframes. This strategy, like the mainframe approach, puts emphasis on leveraging existing applications and on developing smart interfaces for data from spreadsheets or databases. The risks are low because you can use your own programming staff and your only costs are for software and training. ...

The third AI avenue taken by some companies is to concentrate on supporting users who want to purchase or develop small- to medium-sized applications. Many firms have arrived at this approach by default. Having acquired their own expert system building tools, end users and technical professionals began to develop their own applications. If the applications are small, then MIS managers can probably relax. But when the tool population reaches a critical mass, the MIS shop should provide help and training.

The vendors at the low end of the market sell easy-to-use products that nonprogrammers can work with. Small expert system building tools are analogous to spreadsheet packages. With a spreadsheet, users are, in effect, entering knowledge and letting the application manipulate it. The small expert system shell contains an "inference engine" that also knows how to manipulate some type of knowledge, usually in the form of if-then rules. The user enters rules about some analysis or decision process that needs to be communicated and then gives the system to someone who can use it to obtain recommendations. The first generation of small expert shells are being used by the same people who initially brought electronic spreadsheet programs into companies.

The fourth and final strategy is to implement major new strategic applications that will transform the way your company does business. This is a high-cost, high-risk approach that can result in increased profits and competitive gains for your company if you choose the right application, have the right development team, and have lots of support from senior management. This strategy also usually requires a major investment in Lisp programmers and hardware.

The main impetus for large strategic systems has come from the R&D departments of Fortune 500 companies. End users who learn about systems their competitors are working on push for similar projects.

The development of large systems has not been a major concern of most MIS departments. It could become a concern of yours, however, when end users in your company perceive that the competition has achieved a breakthrough in productivity or quality as a result of an AI system. Then you may be asked to research and develop a system overnight. Therefore, some investment in products that keep you in the know about the high end of the AI technology market is probably a good idea.

The smart MIS executive, considering what has been achieved by several companies that have made only modest investments in AI, would be wise to start training some people in artificial intelligence techniques. AI is a new technology that is just beginning to be robust enough for use in the MIS world. The prices of hardware and software continue to fall as the quality improves. Several major vendors are preparing products that, once they finally hit the market, will lead to even better buys in the AI arena.

Artificial intelligence is here to stay. Users will be doing it. Competitors will be doing it. And sooner or later someone will expect you to be doing it. As the leader of the MIS department, you will be asked to organize the corporate AI effort. When that time comes, you will want to have enough experience with the technology to recommend one or more strategies for using the tools that will help shape your company's future. (Reprinted with permission of DATAMATION ™ magazine 1 August 1987 © copyright by Technical Publishing Company, A. Dunn and Bradstreet Company - all rights reserved. Excerpted from "Smart Buys in Artificial Intelligence", pp. 62-66)

Expert systems and computer aided design

Expert systems will revolutionize computer aided design (cad), which is currently more centred on graphics and computer aided drafting than on design itself. The major role which intuition, technical judgement and personal creativity plays will encourage the application of artificial intelligence and the creation of expert sytems geared to producing projects. Ideally, expert systems should be able to be used in the preliminary design, that is in the multidisciplinary phase before the more specific intervention of the cad systems which currently operate. These latter systems will see their services increased by the expert systems, especially in their capacity to optimize and handle knowledge.

On the basis of an operational diagram of the project and of its technical characteristics and constraints, the computer will have to apply optimization algorithms, consult a database containing component catalogues, and simulate a test.

In fact, products have already been announced which are capable of optimizing the set of mechanical parts, or the mechanized process of a plotting table for obtaining a part, providing the description of its manufacture and the type of machines used. Software is available which enables standard elements of a cold-storage plant to be selected and the installation diagram to be plotted. The preparation has also been announced of an expert system which memorizes the design process, enabling it to be subsequently read and adapted to a new project. Finally, in certain industrial domains, such as the design and optimization of electronic circuits, the large industrial groups possess very sophisticated cad systems of which they have exclusive use. (Bulletin IBIPRESS, No. 134, 28 June 1987)

Database software

Competition is hotting up in one corner of America's burgeoning market for computer software. This is the $2-billion-a-year business of supplying software for database management - programs that help users to pick their way through the maze of information stored in their computers.

Until three years ago, the market for such things was growing at an unspectacular 10 per cent or so a year. It was divided into three discrete bits, catering for users of mainframes, minicomputers and microcomputers. Now the boundaries between the three are blurring. Input, a research firm, says that the market for database management systems is growing by 20-25 per cent a year, and that by 1992 it could be worth around $6 billion a year.

The companies that have done most to spur change are Oracle, Relational Technology Informix (RTI), and Unify - all Californian companies that specialize in selling what are known as relational databases for minicomputers. Unlike earlier database programs, these require users only to tell their computers what piece of information they need for their machines to find it for them. In the past, database software required users to specify not only what they wanted but precisely how their machines should go about looking for it.

Oracle has grown fastest. It pioneered relational database products from a set of research papers published by IBM in the late 1970s, and it has not looked back since. Its sales have more or less doubled in each of the past six years (to $131.1 million in 1986). Last month it reported profits after tax of $15.6 million for the year to end of May, up 165 per cent on the previous year. The company's share price has trebled since it offered shares to the public in March last year. Oracle is this year expected to overtake Ashton-Tate, an American company specializing in database software for personal computers, to become the third biggest supplier of database software after IBM and Digital Equipment.

Relational products are already beginning to look old-fashioned. Companies like two-year-old Ontologic of Billerica, Massachusetts, are now developing the latest in database software: object-oriented programs. These are cleverer than relational tools in handling awkward sorts of data like photographs, maps and documents of varying lengths. (The Economist, 15 August 1987)

How to speak Chinese faster

A computer in Washington, DC, lets you edit text in 43 different languages. Doing it with Latin letters, even with all the various accents, is easy. Cyrillic alphabet need a special keyboard. Coping with Arabic, where the letters go from right to left and look different depending on where they come in the word, is irksome. From Amharic to Armenian, from Burmese to Bengali - every foreign language that has a different alphabet presents one problem or another. The toughest is Chinese.

But who could possibly need such a computer in Washington, DC? Answer: an international broadcaster, in this instance the Voice of America, a government-financed radio station. From the bowels of an office-block, the 48 members of its Chinese broadcasting staff beam out to the world each day 8 1/2 hours of news and features in Mandarin Chinese. The "Voice", as its devotees call it, speaks in 42 other languages as well. Its weekly programmes run to over 1,200 hours. When it computerized its newsroom, it decided to ask firms making tenders to cater for all its foreign languages - including Chinese. Xerox won the contract: its bill for the installation of the system and 900 desk-top computers by 1988 is nearly $10 million.

Chinese is a beastly language for computers to handle. Its thousands of characters (or "morphemes"), each usually standing for a distinct idea, defy easy representation. In the 1920s, Chinese telegraphists assigned a number to each: to transmit the character that means person, you would tap out 0086. (That meant that American agents could decipher Chinese telegraphic messages without speaking a word of Chinese.) Only specialists could do a telegraphist's job, though. Printing-machines and typewriters have suffered from the same problem. With modern computers, things are rather different. A high-quality screen can easily display Chinese characters; the problem is not how to edit them, but how to type them in the first place.

Xerox came up with an elegant solution. The journalist types the words in Latin characters as they sound: "Beijing", for instance. The computer then looks up those letters in an internal dictionary, and produces on the screen the right Chinese equivalent. Later, the text can be turned into hard copy on a laser printer. When two different characters fit the same sound, it displays the choices in a little box on the screen. Like the Apple Macintosh, the computer has a "mouse" to move around the screen quickly: the typist points the mouse at the right character, and carries on typing. One advantage is that two- and three-syllable words can be looked up in one go, rather than character-by-character. Another: phrases that are hard to translate can be shortened. Bash in the three letters SDI, and half a line of Chinese euphemism will appear on the screen. That saves the station's sub-editors from having to check that every writer is using the right "house-style" phrase.

With only four hours' training, a good typist can make quite respectable speed. Editing is faster and easier. The Chinese bit of the Voice of America has used up the savings in time and money in a curious way (for a radio station): by publishing a newsletter for its listeners. To their surprise, the presenters have found they can speak faster Chinese: their radio scripts have become more legible. They were caught out by this at first, and had to insert extra news items at the last minute to pad out the allotted time.

A small problem looms when the Voice starts to broadcast in Cantonese on May 2nd. People in Canton read the same Chinese characters as Mandarin-speakers do; they just pronounce them differently. The Voice's system of Latin-letter equivalents (Pinyin, not Wade-Giles) applies only to Mandarin pronunciation. If they want to read as well as write, the new service's journalists will have to be trilingual. They will write the English transliteration of the Mandarin pronunciation of Chinese words - and then read it out in Cantonese. Try to get your tongue round that one. (The Economist, 18 April 1987)

Software bugs: a matter of life and liability

A computerized therapeutic radiation machine has been blamed in incidents that have led to the deaths of two patients and serious injuries to several others. The deadly medical mystery posed by the machine was finally traced to a software bug, "Malfunction 54", named after the message displayed on the operator console. The affair is seen as epitomizing the software reliability crisis at its worst, and raises the thorny legal issue of liability for personal injuries caused by defective programs. The pending lawsuits over the malfunctioning machine may set a legal precedent that could affect all computer users and vendors. Ultimately, such cases call into question our increasing dependence on computers for everything from banking to national defence.

Whether or not the physicians and cancer centres are dropped from the suits, which are still in their early stages, may ultimately depend on the willingness of the Canadian manufacturer, AECL, and its insurance company to shoulder blame for the accidents. If AECL tries to deny or minimize its liability, the suits could turn into a protracted legal battle with the physicians and cancer centres pointing fingers at Therac software and AECL attempting to shift the blame to operator errors.

Perhaps the paramount lesson to be learned for the computer industry at large is whether courts will view software as a service or a product. (Reprinted with permission of DATAMATION [r] magazine[c] (15 May 1987, pp. 89-91). Copyright by Technical Publishing Company, A. Dunn and Bradstreet Company - all rights reserved)

Software sales will lose a little steam this year

This year may not be a particularly robust one for many software companies: A survey in Software News predicts that growth in sales of software for all computers will slow in 1987. The survey studied the software-buying habits of about 2,400 US customers and found that total software industry sales will hit $17.5 billion in 1987. Although this represents a 14 per cent increase, it compares with a 22 per cent gain the year before.

Even minicomputer software, the star player of 1986 would suffer in relative terms. Thanks largely to strong sales of Digital Equipment Corp's Vax machines, sales of minicomputer programs grew 79 per cent in 1986, to $2.5 billion. But customers are expected to spend only $3 billion in 1987, a 20 per cent increase because they did so much buying the previous year. Many microcomputer software customers, confused about the next generation of personal computers and communications technology, will probably put off buying altogether. The resulting sales will rise only 16 per cent, says Software News vs. 23 per cent in 1986. Mainframe software will fare the worst: Sales growth will flatten to an 11 per cent rise over 1986 - the same as the previous year. (Reprinted from the 16 March 1987 issue of Business Week by special permission, (c) 1987 by McGraw-Hill, Inc.)

VI. COUNTRY REPORTS

Australia

ASIC action is heating up down under

Local chip makers are rapidly gaining strength down under. The latest development is the construction by Amalgamated Wireless Australasia Ltd. of a $42 million wafer fabrication facility near Sydney to produce application-specific integrated circuits for the Pacific and Southeast Asian markets. Amalgamated, Australia's largest electronics company, British Aerospace (Australia) Ltd., and the state government of New South Wales will be partners in the plant, which will be geared for a 1.5- m to 2- m double-metal CMOS process when it opens in mid-1988. Not to be outdone, the Victoria state government is also considering construction of an ASIC plant and has approached Plessey Semiconductors, of the UK, for advice. (Electronics, 14 May 1987)

Belgium

Belgium's quiet revolution in electronics

A transformation of research in electronics is taking place in Belgium. Its three main universities, Leuven, Ghent and Brussels, have formed an independent company, the Inter-University Microelectronics Centre (IMEC),* to work on the technologies and manufacturing processes needed for the next generation of semiconductors. Less than a year after opening, the company is carrying out advanced research in conjunction with more than 70 companies world-wide. ...

The Belgium Government backed the launch of IMEC. Initial funds consisted of Bfr 1.1 billion (around £18 million) for a new R&D centre, which opened last year in Leuven, and a further Bfr 1.3 billion for the equipment. Some money also came from the EEC's Regional Development Fund.

The new centre at Leuven includes 10,900 m^2 of laboratories and 3,600 m^2 of "clean rooms" - places where the temperature, purity and humidity of the air are closely controlled. Clean rooms are essential for the manufacture of sophisticated chips with very fine circuits. IMEC's factory is equipped to produce chips with circuit elements that are just 1 micrometre across, one-fiftieth the width of human hair.

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* See also Issue No. 16, p. 42.

IMEC has the facilities to produce prototypes of the chips it develops - so it can verify that the devices it designs actually do the job intended, and that it can manufacture them efficiently and economically. The centre will cost about Bfr 1 billion a year to run, with 60 per cent coming from the Government, and the rest from industrial contracts.

Although IMEC is in the business of making money, it aims to keep at the forefront of both fundamental electronics research and its applications. Continued Government funding will ensure that fundamental research is not neglected. ...

IMEC was the idea of Roger van Overstraeten, a professor at Leuven University. Although he is president of the company, it is governed by a board of directors which includes industrialists, academics and government ministers. The chairman of the board is Eugene van Dyck, from the Bell telephone company in Belgium.

The centre collaborates with companies in two different ways. It invites scientists from industry to work on problems of common interest; and it carries out complete research projects and develops whole manufacturing processes that can then be transferred to the company.

Engineers from Europe's Centre for Particle Physics, CERN, came to Leuven to learn how to design very large-scale integrated (VLSI) chips with IMEC's software. The chips are now in production, for inclusion in future generations of electronic equipment needed by CERN.

Today's users of chips are moving more and more towards what are called application specific integrated circuits - ASICs. These are chips that are built specially for a particular application, so they make best use of the silicon and result in cheaper, smaller ways of implementing a task as an electronic circuit. Building the same function from "off-the-shelf" chips means cobbling together the best fit of electronic devices for whatever you wish to make.

This is not only clumsy, it is also easier for competitors to copy. According to Mike Morgan of European Silicon Structures (a pan-European company specializing in ASICs), the European market for these devices will be around £1 billion in 1990, twice the current value.

Until now, ASICs have been the privilege of only a few - those involved in applications such as defence - because the initial design is so complicated, and because the world has so few skilled designers of chips. The sophisticated software now available helps engineers to design chips by describing what the end product will do, without having detailed knowledge of chip design itself. Centres such as IMEC make this type of software accessible to small companies, most of whom cannot afford either to employ chip designers, or to buy outright the expensive hardware and software that does the job for them.

But perhaps IMEC's most exciting plan is to provide the people who will design and manufacture the chips for tomorrow's computer and communications systems. IMEC's computers are linked to universities and industrial high schools. So students can use its sophisticated software to design chips, and have the designs fabricated on IMEC's prototype manufacturing line.

Six months ago, the centre launched an initiative on "multiproject wafers". These are silicon wafers that contain several different designs of chip from different companies. Besides the design process, the other prohibitive factor in making custom chips lies in making the "mask" - a sort of stencil from which the circuit design is transferred to the wafer of silicon.

By allowing companies to share one mask, IMEC can reduce dramatically the initial cost of developing custom-built chips. Morgan explains that a chip typically has 12 to 14 layers, each needing a mask. The cost of making masks is about $25,000 per chip. "If ten designs are done on one wafer, then the cost per company comes down to $2,500." ... (This first appeared in "New Scientist", London, 4 June 1987, the weekly review of science and technology)

China

Electronics in China: the great leap forward

China's present Government, determined to upgrade the country's infrastructure, modernize industry, and raise the nation's standard of living, recognizes that advanced technologies - and in many cases management techniques borrowed from other countries - are essential ingredients. And because electronics is basic to most modern industries, this area of technology is receiving high priority, says John Callebaut, director of development and government relations for the National Council for US-China Trade, an industry-sponsored group in Washington, DC.

By world standards, China's electronics industry still has a long way to go. In semiconductor production, for example, "there is a big gap in many areas", admits He Mingzhang, deputy director of R&D for National Electronic Devices, the arm of the Ministry of Electronics Industries (MEI) that co-ordinates electronics development and manufacturing. The chief obstacles to progress, he says, are the country's lagging capabilities in computer-aided design, engineering, and manufacturing, coupled with a lack of adequate equipment in certain key semiconductor production areas.

For example, while China has imported several complete semiconductor production lines, it does not have specialized chemical purification systems that would help reduce contamination in critical manufacturing steps. Also, the country is unable to make the sensitive monitoring equipment needed to maintain precise process control, says He.

Nevertheless, China currently produces an array of analog and digital integrated circuits for communications equipment, instrumentation, consumer products, and computers, including 64k RAM chips and 4- and 8-bit microprocessors, according to He. The country has also produced prototype gallium arsenide (GaAs) gate array chips, though still at a low to medium level of integration (fewer than 1,000 devices per chip). All equipment used to fabricate the two-inch GaAs wafers from which the chips are made is domestically designed.

Current semiconductor research programmes focus on microwave components for telecommunications applications and on high-level integrated circuits, according to He. The most ambitious project is a proposed $40 million plant to manufacture chips for automated telephone exchanges. To be located in Wuxi (a city near Shanghai that is becoming known as China's Silicon Valley), the plant will be a joint venture with foreign companies; potential partners include AT&T, West Germany's Siemens, and France's Thomson.

In addition to MEI's own activities, a series of sweeping economic reforms announced by the Government last fall will have a profound effect on the electronics industry, says Zhang Zhidong, vice-president of the ministry's import-export arm. These reforms will loosen the ministry's grip of

China's central planning agencies, which until now have kept tight control over every aspect of production. As the reforms are enacted, planning functions will shift to municipal governments and individual factories, thus "giving factories and other enterprises more decision-making power, including the power to initiate things", says Zhang.

It will even be possible for them to forge their own alliances. One example is the Panda Group in Nanjing province, which consists of several factories making colour TVs and tape recorders. "One factory used to report to the Bureau of Administration and Broadcasting, another to the Administration of Components. In the past, it was unimaginable that the two factories could get together and talk about common problems", says Zhang. But now, "they are able to start co-operating". Another new alliance combines Great Wall Microcomputer, Longxin Electronics, Kunlun Electronic Printing, North Computer Auxiliary Design, and China Computer Leasing into the China Computer Development Corp., which will co-ordinate imports of computers and technology as well as oversee domestic manufacturing.

Interestingly enough, the author of these economic reforms is none other than Zhao Ziyang, the new secretary of the Chinese Communist Party's Central Committee, who recently replaced ousted secretary Hu. Zhao's commitment to such reforms bodes well for China's continued economic alliances with other countries and its increased openness to foreign ideas - despite tensions caused by this past winter's student protests. "We will continue the policy of opening to the outside world", said Zhao in a statement reported in late January by Xinhua, China's official news agency. "We will expand instead of reduce our co-operation with foreign countries" (High Technology, June 1987, p. 65)

China to establish nationwide data bank

China will earmark $1.9 billion by 1997 to establish computer centres in 2,000 districts as part of a data bank network to collect and analyse national economic information. Now, each province collects information and makes a report independently. This takes a great deal of time as does subsequent analysis and evaluation of the data. The network should speed up this process to allow more timely decision making in economic policy. (AEU, No. 2, 1987)

India

Software power comes to India

"India has the potential to be a world power in software like Japan is a world power in the manufacture of hardware." So says Charlie Simon, managing director of Texas Instruments (India), the Dallas-based semiconductor firm's software subsidiary in the southern Indian city of Bangalore. Texas Instruments and other American firms have set up operation in India to take advantage of the country's huge pool of technical and scientific manpower, especially its highly trained computer programmers.

India's educational and technological institutions, offering training in engineering, applied science and advanced technology, are respected around the world, and many students are now entering the computer field. There are estimated to be between 80,000 and 150,000 trained computer programmers in India. Says Simon: "Indians have turned out to be very good programmers because of their fundamental strength in mathematics".

Two years ago Citicorp, the largest American banking firm, established in Bombay a wholly owned subsidiary, Citicorp Overseas Software, to provide its divisions around the world with computer software and consultancy services. Late last year Motorola signed an agreement with PSI Data Systems, an Indian computer-manufacturing company in Bangalore, for the design of semi-customized chips to be used in Motorola products. The biggest American investor, though, is Texas Instruments, which has spent $4 million on its Bangalore plant, including $1 million for a satellite ground station that allows employees in India to transmit programmes directly to design engineers in Dallas for use in new integrated circuits.

The Bangalore operation currently has a staff of about 70, including 55 programmers. Managing Director Simon says that TI was besieged by 2,500 applicants when it first advertized 30 job openings. "There are not enough programmers in the US", he adds. "In choosing India, we matched TI's needs with India's capabilities."

TI's starting salaries in Bangalore average $190 a month, a fraction of the $2,500 a month that a programmer in Dallas receives. Yet by Indian standards the salaries are good, and there are other advantages. Says Ashok Kumar Bareja, a TI software manager in Bangalore: "It is really satisfying to be able to remain in India and yet produce the kind of work you can in the US".

Using TI's satellite channel, which can transmit as many as 90,000 lines of programming in 60 to 90 minutes, Software Manager Ganapati Narayana says he can talk to "technological gurus" at 52 locations in 17 countries and thus keep "in constant touch with people who are on the same wave-length as me". The Bangalore employees are showing how a programmer with a satellite earth station at his disposal can work any place in the world. (TIME, 10 August 1987)

Japan

Working on synchrotrons

Ambitious plans in Japan to build expensive machines for fabricating the next generation of finer silicon chips have created a deep rift within the Government.

The country's Science and Technology Agency has angered the Ministry of Education, Science and Culture by proposing to spend more than £500 million on machines called synchrotrons. They generate fine beams of radiation that technicians can use to etch tiny features on chips. The features may be less than one millionth of a metre in diameter, making the chip far more versatile than existing ones with cruder features. ...

The science agency proposes building 17 synchrotrons. They include one big machine, several medium-sized ones and a number of small ones.

The largest one, several hundred metres in diameter, will absorb energies of between 6 and 8 gigaelectronvolts to produce fine X-rays. The agency estimates that it will cost about £250 million to build and that it will take seven to eight years to construct.

The agency says that it can afford such a large sum because it has cut back on research related to nuclear energy. Already, the Government has allocated to it a preliminary budget of £400,000 for a feasibility study to assess the merits of the synchrotron, and it has asked the agency to select a site for the machine. The agency is expected to choose Nishi Harima near Osaka where the Government is offering land at a substantial discount.

The ministry's rival plan is to modify Japan's largest existing synchrotron to meet industrial needs. The ministry operates a so-called Photon Factory at the National Laboratory for High-Energy Physics in Tsukuba. It operates at voltages of up to

2.5 gigaelectronvolts. The laboratory also houses a larger accumulator ring, with energies up to 6 gigaelectronvolts, that feeds TRISTAN, a huge particle collider that is used in physics research. It is this machine that the ministry wants to readapt.

But its proposal has several shortcomings. One is that the machine is not optimized to produce synchrotron radiation; its beams are not concentrated enough to meet the needs of solid-state physicists. Moreover, the education ministry cannot afford to fund another big facility; it can barely afford to run the ones it already has. For example, the Photon Factory runs for less than 3,000 hours a year. Rival machines in other countries run for up to 5,000 hours a year. The facility is also desperately short of staff.

An extra burden for the facility's 80 or so physicists is that they must accommodate researchers from industry who work there. Last year, 194 industrial researchers booked in at Tsukuba. In addition, the laboratory is conducting joint research with 21 companies. They represent a broad spectrum of industry, for steel and oil companies to those from the chemicals and rubber industries.

Many of these companies devote their efforts to experiments that produce quick, detailed information about the atomic structure of materials. But the overriding goal of researchers from industry is to use the synchrotron machines to make the next-but-one generation of microchip memories.

Four companies - Nippon Telegraph & Telephone (NTT), NEC, Hitachi and, most recently, Fujitsu - have each committed £4 million for construction of a "beam line" (a channel through which synchrotron light is tapped for experimental purposes). They hope to use synchrotrons to etch chips with lines of less than one quarter of a millionth of a metre in width.

Though synchrotrons are expensive, at least £10 million each, they can be hooked up to eight or more beam lines connected to wafer exposers. So they are well suited in theory to the mass production of chips. The problem is that they are too big at present to fit on the factory floor. Chipmakers world-wide are, therefore, hoping to make smaller, more manageable synchrotrons.

In Europe, there are two contenders, COSY Microtec of Federal Republic of Germany and Oxford Instruments, which recently received an order from IBM for a compact synchrotron. ...

The Government's Research and Development Corporation of Japan is giving Sumitomo Electric around £5 million over the next four years to develop a smaller synchrotron.

Another member of the same group of companies, Sumitomo Heavy Industries, is developing its own superconducting compact synchrotron independently. The company hopes to have it ready by 1989. Other companies said to be building their own synchrotrons secretly include Mitsubishi Electric, Hitachi, Toshiba and Furukawa Electric. The biggest and most guarded effort is that of NTT. It is building two synchrotrons at its Atsugi laboratories in Tokyo.

SORtec, a consortium of 13 manufacturers of chips and chip-making equipment, is also actively making smaller machines. The consortium was established to develop synchrotrons and peripheral technologies for microchip photolithography. It plans to build a synchrotron that operates at energies of up to 1 gigaelectronvolt at a facility adjacent to the Photon Factory in Tsukuba.

All this activity indicates that Japan is bidding to dominate the microchip markets of the future. It now seems likely that by the middle of the next decade, Japan will have more synchrotrons in operation than any other country, including the US. (This first appeared in "New Scientist", London, 13 August 1987, the weekly review of science and technology)

Malaysia

Home of electronics multinationals

Kuala Lumpur epitomizes the new East. The city is a melting pot of new ideas and old values. Skyscrapers tower over a city filled with the clamour of a growing country.

On the ground, shining Mercedes race along new highways, while in another part of the city rickshaws wobble through centuries-old street markets.

The contrast is typical of developing countries. Nations whose economies have been based on agriculture and natural resources are now rapidly striding into the late-20th century. Malaysia has been steadily industrializing over the past 30 years and is now building up a formidable electronics industry.

Malaysia has immense natural resources. Tin and rubber made it one of the wealthiest in the region. But in the 1930s the country still relied heavily on imports of manufactured goods. The Government therefore began attracting foreign multinational companies using an attractive package of tax incentives and the availability of cheap labour.

When the first US electronic companies arrived in Malaysia, the Government was concerned that they would shut down once the attractive tax incentives which drew them to the country ran out.

These fears have turned out to be unfounded. Thirteen years after National Semiconductor opened the first US factory in the country nearly all the top US companies have followed. The US operations are mainly assembly and test, with circuit design and fabrication being done in the US. In the 1970s, Malaysia seemed ideal for assembly because of its very low labour costs which were M$3 a day (75p). Now, with increased automation and wage rates rising to M$10 (£2.50) the country no longer has this advantage.

On the surface it would make a lot of sense for the US companies to move their operations closer to their markets in the developed countries. However the Americans have two good reasons for staying.

First, they have too much invested in capital and human resources. Secondly, they are ideally situated to serve the growing market in south-east Asia.

According to Jerry Lee of Texas Instruments the future of the US companies lies firmly in Malaysia. "We came for the cheap labour and the tax advantages", says Lee. "But we are staying because of the expertise we have built up here. As far as assembly and test are concerned we have more expertise here than we have in the US. We sometimes have to send our Malaysian engineers to the States to solve their problems."

Rather than pulling out, the Americans are pumping millions of dollars into the country each year. This year the 16 US companies in Malaysia are expected to invest nearly M$76,500,000 (£19,500,000) worth of some of the most advanced automated assembly and test equipment.

The Japanese electronics companies in the country, which include NEC, Hitachi, Toshiba, Matsushita and Mitsubishi are investing very much less. But the Malaysian Government believes that many Japanese companies will be forced offshore to avoid high labour costs at home and the soaring yen.

According to the Government's masterplan for the electronics industry the priorities are to diversify away from semiconductor test and assembly and to increase Malaysian involvement in the electronics industry.

N. Sadasivan, director general of the Malaysian Industrial Development Association (MIDA) expects that some local Malaysian companies to emerge will serve the semiconductor assembly, such as suppliers of lead frames. But he does not expect the country to develop its own indigenous electronics industry.

The priority as MIDA sees it is to develop a capacity to replace imported components with those produced locally.

"Our policy is to attract foreign multinationals to develop an industry here that acts as an engine to stimulate other parts of our economy." It will act as an engine by creating wealth and drawing both subsidiary companies such as lead frame suppliers and consumer electronic companies. ...

Sadasivan hopes the established electronics industry will continue to expand and hopes to attract investment from Singapore, where labour and land costs have become too high for some companies. He believes once a strong semiconductor industry is in place it will be a matter of time before consumer electronics and computer companies move East. (Electronics Weekly, 20 May 1987)

Netherlands

Dutch flower power

At a time when rapid transportation and lower costs are allowing competitors in countries such as Colombia, Israel, Kenya, and Spain to take advantage of better growing seasons, the Dutch are relying increasingly on computers to maintain their strong lead in the world flower market.

Using computers and automated equipment to control the amount of light and the application of water and fertilizer in greenhouses, where 90 per cent of the cut flowers produced in the Netherlands are grown, the Dutch are improving their productivity in an industry which they have dominated since the tulip age of the Ottoman Empire in the 16th century, when the sultan traded silver and gold for new hybrids of his favourite flower, thus encouraging a vigorous market in what the turks called tuliband, or turban.

Before dawn every weekday, freshly-cut flowers are sorted, assigned a code and catalogued by computer as they arrive from growers for early-morning auctions at markets around the country. Bidders in auction pits use personalized smart cards to log in on the computers. Then, during the auctions, as flower-laden trolleys, guided by chains, pass before them, the bidders listen through headsets to auctioneers, who describe the flowers by grade and classification.

All transactions are registered on the computers, which also quickly compile bills, so that the flowers can be picked up by the buyers within minutes, or sent almost immediately to shipping areas for delivery by plane to export markets in Australia, Japan or the US on the same afternoon or early the next morning.

Officials feel that, without the aid of computers, the Dutch industry would have difficulty keeping up with the output. Well over 20 million cut flowers and one million house plants are bought in auction halls throughout the Netherlands every weekday morning, and the Dutch produce seven billion cut flowers and 500 million house plants each year - 63 per cent of world exports of cut flowers and 51 per cent of exports of potted plants. (Bulletin IBIPRESS, No. 131, 7 June 1987)

United Kingdom

Alvey* gives ISF go-ahead

A project to make the UK a world leader in Information Systems Factories (ISFs), a type of third generation integrated project support environment (ipse), has got the go-ahead from Alvey.

A contract worth more than £200,000 has gone to GEC Research and STC Technology to conduct a study, with help from Edinburgh and Lancaster universities.

"Our job is to identify the critical needs of IF developers and find ways of applying new technologies to these needs", says Gavin Uddy, leader of the study for GEC Research.

David Morgan, director of software engineering for the Alvey Directorate believes 1987 is the year of the ipse: "It is important to start thinking about the next generation, and we see the ISF study as an important step in this process. The ISF architecture is a key component in the integration and application of new technologies." (Computer Weekly, 14 May 1987)

Customized chips bypass small firms

The Government may set up silicon centres in a campaign to increase the use of custom-made chips after finding that the "second revolution", in microelectronics, is bypassing smaller UK companies.

Action is needed to stop these companies missing out, says a study on the use of tailor-made chips by consultancies Shortland Associates and Butler Cox.

The study, commissioned by the Department of Trade and Industry, says the UK is leading Europe in applying custom integrated circuits, although only a third of the market is met by UK chip manufacturers.

Large UK firms have taken advantage of the opportunities offered by specialist chips, yet a staggering 70 per cent of small firms do not use custom-made chips in any form.

Companies using this technology report lower manufacturing costs and increased product reliability and functionality, the report says. Small firms have been able to reduce costs by up to 20 per cent and introduce new product ranges.

The report highlights a worrying trend of small companies that do not use custom integrated circuits of underestimating their competitors' use of the technology. The Government is recommended by the report to create a custom silicon awareness campaign to alert small companies to the benefits of the new chips. (Computer Weekly, 14 May 1987)

UK software engineering initiative

The Department of Trade and Industry has launched an initiative in information technology, aimed at encouraging the development and use of improved software engineering practices, methods and tools in the commercial data processing market. Called II-STARTS, the new initiative folows the STARTS

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* UK's government-backed Alvey research programme.

(Software Tools for Application to Large Real Time Systems) programme, which was set up in 1982 and is run by the National Computing Centre on behalf of the DTI. STARTS aims to raise the standard of software engineering practice in the UK through co-operation between purchasers and suppliers of large real time systems.

John Butcher, Parliamentary Under-Secretary of State for Trade and Industry, who announced the launch of IT-STARTS at a recent DTI conference, said, "Software quality issues, particularly standards, are fundamental to raising the performance of the industry if the UK is to secure a greater slice of the market". Mr. Butcher also announced that the DTI's Focus committee, which advises on IT standards, has recently recommended action to harmonize standards for quality management systems and to encourage their application to software production. Costs and benefits for software and the need for a certification scheme are also to be reviewed. (Engineering, July/August 1987)

EEC

European Community funding for Esprit is doubled

Europe's collaborative computer and telecommunications research projects, Esprit and Race, are to start next year following the agreement of a British compromise plan by European ambassadors.

According to Esprit director Jean Marie Cadiou, the agreement opens the way for a much larger Esprit programme. Funding for Esprit 2 is to be ECU 3.2 billion (£2.2 billion), double the amount of the first Esprit programme. Areas will be integrated design and production systems, high-speed silicon integrated circuits, non-volatile memory macro cells, advanced systems for engineering environments and parallel architectures.

The Race development phase could start as early as spring 1988 and will receive funding of ECU 550 million (£385 million). (Electronics Weekly, 22 July 1987)

Latin America

Network link-up between USA and Latin America for medical research

The Pan American Health Organization (PAHO), the Baylor Research Foundation, the National Research Foundation and the National Cancer Institute USA have started up a new electronic service called Internet to streamline the transfer of the results of medical research between the centres. The network link-up is ensured by microprocessors located in the American research institutes.

Now the Latin American doctors who are members of the American Cancer Research Information Project (LACRIP) can also, within a day, obtain the latest dat on cancer research carried out by other American institutes.

Using an international data communication network and an electronic messaging service, Internet ensures the link-up, via telephone lines, of the microprocessors of the Latin American and Caribbean centres with the headquarters in Washington DC.

When a doctor in Latin America wishes to obtain information, he requests, through his microcomputer, a link-up with the international network. After having inserted his own recognition code, he can access a computerized electronic messaging service in the USA. As soon as there is link-up, the researcher transmits his own request which the central processor puts into an electronic mailbox. The processing centre in Washington sees that the requests made are analysed in the given time limits. To satisfy such requests, the link-up with the data base is then established in real time.

Once the information is obtained, it is sent back to the electronic messaging centre and filed in the mailbox until the researcher at the other end of the continent proceeds to retrieve it. All this can be done within a day.

The Internet system is currently operating between Chile, Costa Rica and the USA, but other countries of Latin America such as Brazil, Venezuela and Uruguay are already preparing the infrastructures for the link-up. (Bulletin IBIPRESS, No. 131, 7 June 1987)

Southeast Asia

Japanese investments

Japanese companies are flocking into Southeast Asia to soften the impact of the high yen on their export performance. Their hosts are hoping they will bring more sophisticated technologies and share their know-how.

In January, a joint Thai-Japanese working group on technology transfer was established, while the small and medium business agency in Tokyo has been urging the Government to promote technology transfer through improved financial and tax incentives, for example.

Preliminary estimates show that Japan's total investments in Southeast Asia were US$13.5 billion in 1986. Data from Japan's Ministry for Trade and Industry show that 40 per cent of total overseas investment in the last eight months of 1986 went to Asian countries.

In Thailand, the number of new Japanese projects seeking government tax incentives rose to 47 last year, from 27 in 1985, the local investment board says. Total Japanese investment rose from US$17 million to US$65 million. The board expects new projects to exceed 100 this year and has set up a special Japan desk to attract more funds.

Narongchai Akarasenee, senior vice-president of the local international finance corporation, says: "Now it is the Japanese partner who needs help. Joint-venture partners on the Thai side can now negotiate with their Japanese counterparts for better terms and conditions, especially on technical know-how".

Indonesia, by contrast, has long paid lip service to technology transfer, but last year's 50 per cent slump in earnings from oil, source of two-thirds of annual export income, has left the country in no position to take any measures that might discourage foreign investment. In 1986, 20 per cent of all new projects and about 40 per cent of the total amount committed by foreign investors came from Japan.

Over the last five years, Indonesia has received more Japanese investment than any other Asean member. At present, however, the Japanese favour Hong Kong, South Korea, Taiwan and China in Asia. These are followed by Thailand and Singapore, with Malaysia and Indonesia a poor third and the Philippines a country of last resort.

The countries with a fast-developing industrial base stand the best chance of improving their technological know-how via Japanese investment.

In Singapore, for example, Japanese companies made investment commitments of US$233.2 million last year, double that committed in 1985 and an amount which exceeded US investment for the first time since 1979.

Aiwa, which started making audio equipment in Singapore 12 years ago, is expanding into such products as compact-disc players and digital audio tape recorders. It is setting up a research and development division which will be headed by 15 local engineers.

Yokogawa Hokushin Electric has set up a US$3.3 million hi-tech engineering centre to make a variety of sophisticated instruments for export. "With Singapore's trying to train more engineers and technicians, this is precisely what we would like to see established," says a senior Singapore official.

The centre will concentrate on sophisticated engineering design and software development for industrial processes. Of 52 employees, 42 are engineers.

Takasago, the biggest flavour and fragrance maker in Japan, is also establishing research and development facilities in Singapore. It has set up a laboratory staffed by 10 researchers, half locals, to "customize products made in Japan to meet local and regional market requirements," a company official says.

Later, Takasago intends to develop fermentation techniques to create new fragrances and flavours.

Sony, Aiwa's parent, has selected Singapore as the site for its first overseas centre for manufacturing precision components. The US$16.7 million centre will expose local workers to new manufacturing skills using computer-aided design and manufacturing, says a Singapore official.

Sony will employ 100 initially, including 30 engineers and technicians who will be sent to work in Malaysia, Taiwan and South Korea after training.

The Japanese machinery exporters' association says that high value-added products requiring sophisticated production and management know-how are mostly being produced in Japan.

Even in the case of South Korea, where technology transfer and research collaboration with Japanese groups is already advanced, the Japanese are mainly transferring component assembly or the manufacture of products that have lost their competitive edge at home.

The less developed Asean countries are in a worse position than South Korea, Singapore and Taiwan. However, in Indonesia Toshiba has entered into a joint venture with a local company and established a small R&D division to develop new designs for radios and tape recorders for the local and African markets.

In Malaysia, Sony is opening a US$16 million plant in Penang where 100 workers will make compact-disc players, radios, radio-cassettes and stereo equipment for export to the US and Europe.

Some Japanese companies are redeploying their subsidiaries in the more industrialized Asian countries such as South Korea and Taiwan to Asean countries like Thailand and Malaysia where labour costs are low. Minebea, a leading miniature bearing manufacturer, has set up facilities in Thailand. Others are producing TV tubes in Taiwan and assembling TV sets in Malaysia.

Even in the Philippines, where political uncertainty has deterred foreign investment, officials say there are new Japanese investments with a stronger technological component in the pipeline - especially in such fields as silk manufacturing, automotive spares, electronics and food processing.

As the composition of Japan's exports has shifted so has that of its investment. In Malaysia, more than 70 per cent of the US$1.1 billion invested by Japanese companies in 1985 was in manufacturing. Natural resources - chiefly oil and natural gas, copper and timber - took 19 per cent.

And investment in manufacturing has been shifting from textiles and machinery towards car and motorcycle assembly and, lately, to hi-tech electrical and electronic goods. The average size of companies, along with their paid-up capital, has also increased.

Low wages are the main attraction in Malaysia, Indonesia, the Philippines and Thailand, which lack the skills and know-how of Singapore, Taiwan or South Korea.

Thailand also lacks the support industries required by Japanese industries. One example is the recently formed Thai-Nippon Steel Engineering and Construction, a 62 per cent Thai-owned US$6 million joint venture to produce offshore steel jackets, bridges and other steel structures.

It will employ about 1,150 Thai workers and 13 Japanese specialists and managers. Its technical director told South: "The Thai engineers and technicians already have the basic knowledge. We have a special computer programme to train them further. Sixty per cent of the 350 workers for the first stage of the project are skilled, and 10 to 15 welders will go to Japan for a four-week training course. That is about all that is required." (South, June 1987, pp. 101-102)

NICs to lose their nickname in 1990s

According to the Nomura General Research Institute, newly industrializing countries (NICs) will catch up with industrialized nations in such fields as steel, petrochemicals and electronics in the 1990s. Korea, Taiwan, Singapore and other NICs are increasing their international competitiveness rapidly due to the strong yen rate. The institute warns that Japanese companies should not depend entirely on the traditional strategy of export but should meet the exigencies of developing high-tech products and establishing an international division of labour.

In the field of electronics, it is noted that Japanese manufacturers are heavily damaged by the strong yen while manufacturers in Korea and Taiwan are showing good business. For example, Samsung Electronics (Korea) increased sales in the first half of fiscal 1986 by 23 per cent with expanded exports to the United States. The company's pretax profit increased 26 per cent. (AEU, No. 2/1987)

VII. ROBOTICS AND FACTORY AUTOMATION

"Just-in-time" production management techniques

By applying methodology instead of technology, UK manufacturing firms can achieve almost all the cost benefits of advanced manufacturing technology (AMT) at a fraction of the price. Just-in-time (JIT) is a management philosophy originating in Japan that aims to cut the time it takes to make products, and free the cash tied up in stock and work-in-progress. It also blows the myth, perpetuated by both management and government, that all Britain's industrial ills are caused by overmanning.

The only barrier to JIT revolutionising industrial practice is an interpretation of the work ethic. In a JIT factory, it is not uncommon to see people and machines standing apparently idle, since only enough stock is manufactured to satisfy demand; nothing is produced 'just in case'. There is a knock-on effect too, JIT puts the onus on a firm's suppliers to deliver just enough, never too early and not too late, by the hour it necessary.

Just-in-time also has implications for the High Street, with city centre stores maximizing the amount of revenue-earning selling space in their prime sites, by reducing the overhead of buffer storage. Leyland's high-technology TX 450 truck, which uses computers to make it quiet and efficient, was developed specifically for the frequent deliveries that JIT demands.

Management consultancy Handley-Walker has initiated several JIT projects, and was recently asked by an aerospace supplier in Lancashire to plan and implement a flexible manufacturing system installation for light alloy products. The complete system was to include automatic guided vehicles, robots and laser cutters. But during the study the consultants discovered that merely by applying JIT principles to the press-shop, the company could achieve 95 per cent of the cost advantages of full FMS for an investment of just £250,000. The positive cashflow resulting from reduced inventory and work-in-progress will ensure that the second stage of the full £3 million FMS installation will be totally self-financing.

Just-in-time is based on a simple but obvious premise: that firms are in business to make money. In the metalworking industry, 50 per cent of costs are accounted for by materials. Only 10 per cent is tied up in direct labour costs and the other 40 per cent is overhead. UK management is obsessed by a need to cut direct labour costs, and as a result, work study people are paid thousands of pounds to shave off pennies.

This is misdirected effort. What management should be doing is attacking waste, compressing lead-times and reducing the amount of work-in-progress littering the shopfloor. The quicker the product gets out to market, the quicker it can be invoiced and the better the cashflow. 'UK management has a mistaken impression that work-in-progress is a company asset', says Handley-Walker director Ian Wilson. 'It is most definitely not. It is a liability and it is costing UK industry millions of pounds each year'.

So how does JIT work? Consider the traditional method of manufacture. Someone decides to produce a batch of components, the size of which is determined by an economic batch quantity formula, i.e. it takes the same amount of time to set up the machine to make one off as it does 500 so you may as well make a few more 'just in case'.

The operator of one machine takes, say half a day to set up and finishes the batch three days later. The parts are then stored. Meanwhile the machines downstream are busy making other products. A day later, an expeditor and materials handler arrive to look for the batch of part-completed products and send them to a second machine. These sit on the floor for a day while the machine finishes its current job, then the operator sets up and four days later the parts go back to storage, and so on down the line. The part may only take a few minutes of machining time to make, but the door-to-door time could be weeks.

Using JIT, however, the product is 'pulled' through the process according to demand. The assembly foreman, for example, might ask for 250 parts to complete the 250 main assemblies for a washing machine sitting in his shop. After the right amount of material to make exactly 250 parts has been drawn from the stores, JIT demands that the parts are processed one at a time. In a JIT factory, there is no intermediate storage, the parts are passed from one machine to another as they are completed, and the machines are often physically linked together by a conveyor. Set-up time is driven down by using quick-change preset tooling and by letting the machines downstream know in advance what job is coming next. Door-to-door time is cut significantly. A continuous flow process with minimal losses is not usually possible, as some operations necessarily take longer than others, but the parts would be flowing to main assembly in a matter of hours rather than weeks, with a dramatic effect on cashflow.

There are other benefits too. Quality is improved. If one operator discovers that another is producing oversize parts, for instance, instead of throwing the piece into the rework bin he can shout to the operator of the first machine to reset the tooling. Using JIT, only two or three parts will need rework, not the whole batch. Expensive floor space, previously utilized for inventory storage, can be put to better use and the clerical staff forever chasing and keeping tabs on work-in-progress can be deployed elsewhere. JIT can also identify and highlight bottlenecks in the process and new technology can then be employed wisely to make the plant more effective. Through JIT, investment can be directly related to improved cashflow.

If JIT can squeeze down lead times it can also be instrumental in bringing new products to market faster, giving companies an edge over their competitors. And in responding only to demand, the method will automatically reduce the amount of potentially obsolescent stock gathering dust in the warehouse.

In practice, as mentioned earlier, some operations in the process will take longer than others. The way components are pulled through the shop is controlled by using kanban (the Japanese word for jobticket) signals. In the simplest case, a kanban can be a square chalked on the floor on the downstream side of a machine. If the kanban is full then the operator of the machine upstream stops working. The result is that machines and operators are seen to be idle.

This is anathema to British management and seems at odds with a methodology that comes from Japan - the land of hard work. But it all makes economic sense. There is no point in keeping people and plant busy just to produce expensive work-in-progress, which may well become obsolete anyway, for no better reason that to satisfy arbitrary accounting procedures. In Japan this time would more likely be spent practising speedier tool changeovers - learning to be like mechanics at a pitstop in motor racing - and taking time to hold meetings on how the product could be improved.

To date, JIT has been applied mainly to straightforward assembly operations such as are found in electronics and electro-mechanical applications. In more complex operations, for example in a press shop environment where machine tools are shared, computers and barcode readers are necessary to control the priority ratings of parts coming from different directions.

A job's priority rating may increase as it passes through the production sequence, as it gathers added value. To prevent certain jobs being continually overtaken by others, the priority rating of each part can be made to increase periodically either in proportion to elapsed time or on every occasion that the component is ignored in preference to another.

JIT is commonly implemented in two stages. The first aims to reduce the door-to-door time of a part travelling through a factory's production process, cutting work-in-progress and finished inventory. The second puts pressure on a company's suppliers to adopt the same discipline. In Japan the most important criterion in choosing a supplier is not price, but proximity. The aim is to replace, say, quarterly deliveries in bulk by, ultimately, hourly ones. A company may intially have to tolerate a small price increase per component, but even so using JIT will still produce a payback. This also has the effect that JIT becomes contagious, to the benefit of everyone down the chain.

Just-in-time can be introduced before a full FMS implementation in a matter of weeks and can prevent the culture shock of change, something the work-force might not accept anyway, whilst generating cashflow that can be reinvested in a controlled and phased way, putting technology where it will ultimately produce the most benefit. (Engineering, May 1987, pp. 295-296)

FMS halves lead times for machine tool production

It was no surprise to discover that Japanese machine tool builder Niigata uses a flexible manufacturing system (FMS) to produce components for its range of horizontal machining centres. Its system 1000 has been operating since 1983 and, representing an investment of approximately £2.7 million, it comprises five Niigata horizontal machining centres (three HN80As and two HN50As) served by a wire guided AGV (automatically guided vehicle). Two CNC units, a mill and a vertical turning machine, pre-machine workpiece datums and these machines, and the adjacent work set-up area, are also serviced by an automatic guided vehicle. A high bay warehouse with two independently crane-serviced sections, one for unpalletised and non-fixturized components (200 positions) the other for those that are (200 positions), plus a tool setting area and automatic work loading/unloading device, complete the system description. A 16-bit minicomputer having 512 Kbyte RAM and 53 Mbyte hard disc, plus five CRTs, are responsible for system functioning.

The FMS handles prismatic parts within one m^3 and parts for 360 machines/year can be made, non-stop for six days a week. Only one shift is manned; four people load/unload components to fixture/pallets, set tools and pre-machine components. The system can operate unattended for more than 24 hours. Over 90 different components are machined (initially it was 70) but with machine tool requirements currently running at 280 units/year, a problem could arise. This represents 78 per cent of capacity, and it was admitted that for the first three years of operation machine utilization had to be 90 per cent - then 75 per cent was acceptable.

Compared with conventional techniques, Niigata says the FMS has halved lead times (five weeks for a HN50B, for instance). But system payback is 10 years. After 10 years, Niigata's intention is to modify, not replace, the system. Running expenses of about £85,000 every six months cover tooling, fixturing and software improvements/additions. Current software improvements include more automation in tool setting and management.

A breakdown of the initial investment reveals that 50 per cent was spent on the machine tools, 15 per cent on jigs/fixtures/tooling, the same for AGVs and storage, another 15 per cent for computer hardware and software, and the remainder for providing an automatic fixturing device and tool supplementation facility, Niigata reckons the breakdown is typical of such an FMS. (Machinery and Production Engineering, p. 42, 1 April 1987)

FMS: East vs West ...

Harvard Business School professor, Ramchaundran Jaikumar, in 1984 studied 35 US and 60 Japanese flexible manufacturing systems and, as the table below shows, there was a marked difference in performance. Professor Jaikumar also reportedly made these assertions as to the reasons for the poor performance of US systems:

- Once installed, the FMS was rarely tinkered with - so its true flexibility was not realised.

- 18 Japanese systems ran unattended overnight; no US installation did.

- 40 per cent of the Japanese companies workforces were college-educated engineers, all trained in the use of CNC machine tools. In the US, eight per cent of the work-force were trained engineers, and less than a quarter were trained in application and use of CNC.

- System design ultimately suffered because of this lack of training. Large teams of specialists tended to design the complex systems in the US (more complex than required). And once the system was designed, the team disbanded so their hands-on software expertise dissipated. Operating responsibility was then left in the hands of people who were reluctant to tamper with things. New parts were rarely introduced and production runs tended to be high. In Japan, on the other hand, small teams of engineers with broad backgrounds designed the systems then stayed together until 90 per cent up-time was achieved. This encouraged a flexible approach where bugs were resolved without recourse to 'hardwire fixes'.

Professor Jaikumar found that the average payback for a Japanese system was three years, even without taking into consideration the strategic benefits of installation. This, he says, discounts the argument that US cost-accounting techniques are inadequate.

FMS: US vs Japan

	US	Japan
System development time (years)	2.5 to 3	1.25 to 1.75
(man hours)	25,000	6,000
No of machines per system	7	6
Types of parts produced per system	10	93
Annual volume per part	1,727	258
No. of parts produced per day	88	120
No. of new parts introduced per year	1	22
No. of systems with untended operation	0	18
Utilization rate (two shifts)	52%	84%
Average metal cutting time per day (hours)	8.3	20.2

(Source: Ramchandran Jaikumar, reported in Harvard Business Review and quoted in Machinery and Production Engineering, 1 April 1987)

Lead time reduced by FMS: Railway locomotives

A £1.5 million flexible manufacturing system (FMS) is to be installed this month by GEC Traction of Preston. Built by Pensotti of Italy, the system will be used in the production of electric traction motor housings, end caps and finish machined sub-assemblies for railway locomotives. About 25 part designs will be processed in batches of 4 to 60. And traditional lead times of 16 weeks will be cut to just 43 hours.

The system is the first to be sold in the UK by Pensotti's agent, Fendius of Warwick. It comprises two vertical turning lathes: a five-axis NDM 160, which has a universal live spindle head for rotating tools to allow it to perform machining centre functions; and a three-axis NT 130. A rail-guided vehicle (from RotoMoss, Italy) will supply 1,500 mm diameter chucks from stands alongside the track, so that the machines can operate as a pair or independently to produce parts up to 1,500 mm high and 1,600 mm square in cast iron and welded sections. Both machines will be controlled by Allen-Bradley 8 650 TC systems linked to a Digital Equipment MicroVAX II cell controller.

The main unit, the NDM 160, has a maximum swing of 2,400 mm and a turning height of 2,000 mm to machine the vertically-mounted housing-type components on their top faces and to produce internal/external features. The main chuck drive motor has a massive 61 kW available.

Its universal head, which is changed into the spindle from a tool magazine mounted on the cross rail, allows features involving milling and drilling to be produced on all faces (except location) and diameters of a part. This spindle can handle driven tools demanding up to 27 kW of power, but for right angle machining the power is stepped down to 21 kW, and to 17 kW for the universal head.

A three-axis, floor-mounted robot will perform normal tool changes from a 72-tool pocket semicircular magazine mounted alongside. There are 12 pockets for turning tools, and 60 for ISO 50 taper toolholders for non-turning applications.

The smaller NT 130 also has 61 kW to drive its rotating chuck, and has twin toolchangers mounted either side of the spindle. One holds 12 turning tools, the other accommodates 24 ISO 50 taper toolholders. (Machinery and Production Engineering, 3 June 1987)

Automated assembly line for kitchen appliances

An 11-station automated line for assembling parts for a kitchen appliance employs the newest technologies in instrumentation, controls and computerized diagnostics.

Now in operation at the In-Sink-Erator Division of Emerson Electric Co. (USA), the line was engineered by the American subsidiary of John Brown Automation Ltd. (England)), a specialist in automated assembly equipment. The line assembles four driveshaft bearing and sealing components into a cast end bell. While the assembly operations are conventional, their control, diagnostics and management information systems are state-of-the-art.

An unusual feature is the way the controls are station-based rather than machine-based, an advantage in assembly machines. Intelligence is distributed among many small microprocessor driven programmable controllers (PC) that are packaged as modules.

The typical assembly machine manufacturer, without its own PC manufacturing capability, must purchase an off-the-shelf programmable controller for centralized, machine based control. An off-the-shelf PC contains a single processor operating hundreds of input and output points, a scheme that can result in design and operating inefficiencies for several reasons.

First is the high sensor count required by modern flexible assembly systems. John Brown Automation, for instance, believes that a high level of interrogation of every machine move and every part position is absolutely necessary for minimizing rejects, diagnosing machine faults, and assuring high system reliability and uptime. The In-Sink-Erator line is believed to be the first in the US with this high level of station interrogation.

As the number of sensors grows, the number of input/output (I/O) signals also grows. With a central controller, machine cycle time then suffers because of the lengthened scan time needed to address all of the I/O points.

Second is the difficulty in predicting during design how many I/O points will be needed. The engineer at a competitive assembly equipment company will make an estimate and then choose a sufficiently large off-the-shelf PC. Invariably, the customer later decides he wants more automation than originally envisioned, and the designer runs out of point capacity.

The choice then is to spend $10,000 or more for the next larger sized PC, or advise the customer that the machine must be limited to the capacity of the original controller. Neither solution is a good one.

The modular approach to control, present on the In-Sink-Erator line, solves both the efficiency and point limitation problems. ...

The basic module is a conventional sequence controller - a complete PC with microprocessor CPU, 1 K byte of erasable programmable read-only memory (EPROM), 16 input and 8 output points, internally selectable counters, timers, and event flags. All I/O points are optically isolated to withstand the shop floor environment.

Special modules simplify the complex control tasks that often occur in assembly operations. Included are designs for handling photoelectrics, dc motors, vibrators, lift and transfer mechanisms, robot axes, reject segregation, start-up testing, and for processing, converting, and displaying analog signals.

The control is purposely designed to handle analog data and process it. This is very difficult with standard PCs.

For example, the In-Sink-Erator installation includes module No. WM-151 which provides analog input of load or displacement, sample and hold, or auto zero limits. This module is used to check bearing insertion load as well as bore diameter and taper.

The John Brown control employs English language programming, based on flow charts and simple commands. Therefore, no knowledge of relay logic, electronics, or computers is necessary. Because machine control is distributed, program writing is split into small, manageable pieces.

The modules' EPROM chips are removable and are programmed and burned-in external to the modules. Programming is available at the factory in England or at the company's USA offices either directly or by telephone.

Users may program chips on a mini-computer with the help of a monitor and printer. Programming may also be accomplished on the shop floor with a portable CRT terminal. ...

Two special modules - message display and video display - work together. The message display unit continuously scans all control modules. If the machine stops, a number is flashed on the display corresponding to the station and sensor.

The video display module refines the diagnosis by indicating in English where the problem lies, what is wrong, and what corrective actions might solve the problem. This module also recognizes a series of interrelated faults, indicating which occurred first and which should have priority attention. Intermittent faults are also captured and displayed. A history of the most recent faults is available, and analog test results are stored.

A color-graphics touch-screen management information system accesses data processing and diagnostics modules to provide company management with real-time producton statistics and records. Fifteen display pages have been custom prepared to In-Sink-Erator's specifications.

A key feature of the Management Information System (MIS) is the trend analysis of such data. This is vital for detecting potential problems, which enables remedial action to be taken before the actual problem occurs.

The system compiles data on machine output, efficiency, rejects, reject rate, uptime, and cycle and waiting times, all on a per shift basis. For individual stations, the MIS gives details on fault summary, downtime, pass/fail, reject rate, etc. Even a graph of the bearing taper statistical distribution is generated.

The MIS is supplied with a keyboard, but the usual mode of operaton is via the touch sensitive screen. Around the front of the CRT is an infrared beam grid pattern which detects the position of the operator's finger. Thus, the software can be entirely menu driven merely by the user touching the appropriate part of the display. ...

At daily, weekly, or monthly intervals, summary data may be generated to aid management in preparing production reports, scheduling production, analyzing trends, etc. The MIS computer features 512 Kb of memory and 6 Mb of hard disc storage. (Industrial World, March 1987, pp. 10-11)

Process control system expands capability

Comprising the entire range of process-control products, from new transmitters to control computers, software, and design and training services, the Intelligent Automation Series (IAS) features tailored applications packages for a host of common industrial-control problems. These packages include: power plant; ammonia plant; crude-oil processing; and textile processing; (others are in preparation). The manufacturer seeks to provide all the hardware, software, and support services needed to operate the system.

The IAS system supersedes the manufacturer's previous line of plantwide process control, the Spectrum system. And it includes a control software package introduced last year - the EXACT expert system - for automated tuning of process controllers. The system's overall architecture and communications protocols are designed to comply with the evolving MAP (Manufacturing Automation Protocol) and FIELDBUS standards, allowing for the inclusion of other manufacturer's equipment with no communications snags.

The smallest components of the system are transmitters, based on a proprietary "quartz sensor" technology. They are said to provide a digital signal having an accuracy of better than 0.1 per cent of calibrated span, and turndown of up to 100:1. No analog-to-digital converters are needed.

Transmitters and other localized equipment communicate via broadband channels with ruggedized I/O enclosures, each of which can hold up to 32 I/O modules. Throughout the system, self-contained modules are used rather than conventional circuit cards, allowing for quick replacement.

The I/O enclosure can be replaced or complemented with a field enclosure, which can contain processor modules for actual process control. Both types of enclosures (as well as processor modules) feature conductive cores and cooling fins to dissipate heat without having to circulate large volumes of air. Operating temperature range is -25 to +70°C for the field enclosure; the I/O enclosure has a 0-60°C range.

The field or I/O enclosure communicate with local or remote workstations, or a multibay central control room. These workstations use high-resolution color graphics, a mouse or trackball, and a keyboard for operator interface. Up to 32 processor modules, which can be connected to each other within a 300-m link, define a node. Depending on the communications technology chosen (MAP carrier band or broadband), up to 100 nodes can be specified.

Extensive work was done to expand and improve the IAS system's control software, says the firm. Key features include a "global" database manager program, and high-level applications programs such as spreadsheet, process optimizer, statistics (including statistical process control), and various data-printing or recording techniques. The database manager allows for plantwide communication with any necessary information (both historical or real-time); its access is secured by passwords.

UNIX system V is the basic operating system for the software; it, together with a proprietary "executive" program, allows for realtime process control. In addition, high-level programming languages such as C, FORTRAN, or BASIC can be used for specific applications; control programs already written in these languages can be transferred and put to use without revising, according to the firm. All the software is designed to be hardware-independent, so that newer languages or updates can be implemented without hardware modifications. (Chemical Engineering, 25 May 1987, p. 29)

Want to design a robot? Try watching a bug

Most of us don't spend much time contemplating insects. But to some engineers, bugs can be downright inspiring. Researchers at Oregon State University believe they may hold the key to a new and highly agile robot. "They're magnificient models for walking machines," declares Eugene F. Fichter, an engineering professor.

Insects, he points out, travel with equal ease over smooth or rough terrain and move horizontally or vertically. Moreover, they're remarkably adept at using their multiple legs to step across wide crevices that otherwise would require jumping. To help create the next generation of walking robots, Fichter and his colleagues will study the motions of insects and spiders, hunting for design clues. Their movements in walking, running, and maneuvering difficult terrains will be filmed; then those images will be digitized and analyzed by computer to determine if insect legs and motions can be adapted to machines thousands of times larger and heavier. (Reprinted from the 16 March 1987, issue of Business Week by special permission, (c) 1987 by McGraw-Hill Inc.)

Robotics in the laboratory

Today's analytical laboratory strains under an increasing load of samples to be processed. To cope, instruments were refined for faster performance, mainly through automation. In this regard, there are notable contributions from the field of robotics.

Starting in the early 1980's with the development of computer-aided chemistry, analytical instruments linked up with computer technology, and so-called laboratory information management systems (LIMS) for the collection of data and its manipulation, storage and management. Instrument makers are now able to provide laboratories with automation systems to handle time-consuming and exacting tasks of sample preparation. This simultaneously increases productivity, improves the quality of analytical results and frees technicians for other work.

To date, automated analytical systems have found their greatest application in the pharmaceutical, food, beverage and environmental laboratories, with biotechnology looming on the horizon.

Robotics applied to laboratory systems vary in the details of their operation. In one system, beakers and flasks are moved about the lab bench by a system of articulated robot arms, a robot electronics module, communications interfaces all under the direction of a personal computer.

With software designed specifically for the analytical chemist, the system allows data accumulated during sample preparation, such as weight, dilution factor and sample identification to be stored easily on disk. The user has the flexibility for combining sequences or entering the name of the sequence, via the keyboard, for immediate action. For the robot, absolute positions, relative positions, finger positions, rack indexing and such parameters as grip pressure and travelling speed are programmable.

The system uses a miniaturized version of an industrial robot - an articulated robot arm that reproduces the five movements of the human arm: rotation around the base of the robot, a shoulder rotation around a horizontal axis, an elbow rotation around a horizontal axis and two wrist rotations around perpendicular axes. These are driven by five DC servo-motors.

The robot has interchangeable fingers to handle different types of vessels and linear transport to extend its reach. Optical sensors using photoencoders, with closed loop feedback, position the robot action. These light-activated sensors located in the robot arm joints send information to the controller to indicate position.

Another system, designed for light-weight tasks in the laboratory, uses a servo motor driven by a signal that represents the difference between commanded and actual positions. In this system, the arm is moved through four basic motions: rotation through the base of the robot around a vertical axis, rotation along the robot arm around a horizontal axis, vertical linear motion and a horizontal linear motion.

Robotics, from initial use by some companies, have also resulted in savings in laboratory technician time.

Typically in a LIMS system, a sequence of processes for every sample is performed. In Perkin-Elmer's "MasterLab", a sequence involves, first, sample preparation in which robotics is used; then, analyses performed by one or more instruments (atomic absorption, infrared, gas chromatograph, liquid chromatograph, ultraviolet/visible, and others). After receipt of the sample, it is logged, labeled, prepared and analyzed. All of the information pertaining to the sample, can be managed by computer to increase the laboratory's data handling efficiency. In recent years, LIMS systems have evolved to provide such features.

"MasterLab" starts with positioning the robot in its work area using a "teach" pendant. Once put into position, the user assigns the location a descriptive name, using common laboratory terminology. All of the robot locations are automatically saved in a directory for future reference.

The chemist programs the sequence for automated sample preparation procedures using a Robot Language (PERL) software. PERL permits both relative and absolute positions to be named and saved. These positions can be combined into a sample preparation method. The programs can then be saved on a floppy disk for recall at a later time.

Hardware consists of an IBM personal computer (PC), or other desk-top compatible computer as system controller, a 5-axis robot and a robot electronics module, and communications interface. Each system can be designed to meet the automation requirements of a specific application or sample preparation procedure. Depending on the application, accessory modules, such as mixers, dispensers or balances may be required to interface with the system.

The PERL language used with the system is designed specifically for the analytical chemist. PERL's "Teach" module teaches the robot and other modules specific actions, positions and quantities that are necessary for the system to perform a task. ... (Industrial World, April 1987, pp. 13-14)

Limping along in robot land

Once it was hailed as the ultimate manufacturing industry, an enterprise that would cut American labor costs, boost productivity and rack up as much as $4 billion in sales by 1990. Blue-chip giants stampeded to buy into the action; bankers panted to finance the heralded expansion. Optimism was seemingly unbounded for the US robotics industry, which produced semi-intelligent machines that were expected to help American businesses compete with low-wage foreign rivals over the next two decades and to improve greatly the quality of American industrial production.

Well, that was five years ago. Rather than becoming the highly successful purveyor of tireless, reliable welders, assemblers and heavy lifters for the auto industry, aerospace and other industrial concerns, robotics today is an industrial accident victim, crippled by a two-year slump. Sales of US robots are expected to decline from an anemic $380 million in 1986 to about $400 million this year, miles below those rosy billion-dollar projections. The number of manufacturers that make robots and related equipment dropped from 328 last year to 300 this year.

Analysts had predicted that 250,000 robots would be in American factories by 1990; today only 25,000 are installed, roughly twice as many as exist in the Federal Republic of Germany, which has a much smaller industrial base. The US lags far behind Japan, where 118,800 robots are in use. Along with sluggish domestic demand, US manufacturers face a shrinking share of the roughly $1.9 billion global robotics market. Reason: Japanese competitors have gained a strong edge in the field and appear likely to continue their domination.

Last month, Westinghouse Electric sold off part of its money-losing Unimation robotics division. Westinghouse's 1983 purchase of Unimation for $107 million marked big business's arrival in robotics; IBM, Bendix and General Electric soon followed. Unimation, founded in 1959, was a robotics pioneer. Its first product was an $18,000 Unimate machine used by General Motors to load forged dies at a New Jersey auto-assembly plant. As recently as 1981, Unimation made 45 per cent of all robots sold in the US. Another setback for robotics will take place soon, when GE plans to fold its $4 million robotmaking plant in Plymouth, Fla. ...

One area of vulnerability for US manufacturers was the hydraulic-robot technology pioneered by Unimation. The company's robots, which became the American industry standard, were large (up to 4,000 lbs), powerful, multipurpose and expensive, ranging in price from $30,000 to $200,000 apiece. But these bulky hydraulic machines, originally programmed to perform tasks by means of magnetic tape similar to that used in tape recorders, were often inaccurate and susceptible to breakdowns. Despite those drawbacks, in the early 1980s hydraulic robots appeared to be the best workhorses available for such automated tasks as parts assembly, materials handling and heavy-duty lifting.

Even as US robotmakers wallowed in their early success, the Japanese, who imported their first hydraulic robot in 1967, were coming up with a new product. Fitted with high-speed computer chips and sophisticated circuitry, the new electric machines received instructions via computer-software programs. The machines tended to be smaller, less expensive ($5,000 to $40,000 each) and not as prone to breakdowns as their US hydraulic counterparts. Though electric robots were less powerful, and thus less capable of heavy industrial tasks, their greater accuracy in tasks such as delicate manipulation and precision welding made them more attractive for the automotive, aerospace and electronics industries. ...

Most analysts expect the number of US robotmakers to keep shrinking through the mid-1990s. By that time robotics technology may have taken another impressive leap forward, with the US once again expected to be the technological trailblazer. Advances now being explored in American universities and research laboratories could lead to the creation of machines capable of walking, improvising tasks and seeing (some robots can already do this crudely, through computerized video cameras). By then, the robots' masters may have learned how to exploit their wondrous inventions without falling to the kind of painful doldrums that now afflict their once glamorous industry. (Time, 13 July 1987, pp. 34-35)

VIII. LEGISLATION AND STANDARDIZATION

Intellectual property turns into high-priced real estate

A wave of legal cases has swept the semiconductor industry as chip makers have become far more aggressive in standing up for the rights to their intellectual property, in the form of technology patents and copyrights. A tightening of practices on the second-sourcing of major chip products can also be seen, as companies who have invested heavily in developing, for example, 32-bit microprocessors, attempt to wring as much return as possible - in the form of dollars or exchanged technology - from their R&D investment.

Avoiding second-source pacts and prosecuting any company that steps on copyright or patent rights while attempting to build similar chips are both ways to prevent direct competition for a new product from appearing quickly to drive prices and profits down. Enforcing intellectual property rights is growing more important because the industry, particularly the Japanese segment, has become very adept at getting competing products to market quickly.

But chip companies are also pursuing such rights more vigorously than ever simply because recent changes of the law and court decisions have made it far easier to do so. Copyright law has been changed to cover both software and chip designs, and the Intel-NEC court case appears to be setting a precedent in favor of the originator of microcode, as well. In addition, a new appeals court that hears only patent cases has made the patent laws easier to enforce.

With new legal tools making it easier to protect intellectual-property rights, established chip companies with fat patent portfolios are moving to capitalize on their past work. Collecting substantial license fees has grown very attractive, and Texas Instruments Inc.'s latest quarterly report shows how big this can pay off. After suing several Japanese makers of dynamic random-access memories, the Dallas company has succeeded in collecting large royalty fees, thanks to its patents on DRAM technology.

Both Intel Corp. and Motorola Inc. are showing great reluctance to let other vendors make versions of their 32-bit processors; second sources have helped drive down the prices of microprocessors in the recent past, cutting into the profits of the original developer. At the very least, Motorola and Intel expect to get something very significant in return for the rights to second-source their 32-bit processors - such as the rights to manufacture parts having what they see as equal value. "Semiconductor companies have stopped giving technology away for a song", says industry analyst Dan Klesken of Montgomery Securities Corp., San Francisco.

Not everyone likes the idea of aggressive protection for intellectual property. Chip makers that don't have a great many patents aren't happy with it, for obvious reasons. More disinterested observers wonder whether the march of progress will slow down considerably if a handful of large companies decline to share their technology and designs.

The latest example of a chip maker successfully reaping rewards in an intellectual-property battle is the extraordinary $108 million item listed on the TI balance sheet for the first quarter of fiscal 1987. The money represents three years of royalty payments the Dallas-based company won from the six Japanese chip makers. A series of lawsuits by TI forced the Japanese companies into settlements that included their signing licensing agreements acknowledging TI's patents on dynamic random-access-memory technology. Further royalties will accrue on a per-unit basis until 1990. ...

Gordon Moore, chairman of Intel, Santa Clara, California, also predicts that semiconductor companies will henceforth become much more aggressive over their intellectual property rights. Intel itself certainly intends to: it has hired a top patent lawyer to guard its interests, Carl Silverman, one-time chief patent counsel for Schlumberger Ltd. and before that for the General Electric Co., and now Intel's chief counsel for intellectual property. ...

Motorola's Semiconductor Products Sector is reportedly seriously considering enforcement of a patented dynamic-bus-sizing concept. Several popular 32-bit microprocessors can self-configure for 8-, 16-, or 32-bit data paths, and their makers may be asked to pay license fees, Motorola managers say. Motorola is also holding out for a major transfer of technology in return for second-source rights to its 32-bit 68020 microprocessor.

Only Thomson CSF has the rights to manufacture the 68020, and only in France - and Motorola is reportedly dragging its feet about transferring the technology to Thomson. Meanwhile, it has rebuffed several determined efforts from Signetics Corp., which has so far struck out with offers of three complex

68000-family peripherals. On the other hand, Motorola managers in Austin, Texas, hint that the 68020, and the future 68030, may become one of the chips made by Motorola's joint venture with Toshiba Ltd. in Japan.

Intel appears to want to go completely without second sources for the 80386, the 32-bit microprocessor that is everyone's bet to take over the office workstation market. AMD made a commodity item out of the 16-bit 80286, which Intel had spent millions to develop, and the Santa Clara firm is not about to let that happen again with its $100 million 80386.

One reason for increased attention to intellectual-property issues is that a growing number of companies have no real assets except their intellectual property. ...

Experts point to the restructuring of the court process and strengthening of copyright and patent law as key factors contributing to the increasing power of intellectual-property rights. Before 1982, patent cases could be appealed to any federal circuit court. In that year, a new appeals court was formed specifically for patent cases. This court "made life more uniform" for patent lawyers, says Intel's Silverman. In some circles, it is seen as a pro-patent court. ...

Coupled with the new patent court are changes in copyright laws that are now being used as the basis for legal rulings. Last September's decision that Intel's 8086-family microcode is protected by copyrights was based on a 1980 amendment bringing software under the protection of the Copyright Act, and the 1984 Semiconductor Chip Protection Act, which covers chip designs. How close a copy can be without infringing on a copyright remains to be determined. ... (Reprinted from Electronics, 30 April 1987, pp. 43-44, (c) 1987, McGraw Hill Inc., all rights reserved)

French integrated circuit industry to be protected by law

In France, a draft law aimed at promoting a specific system for the protection on integrated circuits against pirating is currently being studied by the National Assembly. A similar measure is expected to be adopted shortly by all the producer countries of semiconductors since beginning on 7 October, foreigners will only be protected in the US if their own country has elaborated equivalent legislation.

While in 1985, a law had enabled software to be protected by copyright, the National Assembly is now examining a draft law for the protection of the topography of semiconductor products. The text concerns finished or undistributed components.

This type of protection requires a deposit with INPI (Institute National de la Propriété Industrielle). Simpler and less expensive than depositing a patent, this must be done no later than two years after the topography has been made commercially available, no matter where, and no later than fifteen years after it has been initially fixed or coded if it has never been exploited. The topography cannot be communicated to third parties except at the decision of a judge or the authorization of the registered owner.

In the case where a new semiconductor product is created by an employee during work hours, the employer shall naturally have the right to deposit it unless stipulated otherwise in the contract.

Third parties prohibited from reproducing, commercially exploiting or importing pirated chips will however be allowed to reproduce chips for purposes of analysis or teaching or for creating, on the basis of such an analysis, a different topology. (Bulletin IBIPRESS, No. 140, 31 August 1987)

Standardization in CAD

Various European informatics equipment manufacturers have joined forces in order to define an overall standard in the field of computer aided design (CAD). These companies are Bull, CNET, ES2, ICL, JMEC, Nixdorf-Gadlab, Olivetti, Philips and NMP (association of Saab, Ericsson and Asea). The standardization will concern the form of storing background data - communicating between CAD applications which are processed simultaneously - and man-machine interface which will provide a greater guarantee to the users investments and enable them to choose from a wider range of equipment in their purchasing.

Similar needs have arisen in the United States, data transfer between different factories having computer-aided design and drafting system has fostered the definition and growing acceptance as a standard of the IGES data format, designed by a working group set up by General Electric and Boeing. ... (Bulletin IBIPRESS, No. 135, 6 July 1987)

The Unix standard takes hold

The modality promoted by ATT of the Unix operating system, known as System 5 (system being the commercial version) has incorporated the advantages of other Unix versions (Unix bsd, x Enix, etc.) making the Unix System 5 a probable future standard, the standardization body IEEE (Institute of Electrical and Electronic Engineers) which is developing a Unix standard called Posix is probably taking into account this fact. However, Unix - in all its versions - is taking firm hold: in certain well defined computer market sectors (supermicros, multiuser and minicomputers) Unix is the primary operating system and x-open, a group of computer manufacturers set up to support Unix, is gaining influence. On the basis of current trends, it can be estimated that 21 of the US$7,000 million software market will consist of Unix products. ...

The Unix system 5 was presented by ATT in 1983 and incorporated the most interesting improvements made by the Unix-bsd (Berkeley software distribution) family, which was created in 1975 at the University of California - Berkeley on the basis of a previous version of Unix (ATT's Unix System 3). In 1984, the Unix system 5 release 2 appeared which incorporated the improvements of a recent version of Unix bsd (the 4.2) and graphic functions. With last year's system 5 release 3.0 and this year's release 3.1, Unix can manage and exploit all the advantages of computer networks (sharing data, applications, and peripherals). ... (Bulletin IBIPRESS, No. 132, 14 June 1987)

IX. SOCIO-ECONOMIC IMPLICATIONS

The industrial Engineer's role in improving knowledge worker productivity *

In today's environment, the knowledge worker is increasingly becoming a main force in our economy. Blue collar workers in the United States are rapidly being replaced by automation and by lower paid workers offshore. As a result, our economy is becoming more service oriented with less emphasis on work being performed on the factory floor and more by knowledge workers.

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* By Melvin F. Harris and G. William Vining.

The industrial engineering profession has made significant contributions to American business, particularly in manufacturing. With the onset of the Information Age, and the changing shape and composition of the work-force, we must ask ouselves some fundamental questions.

What does this mean to rational work-force management? To productivity? What role can or should the profession play in this new era? Are these any proven evaluation techniques that can be applied to knowledge workers?

As we move into the Information Age, we must rethink how we apply our valuable industrial engineering resources in improving productivity to this ever-increasing sector of our workforce. We must ask ourselves if our abilities to measure output will necessarily improve productivity.

Our experience has not been good when we have applied some of the basic concepts that were successful in the factory to knowledge workers. Some of the roadblocks that deny us success are that we believe:

- "Someone in management can define the one best method and set a standard." Management requires that most knowledge workers determine "the best way" to do their jobs. We, as IEs, have not successfully defined the best way "to improve the productivity of knowledge workers," except for some clerical workers who have repetitive and simple tasks.

- "Department supervision has enough information and the ability to plan and schedule, in detail, worker activities." Knowledge workers must be given a high degree of control over their time within certain guidelines or milestones. Problem solving activity does not lend itself to overly short interval goals or standards because tasks, unlike factory activities, are not patterned or sequential by nature. Also, too much emphasis on control tends to stifle innovation.

- "Subdivision of labor produces efficiency because of specialization and because work can be measured." Engineering and marketing are less effective if they are subdivided. In fact, because of the long task completion cycles and activity complexity, it is sometimes desirable to integrate many of these functions rather than fragment or subdivide them.

- "Physical objects or outputs must be measured to improve productivity". Although this concept is effective in the factory, it is difficult to measure specific outputs for most knowledge workers. Attempts to define activities invariably result in omitting important job elements, unpredictable occurrences and constant changes in the measurement basis.

- "Activities have a logical and definable sequence". In the factory, the IE analyst can create a complete definition of each micro activity based on a high degree of physical effort and, to a lesser extent, mental cognition. However, it is almost impossible for an analyst to define everything a knowledge worker does because of the wide selection of alternatives with which he or she must deal.

- "Knowledge workers are indirect or overhead employees". One of the increasingly recognizable trends is that knowledge workers are becoming more involved in adding value to products or services because of their increasing involvement in the economy. We must recognize the shift from seeing them as "indirect" or "overhead" employees to a more direct co-relation to product cost and service delivery.

As competition intensifies, even in the face of the customer demands for a wider range of products and better quality, management must still cut costs and at the same time meet customer requirements. Unfortunately, if we as IEs do not have the necessary tools to use, then management must resort to undesirable actions such as "across the board cuts".

These types of cuts can sometimes cripple certain units of an organization and, more often than not, have an adverse effect on productivity, quality, customer service and employee morale.

Through trial and error, and sometimes through failure, we have learned that these past concepts do not serve the needs of the Information Age. But if they do not, how do we go about formulating a new beginning? A look at the past, interestingly enough, can be helpful.

As we examine our past, we see what happened in the early stages of the Industrial Age. First, the size and scope of factories brought new problems to owners. They could no longer control the work effort by visual inspection. As a result, the concepts of production were formulated and evolved into management principles for planning and control.

Secondly, the efforts of people were defined in ways that fit a physical production process. On the floor experimentation was used to improve production and management techniques.

Thirdly, because the process was to convert raw material into tangible products, valuation norms were based on physical counts. Methods of the Scientific Age were copied where situations were studied and tested against various hypotheses.

Trial and error experiments were accepted ways to progress. Basic principles then were developed and theories created which later served as guideposts all across industry.

As we examine the concepts developed by some of the pioneers of the IE profession such as Taylor, Gilbreth and Gantt, we have noted that the process is appropriate, but the context needs to change.

Today we see that success on the factory floor prompted some practioners to move these concepts to the office without a basic examination of the similarities and differences of production and knowledge workers. An in-depth analysis reveals that:

- Knowledge workers add value to products and services by thinking and making decisions as well as by doing.

- A service base economy deals as much with intangibles as with physical measurable things.

- Variety, complexity and the intermittent nature of many knowledge worker tasks defy the type of potential, sequential job designations used in the factory.

Supervisors of knowledge workers cannot tightly plan and control their work pace and priorities because the contexts of events are not sufficiently known.

The profession needs to develop a consensus of belief that a new era has arrived and new thinking must be applied. We need to take a basic look at what goes on in the office and define process models that fit.

We must develop some new basic principles, and use trial and error experiments to test validity. Also, we must recognize the social, cultural and economic differences between factory and knowledge workers.

Some of these realities are that knowledge workers are management, they are closer to customers and market forces than factory employees, and there are intrinsic qualities to many knowledge worker jobs which can promote job satisfaction.

Concepts must be formulated around the reality that continuing technological innovation, global competition and personal value systems are major factors to be accommodated.

Finding ways to create processes and job descriptions which are flexible, allow innovation and value the individual will challenge everyone's thinking. ... (Excerpts reprinted with permission from Industrial Engineering magazine, July 1987, pp. 28-32. Copyright Institute of Industrial Engineers, 25 Technology Park/Atlanta, Norcross, Georgia 30092, USA)

Studies underline hazards of computer terminals

A Swedish group has found more evidence that electromagnetic radiation from computer terminals can have harmful effects. The study, reported in the July/August issue of VDT News, a newsletter published in New York on video-display terminals (VDTs), is the second from Sweden to detect statistically significant effects on pregnant mice, although the experimental observations were not identical.

Last year, Berhard Tribukait's group at the Karolinska Institute in Stockholm reported a significant increase in malformed fetuses in mice exposed to pulsed magnetic fields like those produced by the transformers in VDTs. Gunnar Walinder's group at the Swedish University of Agricultural Sciences in Uppsala now reports significantly more fetal deaths in pregnant mice exposed to magnetic fields. Walinder's group also found increased - but not statistically significant - levels of fetal malformations.

The underlying reasons for the observations remain unclear. The two experiments differed in several details, including length of exposure and the strain of mice. Louis Slesin, editor and publisher of VDT News, says, "These two sets of data, taken together, add credibility to claims that VDT radiation presents a risk to pregnant women". Despite widespread use of VDTs in the US, the country supports virtually no research on possible health hazards. The Office of Naval Research sponsors experiments in several laboratories on chick eggs, and the National Institute of Occupational Safety and Health (NIOSH) is conducting an epidemological study.

Critics cite flaws in both - the naval study because of metabolic differences between chickens and humans, the NIOSH study because it may not measure exposure to VDT fields. Slesin says no other studies have been funded even though the general public appears more concerned than bureaucrats. (This first appeared in New Scientist, London, 13 August 1987, the weekly review of science and technology)

X. GOVERNMENT POLICIES

Communications and the international division of labour

At the start of a journey by air, every aircraft passenger must hand over his boarding pass showing his name, his destination and the point of origin and the number of his flight. In the case of American Airlines, these documents are sent later to Barbados, where local operators enter the information digitally on a magnetic medium and then transmit it via satellite to the company's central computer in the mid-western United States. The reason for this seemingly complex operation is trivial, namely its low cost. Allowing for the cost of transport, data transmission and salaries, the saving is approximately 50 per cent. This working method is becoming more widespread and it is estimated that it provides between 5,000 and 20,000 jobs for these so-called offshore workers. A number of companies have realized the business opportunity that this represents and there is now beginning to be a supply of services carried out outside the United States. There is obviously no reason why this phenomenon should not grow and spread to other countries.

The possibility thus created has serious implications for developed countries which are experiencing a reorientation of their economy from essentially manufacturing activity to services. Many of the jobs in the latter sector can be exported if greater transparency can be achieved in international communication media.

The functions associated with data processing are seen as one of the growth sectors of the services economy. The labour supply is such that a situation can be envisaged in which this growth will take place outside national frontiers. This fact may also have an impact on pay levels in these sectors, since in many cases labour is the principal cost component. This transfer of jobs is not confined to administrative or clerical services, however. Some design work in engineering, architecture, etc., is carried out in India, the Philippines and Brazil at one quarter of the cost of equivalent work in the United States. All this has been made possible by communications technology and computers. People in different continents can keep in continuous contact simply by pressing a few keys. This phenomenon may reach the proportions of an enormous business if account is taken, for example, of the fact that the entire system for booking hotel rooms and aircraft seats can operate outside the United States.

This situation obviously may have a number of positive aspects for the third world, but all sorts of questions will need to be answered. For example, given that in many cases the development of communications infrastructures is controlled by governments, what are the minimum conditions that must be created for this situation to constitute a new business opportunity? In what types of areas can services be offered?

Questions also arise for the organizations operating in different fields, and not only in relation to the United States. What, for example, are the skills which we may share with other third world countries? This is an issue of tremendous importance and one which we need to look at through new eyes.

Some third world countries have already taken initiatives in relation to the new employment opportunities which are developing. Thus, Jamaica has given one of its ministries the task of encouraging the recruitment of Jamaican personnel by United States corporations by offering, in addition to the benefits arising from low labour costs, tax incentives for companies set up in Jamaica for this purpose.

Even if there is no basis for speculation regarding the policy of the United States Government concerning the free transmission of data across frontiers, this new development will probably tend to be increasingly considered in any debate on this topic. Aspects which will need to be investigated are not only the advantages of possessing information on a particular country, but also the effects on employment of workers in the international communications system.

In dealing with the question of trans-border flow of data, it will be difficult to avoid considering also the phenomenon of the transfer of jobs. It is obvious that the possibilities now developing may expand considerably in the future, since there is steady growth in the production of complex equipment for the performance of sophisticated tasks, the results of which can be transmitted instantaneously to any corner of the globe. A case in point is the current growth of computer graphics. Striking and rapid developments are taking place in various fields such as film animation, architectural design, composition, diagramming, etc. Many kinds of tasks can be performed at a distance and, with technology facilitating human contacts, there will be greater possibilities of creating links between work communities situated at a great distance from one another.

Not only is work now being done at a distance, but distance itself is dissolving as communications break down borders and this raises questions concerning possibilities of integration in Latin America. The challenge for many third world communities will be how they can become integrated in the circuits where these new possibilities are developing, and how they can prepare themselves for this. We are now faced with the need really to understand the phenomenon underlying this development, namely human communications.

While remote performance of work operations is something that was predicted quite some time ago, only participation in it will enable us to understand it in all its complexity. What is involved here is not merely work which can be carried out outside the walls of an office, but the emergence of entirely new ways of co-ordinating efforts. Among other new factors which we do not yet fully perceive, there is the increasing capacity to maintain many dialogues with different interlocutors, an increase in the speed of dissemination of ideas, a need for a new form of work and for sophisticated co-ordination of efforts. The phenomenon of continuously expanding networks of work operations in constant communication with one another is something of which we are unaware but which is at our doors and it is a challenge we must not fail to take up. This is not simply another technology which we in the third world do not understand, it is a question of seizing an opportunity to participate in something which will happen in any event in some form or another. It is something that already has limitless prospects of expansion. (Boletin Interdoc CONTACT-0, ILET, Chile, May 1987)

Brazil's national informatics policy

Brazil's path towards establishing a national computer industry is radically at odds with the policy chosen by most other developing countries. The latter group - and particularly the booming economies of south east Asia - has generally opted for an export-oriented industrialization strategy, backed up by a programme of heavy foreign investment.

Under this strategy multinational corporations supply the capital, the technology and the expertise; the host country supplies a cheap and docile labour force, and a benevolent financial and regulatory climate, and the result should be a mutually beneficial exchange involving skills transfer, employment and a contribution to the foreign exchange reserves.

The Brazilian Government has rejected this path. Instead of encouraging foreign investment, it has actively sought to prevent it. The Brazilians have tried to establish a domestically-owned and controlled industry - and one which is based primarily on production for the domestic rather than the export market.

Such a strategy is only possible because of the size of that domestic market. Brazil is now the world's eighth largest capitalist economy; and while its use of computer equipment is still way behind that of most developed countries, it is huge by developing country standards. By 1981 Brazil was one of the 10 largest markets for computers - with a market some 10 per cent that of Japan. In the same year the country had 50 per cent of the installed base of computers in Latin America.

Estimates of the current value of the computer market vary widely, with many sources suggesting a figure of around $1 billion. Last year the Secretaria Especial de Informatica (SEI), the government agency responsible for overseeing the implementation of the national computer policy, estimated the market to be worth $2.3 billion, with an annual growth rate of around 15 per cent.

The decision to create a national computer industry owes its origins to the circumstances of the 1970s. Brazil was then in the throes of a period of massive, foreign-funded economic growth - often referred to as the Brazilian 'miracle'.

Several sectors of Brazilian industry - particularly the aircraft, automotive, steel and petrochemical industries - reached a stage of development that required the use of computerised manufacturing or processing techniques. In the years from 1973 to 1982 the number of installed computers in the country increased 15-fold. Domestic computer production, which had begun in a small way in the 1960s, could hardly keep pace with a boom such as this, and by the mid-1970s 80 per cent of equipment, and 60 per cent of components, were imported.

Development based purely on imported computer systems, or on a computer industry dominated by foreign owned multinationals, was economically and technically feasible. But for many Brazilians, of widely differing political views, it was politically unacceptable. For the armed forces, then in power, Brazilian control over technology was a military necessity. For their leftist and nationalist opponents, industrialization based on imported computers would ensure that Brazil remained in a permanent state of technological dependence and underdevelopment.

In the words of the preamble to the 1984 National Informatics Policy, '... allowing Brazil to become an importer of technology ... would be clear regression, a relative move back to a previous stage of our industrialization ... the country cannot dispense with acquiring capability in this area, under the penalty of worsening the present situation of external dependency'.

The result, in 1975, was a system of import controls which effectively excluded the multinationals from the Brazilian market for mini and microcomputers. Since then the protectionist measures have been extended and consolidated. The 1984 National Informatics Policy proclaims a reservado do mercado (protected market). A series of 'informatics laws' now bans foreign investment in hardware and software, and a package of 'favourable treatment' - including administrative, tax, social security and labour law provisions - is available to local companies under the country's Microcompany Statute.

Regulations prescribe federal agencies from contracting for services with foreign companies unless there is no Brazilian company trading in the market. Local companies are carefully defined as those incorporated, and with their head office, in Brazil, and with 70 per cent of the voting stock owned by persons resident in Brazil.

The strategy has clearly borne fruit. In the 10 years since its introduction the country has gained some 300 local manufacturers, who together sell products worth around $1.5 billion a year. And whereas 10 years ago the multinationals were in control of the entire computer market, today Brazilian-owned firms control around half of it. Figures produced by the Association of Brazilian Computer Manufacturers (Abicomp) suggest that, since about 1984, domestic-owned firms have been earning more from the Brazilian market than the foreign owned companies. Informatics is now one of the most profitable sectors of the economy.

Another gain for the national economy, and one which may in the long term prove more important, is the creation of a skilled work-force. According to the nationalists, the multinationals have been interested in transferring skills, but only at the rather limited levels required for operations in the host country. Thus, they have trained technicians, and sales staff; but are less interested in training technologists.

In the words of one computer engineer, 'they sell the miracle but not the saint'. Managerial skills have been subject to the same kind of uneven development. A common complaint of those Brazilian firms which have recruited staff from the multinationals is that they don't have the ability to take strategic management decisions.

The country now has around 6,000 computer engineers - and the local computer industry has increased its employment of graduates by almost 300 per cent in the past eight years. The local companies also employ many more staff in an R&D role - around seven times as many as the foreign subsidiaries.

The local industry now constitutes a powerful addition to the protectionists lobby; together with Abes, the software producers' association, Assespro, the computer professionals' organization, and the avowedly nationalist Movimento Brasil Informatica (MBI), Abicomp is now pressing for an extension of the protectionist regime.

One thing it has already achieved is a revision of the software regulations adopted last September, which extend the protection of author's copyright to software. The nationalists regard this as a retreat from the principle of the protected market. ...

One MBI member, told <u>Latin America Weekly Report</u> that '... there were internal and external pressures and we must now mobilise forces within the country to fight against this retreat'. MBI activists argue that treating software as authors' property, rather than as industrial property, makes it easy to trade and difficult to subject to customs control. Moreover, since payment is arranged between 'author' and publisher, restrictions on the transfer of profits abroad will also be very difficult. ...

There is a bronze plaque on the wall in Brazil's Ministry of Science and Technology. It reads: 'President Sarney will not, for any reason, change the protected market for computers. This policy was voted by Congress, is in line with national interests, and will not be modified or attenuated'. ... (Excerpted from <u>Computing</u>, pp. 22-23, 9 July 1987)

XI. RECENT PUBLICATIONS

<u>UNIDO Publications:</u>

IPCT.29 (SPEC)	The UNIDO programme of technological advances; Microelectronics (a revision of UNIDO/IS.445/Rev.2), prepared by the Secretariat
IPCT.30 (SPEC)	Computers in the meat processing industry: a case study of application and implementaton experience in a developing country, by A.A. Pardo
IPCT.31	Technology Trends Series No. 4: The international telecommunications industry: the impact of microelectronics technology and the implications for developing countries, by M. Hobday
IPCT.33	Technology Trends Series No. 5: Global trends in microelectronics components and computers, by K. Guy and E. Arnold
IPCT.39 (SPEC)	The UNIDO programme on technological advances (a revision of UNIDO/IS.411/Rev.2), prepared by the secretariat.
IPCT.41 (SPEC)	Expert systems: prospects for developing countries, by Anil K. Jain
IPCT... (SPEC)	Special consideration for the establishment of silicon foundries and design centres, by O. Manck

<u>Economic Commission for Europe:</u>

ECE/ENG.AUT/29	Software for industrial automation
Sales No.: E.87.II.E.19	The aim of the study is to highlight the increasing importance of software for industrial automation. It reviews recent development in automation of discrete manufacturing processes, in particular in engineering industries, and the key role played by software in several technological applications

<u>International Labour Office:</u>

SAP 6.1/WP.9	Social and labour effects of computer-aided-design/computer-aided manufacturing (CAD/CAM), by Karl-H. Ebel and Erhard Ulrich.

This report contains observations, based on case studies and comparative research, on the impact of CAD/CAM on employment, work organization, working conditions, job content, training, and industrial relations in various countries. It concentrates on changes in design and technical offices and their links with production. So far, there is little evidence of a negative effect on employment levels. The increase in productivity is balanced by various compensatory effects. Computer and mathematical skills are in growing demand in design offices. In general, CAD appears to strengthen group work. Intensity of CAD work leads to stress. Linking of CAD and CAM continues to be steeped in managerial, organizational and technical difficulties and makes slow progress. CAD has led to shift work and flexible working hours in design offices. despite a certain resistance of the staff and unions. Older staff find it hard to adapt. Until now, training in CAD has been far too unsystematic and appropriate curricula need to be developed. As a next step computer-integrated manufacturing (CIM) will become fully operational before the year 2000. However, its smooth introduction and development requires an adequate preparation of the work-force.

Role of computer technology in developing countries

The International Journal "Information Technology for Development" published by the UK Council for Computing Development, on which we reported in earlier issues, carries in its March 1987 issue an article on the above topic. The author is Gopal K. Gupta, Department of Computer Science, James Cook University, Townsville, Queensland 4811, Australia. It looks at the question of whether computer technology is an appropriate technology for the developing countries and comes to the conclusion that developing countries cannot afford to ignore it and that there are many appropriate uses that will result in advantages such as more efficient use of scarce resources; increased productivity; and improved quality of decisions made by governments and business. It also argues that the use of computers in small organizations is likely to have more impact on developing countries. The author groups developing countries into six major groups according to income, GNP growth rate, type of economy and manpower. The report comes to the conclusion that development of an indigeneous computing industry is likely to need substantial support from the governments in the forms of financial support, infrastructure including educational and R&D facilities and tax incentives to local computing industry. Information Technology for Development is published quarterly, at an annual subscription of £40 in the UK, $100 in North America and £50 elsewhere. It can be ordered from Oxford University Press, Walton Street, Oxford OX2 6DP, UK.

Report on expert systems in the UK

A leading artificial intelligence consultant has slammed UK managers for their business secrecy and lack of commitment to expert sytems which is threatening Britain's competitiveness in the field.

Alex d'Agapayeff, founder of Expertech and chairman of the British Computer Society (BCS) expert systems group, was speaking at the launch of his latest report, Expert Systems in UK Business.

'If an application is really successful then it will be really secret', he said. 'Nobody has ever heard of the more sophisticated systems. This is extraordinarily bad, both for the company concerned and for Britain'.

D'Agapayeff also cited the mistaken management belief that expert sytems were prohibitively expensive, as an obstacle to their take-up by British business.

The report, commissioned by the Alvey directorate, set out to update a similar survey conducted by D'Agapayeff in 1984.

D'Agapayeff spoke to 15 leading British companies during the survey and concedes that his report is largely impressionistic because of the shortage of hard data. He does not believe that Japanese and American competitors have got any further than the UK in developing practical applications. But the difference was that they knew that expert systems did concern senior management. An exception in the UK is building societies because of deregulation. D'Agapayeff said that awareness fell away sharply after the first 500 of the Times top 1,000 companies.

However, Brian Oakley, director of the Alvey programme, claimed that the level of awareness had increased sharply, due to the BCS specialist group and the expert systems awareness clubs established by Alvey. (Computing, 16 July 1987)

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