PROCEEDINGS OF THE IEEE THROUGH 100 YEARS: 1980–1989

I. INTRODUCTION AND OVERVIEW

In many ways the PROCEEDINGS OF THE IEEE in the 1980s (Fig. 1) continued along the path established in the 1970s, having ceded the publication of leading-edge technical articles to the many specialized IEEE TRANSACTIONS. As editor Harlow Freitag described the PROCEEDINGS in 1980:

> "It attempts to bring to its subscribers a balanced program of papers of wide interest, with an emphasis on tutorial and review papers on topics of current importance in all fields of relevance to the Institute. We try therefore to publish papers that appeal broadly to every technical segment of the profession and hence to the entire membership of the IEEE. It is usually quite clear what papers are better suited for the TRANSACTIONS than for the PROCEEDINGS. By the same token, we are conscious of our responsibility to locate the best and latest work being carried out in particular fields and to cover this work in a way suitable to the PROCEEDINGS readership. We believe that this allows our readers to remain current about those topics which, while outside the course of their specialties, may very well be useful in the course of their work" [1].

Fig. 1. *NASA's space shuttle fleet began setting records with its first launch on April 12, 1981 and it is perhaps somewhat emblematic of the technology evolution of that era, among the other areas, described below. This journal published several articles on space technology during the decade, including an article in March 1987 entitled: "The new AP101S general purpose computer for the space shuttle." The final space shuttle mission, STS-135, ended July 21, 2011 when Atlantis rolled to a stop at its home port, NASA's Kennedy Space Center in Florida, paving the way for commercial space projects.*

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As in the 1970s, a large percentage of these articles appeared in up to six special issues per year. In addition, the remaining issues were increasingly dominated by special sections on specific topics that differed from special issues chiefly in that there was still room in the issue for one or two other articles. Hence, the number of standalone articles, whether invited or submitted, declined. By 1989, every one of the monthly issues was either a special issue or contained a special section. In a related change, the PROCEEDINGS' editors decided in 1987 to discontinue the "Proceedings Letters" section, which contained timely publication of brief reports of important new research, because for the most part these letters reported on work too narrowly focused to be of interest to the broad readership [2].

For the IEEE, the 1980s was a decade of both growth and celebration. Membership grew from 213 812 to 312 691. In 1984, the IEEE commemorated its centennial, or more strictly the centennial of IEEE's older predecessor institute, the American Institute of Electrical Engineers (Fig. 2). As part of the planning that began long before the centennial year, the IEEE established its History Center in 1980 with Dr. Robert Friedel as the first director. The IEEE has maintained a professionally staffed history center ever since. The current staff of the history center is the author of this series of articles. For the centennial the History Center produced an exhibit, "A Century of Electrical Progress," both in a conventional format with artifacts, and as a widely distributed poster exhibit. The IEEE published two centennial histories, one popular [3], and the other scholarly [4], and held a series of major events, including a Centennial Convocation in Boston, MA, in May, and a Centennial Technical Convocation in Philadelphia, PA, in October. The PROCEEDINGS contributed by reprinting in its pages a series of classic technical papers from the PROCEEDINGS OF THE IRE and the TRANSACTIONS OF THE AIEE, each accompanied by an introduction from noted historian of technology (and future IEEE Fellow) James Brittain. Friedel also organized an IEEE centennial session on the history of electronic scientific instrumentation at the 1984 American Association for the Advancement of Science meeting, the papers from which were published as a special section in the PROCEEDINGS in July 1985. This was no doubt the only time the PROCEEDINGS has published a group of invited papers by historians, rather than technical professionals.

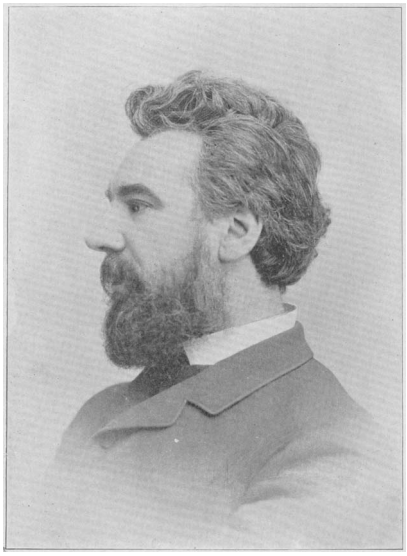

Fig. 2. *Alexander Graham Bell, AIEE co-founder (from the TRANSACTIONS OF THE AIEE, vol. 10, 1893).*

A range of electronic technologies reached fruition in the 1980s, including personal computers, laser applications, a variety of medical diagnostic tools, and any number of products made possible by ever cheaper and more powerful microchips. Many of the innovations were reflected in the pages of the PROCEEDINGS. In the United States, the largest communications company, the AT&T national telephone monopoly, was broken up into eight companies on January 1, 1984 in settlement of an antitrust suit brought by the government. The PROCEEDINGS responded with a special section in September 1986 on "Communications: The next ten years." It included a paper on the "Political economy of telecommunications" by John Haring of the U.S. Federal Communications on the changing regulatory environment in the United States [5] as well as three more papers on the changes taking place and expected to take place over the next decade, such as the ongoing transition from voice transmission to data transmission and changes in network architecture and in other key communications technologies and services. Interestingly none of the authors predicted the importance that personal computers would have in data communications—rather the article dealing with the future of telecommunications services and use suggested that people would have computer terminals in their homes to communicate with mainframe computers [6].

While the PROCEEDINGS in the 1980s published issues on a wide range of topics from nuclear fusion to biomedical engineering, ultrahigh-frequency (UHF) television, superconductivity, and space, the single most striking observation that one can make from the list of special issue and section topics is the central role that computing in all its guises came to play in the PROCEEDINGS' areas of interests. Between articles on computing itself, and articles on the application of computing to a whole host of areas, fully 26 of the 76 special issues and sections were devoted to computing. There were multiple issues devoted to computer hardware and software, a few on interdisciplinary topics, and a larger number on computer applications.

In addition, another eight issues and sections dealt with the related topic of microelectronics, specifically very large-scale integration (VLSI), the incorporation of tens of thousands to several millions of individual components on a single microchip, both in terms of technology and design. The challenges and the possibilities expanded as the number of components possible on a single chip continued to grow. Intel's 8088 microprocessor, introduced in 1979, contained 29 000 transistors; Intel's

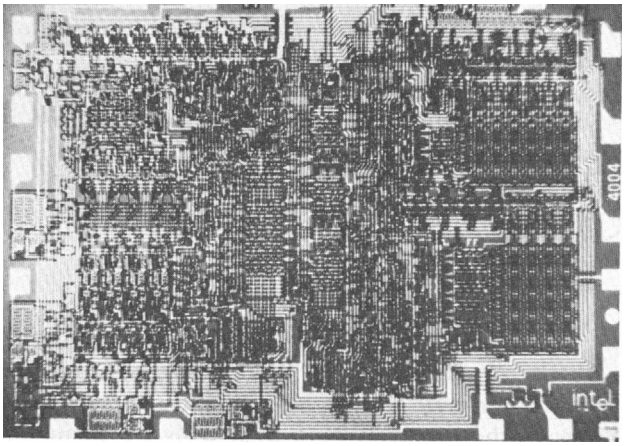

Fig. 3. *The Intel 4004 microprocessor (from [3]).*

80486 microprocessor chip, introduced a decade later, had 1 200 000 transistors (Fig. 3) [7].

Robert Noyce (Fig. 4), coinventor of the integrated circuit and cofounder of Intel, noted the interdependence of chips and computers in 1976:

> "The development of semiconductor devices has depended upon a synergism with computers. This is particularly true for integrated circuits, whose development was motivated by the computer applications. With each advance in components, the computers resulting from their use reached a wider market, motivating further advances in the semiconductor technology" [8].

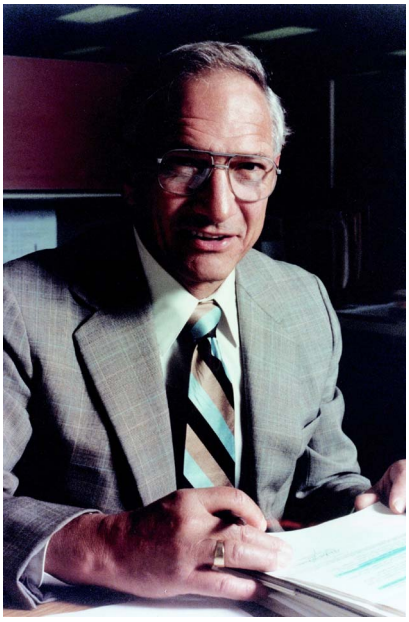

Fig. 4. *Robert Noyce.*

It is to these areas that we will turn in the remainder of this article.

II. VERY LARGE-SCALE INTEGRATION

The December 1982 Special Issue on Very Fast Solid-State Technology was the first of eight issues or sections on microchips. Guest editor Richard Eden had recently left Rockwell International to become a founder and vice president of an entrepreneurial startup, GigBit Logic Inc. In his introduction to the issue, Eden noted the increasing centrality of digital technology and integrated circuits to a broad range of IEEE technologies:

> "Throughout the past decade, digital technology has played an increasingly pervasive role in the electronics, communications, and data processing industries, and this trend is certainly expected to increase through the 80's. As a consequence professionals in many areas of electronics who are not themselves experts in solid-state devices or integrated circuits, must anticipate having to make future technical, management, or business decisions on the basis of their grasp of where this technology is leading" [9].

Eden went on to note that the purpose of his issue was to accomplish a grasp of where one area of digital technology was leading: very fast chips, and their applications. While several other areas were covered, three of the papers dealt with the promise of gallium arsenide as the material for such chips. Eden himself contributed one article himself on the advantages of gallium arsenide to silicon in such chips [10]. A team of authors, led by Long contributed a second paper broadly exploring GaAs for high-speed circuits [11], and a team led by Greiling wrote on using Electron Beam fabrication techniques to fabricate such chips [12]. Work on GaAs VLSI continued through the decade, leading to a PROCEEDINGS special section in July 1988, where guest editor Sven A. Roosild noted that "digital GaAS ICs are beginning to rise above the taunt of being the technology of the future," while remaining a niche technology [13]. Eden contributed a paper to this issue as well, tracing the development and introduction GaAs integrated circuits from the first LSI circuits in the 1970s through then-current VLSI chips [14]. Three additional papers covered the state of GaAs chips in the late 1980s.

Other special issues and sections covered broader areas of VLSI, where silicon remained, as it is today, the predominant material for chips. January 1983 brought an issue with 14 papers on various aspects of VLSI design, several of which stressed the overwhelming reliance on computer-aided design (CAD) for this purpose, and offered specific CAD strategies or tools. September 1985 brought a section on advanced packaging for VLSI, May 1986 an issue on fault tolerance in VLSI, and June 1987 a section on application-specific integrated circuits, which in that year had a 20% market share, the remainder being general purpose integrated circuits. December

1986 brought a special issue looking forward to integrated circuit technologies of the future. Finally, the September 1989 issue turned from the technical to organizational, with a set of articles on cooperative semiconductor research, with articles on cooperative ventures both government supported and private in the United States, Japan, and Europe.

III. COMPUTER HARDWARE AND SOFTWARE

In keeping with the mission of the PROCEEDINGS, the issues and sections devoted to computing hardware and software focused on areas and approaches of interest to a broader audience than just computer researchers.

In March 1984, the PROCEEDINGS published a special issue on personal computers (PCs), which had over the previous few years found their way on to many an engineer's desk and to a lesser extent into their homes, and beyond that into business and education. In under a decade, personal computers had evolved from the Altair 8800 hobbyist kits of 1975 to useful machines with computing power equaling 1960s mainframes. The issue's guest editors, Amar Gupta and Hoo-Min D. Toong, both from the Massachusetts Institute of Technology (MIT, Cambridge), contributed the issue's first and last articles. The former was a broad overview of the first decade of the PC in which they noted its amazing pace of growth, by two orders of magnitude over the previous six years. The authors then went on to discuss each of the subsystems that went into a PC—the central processing unit, the memory subsystems, and the input–output subsystems, and then each of the software components—the operating system, programming languages and their development tools, and application packages [15]. Their concluding article looked forward toward new directions in PC software, predicting future applications in a variety of areas: office productivity, graphics, presentations, other applications, and trend analysis [16]. Much of what they predicted came to pass over the next few years.

But the heart of the issue was a series of ten articles, nine of which were submitted by companies in the PC business. The tenth was from Intel, then as now a leading manufacturer of microprocessors. Most of these invited articles were overviews of the individual company's PC offerings, and more than anything else sought to convince PROCEEDINGS' readers of the superiority of those offerings for one or more uses. Tellingly, in many cases, senior management of the companies were among the listed coauthors. Thus, William Hewlett (Fig. 5) was the second author of Hewlett-Packard's contribution [17], Ken Olson (Fig. 6) the first author of the Digital Equipment paper [18], and Frederick A. Wang of Wang Laboratories' paper [19]. Robert Noyce coauthored Intel's article on its 088/086 family of personal computer microprocessors [20].

Interestingly, two prominent companies took a different approach with their contributions, and rather than survey their product lines, presented papers on specific new models, in both cases ultimately commercially unsuccessful ones. Thus, IBM's contribution was on its low-priced consumer oriented PC Jr. (with its eventually infamous "Chiclet" keyboard) rather than on its market leading PCs [21], and Apple's on its innovative Lisa, which was equipped with two then-novel features, a mouse and a graphical interface, rather than on its Apple II (Fig. 7) [22].

Fig. 5. *William Hewlett (IEEE History Center).*

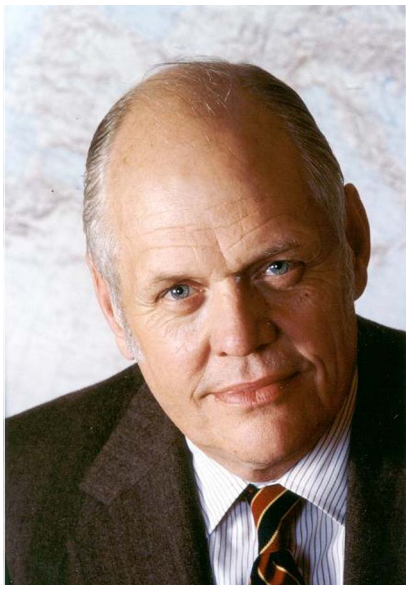

Fig. 6. *Ken Olson (IEEE History Center).*

The PROCEEDINGS followed this issue with a special section in December 1985 focused on the novel but growing use of PCs by engineers with a special section on PC software for professional engineering applications.

In addition to these two issues on the PC, the PROCEEDINGS published a special issue in December 1989 at the opposite end of the computing hardware scale—supercomputers, and a special issue in July 1984 and a special section in October 1989 on optical computing, a technology whose promise has still not been realized a quarter century later.

There were two special issues on artificial intelligence, a far more theoretical computer science area. The first, in July 1986, was a special issue on natural language processing, in which guest editor Giacomo Ferrari focused

Fig. 7. *Apple II.*

on the aspect of "the computational modeling of the human process of understanding natural language." He noted that natural language processing was an important subfield of artificial intelligence [23, p. 889]. The papers included were theoretical studies, in a range of subfields, from linguistics to man–machine interactions that their authors hoped could lead to practical applications. A second subfield of artificial intelligence, knowledge representation, was the subject of a special issue the following October.

A September 1989 section on software maintenance sought in its three papers to increase the PROCEEDINGS readers' understanding of the problems and challenges in this area, while explaining the crucial role that such maintenance played in the reliability of systems in crucial areas including, among others, air traffic control, defense, nuclear power plants, and banking. Such is the extent to which computer applications had spread throughout the global economy.

A special section in June 1986 contained three papers on the convergence of software and hardware engineering development, though one of the papers, on technology transfer between VLSI design and software engineering, noted that it was still a meager trend due to the traditional isolation of the two subcultures [24].

IV. COMPUTER APPLICATIONS

For many engineers, the use of computers had by the 1980s become essential for their work. Power engineers, for example, increasingly relied on computers for the operation of their systems; the PROCEEDINGS devoted a special issue in December 1987 to this topic, showing how these uses had increased and evolved since the last special issue devoted to the topic had appeared in 1974. Computers now formed the backbone of control centers for bulk power systems (or energy management systems) [25].

As noted above in the section on VLSI, computer chips had become so complex that there was really no alternative to CAD. But CAD had spread far beyond chip design. An October 1981 special issue on CAD indeed contained six papers on the state of the art in VLSI chip design, and a seventh on the broader but related question of the design of digital systems. But the issue also demonstrated the breadth to which CAD had been put with papers by Talukdar and Wu on computer-aided dispatching for electric power systems [26], Westerburg on the use of CAD in chemical engineering [27], and Fenves on CAD in civil engineering [28]. The issue also included a paper by Eastman on the development of integrated databases of CAD information to support a broad range of applications [29].

The December 1984 PROCEEDINGS special section had nine papers to one area of CAD: the CAD of control systems. This was yet another indication of how CAD was spreading into additional areas of the profession. The genesis for this issue came from the IEEE Control Systems Society. This was a new area for control systems engineers; the IEEE CONTROL SYSTEMS MAGAZINE had published its first series of articles on the subject only in 1981, and the society held its first symposium on the subject in 1983 [30].

Theory and application could not always be divorced. A May 1981 special issue on image processing contained both types of papers, as did a March 1983 issue on computerized tomography. The first half of the latter issue had seven papers on medical applications, discussing how computers were used to interpret X-ray, ultrasound, and nuclear magnetic resonance (NMR) images. The second half of the issue stepped back from these applications with six papers on the theoretical foundations of the field [31]. The use of computers in medicine went far beyond tomography; a special section in June 1988 on medical computing and a special issue in September 1988 on emerging electromedical systems together provided evidence of the many ways in which computing and electronics were changing medical practice. The first issue focused on medical computer simulations and modeling; the latter covered several areas where technology, not just computers, had been effectively incorporated into medicine with groups of papers on medical imaging using computers, applied neural control, and interventional and implantable systems.

Finally, there were two issues on supercomputer applications. The first issue, in January 1984, dealt with the spread of supercomputer use from government and military applications to large commercial applications,

including aircraft wing design and oil exploration and production, and scientific research [32]. A special section in July 1989, on large-scale problems in supercomputing, contained an overview followed by three papers dealing with the use of supercomputers to attack large-scale problems in advanced energy system design, aerospace, molecular biology, and models of the oceans, atmosphere, and the solid earth from spaceborne observations. For the most part, these were areas that had long been the province of supercomputers. There were still problems where the ultimate in available computing power was required to achieve solutions in a timely way [33]. ■

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APPENDIX
SPECIAL ISSUES AND SECTIONS IN THE PROCEEDINGS OF THE IEEE DURING THE 1980s (ENTRIES ARE SPECIAL ISSUES EXCEPT WHERE SECTION IS NOTED)

1980

January	Biological Effects and Medical Applications of Electromagnetic Energy.
July	Digital Encoding of Graphics.
September	Software Engineering.
October	Optical Fiber Communications.
December	Efficient Use of the Spectrum.

1981

January	Special Section on Acousto-Optic Signal Processing.
February	Fundamental Limits in Electrical Engineering.
May	Image Processing.
August	Magnetic Fusion Development (i.e., Nuclear Fusion).
October	Computer-Aided Design.

1982

January	Very Fast Solid-State Technology.
June	Laser Applications.
September	Spectral Estimation.
November	UHF Television.

1983

January	VLSI Design: Problems and Tools.
March	Computerized Tomography.
April	Special Section on Office Automation.
May	Micron and Submicron Circuit Engineering.
July	Robotics and the Factory of the Future.
August	Special Section on Switched-Capacitor Circuits.
September	Special Section on Advanced Concepts of Energy Storage Systems.
October	Global Navigation Systems.
December	Open Systems Interconnection (OSI)—New International Standards Architecture and Protocols for Distributed Information Systems.

1984

January	Supercomputers—Their Impact on Science and Technology.
March	Personal Computers.
July	Optical Computing.
October	Seismic Signal Processing.
November	Satellite Communication Networks.
December	Special Section on Computer-Aided Design of Control Systems: Systems and Algorithms.

1985

January	Special Section on Near-Millimeter Waves.
February	Radar.
April	Visual Communications Systems.
June	Perceiving Earth's Resources from Space.
July	Special Section on Electronic Instrumentation for the Science: Historical Perspectives.
September	Special Section on Advanced Packaging for VLSI.
October	Special Section on Demand-Side Management for Electric Utilities.
November	Man–Machine Speech Communication.
December	Special Section on Personal Computer Software for Professional Engineering Applications.

1986

January	Radio Measurement Methods and Standards.
February	Special Section on Geotomography.
March	Seismic Inversion.
May	Fault Tolerance in VLSI.
June	Special Section on the Convergence of Hardware Engineering Development Methodologies.
July	Natural Language Processing.
September	Special Section on Telecommunications: The Next Ten Years.
October	Knowledge Representation.
November	Special Section on Magnetic Information Storage Technology.
December	Integrated Circuit Technologies of the Future.

1987

January	Packet Radio Networks.
March	Progress in Space—From Shuttle to Station.
May	Distributed Database Systems.
June	Special Section on Application-Specific Integrated Circuits.
August	Chaotic Systems.
September	Hardware and Software for Digital Signal Processing.

November	Special Section on Integrated Optics and Optoelectronics.
December	Computers in Power System Operations.
1988	
February	Special Section on Microwave Magnetics.
April	Power Electronics.
May	Special Section on Cryptology.
June	Special Section on Medical Computing.
July	Special Section on Gallium Arsenide VLSI.
August	Computer Vision.
September	Emerging Electromedical Systems.
November	Special Section on Space Radiation Effects on Microelectronics.
1989	
January	Dynamics of Discrete Event Systems.
February	Special Section on Electromagnetic Prospecting for Oil and Gas.
March	Special Section on LIDAR Applications.
April	Special Section on Software Maintenance.
May	Radar Cross Sections of Complex Objects.
June	Special Section on Electric Utility Systems Planning Issues and Methods.
July	Special Section on Large-Scale Problems and Supercomputing.
August	Superconductivity.
September	Cooperative Semiconductor Research.
October	Special Section on Optical Computing.
November	Air Traffic Control.
December	Supercomputer Technology.

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