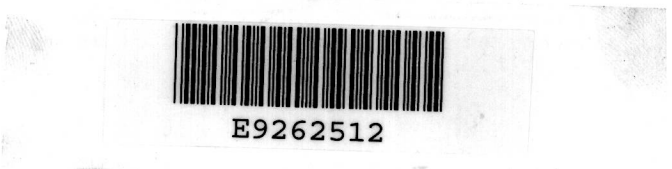
ENTREPRENEURS IN HIGH TECHNOLOGY

Lessons from MIT and Beyond

EDWARD B. ROBERTS



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Entrepreneurs in High Technology

TO MY PARTNERS

In Entrepreneurship

Alexander Pugh and Henry Weil
Neil Pappalardo, Morton Ruderman,
Jerome Grossman, and Curtis Marble
Paul Kelley, Gordon Baty, Joseph Lombard,
and Jerome Goldstein

In Life

Nancy Roberts

PREFACE

When I was a child growing up in a suburb of Boston, my parents often took me to the outdoor concerts of the Boston Symphony Orchestra at the Esplanade along the Boston shores of the Charles River. Looking across the Charles toward Cambridge in the evenings I was repeatedly awed by the looming majesty of M.I.T.'s bulk and, alongside it, the bright blue flashing roof-sign and logo of Electronics Corporation of America, an early high-technology firm located a few doors down Memorial Drive from what is now the MIT Sloan School of Management. My first strongly formed images of MIT were thus intimately interwoven with a fascination for technological entrepreneurship. Little did I realize then that my life's work would be at that interface of MIT and entrepreneurship.

This, then, is a book about entrepreneurs. But it is mostly about a very special group of entrepreneurs who were nurtured at or nearby MIT in the post-World War II explosion of science and technology and its applications to industrial and societal advance. Trained in high-technology in MIT's labs and academic departments or in the local industrial marvel that became known as the "Route 128 phenomenon", these entrepreneurs took their technical and innate skills with them to found their own new companies. The book explains the origins of these people and of the companies they founded and grew. It focuses on people, technology, money, and markets and their interplay in the formation, development and success or failure of hundreds of high-technology companies in the Greater Boston area.

The formal studies that led to this book began in 1964 and continue to the present. But three years earlier, out of a gnawing curiosity while I was still an economics doctoral student at MIT, I had cross-registered at the Harvard Business School to enroll in their New Enterprises subject, the only related subject then available in the Greater Boston area. And in 1963, just one year before this research began, I recruited my close MIT System Dynamics colleague, Jack Pugh, to join me in forming Pugh-Roberts Associates, my first act of business entrepreneurship. Over a quarter-century has passed since these beginnings and they have been exciting and fulfilling years, made whole especially by the combination of new enterprises research and action that have paralleled and become integral with my family life.

This book fuses my work with many close working colleagues, including research associates, graduate research assistants, and many thesis students. But it also draws from the unique environment of MIT and Greater Boston, and the generous willingness of the entrepreneurial community to share their experiences, their pains and their successes. The research could not have been carried out in a less thriving, less self-assured, less open

community. My hope is that the insights provided from the findings presented in this book somehow contribute to fulfilling other entrepreneurs' dreams and other communities' hopes.

Cambridge, Massachusetts E. B. R.
April 1991

ACKNOWLEDGMENTS

Many people enabled the underlying research embodied in this book to be accomplished and the book itself to be written. Most significant at the outset was my close research colleague of many years Herbert Wainer. Herb was my first graduate research assistant on the project and then stayed with me as a research associate for several critical years while much data gathering and analysis was undertaken and many of the needed additional phases of research conceived. Nearly forty other graduate students contributed importantly to the multi-phase research program, all identified in the book's Appendix in regard to their individual areas of effort. During the early years I benefited from the encouragement and research insights of the late Donald Marquis, founder of the MIT Program on the Management of Research and Development, who inspired a focus on ambitious technology-related studies and careful measurement of results. And Jay Forrester, who attracted me from Electrical Engineering to a career in the MIT Sloan School of Management, constantly inspired entrepreneurial thoughts and acts by his own pioneering examples and insights.

As the research work emerged into written form I gained enormously from thoughtful comments from many colleagues. Of special note, F. Michael Scherer, Ian MacMillan and Andrew Van de Ven produced detailed assessments of all aspects of the book which I deeply appreciate. Ralph Katz, Marc Meyer and Steven Ruma also provided significant help. Karl Vesper, Jeffry Timmons, Rosabeth Moss Kantor and David Morgenthaler gave important encouragement and commentary on the work. Of course, my editor Herbert J. Addison supplied insightful guidance and the persuasiveness for me to make substantial changes, as well as unfailing support throughout the publication process.

My wife Nancy tried for years to get me to turn those piles of notes and drafts into a book, perhaps just to clean up the mess. But then she read and marked up all parts of the manuscripts and helped assure me that the effort was credible. Nancy was also involved in at least the background of all of my personal entrepreneurial ventures so she became a second source of memory for many details and perspectives. She shares more than anyone else in the overall credits.

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Entrepreneurs in High Technology

CHAPTER 1

High-Technology Entrepreneurs

An upper floor in an old factory building or a converted warehouse somewhere in Cambridge, Massachusetts, housing a new technical company founded by several people associated with the Massachusetts Institute of Technology (MIT) and driven by the spirit of entrepreneurship—this describes the beginnings of numerous high-technology enterprises in the Boston area. Most of this book focuses on lessons learned broadly from investigating several hundreds of these firms. But aggregate statistics on the formation of spin-off companies from a great research university or even extensive details on the personal backgrounds of their founders do not provide a sufficient picture of the formation and growth of a new technological enterprise. A technical idea and a set of circumstances are not enough. The formation and the survival of an organization depend on unique people who take the risks of leaving their established organizations to start and build a new firm. This chapter presents a brief backdrop of early entrepreneurship at MIT, followed by four in-depth histories of an entrepreneurial founder and his technical company. In each case I have combined objective research with personal involvements as co-founder, director, or consultant. Each company is substantially different from the others. Together, they reflect the diversity that is high-technology entrepreneurship. The main themes of the book follow these cases along with a preview of the chapters.

Founders and Firms

In the Beginning

The first modern technology-based companies in the Boston area seem inevitably linked to MIT. A number of unique faculty, who sensed needs or opportunities, or both, to transfer their technological skills and know-how to the marketplace, became the early technological entrepreneurs of Greater Boston. EG&G, Inc., for example, is a case of a "pure" and early MIT spin-off, with all three founding partners associated with the Institute as staff or faculty both before and after the start-up of their company. Faced with a

dearth of job opportunities when he graduated from MIT, in 1931, in the midst of the depression, Kenneth J. Germeshausen accepted the offer of his professor, Harold E. "Doc" Edgerton, to form a consulting partnership. In his doctoral dissertation Edgerton had pioneered the development of stroboscopic photography. He and Germeshausen began their firm with the application of "strobe" analysis to industrial problems and progressed to the development of related inventions that they then licensed to other companies for their commercial exploitation. Two years later, Herbert Grier, a 1933 MIT graduate in electrical engineering, joined the partnership, continuing work on high-speed motion picture techniques and the related flash lamps and cameras.

The partnership's work was carried out in space furnished by MIT, with the company supporting the lab, buying the supplies, paying technicians and all other out-of-pocket costs. In return the company was expected to be on call to help any other part of MIT that had problems in its field. Today, this arrangement would certainly be regarded as irregular, but this is evidence of the long tradition at MIT of encouraging entrepreneurial activities, even nurturing them physically under its own roof. Partnership activities were interrupted by the advent of World War II when Germeshausen was asked to join the MIT Radiation Laboratory, the center of U.S. radar development efforts, and Grier and Edgerton joined other MIT laboratories engaged in wartime research. In 1945, Germes, as his friends called him, began work on a secret contract with a large government agency through MIT and found himself spending almost full time on it. Since MIT did not want to be so heavily involved in classified work, the partnership was revived to take on this contract work. This government project, which became the detonation device and broader instrumentation support for the entire U.S. nuclear bomb program, led the original three partners to decide to start Edgerton, Germeshausen and Grier, Inc. (later changing its imposing name to EG&G, Inc.), formally incorporated in 1947 with the three partners investing $5,000 each with equal ownership.

Nearly 35 years have past. Typical of most of the faculty-initiated enterprises, Edgerton remained at MIT and gradually phased out of active involvement in EG&G. Under Germeshausen's long leadership the company grew dramatically, heavily from its early and enduring work for the U.S. Atomic Energy Commission (which became part of ERDA and is now in the Department of Energy). Gradually, Bernard O'Keefe, who joined the company shortly after the war, assumed increasing responsibilities and eventually took over as president and chief executive. Barney built EG&G much further, largely on the basis of effective technology-based acquisitions. By 1990, with none of its founders still active, the company's sales have grown to over $1.5 billion, including many acquisitions that now account for half the annual growth.

The EG&G story is paralleled by many other academic spin-offs from MIT. Pre-World War II activities of Vannevar Bush, professor of electrical

engineering and later vice president of MIT, include co-founding what became an initiating part of the Raytheon Corporation. Right after the war the entrepreneurial trend accelerated. In 1946, John G. Trump founded High Voltage Engineering Corporation to build and apply atomic particle accelerators and electrostatic generators developed by his MIT colleague and co-founder, Robert J. Van de Graaff. Denis M. Robinson, recruited to head the start-up, recalls: "I was very doubtful whether this was something too 'chancy' for somebody nearly 40, who really had only one more throw of the dice. He (Trump) wanted to make accelerators for generating x rays for cancer treatment. I went to some people I knew in that field and they were so intransigently opposed and narrow-minded about it that I decided to throw in my lot with him just on that" (*International Science and Technology*, 1965). High Voltage Engineering eventually grew to over $100 million in sales.

In 1948, Richard H. Bolt, an MIT professor in the Physics Department and director of the MIT Acoustics Laboratory, and Leo L. Beranek, an electrical engineering faculty member and technical director of the Acoustics Lab, formed the partnership of Bolt and Beranek to offer consulting services in acoustics, responding to a call from the architects of the United Nations Headquarters buildings. When they recruited Robert B. Newman, a graduate student in architecture, to join them as a full partner in 1950, the name of the firm was changed to Bolt Beranek and Newman (now BBN Inc.). With emphasis gradually shifting over three decades from acoustics and noise control toward signal processing and computing, BBN, in 1989, had sales of $292 million.

Each of these faculty-based enterprises exemplifies the importance of direct transfer of advanced technology to the commercial marketplace. But although these professors and their early new enterprises became visible very quickly, most firms in the Greater Boston area that have been formed and grown in areas of high-rate-of-change technology are not founded by academics. Rather, they are created by engineers who had worked for a major MIT or industrial lab. The first in-depth example that follows, Digital Equipment Corporation (DEC), was founded by two former employees of MIT's Lincoln Laboratory, a major government-sponsored research and development organization established by MIT in the late 1940 to focus on the problems of air defense of the United States. Like the faculty-based companies DEC reiterates the importance of transfer of advanced technology to the initial product lines of an entrepreneurial firm. But DEC also demonstrates the critical contribution toward corporate "take-off" of a continuing flow of highly skilled professionals from a closely connected university into a rapidly growing and exciting organization.

Kenneth Olsen and Digital Equipment Corporation

Born in Bridgeport, Connecticut, in 1926, Kenneth Harry Olsen was the son of a machinery designer/sales engineer and was brought up in an

evangelical Scandinavian Protestant family. His father's religious values and commitments influenced Ken deeply, his activities even today being strongly church-related. With a tool shop in the basement, Ken and his younger brother Stan became inventive gadgeteers, working with both mechanical and electrical devices. Joining the Navy directly from Stratford High School near the end of World War II, Ken received further training as an electronics technician before entering MIT, where he majored in electrical engineering.

Upon receiving his bachelor's degree Olsen joined Jay W. Forrester's MIT Digital Computer Laboratory group in July 1950 as a research associate. Forrester's team was just beginning to tackle the problems of upgrading the pioneering MIT real-time Whirlwind Computer into the basis for the SAGE (Semi-Automatic Ground Environment) system, the nation's first continental air defense system. MIT had recently established Lincoln Laboratory as prime contractor to the Air Force for this major program. Olsen's responsibilities quickly grew in that organization, taking on the project engineer's role for the first memory test computer (MTC) for the magnetic core memories created by Forrester and his associates, while also completing MIT requirements for his master's degree. Soon after IBM received the contract to supply the SAGE system's AN/FSQ-7 computer, Olsen and his wife Aulikki and young child moved to Poughkeepsie, New York, to become MIT's on-site liaison to the IBM development and manufacturing organization. The year-plus of day-to-day work with IBM taught Olsen much about the ways of a large bureaucratic organization, most of it not especially to the tastes of this young man who had grown up in MIT's far more free-wheeling environs. But he also learned to appreciate the disciplines of a well-run company. Returning to Lincoln Lab, Olsen took on leadership of the TX-2 computer development project, a small fast experimental machine designed around new transistorized circuits.

In late 1956, Olsen was approached by some other engineers who wanted him to join them in forming a new company. Ken remembers them as "vague in their thinking—they didn't have any specific products in mind; they just wanted to go into business". When their proposal failed, the germ was planted in Ken's mind to do something on his own. Despite having moved up to a section chief's job, the challenge of Lincoln Lab was wearing out and he felt he had to move. During the spring of 1957, discussions with Harlan Anderson, a Lincoln Lab engineer since 1952, who had worked in Olsen's early MTC project group, evolved the concept of a new computer company. They intended to design and build machines that reflected the Whirlwind/TX-2 real-time interactive approach, in contrast to the large number-crunching data processing computers that IBM and Univac already had in the marketplace.

With few financing alternatives apparent in the summer of 1957 Olsen and Anderson contacted American Research and Development Corporation (ARD) to fund their proposed Digital Computer Corporation (see Chapter 5 for further discussion of AR&D's pioneering role in the venture capital

industry). In his commencement address at MIT in 1987, Olsen reminisced on this experience. "AR&D told us that this was not the right time for starting a company... [The AR&D staff] gave us three pieces of advice: Don't use the word computer, because *Fortune* magazine said no one is making money in computers... The promise of five per cent profit on sales in our initial presentation is not high enough; raise it... [so] we promised ten per cent.... Promise fast results, because most of the [AR&D] board members were over 80. So we promised to make a profit in one year" (Olsen, 1987, p. 8). With the business plan thus revised to meet the investors' stated prejudices, the AR&D board approved the investment in Digital Equipment (note, *not Computer*) Corporation of $70,000 for which they took 70 percent of the authorized stock. Intrigued by the young technologists and their objectives, but skeptical about their lack of management training and experience, AR&D insisted that stock be reserved to hire an experienced manager for this start-up. As that third key person was never brought on-board, the AR&D holdings turned out to be 78 percent of the total equity issued in DEC, the single investment that "made" the ARD portfolio so successful over the years, perhaps the best investment in the history of venture capital. But Olsen has never expressed regret about the limited initial funds or the disproportionate stock holdings by ARD. Ken has often remarked, "The nice thing about $70,000 is that you can watch every dollar", and he has frequently praised his investors for their long view and their lack of interference in DEC's efforts.

Incorporating DEC on August 28, 1957, were two young married couples, Kenneth and Eeva-Liisa Aulikki Olsen and Harlan and Lois Jean Anderson, somewhat prototypical of American entrepreneurial beginnings; but certainly not typical in the outcomes they achieved over the next three decades. Olsen was 31 and Anderson just 28 when the company was started, leaving Lincoln Lab to occupy inelegant but more importantly inexpensive space (25 cents per square foot per year, including watchman service and heat!) in an old textile mill in Maynard, Massachusetts, not far out into the countryside from their previous MIT lab location. On their first day at the mill they were joined by Stan Olsen, Ken's younger brother who had graduated from Northeastern University in Boston and had worked at Lincoln Lab as a technician, the only Olsen family member ever to work at Digital. For several years that initial threesome provided much of the functional leadership at Digital, with Ken handling engineering, "Andy" doing finance, and Stan running production.

The entrepreneurs began by developing a line of high speed transistorized circuit modules, similar to what had been created at Lincoln Lab for the TX-0 and TX-2 computers, but redesigned to accommodate the newest transistors available. Olsen says he saw the need for these packaged modules while at the lab and believed that DEC could develop a better line of products than was available at the time. Dick Best, Lincoln Lab's top-notch circuit designer, joined DEC as employee #5 to move this project